



**BUREAU
VERITAS**

Gas Fuelled Ships

January 2020

**Rule Note
NR529 DT R03 E**

**Marine & Offshore
8 Cours du Triangle - CS 50101
92937 Paris La Defense Cedex - France
Tel: + 33 (0)1 55 24 70 00
<https://marine-offshore.bureauveritas.com/bv-rules>
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GENERAL CONDITIONS

1. INDEPENDENCE OF THE SOCIETY AND APPLICABLE TERMS

- 1.1 The Society shall remain at all times an independent contractor and neither the Society nor any of its officers, employees, servants, agents or subcontractors shall be or act as an employee, servant or agent of any other party hereto in the performance of the Services.
- 1.2 The operations of the Society in providing its Services are exclusively conducted by way of random inspections and do not, in any circumstances, involve monitoring or exhaustive verification.
- 1.3 The Society acts as a services provider. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty. The Society is not and may not be considered as an underwriter, broker in Unit's sale or chartering, expert in Unit's valuation, consulting engineer, controller, naval architect, designer, manufacturer, shipbuilder, repair or conversion yard, charterer or shipowner; none of them above listed being relieved of any of their expressed or implied obligations as a result of the interventions of the Society.
- 1.4 The Society only is qualified to apply and interpret its Rules.
- 1.5 The Client acknowledges the latest versions of the Conditions and of the applicable Rules applying to the Services' performance.
- 1.6 Unless an express written agreement is made between the Parties on the applicable Rules, the applicable Rules shall be the Rules applicable at the time of entering into the relevant contract for the performance of the Services.
- 1.7 The Services' performance is solely based on the Conditions. No other terms shall apply whether express or implied.

2. DEFINITIONS

- 2.1 "Certificate(s)" means classification or statutory certificates, attestations and reports following the Society's intervention.
- 2.2 "Certification" means the activity of certification in application of national and international regulations or standards, in particular by delegation from different governments that can result in the issuance of a Certificate.
- 2.3 "Classification" means the classification of a Unit that can result or not in the issuance of a classification Certificate with reference to the Rules. Classification is an appraisalment given by the Society to the Client, at a certain date, following surveys by its surveyors on the level of compliance of the Unit to the Society's Rules or to the documents of reference for the Services provided. They cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value for sale, insurance or chartering.
- 2.4 "Client" means the Party and/or its representative requesting the Services.
- 2.5 "Conditions" means the terms and conditions set out in the present document.
- 2.6 "Industry Practice" means international maritime and/or offshore industry practices.
- 2.7 "Intellectual Property" means all patents, rights to inventions, utility models, copyright and related rights, trade marks, logos, service marks, trade dress, business and domain names, rights in trade dress or get-up, rights in goodwill or to sue for passing off, unfair competition rights, rights in designs, rights in computer software, database rights, topography rights, moral rights, rights in confidential information (including know-how and trade secrets), methods and protocols for Services, and any other intellectual property rights, in each case whether capable of registration, registered or unregistered and including all applications for and renewals, reversions or extensions of such rights, and all similar or equivalent rights or forms of protection in any part of the world.
- 2.8 "Parties" means the Society and Client together.
- 2.9 "Party" means the Society or the Client.
- 2.10 "Register" means the public electronic register of ships updated regularly by the Society.
- 2.11 "Rules" means the Society's classification rules and other documents. The Society's Rules take into account at the date of their preparation the state of currently available and proven technical minimum requirements but are not a standard or a code of construction neither a guide for maintenance, a safety handbook or a guide of professional practices, all of which are assumed to be known in detail and carefully followed at all times by the Client.
- 2.12 "Services" means the services set out in clauses 2.2 and 2.3 but also other services related to Classification and Certification such as, but not limited to: ship and company safety management certification, ship and port security certification, maritime labour certification, training activities, all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board. The Services are carried out by the Society according to the applicable referential and to the Bureau Veritas' Code of Ethics. The Society shall perform the Services according to the applicable national and international standards and Industry Practice and always on the assumption that the Client is aware of such standards and Industry Practice.
- 2.13 "Society" means the classification society 'Bureau Veritas Marine & Offshore SAS', a company organized and existing under the laws of France, registered in Nanterre under number 821 131 844, or any other legal entity of Bureau Veritas Group as may be specified in the relevant contract, and whose main activities are Classification and Certification of ships or offshore units.
- 2.14 "Unit" means any ship or vessel or offshore unit or structure of any type or part of it or system whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovercrafts, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment, subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

3. SCOPE AND PERFORMANCE

- 3.1 Subject to the Services requested and always by reference to the Rules, the Society shall:
- review the construction arrangements of the Unit as shown on the documents provided by the Client;
 - conduct the Unit surveys at the place of the Unit construction;
 - class the Unit and enter the Unit's class in the Society's Register;
 - survey the Unit periodically in service to note whether the requirements for the maintenance of class are met.
- The Client shall inform the Society without delay of any circumstances which may cause any changes on the conducted surveys or Services.
- 3.2 The Society will not:
- declare the acceptance or commissioning of a Unit, nor its construction in conformity with its design, such activities remaining under the exclusive responsibility of the Unit's owner or builder;
 - engage in any work relating to the design, construction, production or repair checks, neither in the operation of the Unit or the Unit's trade, neither in any advisory services, and cannot be held liable on those accounts.

4. RESERVATION CLAUSE

- 4.1 The Client shall always: (i) maintain the Unit in good condition after surveys; (ii) present the Unit for surveys; and (iii) inform the Society in due time of any circumstances that may affect the given appraisalment of the Unit or cause to modify the scope of the Services.
- 4.2 Certificates are only valid if issued by the Society.
- 4.3 The Society has entire control over the Certificates issued and may at any time withdraw a Certificate at its entire discretion including, but not limited to, in the following situations: where the Client fails to comply in due time with instructions of the Society or where the Client fails to pay in accordance with clause 6.2 hereunder.
- 4.4 The Society may at times and at its sole discretion give an opinion on a design or any technical element that would 'in principle' be acceptable to the Society. This opinion shall not presume on the final issuance of any Certificate or on its content in the event of the actual issuance of a Certificate. This opinion shall only be an appraisal made by the Society which shall not be held liable for it.

5. ACCESS AND SAFETY

- 5.1 The Client shall give to the Society all access and information necessary for the efficient performance of the requested Services. The Client shall be the sole responsible for the conditions of presentation of the Unit for tests, trials and surveys and the conditions under which tests and trials are carried out. Any information, drawing, etc. required for the performance of the Services must be made available in due time.
- 5.2 The Client shall notify the Society of any relevant safety issue and shall take all necessary safety-related measures to ensure a safe work environment for the Society or any of its officers, employees, servants, agents or subcontractors and shall comply with all applicable safety regulations.

6. PAYMENT OF INVOICES

- 6.1 The provision of the Services by the Society, whether complete or not, involve, for the part carried out, the payment of fees thirty (30) days upon issuance of the invoice.

6.2 Without prejudice to any other rights hereunder, in case of Client's payment default, the Society shall be entitled to charge, in addition to the amount not properly paid, interests equal to twelve (12) months LIBOR plus two (2) per cent as of due date calculated on the number of days such payment is delinquent. The Society shall also have the right to withhold Certificates and other documents and/or to suspend or revoke the validity of Certificates.

- 6.3 In case of dispute on the invoice amount, the undisputed portion of the invoice shall be paid and an explanation on the dispute shall accompany payment so that action can be taken to solve the dispute.

7. LIABILITY

- 7.1 The Society bears no liability for consequential loss. For the purpose of this clause consequential loss shall include, without limitation:
- Indirect or consequential loss;
 - Any loss and/or deferral of production, loss of product, loss of use, loss of bargain, loss of revenue, loss of profit or anticipated profit, loss of business and business interruption, in each case whether direct or indirect.
- The Client shall defend, release, save, indemnify, defend and hold harmless the Society from the Client's own consequential loss regardless of cause.
- 7.2 Except in case of wilful misconduct of the Society, death or bodily injury caused by the Society's negligence and any other liability that could not be, by law, limited, the Society's maximum liability towards the Client is limited to one hundred and fifty per-cents (150%) of the price paid by the Client to the Society for the Services having caused the damage. This limit applies to any liability of whatsoever nature and howsoever arising, including fault by the Society, breach of contract, breach of warranty, tort, strict liability, breach of statute.
- 7.3 All claims shall be presented to the Society in writing within three (3) months of the completion of Services' performance or (if later) the date when the events which are relied on were first discovered by the Client. Any claim not so presented as defined above shall be deemed waived and absolutely time barred.

8. INDEMNITY CLAUSE

- 8.1 The Client shall defend, release, save, indemnify and hold harmless the Society from and against any and all claims, demands, lawsuits or actions for damages, including legal fees, for harm or loss to persons and/or property tangible, intangible or otherwise which may be brought against the Society, incidental to, arising out of or in connection with the performance of the Services (including for damages arising out of or in connection with opinions delivered according to clause 4.4 above) except for those claims caused solely and completely by the gross negligence of the Society, its officers, employees, servants, agents or subcontractors.

9. TERMINATION

- 9.1 The Parties shall have the right to terminate the Services (and the relevant contract) for convenience after giving the other Party thirty (30) days' written notice, and without prejudice to clause 6 above.
- 9.2 In such a case, the Classification granted to the concerned Unit and the previously issued Certificates shall remain valid until the date of effect of the termination notice issued, subject to compliance with clause 4.1 and 6 above.
- 9.3 In the event where, in the reasonable opinion of the Society, the Client is in breach, or is suspected to be in breach of clause 16 of the Conditions, the Society shall have the right to terminate the Services (and the relevant contracts associated) with immediate effect.

10. FORCE MAJEURE

- 10.1 Neither Party shall be responsible or liable for any failure to fulfil any term or provision of the Conditions if and to the extent that fulfilment has been delayed or temporarily prevented by a force majeure occurrence without the fault or negligence of the Party affected and which, by the exercise of reasonable diligence, the said Party is unable to provide against.
- 10.2 For the purpose of this clause, force majeure shall mean any circumstance not being within a Party's reasonable control including, but not limited to: acts of God, natural disasters, epidemics or pandemics, wars, terrorist attacks, riots, sabotages, impositions of sanctions, embargoes, nuclear, chemical or biological contaminations, laws or action taken by a government or public authority, quotas or prohibition, expropriations, destructions of the worksite, explosions, fires, accidents, any labour or trade disputes, strikes or lockouts.

11. CONFIDENTIALITY

- 11.1 The documents and data provided to or prepared by the Society in performing the Services, and the information made available to the Society, are treated as confidential except where the information:
- is properly and lawfully in the possession of the Society;
 - is already in possession of the public or has entered the public domain, otherwise than through a breach of this obligation;
 - is acquired or received independently from a third party that has the right to disseminate such information;
 - is required to be disclosed under applicable law or by a governmental order, decree, regulation or rule or by a stock exchange authority (provided that the receiving Party shall make all reasonable efforts to give prompt written notice to the disclosing Party prior to such disclosure).
- 11.2 The Parties shall use the confidential information exclusively within the framework of their activity underlying these Conditions.
- 11.3 Confidential information shall only be provided to third parties with the prior written consent of the other Party. However, such prior consent shall not be required when the Society provides the confidential information to a subsidiary.
- 11.4 Without prejudice to sub-clause 11.1, the Society shall have the right to disclose the confidential information if required to do so under regulations of the International Association of Classifications Societies (IACS) or any statutory obligations.

12. INTELLECTUAL PROPERTY

- 12.1 Each Party exclusively owns all rights to its Intellectual Property created before or after the commencement date of the Conditions and whether or not associated with any contract between the Parties.
- 12.2 The Intellectual Property developed by the Society for the performance of the Services including, but not limited to drawings, calculations, and reports shall remain the exclusive property of the Society.

13. ASSIGNMENT

- 13.1 The contract resulting from to these Conditions cannot be assigned or transferred by any means by a Party to any third party without the prior written consent of the other Party.
- 13.2 The Society shall however have the right to assign or transfer by any means the said contract to a subsidiary of the Bureau Veritas Group.

14. SEVERABILITY

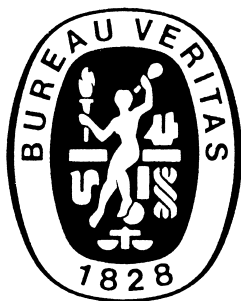
- 14.1 Invalidity of one or more provisions does not affect the remaining provisions.
- 14.2 Definitions herein take precedence over other definitions which may appear in other documents issued by the Society.
- 14.3 In case of doubt as to the interpretation of the Conditions, the English text shall prevail.

15. GOVERNING LAW AND DISPUTE RESOLUTION

- 15.1 These Conditions shall be construed and governed by the laws of England and Wales.
- 15.2 The Parties shall make every effort to settle any dispute amicably and in good faith by way of negotiation within thirty (30) days from the date of receipt by either one of the Parties of a written notice of such a dispute.
- 15.3 Failing that, the dispute shall finally be settled under the Rules of Arbitration of the Maritime Arbitration Chamber of Paris ("CAMP"), which rules are deemed to be incorporated by reference into this clause. The number of arbitrators shall be three (3). The place of arbitration shall be Paris (France). The Parties agree to keep the arbitration proceedings confidential.

16. PROFESSIONAL ETHICS

- 16.1 Each Party shall conduct all activities in compliance with all laws, statutes, rules, economic and trade sanctions (including but not limited to UN sanctions and EU sanctions) and regulations applicable to such Party including but not limited to: child labour, forced labour, collective bargaining, discrimination, abuse, working hours and minimum wages, anti-bribery, anti-corruption, copyright and trademark protection, personal data protection (<https://personal.dataprotection.bureauveritas.com/privacypolicy>).
- Each of the Parties warrants that neither it, nor its affiliates, has made or will make, with respect to the matters provided for hereunder, any offer, payment, gift or authorization of the payment of any money, directly or indirectly, to or for the use or benefit of any official or employee of the government, political party, official or candidate.
- 16.2 In addition, the Client shall act consistently with the Bureau Veritas' Code of Ethics. <https://group.bureauveritas.com/group/corporate-social-responsibility>



RULE NOTE NR 529

NR 529 Gas-fuelled Ships

Premise

International Code of Safety for Ships Using Gases or other Low-Flashpoint Fuels (IGF Code)

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January 2020

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International Code of Safety for Ships Using Gases
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PREMISE

P.1 General

P.1.1 This Rule Note incorporates the text of the "INTERNATIONAL CODE OF SAFETY FOR SHIPS USING GASES OR OTHER LOW-FLASHPOINT FUELS (IGF CODE)" adopted by the IMO Maritime Safety Committee, at its 95th session, on 11 June 2015, through Resolution MSC.391(95), with the exception of the provisions of Parts C-1 and D, which are not within the scope of classification. *This text is printed in italics type.*

P.1.2 Classification requirements additional to the provisions of the IGF Code are printed in the Roman characters used for this item P.1.2 and the relevant number is prefixed by the letter C and are identified by a vertical line placed in the margin of the text.

The additional classification requirements are of the following categories:

- Additional classification requirement or interpretation completing or interpreting a specific clause of the Code:
In such case the classification requirement is located just after the concerned Code requirement and is identified with the IGF Code reference prefixed by C.
For instance, classification requirements related to interpretation of IGF Code provision 1.2.3 would be C1.2.3.
- Additional classification requirement or set of requirements completing an article or chapter of the Code:
In such a case, the classification requirements are added within the corresponding chapter or article, with the reference of this chapter/article prefixed by C and suffixed by incremental letters starting from (a).
For instance, additional classification requirements to an article 1.2 would be C1.2(a), C1.2(b)...

P.1.3 The provisions of the IGF Code incorporated in this Rule Note are applicable for classification, as applicable for the assignment of additional service feature **gasfuel** or **dualfuel** as defined in NR467, Pt A, Ch 1, Sec 2 [4.11].

In those provisions of the IGF Code that are being used for classification purposes, the words "Administration" and "Code", wherever mentioned, are to be understood as equivalent to the words "Society" and "Rules", respectively.

The following references to BV rules and notes are used in this Rule Note:

- NR467 refers to NR467 - Rules for the classification of steel ships
- NR216 refers to NR216 - Rules on materials and welding for the classification of marine units
- NR320 refers to NR320 - Certification scheme of materials and equipment for the classification of marine units

P.1.4 This Rule Note is composed of the following main components:

- This Premise section providing general information
- IGF Code Preamble
- IGF Code Parts A, A-1 and B-1 with associated classification requirements as defined in P.1.2
- The Annex to Part A-1 of IGF Code
- Appendix 1 to 3 containing additional classification requirements.

P.2 Compliance with other rules

For any items not expressly stipulated or modified for classification purposes by these Rules, the requirements of the Society Rules are to apply wherever relevant.

Classification of a ship with the Society, or more generally any Society actions and decisions, do not absolve the interested parties from compliance with additional and/or more stringent requirements and provisions for their application, issued by the Administration of the State whose flag the ship is entitled to fly and/or of the State where the base port from which the ship is intended to operate is situated.

P.3 Novel or unusual features

Ships presenting novel or unusual arrangements for items such as systems, apparatuses and devices, described in these rules, to which the requirements of these rules do not apply directly, either in whole or on part, may be classed on an individual basis, at the discretion of the Society.

INTERNATIONAL CODE OF SAFETY FOR SHIPS USING GASES OR OTHER LOW-FLASHPOINT FUELS (IGF CODE)

1 **Preamble**

The purpose of this Code is to provide an international standard for ships using low-flashpoint fuel, other than vessels covered by the IGC Code.

The basic philosophy of this Code is to provide mandatory provisions 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 fuels involved.

Throughout the development of this Code it was recognized that it must be based upon sound naval architectural and engineering principles and the best understanding available of current operational experience, field data and research and development. Due to the rapidly evolving new fuels technology, the Organization will periodically review this Code, taking into account both experience and technical developments.

This Code addresses all areas that need special consideration for the usage of the low-flashpoint fuel. The basic philosophy of the IGF Code considers the goal based approach (MSC.1/Circ.1394). Therefore, goals and functional requirements were specified for each section forming the basis for the design, construction and operation.

The current version of this Code includes regulations to meet the functional requirements for natural gas fuel. Regulations for other low-flashpoint fuels will be added to this Code as, and when, they are developed by the Organization.

In the meantime, for other low-flashpoint fuels, compliance with the functional requirements of this Code must be demonstrated through alternative design.

PART A

2 General

2.1 Application

Unless expressly provided otherwise this Code applies to ships to which part G of SOLAS chapter II-1 applies.

C2.1(a) Application

This Rule Note applies to ships using liquefied or compressed natural gas as fuel either as single fuel or together with oil fuel. In accordance with NR467, Pt A, Ch 1, Sec 2 [4.11], such ships will be assigned the additional service feature **gasfuel** or **dualfuel** respectively.

This Rule Note does not apply to liquefied gas carriers.

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

C2.1(b) Documentation to be submitted

With reference to C2.1(a), for ships to be assigned the additional service feature **gasfuel** or **dualfuel**, the documents to be submitted are listed in Tab C2.1.

Table C2.1 : Documents to be submitted

No	A / I (1)	Documents
1	A	General arrangement of the ship 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 utilization units (engines, gas turbines, boilers and gas combustion units)
3	A	Gas-dangerous zone plan
4	A	Air locks between safe and dangerous zones
5	A	Risk analysis as per 4.2 and follow-up report of the recommendations
6	A	Details of hull structure in way of liquefied fuel containment system and relative stress analysis, including support arrangement for tanks, saddles, anti-floating and anti-lifting devices, deck sealing arrangements, etc.
7	A	Calculation of the hull temperature and associated distribution of quality and steel grades
8	A	Scantlings, material and arrangement of the fuel containment system, including the secondary barrier, if any
9	A	Hull ship motion analysis, where a direct analysis is preferred to the methods indicated in Chapter 6
10	A	Sloshing calculation where relevant
11	A	Stress analysis of the fuel containment, including fatigue analysis and crack propagation analysis for type “B” tanks.
12	A	Details of ladders, fittings, swash bulkheads and towers in tanks and relative stress analysis, if any
13	A	Details of tank domes and deck sealings
14	A	Fuel containment system testing and inspection procedures
15	A	Inspection/survey plan for the liquefied gas fuel containment system as requested in 6.4.1.8
16	A	Vent mast detailed drawing
17	I	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
18	A	Gas fuel tank pressure control philosophy
19	A	Details of insulation
20	A	Plans and calculations of safety relief valves
(1) A =to be submitted for approval I = to be submitted for information		

No	A / I (1)	Documents
21	A	Diagram of the liquefied and gaseous fuel gas piping system, including venting system
22	A	Arrangement of the double piping or duct system
23	A	Specification of the control, monitoring and safety systems for the gas installation (Cause and effect matrix)
24	A	Stress analysis of the piping systems, when their design temperature is -110°C or lower
25	A	Material, thickness and joints of the gas pipes
26	A	Diagram of the inert gas piping system
27	A	Diagram of the ventilation in all spaces containing gas piping
28	A	Ventilation duct arrangement in gas-dangerous spaces and 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	A	Details of process pressure vessels and relative valving arrangement
33	A	Bilge system of the spaces related to fuel gas storage and preparation
34	A	Hull structure heating system, if any
35	A	Emergency shutdown system
36	A	Fuel containment system instrumentation, including fuel and hull temperature monitoring system
37	A	Interbarrier space drainage, inerting and pressurisation systems if fitted
38	A	Details of fire-extinguishing appliances and systems related to gas installation: Water spray system when required to be fitted, Dry chemical powder, Fire Main
39	I	Specification and type-approval reference of the gas utilization units
40	A	Diagram of the gas fuel supply systems, for each gas utilization unit
41	A	Arrangement of the GVUs
42	A	Diagram of the fuel oil system including pilot fuel supply
43	A	Diagram of the engine lubricating oil system
44	A	Diagram of the engine cooling system
45	A	Diagram of the engine crankcase venting systems
46	A	Drawings of the boilers, including burners
47	A	Drawing of the exhaust gas ducts
48	A	Specification of the control, monitoring and safety systems for each gas utilization unit
49	I	Instrumentation list
50	I	Safety certificates for electrical equipment located in gas-dangerous spaces or zones, where applicable
51	A	Schematic electrical wiring diagram in hazardous areas
52	A	Failure modes and effects of single failure for electrical generation and distribution systems as requested in 14.3.4
53	A	Arrangement of electrical installation in hazardous areas, including lighting system
54	I	Fuel containment system gas freeing procedure, including emptying, inerting and aerating
55	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
56	A	Stress analysis of the high pressure piping systems
57	A	HAZOP study for very high pressure gas fuel installations and report of the follow-up recommendations
58	A	FMECA analysis for very high pressure gas fuel equipment
59	A	FMEA analysis for the systems intended to maintain the fuel tank pressure and temperature (see C6.9.6.1)
60	A	List of failure modes and relevant repair procedures for heat exchangers, when requested in C6.9.6.2
61	A	Bunkering procedure
(1) A =to be submitted for approval		
I = to be submitted for information		

2.2 Definitions

Unless otherwise stated below, definitions are as defined in SOLAS chapter II-2.

2.2.1 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.

2.2.2 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).

2.2.3 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.

C2.2.3 Bunkering also covers the transfer of fuel vapour from the ship's tank to the bunkering facilities.

2.2.4 Certified safe type means electrical equipment that is certified safe by the relevant authorities recognized by the Administration 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.

2.2.5 CNG means compressed natural gas (see also 2.2.26).

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

2.2.7 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.

2.2.8 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.

2.2.9 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.

C2.2.9 Bleed valve means the valve in the double block and bleed set of valves intended for the pressure release.

2.2.10 Dual fuel engines means engines that employ fuel covered by this Code (with pilot fuel) and oil fuel. Oil fuels may include distillate and residual fuels.

2.2.11 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 2 : See also definition in IEC 60092-502:1999.

2.2.12 ESD means emergency shutdown.

2.2.13 Explosion means a deflagration event of uncontrolled combustion.

2.2.14 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.

2.2.15 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:

- .1** 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;
- .2** 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
- .3** Tank connection space is a space surrounding all tank connections and tank valves that is required for tanks with such connections in enclosed spaces.

C2.2.15.3 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. Such equipment is considered to only contain potential sources of release, but not sources of ignition.

Tank connection spaces containing a GVU are to comply with requirement C5(a), paragraphs c), d) and e).

C2.2.15 For membrane tanks, the hull structure that supports the membrane may be the boundary of the fuel storage hold space.

2.2.16 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.

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

C2.2.17 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.

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

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

2.2.20 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.

2.2.21 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.

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

C2.2.22 High pressure may be referred as HP.

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

2.2.24 LEL means the lower explosive limit.

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

2.2.26 LNG means liquefied natural gas.

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

2.2.28 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.

2.2.29 MARVS means the maximum allowable relief valve setting.

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

2.2.31 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.

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

2.2.33 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.

2.2.34 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 deckhead.

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

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

2.2.37 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.

2.2.38 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.³

Note 3 : Refer also to IEC 60092-502:1999 Electrical Installations in Ships – Tankers – Special Features.

2.2.39 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.

C2.2.39 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.

2.2.40 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.

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

C2.2(a) 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.

C2.2(b) 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.

C2.2(c) Low pressure means a maximum working pressure lower than or equal to 1,0 MPa.

C2.2(d) Machinery spaces mean spaces as defined in SOLAS Convention, Regulations 3.30 and 3.31.

C2.2(e) *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.

C2.2(f) *Room with high fire risk includes as a minimum, but should not be restricted to:*

- 1 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;
- 2 vehicle, ro-ro and special category spaces;
- 3 service spaces (high risk): galleys, pantries containing cooking appliances, saunas, paint lockers and store-rooms having areas of 4 m² 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
- 4 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 m² or more, as provided in SOLAS regulation II-2/9.2.2.3.

C2.2(g) *Vent mast is a venting system to which fuel tank pressure relief valves are connected and which complies with 6.7.2.7.*

C2.2(h) *Very high pressure (VHP) means a maximum working pressure greater than 2,0 MPa*

2.3 *Alternative design*

2.3.1 *This Code contains functional requirements for all appliances and arrangements related to the usage of low-flashpoint fuels.*

2.3.2 *Fuels, appliances and arrangements of low-flashpoint fuel systems may either:*

- .1** *deviate from those set out in this Code, or*
- .2** *be designed for use of a fuel not specifically addressed in this Code.*

Such fuels, appliances and arrangements can be used provided that these meet the intent of the goal and functional requirements concerned and provide an equivalent level of safety of the relevant Chapters.

2.3.3 *The equivalence of the alternative design shall be demonstrated as specified in SOLAS regulation II-1/55 and approved by the Administration. However, the Administration shall not allow operational methods or procedures to be applied as an alternative to a particular fitting, material, appliance, apparatus, item of equipment, or type thereof which is prescribed by this Code.*

C2.3.3 Refer also to the following IMO circulars:

- Circular MSC.1/Circ.1212: Guidelines on alternative design and arrangements for SOLAS chapters II-1 and III
- Circular MSC.1/Circ.1455: Guidelines for the approval of alternatives and equivalents as provided for in various IMO instruments.

3 Goal and Functional Requirements

3.1 Goal

The goal of this Code is to provide for safe and environmentally-friendly design, construction and operation of ships and in particular their installations of systems for propulsion machinery, auxiliary power generation machinery and/or other purpose machinery using gas or low-flashpoint fuel as fuel.

3.2 Functional requirements

3.2.1 *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.*

3.2.2 *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.*

3.2.3 *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.*

3.2.4 *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.*

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

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

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

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

3.2.9 *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.*

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

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

3.2.12 *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.*

C3.2.12

(a) This applies in particular to ESD protected machinery spaces.

(b) A "source that might release gas" is to be considered as a "source of release" as defined in 2.2.39.

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

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

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

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

3.2.17 *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.*

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

4 General Requirements

4.1 Goal

The goal of this Chapter is to ensure that the necessary assessments of the risks involved are carried out in order to eliminate or mitigate any adverse effect to the persons on board, the environment or the ship.

4.2 Risk assessment

4.2.1 *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.*

4.2.2 *For ships to which part A-1 applies, the risk assessment required by 4.2.1 need only be conducted where explicitly required by 5.10.5, 5.12.3, 6.4.1.1, 6.4.15.4.7.2, 8.3.1.1, 13.4.1, 13.7 and 15.8.1.10 as well as by 4.4 and 6.8 of the annex.*

4.2.3 *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 Administration.*

C4.2.3 The risk analysis is also to cover gas and liquid fuel leakage.

C4.2(a) Additional requirements for risk assessment

- (a) Risk assessment is to be carried out in accordance with IACS Recommendation N° 146 "Risk assessment as required by the IGF code".
- (b) An HAZID study is to be carried out for each gas-fuelled ship. It should 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
 - GUV spaces (except GUV 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 15.8.1.10).
 - Containment systems and adjacent structure (see 6.4.15.4.2.1.3).

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.

- (c) A FMECA analysis is to be carried out for the very high pressure equipment, including:
 - LNG pumps
 - compressors
 - diesel engines
 - electrical generation and distribution systems (see 14.3.4).
- (d) An HAZOP study is to be carried out for the very high pressure gas fuel installation. Type approved equipment need not be considered in the study.
- (e) 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.

4.3 **Limitation of explosion consequences**

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

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

Note 4 : *Double wall fuel pipes are not considered as potential sources of release.*

C4.3(a) Additional requirements for explosion analysis

An explosion analysis is required for ESD-protected machinery spaces. It may also be required for other gas 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.

PART A-1 SPECIFIC REQUIREMENTS FOR SHIPS USING NATURAL GAS AS FUEL

Fuel in the context of the regulations in this part means natural gas, either in its liquefied or gaseous state.

It should be recognized that the composition of natural gas may vary depending on the source of natural gas and the processing of the gas.

5 Ship Design and Arrangement

5.1 Goal

The goal of this chapter is to provide for safe location, space arrangements and mechanical protection of power generation equipment, fuel storage systems, fuel supply equipment and refuelling systems.

5.2 Functional requirements

5.2.1 This chapter is related to functional requirements in 3.2.1 to 3.2.3, 3.2.5, 3.2.6, 3.2.8, 3.2.12 to 3.2.15 and 3.2.17. In particular the following apply:

- .1** 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
- .2** fuel containment systems, fuel piping and other fuel sources of release shall be so located and arranged that released gas is lead to a safe location in the open air
- .3** 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
- .4** fuel piping shall be protected against mechanical damage
- .5** 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

C5.2.1.5 Unacceptable loss of power is defined in 2.2.40.

- .6** the probability of a gas explosion in a machinery space with gas or low-flashpoint fuelled machinery shall be minimized.

5.3 Regulations – General

C5.3(a) Typical location arrangements acceptable for fuel tanks of passenger ships are given in Table C5.3.

5.3.1 Fuel storage tanks shall be protected against mechanical damage.

5.3.2 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.

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

- .1 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).
- .2 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.
- .3 For independent tanks the protective distance shall be measured to the tank shell (the primary barrier of the tank containment system). For membrane tanks the distance shall be measured to the bulkheads surrounding the tank insulation.
- .4 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 5.3.3.1

C5.3.3.4.1 With reference to 5.3.3.4.1, the transition between the minimum protective distances $B/10$ and $B/15$ is to be in compliance with Tab C5.3.

.2 For cargo ships:

- .1 for $V_c \leq 1000 \text{ m}^3$: 0,8 m
- .2 for $1000 \text{ m}^3 < V_c < 5000 \text{ m}^3$:
 $0,75 + V_c \cdot 0,2 / 4000 \text{ m}$
- .3 for $5000 \text{ m}^3 \leq V_c < 30000 \text{ m}^3$:
 $0,8 + V_c / 25000 \text{ m}$, and
- .4 for $V_c \geq 30000 \text{ m}^3$: 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.

- .5 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.
- .6 For multihull ships the value of B may be specially considered.
- .7 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).
- .8 For ships with a hull structure providing higher collision and/or grounding resistance, fuel tank location regulations may be specially considered in accordance with section 2.3.

5.3.4 As an alternative to 5.3.3.1, the following calculation method may be used to determine the acceptable location of the fuel tanks:

- .1 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 5 : 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.

- .2 f_{CN} is calculated by the following formulation:

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

where:

f_ℓ : 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:
 $f_t = 1 - r(x1, x2, b)$ ⁶

Note 6 : 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).

.3 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.

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

.5 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 5.3.3.1.

.2 For cargo ships:

.1 for $V_c \leq 1000 \text{ m}^3$: 0,8 m

.2 for $1000 \text{ m}^3 < V_c < 5000 \text{ m}^3$:
 $0,75 + V_c \times 0,2/4000$ m

.3 for $5000 \text{ m}^3 \leq V_c < 30000 \text{ m}^3$:
 $0,8 + V_c/25000$ m, and

.4 for $V_c \geq 30000 \text{ m}^3$: 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.

.6 In case of more than one non-overlapping fuel tank located in the longitudinal direction, f_{CN} shall be calculated in accordance with 5.3.4.2 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.

.7 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 5.3.4.5 shall be met on both sides.

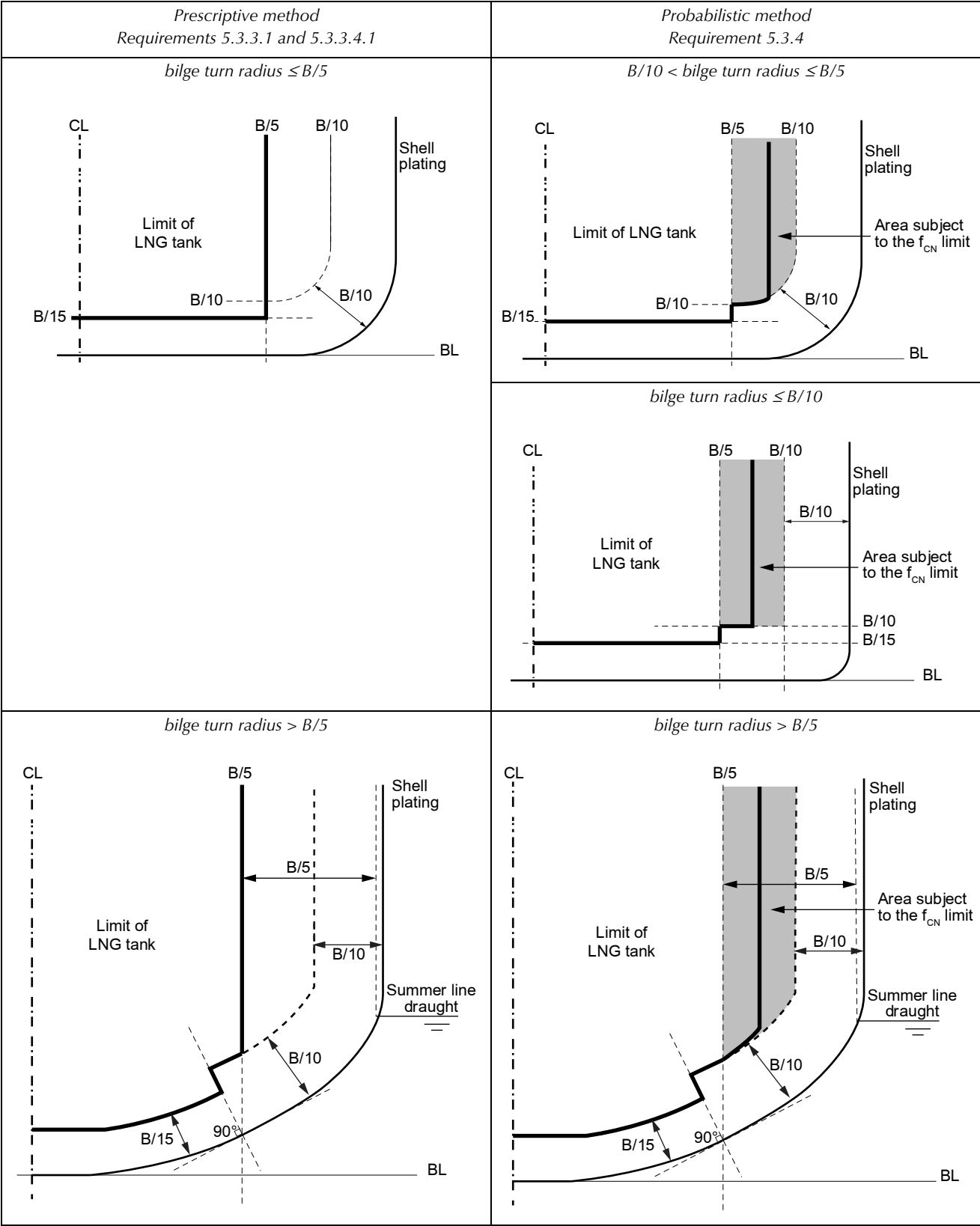
.8 For ships with a hull structure providing higher collision and/or grounding resistance, fuel tank location regulations may be specially considered in accordance with 2.3.

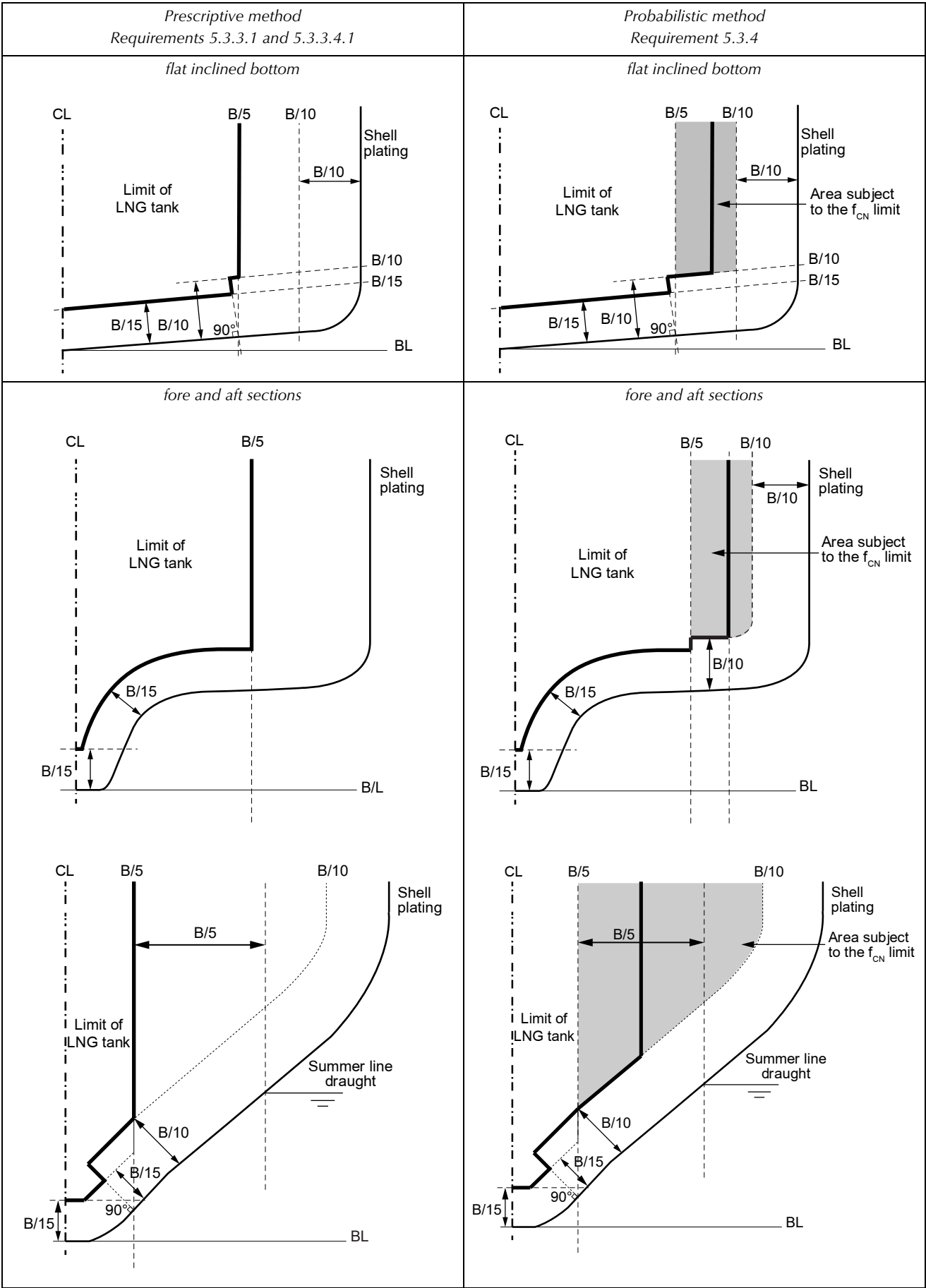
5.3.5 When fuel is carried in a fuel containment system requiring a complete or partial secondary barrier:

.1 fuel storage hold spaces shall be segregated from the sea by a double bottom, and

.2 the ship shall also have a longitudinal bulkhead forming side tanks.

Table C5.3 : Location of fuel storage tanks - Passenger ships





5.4 Machinery space concepts

5.4.1 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:

- .1** 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.
- .2** 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.

C5.4.1.2 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 exceeds 100 kW per cylinder,
- for gas pipes located in gas tight GUV spaces enclosures,
- for venting pipes.

Single wall gas piping is not permitted elsewhere.

5.5 Regulations for gas safe machinery space

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

5.5.2 All fuel piping within machinery space boundaries shall be enclosed in a gas tight enclosure in accordance with 9.6.

C5.5.2 The gas tight enclosure is not required for venting pipes and for gas pipes located in gas tight GUV spaces / enclosures. See Table C9.1.

5.6 Regulations for ESD-protected machinery spaces

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

5.6.2 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:

- .1** gas detector
- .2** shut off valve
- .3** redundancy, and
- .4** efficient ventilation.

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

- .1 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.
- .2 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.
- .3 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.

C5.6.3 Gas supply piping may be accepted without a gastight external enclosure only in the cases mentioned in C5.4.1.2 above. In all other cases, the gas fuel piping is to be enclosed by a double pipe or duct in accordance with 9.6.1. With reference to 5.6.3.1, the "ESD-protected" concept is not acceptable for the propulsion machinery space of a ship fitted with a single engine mechanical propulsion plant.

5.6.4 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.

5.6.5 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.

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

5.6.7 The ventilation system of ESD-protected machinery spaces shall be arranged in accordance with 13.5.

C5.6(a) The gas detection equipment fitted to ESD protected machinery spaces is to comply with 15.8.4.

5.7 Regulations for location and protection of fuel piping

5.7.1 Fuel pipes shall not be located less than 800 mm from the ship's side.

C5.7.1 5.7.1 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 5.7.1 is the distance between the inner pipe and the ship's side.

5.7.2 Fuel piping shall not be led directly through accommodation spaces, service spaces, electrical equipment rooms or control stations as defined in the SOLAS Convention.

C5.7.2 The following additional requirements apply:

- (a) In accordance with 9.5, gas and liquefied fuel piping may be led through other enclosed spaces outside machinery spaces provided it is protected by a secondary enclosure. This enclosure is to be arranged in accordance with C9.5.1. The secondary enclosure may however be omitted in the cases mentioned in Table C9.1.
- (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 C9.5.1(a) 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 9.6.1.2, and
 - provided with a gas detection arrangement in accordance with 15.8.

- (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 9.5.1(b) 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.

5.7.3 *Fuel pipes led through ro-ro spaces, special category spaces and on open decks shall be protected against mechanical damage.*

C5.7.3 The provisions of 5.7.3 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 C5.7.2(b), except that the fire integrity of the trunk or casing is to be according to the "A-60" standard.

5.7.4 *Gas fuel piping in ESD protected machinery spaces shall be located as far as practicable from the electrical installations and tanks containing flammable liquids.*

C5.7.4 5.7.4 applies only to the single wall gas fuel piping.

5.7.5 *Gas fuel piping in ESD protected machinery spaces shall be protected against mechanical damage.*

C5.7.5 5.7.5 applies only to the single wall gas fuel piping.

5.8 Regulations for fuel preparation room design

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

C5.8 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.

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 6.3.4.

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.

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.

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.

5.9 Regulations for bilge systems

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

C5.9.1 Areas where fuel can be present include:

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

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

5.9.2 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.

5.9.3 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.

5.10 Regulations for drip trays

5.10.1 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.

C5.10.1 Drip trays are to be fitted in particular in the following locations:

- in way of the fuel storage tanks located on open deck (see 6.3.10 and 6.5.2.2),
- at the bunkering station (see 8.3.1.5),
- in fuel preparation rooms, in way of possible liquid fuel leakage sources including detachable pipe connections, pumps, valves and heat exchangers.

5.10.2 Drip trays shall be made of suitable material.

C5.10.2 Suitable material means stainless steel or other material having a design temperature corresponding to the temperature of the fuel in the storage tank.

5.10.3 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.

C5.10.3 5.10.3 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.

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

C5.10.4 5.10.4 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.

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

C5.10.5 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.

C5.10(a) 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.

5.11 Regulations for arrangement of entrances and other openings in enclosed spaces

5.11.1 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 5.12 shall be provided.

5.11.2 *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 5.12 shall be provided.*

5.11.3 *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.*

C5.11.3 Access to the tank connection space from the fuel storage hold space through a gastight door and an airlock complying with 5.12 may be considered, subject to the provisions of 2.3.2 and 2.3.3.

5.11.4 *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 5.12.*

5.11.5 *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.*

C5.11(a) The access to GUV rooms from gas-safe machinery spaces is to be arranged through an air lock complying with 5.12.

5.12 Regulations for airlocks

5.12.1 *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 Lines, the door sill shall not be less than 300 mm in height. The doors shall be self-closing without any holding back arrangements.*

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

C5.12.2 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.

5.12.3 *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 4.2.*

C5.12.3 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.

5.12.4 *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 m². Airlocks shall not be used for other purposes, for instance as store rooms.*

5.12.5 *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.*

5.12.6 *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.*

C5.12.6 A monitoring system is to be provided to monitor the differential pressure between the hazardous space and the air lock.

5.12.7 *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.*

C5.12.7 Requirement 5.12.7 applies to the electrical equipment located in the air lock. It also includes the gas detection system required by 15.8.1.7.

C5(a) Regulations for gas valve unit spaces

- (a) 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.
- (b) Gas valve units may also be located in another independent space, provided it fulfil the criteria applicable to fuel preparation rooms, in particular with respect to location, access, ventilation and gas detection. See also 5.11.4.
- (c) 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.
- (d) 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.
- (e) 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 13.8 and provided with gas detection arrangements. Manual shut off valves are to be capable of being operated from outside the enclosure.

6 Fuel Containment System

6.1 Goal

The goal of this chapter is to provide that gas storage is adequate so as to minimize the risk to personnel, the ship and the environment to a level that is equivalent to a conventional oil fuelled ship.

6.2 Functional requirements

Chapter 6 relates to functional requirements in 3.2.1, 3.2.2, 3.2.5 and 3.2.8 to 3.2.17. In particular the following apply:

- .1** *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.*
- .2** *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*
- .3** *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*
- .4** *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.*

6.3 Regulations – General

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

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

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

6.3.4 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.

C6.3.4 A tank connection space may be required also for tanks on open deck. This may apply for ships where restriction of hazardous areas is safety critical. A tank connection space may also be necessary in order to provide environmental protection for essential safety equipment related to the gas fuel system like tank valves, safety valves and instrumentation. A tank connection space may also be required as a result of the risk analysis required in 6.4.1.1.

The ability of the tank connection space to withstand a leakage is to be justified by a suitable analysis to be carried out as follows:

- .1 A leakage scenario is to be determined and approved by the Society. For type C tanks, a complete failure (rupture) need to be considered only for the pipes located downstream of the first valve.

Note: A risk analysis may be carried out to justify the relevance of the leakage scenarios to be considered.

- .2 The following parameters are to be evaluated:

- amount of liquid fuel spilled and fuel gas released until the automatic closing of the valve required in 9.4.1,
- pressure built up due to the gas leakage and liquid fuel vaporisation, taking into account the ventilation system required in 13.4.1 and the pressure relief device fitted to the tank connection space,
- gas concentration in the TCS,
- temperature reached in the tank connection space and in the tank hold space.

Tank connection spaces are to be fitted with leakage detection arrangements in accordance with 15.3.2.

6.3.5 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 Administration.

6.3.6 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 6.4.15.3.1.2.

C6.3.6 In addition, the piping between the tank and the first valve is to be contained in a pipe arranged in accordance with 6.3.9.

6.3.7 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.

C6.3.7 The steel grade of the bulkheads is to be in accordance with Table 7.5 for its design temperature.

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

C6.3.8 For the probable maximum leakage and lowest temperature likely to be reached in such leakage conditions, refer to 6.3.4.

6.3.9 *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.*

C6.3.9 For type C tanks, the secondary barrier required in 6.3.9 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 7.3 and 7.4 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 6.4.4.

6.3.10 *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.*

C6.3.10 (a) Whether a drip tray is needed or not should be decided in accordance with the following:

- 1 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;
- 2 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
- 3 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.

C6.3.10 (b) The volume of the drip tray is to be determined in accordance with 6.3.4.

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.

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

C6.3.11 Type C tanks may be emptied by means of inert gas pressurization.

6.3.12 *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 6.10.*

C6.3.12 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.

6.4 Regulations for liquefied gas fuel containment

6.4.1 General

6.4.1.1 *The risk assessment required in 4.2 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.*

C6.4.1.1 An HAZID is to be carried out covering at least the tank, the tank connection space (TCS) and the adjacent structure.

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.

6.4.1.2 *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.*

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

6.4.1.4 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 Administration 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.^{7 8}

Note 7 : Refer to IACS Rec.034.

Note 8 : 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 6.4.1.4.

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

- .1** 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
- .2** being appropriate for uncertainties in loads, structural modelling, fatigue, corrosion, thermal effects, material variability, aging and construction tolerances.

6.4.1.6 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 6.4.15. There are three main categories of design conditions:

- .1** *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.
- .2** *Fatigue Design Conditions* – The liquefied gas fuel containment system structure and its structural components shall not fail under accumulated cyclic loading.
- .3** *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 Code:
 - .1** *Collision* – The liquefied gas fuel containment system shall withstand the collision loads specified in 6.4.9.5.1 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 6.7.3.1 under the fire scenarios envisaged therein.
 - .3** *Flooded compartment causing buoyancy on tank* – The anti-flotation arrangements shall sustain the upward force, specified in 6.4.9.5.2 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.

6.4.1.7 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.

6.4.1.8 An inspection/survey plan for the liquefied gas fuel containment system shall be developed and approved by the Administration. 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 6.4.12.2.8 or 6.4.12.2.9.

6.4.1.9 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.

6.4.2 Liquefied gas fuel containment safety principles

6.4.2.1 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.

6.4.2.2 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 6.4.2.3 to 6.4.2.5 as applicable.

6.4.2.3 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:

- .1** 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
- .2** 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.

6.4.2.4 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.

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

6.4.3 Secondary barriers in relation to tank types

Secondary barriers in relation to the tank types defined in 6.4.15 shall be provided in accordance with the following table:

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

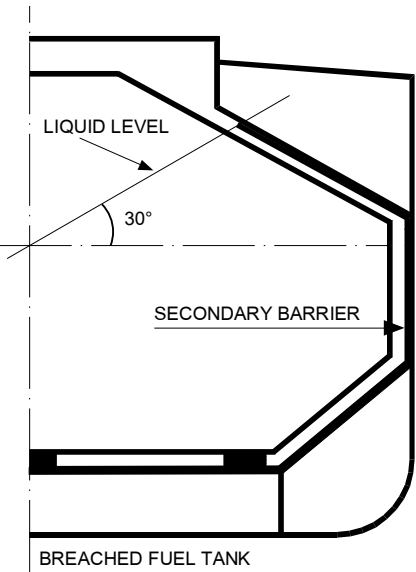
6.4.4 Design of secondary barriers

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

- .1 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 6.4.12.2.6
- .2 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
- .3 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
- .4 it is capable of being periodically checked for its effectiveness by means of a visual inspection or other suitable means acceptable to the Administration
- .5 the methods required in 6.4.4.4 shall be approved by the Administration 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.
- .6 the secondary barrier shall fulfil its functional requirements at a static angle of heel of 30°.

C6.4.4 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 Figure C6.4.4).

Figure C6.4.4 : Secondary barrier extension



6.4.5 Partial secondary barriers and primary barrier small leak protection system

6.4.5.1 Partial secondary barriers as permitted in 6.4.2.3 shall be used with a small leak protection system and meet all the regulations in 6.4.4.
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.

6.4.5.2 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 6.4.12.2.6, 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.

6.4.5.3 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.

6.4.5.4 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.

6.4.6 Supporting arrangements

6.4.6.1 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 6.4.9.2 to 6.4.9.5, 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.

6.4.6.2 Anti-flotation arrangements shall be provided for independent tanks and capable of withstanding the loads defined in 6.4.9.5.2 without plastic deformation likely to endanger the hull structure.

6.4.6.3 Supports and supporting arrangements shall withstand the loads defined in 6.4.9.3.3.8 and 6.4.9.5, but these loads need not be combined with each other or with wave-induced loads.

6.4.7 Associated structure and equipment

6.4.7.1 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).

6.4.8 Thermal insulation

6.4.8.1 Thermal insulation shall be provided as required to protect the hull from temperatures below those allowable (see 6.4.13.1.1) and limit the heat flux into the tank to the levels that can be maintained by the pressure and temperature control system applied in 6.9.

C6.4(a) Use of fuel heater to raise the fuel temperature

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".

6.4.9 Design loads

6.4.9.1 General

6.4.9.1.1 Section 6.4.9 defines the design loads that shall be considered with regard to regulations in Sections 6.4.10 to 6.4.12. This includes load categories (permanent, functional, environmental and accidental) and the description of the loads.

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

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

6.4.9.2 Permanent loads**6.4.9.2.1 Gravity loads**

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

6.4.9.2.2 Permanent external loads

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

6.4.9.3 Functional loads

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

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

6.4.9.3.3 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.

6.4.9.3.3.1 Internal pressure

- .1** In all cases, including 6.4.9.3.3.1.2, P_0 shall not be less than MARVS.
- .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, P_0 shall not be less than the gauge vapour pressure of the liquefied gas fuel at a temperature of 45°C except as follows:
 - .1** Lower values of ambient temperature may be accepted by the Administration for ships operating in restricted areas. Conversely, higher values of ambient temperature may be required.
 - .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.
- .3** Subject to special consideration by the Administration and to the limitations given in 6.4.15 for the various tank types, a vapour pressure P_h higher than P_0 may be accepted for site specific conditions (harbour or other locations), where dynamic loads are reduced.
- .4** Pressure used for determining the internal pressure shall be:
 - .1** $(P_{gd})_{max}$ is the associated liquid pressure determined using the maximum design accelerations.
 - .2** $(P_{gd\ site})_{max}$ is the associated liquid pressure determined using site specific accelerations.
 - .3** P_{eq} should be the greater of P_{eq1} and P_{eq2} calculated, in MPa, as follows:

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

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

- .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 6.4.9.4.1.1. The value of internal liquid pressure P_{gd} resulting from combined effects of gravity and dynamic accelerations shall be calculated, in MPa, as follows:

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

where:

α_{β} Dimensionless acceleration (i.e. relative to the acceleration of gravity), resulting from gravitational and dynamic loads, in an arbitrary direction; (see Figure 6.4.1).

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 Figure 6.4.2).

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:

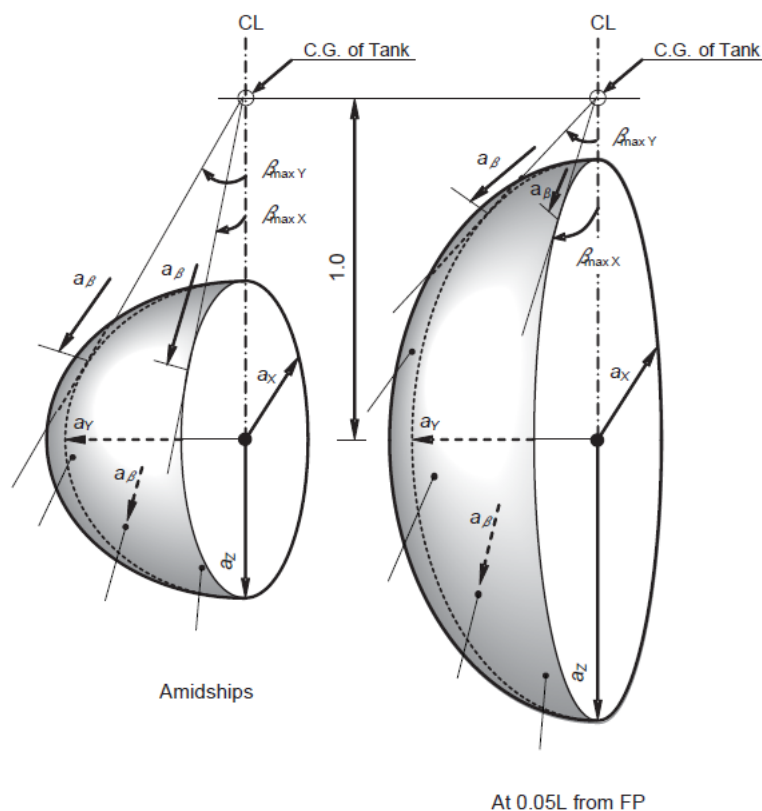
V_t Tank volume without any domes

FL Filling limit according to 6.8

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

The direction that gives the maximum value $(P_{gd})_{\max}$ or $(P_{gd \text{ site}})_{\max}$ shall be considered. Where acceleration components in three directions need to be considered, an ellipsoid shall be used instead of the ellipse in Figure 6.4.1. The above formula applies only to full tanks.

Figure 6.4.1 – Acceleration ellipsoid



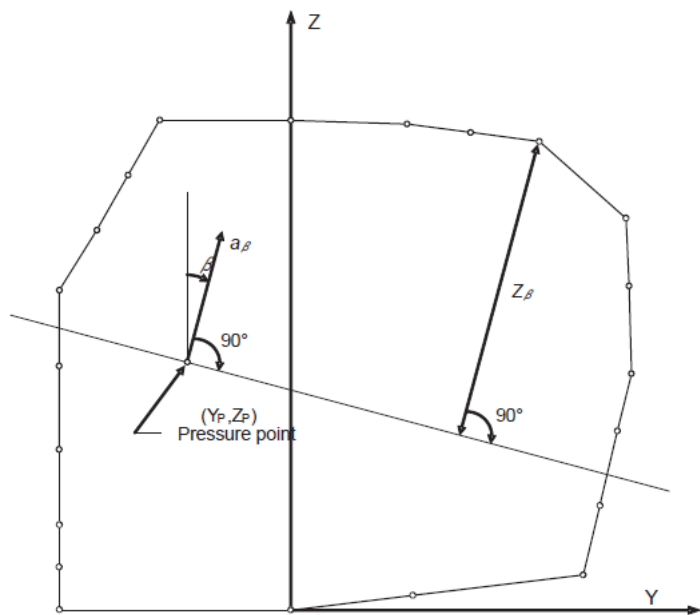
a_{β} = Resulting acceleration (static and dynamic) in arbitrary direction β

a_x = Longitudinal component of acceleration

a_y = Transverse component of acceleration

a_z = Vertical component of acceleration (refer to 6.4.9.4.1.1)

Figure 6.4.2 – Determination of internal pressure heads



6.4.9.3.3.2 External pressure

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.

6.4.9.3.3.3 Thermally induced loads

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

6.4.9.3.3.3.2 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 6.9.2).

6.4.9.3.3.4 Vibration

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

6.4.9.3.3.5 Interaction loads

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.

6.4.9.3.3.6 Loads associated with construction and installation

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

6.4.9.3.3.7 Test loads

Account shall be taken of the loads corresponding to the testing of the liquefied gas fuel containment system referred to in 16.5.

6.4.9.3.3.8 Static heel loads

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

C6.4.9.3.3.8 See Guidance to detailed calculation of pressure for a static heel angle of 30°C, as given in NR467, Pt D, Ch 9, App 1, [3].

6.4.9.3.9 Other loads

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

6.4.9.4 Environmental loads

6.4.9.4.1 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.

6.4.9.4.1.1 Loads due to ship motion

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:

- .1 vertical acceleration: motion accelerations of heave, pitch and, possibly roll (normal to the ship base)
- .2 transverse acceleration: motion accelerations of sway, yaw and roll and gravity component of roll, and
- .3 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 Administration⁹. Ships for restricted service may be given special consideration.

Note 9 : Refer to section 4.28.2.1 of the IGC Code for guidance formulae for acceleration components.

6.4.9.4.1.2 Dynamic interaction loads

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.

6.4.9.4.1.3 Sloshing loads

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

C6.4.9.4.1.3 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.

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

6.4.9.4.1.4 Snow and ice loads

Snow and icing shall be considered, if relevant.

C6.4.9.4.1.4 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 11, Sec 11, [5.2.2].

6.4.9.4.1.5 Loads due to navigation in ice

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

6.4.9.4.1.6 Green sea loading

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

C6.4.9.4.1.6 Water pressure due to green seas is to be calculated, for tanks located on exposed decks, in accordance with NR467, Pt B, Ch 8, Sec 4, [2.2.2].

6.4.9.4.1.7 Wind loads

Account shall be taken to wind generated loads as relevant.

6.4.9.4.1.7 Wind pressure is to be calculated in accordance with NR467, Pt B, Ch 8, Sec 4, as relevant.

6.4.9.5 Accidental loads

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.

6.4.9.5.1 Collision load

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

Ship length L	Design 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

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

6.4.9.5.1 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.

6.4.9.5.2 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 anti-flotation chocks and the supporting structure in both the adjacent hull and tank structure.

6.4.10 Structural integrity

6.4.10.1 General

6.4.10.1.1 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.

6.4.10.1.2 The structural integrity of liquefied gas fuel containment systems can be demonstrated by compliance with 6.4.15, as appropriate for the liquefied gas fuel containment system type.

6.4.10.1.3 For other liquefied gas fuel containment system types, that are of novel design or differ significantly from those covered by 6.4.15, the structural integrity shall be demonstrated by compliance with 6.4.16.

6.4.11 Structural analysis

6.4.11.1 Analysis

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