RULES
FOR THE CLASSIFICATION OF SHIPS

Part 33 – SHIPS USING GASES OR OTHER LOW-FLASHING FUEL

January 2025

CROATIAN REGISTER OF SHIPPING
Hrvatska (Croatia) • 21000 Split • Marasovića 67 • P.O.B. 187
Tel.: (...) 385 (0)21 40 81 11
Fax.: (...) 385 (0)21 35 81 59
E-mail: tech.coord@crs.hr
web site: www.crs.hr

By the decision of the General Committee of Croatian Register of Shipping,

RULES FOR THE CLASSIFICATION OF SHIPS
Part 33 – SHIPS USING GASES OR OTHER LOW-FLASHING FUEL

have been adopted on 20th December 2024 and shall enter into force on 1st January 2025

GENERAL TERMS AND CONDITIONS

(March 2022)

Article 1
GENERAL

1.1 CROATIAN REGISTER OF SHIPPING (hereinafter: the *Register*) shall at all times remain an independent contractor and neither the *Register* nor any of its officers, surveyors, auditors, inspectors, agents, appointers, officers or managers shall act as an employee, servant or agent of any other party in the performance of the Services rendered by the *Register*.

1.2 The *Register* acts as a service provider. The Services provided by the *Register* cannot be construed as a commitment by the *Register* to achieve any result or as a warranty.

1.3 The provision of Services is subject to these General Terms and Conditions. No other terms and conditions shall apply, either expressly or by implication, unless expressly agreed in writing between the Parties.

1.4 These General Terms and Conditions shall be incorporated into, or referred to in any Contract and shall prevail over and exclude any other terms and conditions that the Client may wish to impose.

Any amendments to and/or deviations from these General Terms and Conditions, as well as any additional terms and conditions of the Client, shall be binding or valid only if set forth in writing and duly signed by the authorised representatives of both Parties.

1.5 The invalidity of one or more provisions of these General Terms and Conditions shall not affect the remaining provisions.

1.6 The Client acknowledges that the latest version of these General terms and Conditions and the latest version of applicable Rules apply to the Services provided by the *Register*.

1.7 Definitions in these General Terms and Conditions take precedence over other definitions that may appear in other documents issued by the *Register*.

1.8 The Client should at all times be aware of the provisions of these General Terms and Conditions, as they may be further amended, with their latest up to date version available on the web site of the *Register*.

Article 2
DEFINITIONS

2.1 **Certificate** means either a class certificate or statutory certificate, statement, attestation, statement of compliance, and a report following the Services provided by the *Register*.

2.2 **Certification** means the activity of certification in application of international and national standards and international industry practice provided by the *Register*.

Certification is an appraisement given by the *Register* to the Client and cannot be construed as an implied or express warranty of safety, fitness for purpose, seaworthiness of the vessel or its value for sale, insurance or chartering.

The purpose of Certification is to provide classification and statutory services and assistance to the maritime industry, Flag State Administrations, and regulatory authorities relating to maritime safety and pollution prevention.

2.3 **Classification** includes all activities and Services provided by the *Register* in accordance with the Rules. Classification may or may not be accompanied by the issuance of a Certificate of class with reference to the Rules.

Certificate of class is valid only if issued by the *Register*.

However, Certificate of class should not be construed as a guarantee of the safety, fitness for purpose or seaworthiness of the vessel. It is merely an attestation that the vessel complies with the Rules developed and published by the *Register*.

In addition, the *Register* is not a guarantee of the safety of life or property at sea or the seaworthiness of a vessel because, although the classification of a vessel is based on the assumption that the vessel will be properly loaded, operated, and maintained by competent and qualified personnel, the *Register* has no control over how a vessel is operated and maintained between the periodic surveys it conducts.

2.4 **Statutory certification** means certification made by the *Register* on behalf of the Flag State Administrations when and to the extent that the *Register* has been authorised to do so by the respective Flag State.

Statutory certification and services include the assessment of vessels registered by the Flag State and/or ship management companies to determine whether such ships/companies comply with the applicable requirements of international conventions, codes and national legislation, and the issuance of, or assistance in the issuance of, the appropriate certificates and documents.

Statutory certification includes, but is not limited to, certification, survey, and issuance of statutory certificates on behalf of the Flag State.

In cases where the *Register* acts on behalf of Flag State Administrations, the *Register* shall follow guidance issued by IMO (Resolutions, Circulars, etc.) or by IACS through Unified Interpretations (UI), unless otherwise directed by the Flag State.

2.5 **Client** means the shipowner, company, shipyard and/or party requesting Services or taking ownership of a classed vessel. In cases where shipowners have authorized another party to operate the vessel on their behalf, that party shall be considered as the company.

In addition to the above the Client means the person and/or entity that has requested Services from the *Register* and that has entered into a Contract or an agreement for Services with the *Register*.

2.6 **Parties** means the *Register* and Client together.

2.7 **Party** means the *Register* or the Client.

2.8 **Contract** means the contract in the form of a written agreement between the Client and the *Register* requesting Services, including these General Terms and Conditions and the Rules.

The provisions related to the Contract in these General Terms and Conditions shall apply even if there is no written agreement between the Client and the *Register*.

The Client may request the *Register* in writing to make a change to the contracted Services. However, the *Register* shall not be obligated to accept or execute any such change until a written agreement has been signed with the Client regarding the compensation and the possible impact of the change on the schedule as an addendum to the originally contracted Services.

2.9 **Services** shall mean the services specified in 2.2. 2.3 and 2.4, but also other services related to certification, classification and statutory certification, such as, but not limited to: ISM Code certification, ISPS Code, MLC 2006 certification, fuel oil consumption reporting, IHM certification, approval of manufacturers and service providers, certification of materials and products, training activities, conformity assessment, and any other relevant activities such as third party inspections, testing, shore and shipboard trials.

The Services provided by the *Register* are performed on a random basis and in no case include a full inspection of all items.

The *Register* shall provide the Services in accordance with related Contract(s), the provisions of these General Terms and Conditions, Rules, the international and national standards, the international conventions, the EU Regulations, the Flag State requirements and the industry practices applicable to the particular Service and always assuming that the Client is aware of these standards and the industry practices.

When providing Services, the *Register* does not guarantee the accuracy of the information or advice provided.

In providing Services, the *Register* does not assess compliance with standards other than the Rules, international and national standards, international conventions, EU regulations, Flag State requirements and industry practice, to the extent agreed in writing or specified in the Contract.

2.10 The ***Register*** means the Croatian Register of Shipping, an entity organized and existing under Croatian law, which, according to the Law on the Croatian Register of Shipping (Official Gazette No. 1996/81, 2013/76 and 2020/62) and the Charter of the *Register*, is an independent, not-for-profit, but public welfare oriented, public foundation that performs tasks:

- classification of sea-going ships,
- statutory certification of sea-going ships on behalf of the Flag State Administrations,
- classification of inland navigation vessels,
- statutory certification of inland navigation vessels,
- statutory certification of recreational crafts,
- certification of materials and products,
- conformity assessment of recreational crafts,
- conformity assessment of marine equipment,
- conformity assessment of pressure vessels,
- certification/registration of quality management systems.

2.11 **Vessel** means a ship, vessel, unit or offshore structure of any kind, whether or not connected to the shore or sea/river bed, located at sea or in inland waters and intended for transportation or special operations on the water, as decided by the *Register*.

2.12 **Rules** means the Rules for the classification, guidelines, instructions, or other documented evidence of the *Register* related to the Services provided.

The competent interpretation of the requirements specified in the Rules or other regulations published by the *Register* shall be the exclusive responsibility of the *Register's* Head Office, notwithstanding any possible different interpretations by other parties.

In cases where the Rules do not contain detailed requirements, the specific approval by the *Register* shall be based on the principles of the Rules and shall ensure a safety standard equivalent to that of the Rules.

Article 3
RESPONSIBILITIES

3.1 It is the Client's responsibility to ensure that all surveys required for vessel’s class maintenance are conducted in a timely manner and in accordance with the Rules.

3.2 The *Register* may suspend or withdraw the vessel's existing Certificate of class in the event of serious deficiencies and replace it with a new Certificate of class with a shortened period of validity during which the deficiencies are to be rectified.

In addition, the *Register* shall suspend or withdraw a vessel's Certificate of class if the deficiencies are of such a magnitude as to endanger the class of the vessel, its safety and integrity, the safety of the crew, passengers, or the marine environment, and shall require that the vessel is to be inspected at the first port of call where the necessary repairs are to be carried out.

3.3 The Client should inform the *Register*:

(i) in the event of a change in the intended use of a vessel, a conversion and alteration of the hull, machinery installations and other equipment affecting the Class of the vessel assigned by the *Register*. Conversions and alterations must be made under the supervision of the *Register* and must comply with the requirements of the Rules and/or additional requirements of the *Register*,

(ii) in cases where the vessel has been damaged to such an extent that the Class of the vessel is likely to be affected and the safety and integrity of the vessel is likely to be compromised. In such cases, the vessel must be surveyed at the first port of call or as further directed by the *Register*. The survey shall be to the extent deemed necessary by the *Register*, by taking into account the extent of the damage.

(iii) in cases where class-related deficiencies and/or defects are found as a result of a Flag State inspection or Port State Control. Should the Client fail to notify the *Register* of the detention of the vessel by Port State Authorities due to class related deficiencies, the *Register* reserves the right to suspend or withdraw the Certificate of class.

3.4 The *Register* shall have full control over Certificates issued and may suspend or withdraw a Certificate at any time in its sole discretion if the Client fails to comply with the following requirements set forth in the *Rules for the Classification of Ships, Part 1 - General Requirements, Chapter 1 - General Information*, as applicable:

(i) para. 5.3 - *Maintenance of the validity of Certificate of Class*,
(ii) para. 5.4 - *Period of Validity*,
(iii) para. 5.5 - *Extension of the Period of Validity*,
(iv) para. 5.6 - *Suspension and Reinstatement of Class in the Case of Overdue Surveys*, and
(v) para. 5.7 - *Withdrawal of Class*.

3.5 The *Register* may suspend or withdraw a Certificate at any time in its sole discretion if the Client fails to comply with the following requirements set forth in the *Rules for the Classification of Inland Navigation Vessels, Part 1 - Classification and Surveys, Chapter I - Principles of Classification*, as applicable:

(i) para. 2.8 - *Maintenance of the Validity of the Certificate of Class*,
(ii) para. 2.9 - *Extension of validity of the Certificate of Class*,

and following requirements set forth in the *Rules for the Classification of Inland Navigation Vessels, Part 1 - Classification and Surveys, Chapter II - Classification*, as applicable:

(iii) para. 2.1 – *Suspension of Class*,
(iv) para. 2.2 – *Withdrawal of Class*.

3.6 In addition to clauses 3.2, 3.4 and 3.5 of this Article, the *Register* reserves the right to terminate the Services and related Contract in the event of a breach of the provisions of these General Terms and Conditions.

3.7 If the Client fails to provide the *Register* with the required access or information at the agreed times or fails to prepare for the Service in a timely manner, the *Register* may suspend the provision of the Service until it receives the Client's instructions for access and/or the required information.

The *Register* shall not be liable for the consequences of such suspension, and the Client shall be responsible for the *Register's* additional fees and other unnecessary costs and expenses incurred by the *Register*.

3.8 The Client is obliged to perform timely payments of the invoices for provided Services. However, the *Register* may retain or withhold any Service or Certificate to the Client in the case of outstanding payments, whether mutually related or not, arising out of the entire business relationship with the Client.

Article 4
HEALTH, SAFETY AND ENVIRONMENT

4.1 Both the *Register* and the Client shall apply reasonable standards to promote safety, health, and environmental protection and to provide a safe working environment for their personnel.

4.2 The Client shall provide the *Register* with all access and information necessary for the safe and efficient performance of the requested Services as required by the Rules.

4.3 During the survey, personnel of the *Register* should have secure access to all work that directly or indirectly affects the Service.

4.4 The *Register* has the right to refuse to conduct an activity or visit an area or site if the *Register* in its sole discretion, believes that relevant risks are unacceptable or are not adequately addressed, contained, or otherwise mitigated. Such a decision shall suspend the obligations of both Parties under the Contract without incurring any liability or penalty until the Parties agree on how to proceed.

Article 5
THIRD PARTIES AND SUBCONTRACTORS

5.1 Each specific Contract, including any Certificates issued, relates specifically to the Client, and no rights, obligations, interests, claims, benefits or Certificates issued shall extend to any third party without the prior written consent of the *Register*.

5.2 The Client shall not be entitled to grant any right to use the Certificates to any third party without the prior written consent of the *Register*.

5.3 The Client shall not without *Register's* consent, cede, assign, transfer, subcontract or deal in any manner with all or any of its rights or obligations under any Service and related Contract.

5.4 With regard to third party rights to access information and Certificates under confidentiality clause reference is to be made to Article 9.

Article 6
TAXES

6.1 Each Party shall be responsible for and shall bear all taxes, duties or similar governmental charges levied or imposed on any activity of that Party.

6.2 Prices, fees, rates, or remuneration are exclusive of any form of sales tax, value added tax, administrative fees and services tax and/or other similar taxes, including any surcharges. If any such indirect tax is or becomes applicable to the Services provided under the Contract, the Client shall be responsible for the payment of such indirect taxes.

Article 7
PAYMENT OF INVOICES

7.1 The provision of Services by the *Register*, whether complete or not, shall include payment of fees thirty (30) days after issuance of the invoice for the portion of the Services performed.

7.2 In the event that the Client fails to meet the requirements for payment in accordance with the instalments and terms of payment contained herein, the *Register* reserves the right to charge the Client with the interest rate in accordance with the applicable laws of the Republic of Croatia.

7.3 If the Client disputes an invoice or part of an invoice, the Client shall notify *Register* thereof in writing without undue delay. If no notification is received by the due date, Client shall be deemed to have accepted the invoice in full. If only part of an invoice is disputed, the undisputed amount must be paid by the due date.

Consequently, no disputes arising between the *Register* and the Client shall interfere with prompt payment of invoices by the Client. Any rights of lien or retention in favour of the Client or otherwise, are hereby excluded.

7.4 In the event of cancellation of all or part of the Services prior to their final completion, the Client shall pay all costs incurred by the *Register* on pro-rata basis for the portion of the Services provided to date. In such event, the *Register* will not claim the Client for loss of profit or reduced income. All reasonable costs directly attributable to the early termination and all amounts due to the *Register* at that time shall become immediately due and payable.

7.5 In the event of termination of the Service and related Contract, the *Register* shall be entitled to retain any payments, deposits or prepayments of fees made by the Client prior to the date of termination up to the amount to which the *Register* is entitled.

Article 8
TERMINATION

8.1 The Parties shall have the right to terminate the Services and the related Contract(s) by written notice to the other Party, and without prejudice to Article 7, in the following cases:

(i) if the other Party commits a material breach of these General Terms and Conditions and/or the Contract and fails to rectify such breach in accordance with clause 8.4 of this Article,

(ii) if the other Party becomes insolvent, is unable to pay its debts as they become due, or becomes subject to bankruptcy proceedings, administration, receivership, dissolution, liquidation, winding up or otherwise ceases to carry on its business; or

(iii) for convenience, after giving the other Party thirty (30) days' prior written notice of termination.

8.2 The Classification issued for the relevant vessel and the Certificates previously issued shall remain valid until the effective date of termination or, in the event of such termination, immediately, subject to compliance with Article 3 and Article 7.

8.3 If, in the reasonable opinion of the *Register*, the Client breaches or is suspected of breaching Article 14 or Article 15, the *Register* shall have the right to terminate the Service and related Contract with immediate effect.

8.4 Notwithstanding the provisions of clause 8.1 of this Article, the Party intending to terminate Services for non-compliance or breach of the provisions of these General Terms and Conditions shall notify the other Party of the non-compliance or violation of the provisions of these General Terms and Conditions and set a reasonable deadline of 15 (fifteen) days for the other Party to remedy the breaches of the provisions of these General Terms and Conditions.

If the Party fails to remedy the breaches of the provisions of these General Terms and Conditions within the aforementioned period, the other Party shall have the right to terminate Services without further notice.

8.5 Termination of the Service and related Contract pursuant to the provisions of these General Terms and Conditions shall not give either Party the right to claim any additional compensation, indemnity or reimbursement from the other Party as a result of such termination, but such termination shall not affect any rights or remedies available to a Party at the time the termination becomes effective or any obligations or liabilities incurred by a Party.

Article 9
CONFIDENTIALITY

9.1 The Parties agree to keep confidential all facts, data, information, etc. related to the other Party's business that they have learned in the course of providing Services. Such information and data shall not be disclosed by the Parties to any third party and shall not be used or misused to the detriment of the other Party.

9.2 The *Register* will keep confidential any data, plans or other technical information received from the Client and will not disclose it to any third party outside the *Register*, unless authorised by the Client. This obligation shall continue to apply after termination of the Services. This obligation shall not apply to any data, plans or other technical information that was in the possession of the *Register* prior to being disclosed to the *Register* by or on behalf of the Client, or that becomes publicly available through no fault of the *Register*, or is otherwise provided to the *Register* by an independent source that is under no obligation of confidentiality to the *Register*.

9.3 Certificates issued by the *Register* to the Client as a result of the Services provided shall not be covered by the confidentiality Article.

Notwithstanding the foregoing, the Client shall be entitled to disclose any data to its affiliates involved in the transactions related to the Services or the Client's core activities.

9.4 Notwithstanding clause 9.1 and clause 9.2 of this Article, the *Register* shall have the right to disclose the Confidential Information to the following parties if required by regulations of:

(i) authorised representatives of the Flag State Administration,
(ii) authorised audit teams (i.e., accreditation body or EC auditors),
(iii) the International Association of Classification Societies (IACS),
(iv) a court of competent jurisdiction, government agency, or other relevant public authority, in accordance with applicable law, court order, or other public regulation.

9.5 The Client acknowledges that the *Register* is required to provide access to information to the EU Commission or any person acting on its behalf in accordance with applicable EU requirements and that the Client shall give the EU Commission with unrestricted access to the vessels for the purpose of inspection.

9.6 The obligations in this Article shall survive the conclusion of the Service or the termination of related Contract and shall continue for as long as the relevant information remains confidential.

Article 10
INTELLECTUAL PROPERTY

10.1 Each Party shall be the sole owner of all rights to its Intellectual Property created before or after the effective date of these General Terms and Conditions, whether or not associated with any Contract between the Parties.

10.2 The Intellectual Property developed by the *Register* for the provision of the Services, including but not limited to drawings, calculations and reports, shall remain the exclusive property of the *Register*.

Article 11
PROFESSIONAL ETHICS

11.1 Each of the Parties warrants that, with respect to the matters contemplated herein, neither it nor its affiliates has made or will make, directly or indirectly, any offer, payment, gift or authorization of money to any government official or employee, political party, public official or candidate for the benefit or advantage thereof.

11.2 In providing the Services, the *Register* shall strictly adhere to the requirements of its Code of Ethics relating to business activities.

Article 12
FORCE MAJEURE

12.1 For the purposes of these General Terms and Conditions, the term "Force Majeure" includes any event that directly or indirectly prevents the Parties from fulfilling their obligations due to events beyond their control, such as: strikes, wars, riots, piracy, civil commotion, malicious damage, pandemic, compliance with laws or government orders, rules, regulations or directives, sanctions and embargoes, accidents, defects of plants or machinery, seizures, fires, floods, storms and the like.

12.2 If either Party is prevented or delayed from performing its obligations by Force Majeure, such Party shall promptly notify the other Party in writing of the circumstances of the Force Majeure and its influence and, after such notification, shall not be liable for performance of any obligations prevented by the influence of the Force Majeure during its duration. Upon termination of the influence of the Force Majeure, the same Party should proceed with the planned activities in order to fulfil its obligations.

12.3 If one of the Parties is prevented by Force Majeure in its activities and fulfilment of its obligations and this event lasts continuously for three (3) months, the other Party shall be entitled to terminate the Service and related Contract without liability.

12.4 Neither of the Parties shall be liable for non-compliance with these General Terms and Conditions due to Force Majeure. If one of the Parties is prevented from fulfilling its obligations under these General Terms and Conditions due to Force Majeure, it shall immediately notify the other Party in writing within a reasonable period of time, stating the reasons for the Force Majeure and providing relevant evidence, if any.

Article 13
INDEMNIFICATIONS

13.1 Each Party shall indemnify the other Party against all claims arising out of the performance of the Services in respect of bodily injury, illness or death of any of its employees or other representatives and in respect of loss of or damage to the Party's property.

This provision shall apply whether or not the damage is caused or contributed to by the negligence of the other Party. Both Parties are obliged to take out separate insurances for these liabilities.

13.2 The Client shall indemnify the *Register* from and against all claims arising from the Client's violation of the provisions of these General Terms and Conditions and from the misuse of the Certificates issued by the *Register*.

13.3 The Client shall indemnify the *Register* against any financial responsibility or amounts arising from non-payment, late payment or payment of withholding taxes to the non-relevant tax authority or any other relevant governmental body.

13.4 Each Party shall notify the other Party without undue delay as soon as it becomes aware of any incident that could give rise to a claim against the other Party in respect of the Service provided and related Contract.

Article 14
ANTI-CORRUPTION

14.1 Each Party agrees that in performing its obligations under any Service, it will ensure that its affiliates, employees and/or agents, subsidiaries, subcontractors, consultants, and any other persons providing Services will:

(i) comply with all applicable anti-bribery and anti-corruption laws (collectively, Anti-Bribery Laws) and, in particular, do not, directly or indirectly, offer, promise, grant, authorise the payment of, or confer any financial or other benefit on any public or government official:
   - to a public or governmental official to obtain or retain business with the intent to influence such official in his or her capacity as an official, if such official is not permitted or required by written law to be influenced by the offer, promise or gift; or
   - to another person with the intent to induce or reward the improper performance of a function or activity or for any other illegal purpose,

(ii) maintain adequate systems and procedures designed to prevent activities, practises, or conduct in connection with services that would constitute an offence under an anticorruption law; and
(iii) take reasonable steps to prevent similar acts by customers, contractors, subcontractors, agents and other third parties, persons under its control or influence.

14.2 Any failure by a Party to comply with or ensure compliance with its obligations under this Article shall, notwithstanding anything to the contrary in these General Terms and Conditions, be deemed a breach of these General Terms and Conditions which shall entitle the other Party to suspend and/or terminate the Services by notice in writing with immediate effect without further liability to the other Party except for any liability which may have arisen prior to the date of termination or suspension (as the case may be).

14.3 If a Party elects to suspend the provision of Services under these General Terms and Conditions pursuant to this Article, it shall have the sole and absolute discretion to determine:

(i) when it will resume performance (if at all); and
(ii) extend the period for performance of its obligations under the Services in its sole discretion.

Article 15
SANCTIONS

15.1 Each Party shall conduct all activities in compliance with all laws, statutes, rules, economic and trade sanctions (including, but not limited to, U.S. 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.

15.2 Each Party hereby represents and warrants that it is not or will not be subject to any economic or trade sanctions ("Sanctions") imposed by the United States of America, the European Union, the United Kingdom, any EU Member State, or the United Nations with respect to any country and/or by any sanction giver with respect to any company/individual.

15.3 Each Party represents and warrants that it will strictly comply with all Sanctions.

15.4 Nothing in these General Terms and Conditions shall be construed as causing or obligating either Party to act or refrain from acting in a manner inconsistent with, punishable by, or prohibited by any Sanctions.

15.5 Neither Party shall be obligated to perform any obligation arising under these Terms and Conditions (including, without limitation, the obligation to):

(i) perform, deliver, accept, sell, purchase, pay or receive any funds to, from or through any person or entity; or
(ii) engage in any other action whatsoever,

if doing so violates or is inconsistent with sanctions and/or recommendations of international (intergovernmental) organisations to combat the financing of terrorism and other criminal activities and/or money laundering or exposes such Party to investigation or penalties.

15.6 In the event that a Party breaches any Sanctions or the Party's Business and/or Transactions arising out of or in connection with these General Terms and Conditions breach any Sanctions or otherwise violate the recommendations of one or more international (intergovernmental) organisations for combating the financing of terrorism and other criminal activities and/or money laundering, the other Party shall be entitled to terminate these General Terms and Conditions by written notice with immediate effect without incurring any liability to the other Party, except for liabilities (if any) incurred prior to the date of termination.

Article 16
LIABILITY

16.1 The *Register* is not, and cannot be considered as, an underwriter, consulting engineer, naval architect, shipbuilder, shipowner, or ship management company, nor can it assume the obligations and responsibilities associated with such functions, although the *Register's* experience may enable it to respond to inquiries about matters not covered by its Rules, policies, instructions, or other documented evidence.

16.2 The practices and procedures of the *Register* shall be selected by the *Register* in its sole and absolute discretion based on its experience and knowledge and in accordance with generally accepted professional standards in the relevant field of classification societies.

16.3 Nothing herein contained shall release any designer, naval architect or engineer, shipbuilder or manufacturer, shipyard, vendor, supplier, contractor or subcontractor, repairer or owner, from any information, report, certificate or similar document issued in connection with the provision of Services by the *Register*, operator, manager or other person or entity from any express or implied warranty or other contractual obligation or responsibility, or from any negligent act, error or omission of any kind whatsoever, nor shall they create any right, claim or benefit for any third party.

16.4 The *Register* shall exercise due care in the selection or appointment of its surveyors and all other employees whose presence and work is necessary for the provision of the Services.

16.5 If any person or entity using the Services of the *Register* suffers any loss, damage or expense that is or is shown to have been caused by a negligent act, omission or error of the *Register's* officers, surveyors, auditors, inspectors, agents, appointers, officers or managers, or those purporting to act in the name of and on behalf of the *Register*, or a negligent inaccuracy, advice, report or evidence given by or in the name of or/and on behalf of the *Register*, then the liability of the *Register* is limited in respect of any direct or indirect claim shall be limited to an amount not exceeding five times the fee charged or to be charged by the *Register* for the relevant Service.

16.6 Any liability for consequential damages is expressly excluded.

For purposes of this clause, consequential damages include, without limitation:

(i) indirect or consequential damages,
(ii) loss and/or delay of production, loss of products, loss of use, loss of bargain, loss of revenue, loss of profit or anticipated profit, loss of business and business interruption, in each case directly or indirectly.

16.7 The Parties are not entitled to assign the performance of obligations under these General Terms and Conditions or parts thereof to third parties without the prior written consent of the other Party.

16.8 If during the term of the Contract, there is a transfer of function due to change of status (merger, acquisition, division, etc.), all obligations and rights under these General Terms and Conditions and associated Contract will be transferred to the legal successor of the Party concerned.

Article 17
GOVERNING LAW AND RESOLVING OF DISPUTES

17.1 These General Terms and Conditions and any dispute or claim between the Parties arising from or in connection with it, or the Services provided hereunder, will be governed and interpreted in accordance with the English law.

17.2 The Parties shall use their reasonable efforts to resolve any claim or dispute arising in relation to rendered Service by negotiations within a reasonable time.

17.3 Should the Parties fail to resolve any claim or dispute by negotiations, the dispute shall be exclusively subject to the jurisdiction of the Permanent Arbitration Court with the Croatian Chamber of Economy in Zagreb, Republic of Croatia.

17.4 The Parties agree to keep the any arbitration proceedings confidential.

17.5 Notwithstanding the above, any claim not presented within three (3) months of the completion of the particular Services, or within three (3) months of from the date when the events which are relied on were first discovered by the Client, shall be deemed waived and absolutely time barred.

17.6 Any objections against the line adopted by any of the *Register's* servants in fulfilling their duties or against the conclusions reached are to be raised to the *Register* by the Party as soon as possible.

If the Party is not satisfied with the final conclusions and interpretations by the *Register* the arbitration lays upon the Commission for appeal for Classification and Statutory certification of ships, which is to be formed according to the Regulation 39 of the Charter of the *Register*.

REVIEW OF AMENDMENTS IN RELATION TO PREVIOUS EDITION OF THE RULES

RULES FOR THE CLASSIFICATION OF SHIPS
Part 33 – SHIPS USING GASES OR OTHER LOW-FLASHING FUEL

All major changes in respect to the Rules for the classification of ships, Part 33 – Ships using gases or other low-flashing fuel, edition July 2022, as last amended by Amendments No. 4, edition July 2024, throughout the text are shaded (if any).

Items not being indicated as corrected have not been changed.

The grammar and print errors, have been corrected throughout the Rules and are not subject to above indication of changes

This Part of the Rules includes the requirements of the following international Organisations:

International Maritime Organization (IMO)

Conventions: International Convention for the Safety of Life at Sea, 1974 (SOLAS 74) and all subsequent and applicable amendments adopted up to MSC 106
Protocol of 1988 relating to the International Convention for the Safety of Life at Sea, 1974, as amended (SOLAS PROT 1988)

Codes: International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code) as adopted by MSC.391(95), as amended by MSC.422(98), MSC.458(101) and MSC.475(102)

Circulars: MSC.1/Circ.1394 (Rev.2, July 2019), MSC.1/Circ.1599 (Rev.3, July 2024), MSC.1/Circ.1647, MSC.1/Circ.1621, MSC.1/Circ.1622 (Rev.1, July 2024)

International Association of Classification Societies (IACS)

Unified Requirements (UR):
M78 (Rev.2, Jan 2024), M82 (Mar 2023), W1 (Rev.4, Apr 2021), Z25 (Rev.1 Sep.2017)

Unified Interpretations:
GF1 (Jan 2017), GF2 (Sep 2017) GF3 (Dec 2017), GF4 (Dec 2017), GF5 (Dec 2017), GF6 (Dec 2017), GF7 (Dec 2017), GF8 (Dec 2017), GF9 (Dec 2017), GF10 (Dec 2017), GF11 (Dec 2017), GF12 (Dec 2017), GF13 (Rev.1, May 2023), GFGF14 (July 2018), GF15 (July 2018), GF16 (Nov 2018), GF17 (Dec 2018), GF18 (Feb 2019), GF19 (Dec 2023)

Recommendations (Rec.):
No.142 (June 2016), No.146 (Aug 2016), No.148 (Rev.1 Mar 2020)

Contents

1 PREMISE OF THE RULES

1.1 GENERAL

1.1.1 The Rules for the classification of ships, Part 33 - Ships using gaseous or other low-flashing fuel (hereafter referred to as: the Rules) of CROATIAN REGISTER OF SHIPPING (hereafter referred to as: the Register) are incorporating the text of the "International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code)" as adopted by the IMO Maritime Safety Committee, at its 95th session, on 11 June 2015, through Resolution MSC.391(95), as amended by Resolution MSC.422(98) adopted on 15 June 2017, Resolution MSC.458(101) adopted on 14 June 2019, and Resolution MSC.475(102) adopted on 11 November 2020 with the exception of the provisions of Parts C-1 and D, which are not within the scope of classification.

1.1.2 This Rules are an extension of the requirements contained in other Parts of the Rules for the classification of ships of the *Register*, as well as in all other Rules of the *Register* in which reference to this Rules has been made.

1.1.3 Under this Rules are also unified interpretations of the IGF Code and recommendations with their source such as IMO (International Maritime Organization), IACS (International Association of Classification Societies), etc., and are additional to the requirements of the *Register*.

1.1.4 In certain sections of this Rules, additional classification requirements not directly related to a particular IGF Code item, are printed in italic Times New Roman and numbered with preceding prefix C (e.g. class related requirement related to para 1.2.3 of the IGF Code would be indicated as *C1.2.3*).

1.2 PREAMBLE

1.2.1 The purpose of this Rules is to provide mandatory provisions for ships using low-flashpoint fuel, other than ships covered by the IGC Code.

1.2.2 This Rules are incorporating mandatory provisions of the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code) 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.

1.2.3 Amendments to the International Convention for the Safety of Life at Sea (SOLAS) require for new ships using natural gas or other alternative fuels to provide compliance with the requirements of the IGF Code.

1.2.4 Throughout the development of IGF 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 IGF Code, taking into account both experience and technical developments.

IGF 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.

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

The use of methyl/ethyl alcohol as fuel is covered presently by IMO Circ. MSC.1/Circ.1621 - *Interim guidelines for the safety of ships using methyl/ethyl alcohol as fuel* (see Part A, 2.1.2 of this Rules).

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

1.2.6 The amendments to SOLAS chapter II-1, include amendments to Part F – “Alternative design and arrangements”, to provide a methodology for alternative design and arrangements for machinery, electrical installations and low-flashpoint fuel storage and distribution systems; and a new Part G – “Ships using low-flashpoint fuels”, to add new regulations to require ships constructed after the entry into force on 1 January 2017 to comply with the requirements of the IGF Code. Related amendments to Chapter II-2 and the Appendix (Certificates) also entered into force.

PART A

2 GENERAL

2.1 APPLICATION

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

2.1.1 With regard to criteria for the arrangement and installation of fuel cell power installations, providing delivery of electrical and/or thermal energy, regardless of the specific fuel cell type, refer to IMO Circ. MSC.1/Circ.1647 - *Interim guidelines for the safety of ships using fuel cell power installations*. These Interim Guidelines apply to ships to which part G of SOLAS chapter II-1 applies.

Also, these Interim Guidelines are related to the goals and functional requirements of the IGF Code. In particular, the following applies:

.1 The safety, reliability and dependability of the systems should be equivalent to that achieved with new and comparable conventional oil-fuelled main and auxiliary machinery installations, regardless of the specific fuel cell type and fuel.

.2 The probability and consequences of fuel-related hazards should 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 should be initiated.

.3 The design philosophy should ensure that risk reducing measures and safety actions for the fuel cell power installation do not lead to an unacceptable loss of power.

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

.5 Equipment installed in hazardous areas should be minimized to that required for operational purposes and should be suitably and appropriately certified.

.6 Fuel cell spaces should be configured to prevent any unintended accumulation of explosive, flammable or toxic gas concentrations.

.7 System components should be protected against external damages.

.8 Sources of ignition in hazardous areas should be minimized to reduce the probability of explosions.

.9 Piping systems and overpressure relief arrangements that are of suitable design, construction and installation for their intended application should be provided.

.10 Machinery, systems and components should be designed, constructed, installed, operated, maintained and protected to ensure safe and reliable operation.

.11 Fuel cell spaces should 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.

.12 Suitable control, alarm, monitoring and shutdown systems should be provided to ensure safe and reliable operation.

.13 Fixed leakage detection suitable for all spaces and areas concerned should be arranged.

.14 Fire detection, protection and extinction measures appropriate to the hazards concerned should be provided.

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

.16 The technical documentation should 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.

.17 A single failure in a technical system or component should not lead to an unsafe or unreliable situation.

.18 Safe access should be provided for operation, inspection and maintenance.

The application of the requirements of these Interim Guidelines, including approval and criteria for the arrangement and installation of fuel cell power installations on board ships, is subject to prior agreement with the Flag State.

2.1.2 With regard to criteria for the use of methyl/ethyl alcohol as fuel, refer to IMO Circ. MSC.1/Circ.1621 - *Interim guidelines for the safety of ships using methyl/ethyl alcohol as fuel* (see Appendix 1 of this Rules).

C2.1 APPLICATION

Application to existing ships is subject to the decision by the Register to the extent it deems necessary.

For the application of this Rules for non-conventional size ships or ships having GT less than 500, the technical and safety requirements are to be formulated by the Register in agreement with the Maritime Administration of the Government of the State whose flag the ship is entitled to fly (hereinafter referred to as the Administration).

This Rules are covering the gas or methyl/ethyl alcohol fuel-related installations of the ship, including bunkering system in extent installed on the ship only.

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 *NOTE: 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. [1)]

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 Rules, 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.

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

C2.2.10 *NOTE: Dual fuel engines are usually defined by engine manufacturers as the engines that can burn natural gas or methyl/ethyl alcohol as fuel simultaneously with liquid diesel fuel, either as pilot oil (dual fuel mode or gas mode) or bigger amount of liquid diesel fuel with fuel sharing (specified dual fuel mode), and also has the capability of running on liquid diesel fuel oil only (Diesel mode, or fuel oil mode).*

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. [2)]

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.

C2.2.15.1 *(UI GF3, Dec 2017) 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.*

C2.2.15.2 *A tank connection space may also contain equipment such as vaporizers or heat exchangers. Such equipment is considered to only contain potential sources of release, but not sources of ignition.*

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 *(UI GF4, Dec 2017) 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 ship 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.

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

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

C2.2.21 *Hazardous areas are divided into zone 0, 1 and 2 as defined below and according to the area classification specified in 12.5:*

Zone 0 *Area in which an explosive gas atmosphere is present continuously or is present for long periods.*

Zone 1 *Area in which an explosive gas atmosphere is likely to occur in normal operations.*

Zone 2 *Area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it does occur, is likely to do so only infrequently and will exist for a short period only.*

NOTE: The definition of hazardous area is only related to the risk of explosion. In this context, health, safety, and environmental issues, i.e. toxicity, is not considered.

2.2.22 **High pressure** means a maximum working pressure greater than 1.0 MPa.

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 pressure relief valves (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)]

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.

NOTE: Source of release includes any point of a single walled gas fuel pipe. Gas piping with a pressure less than 1 barg 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.

2.2.42 Ship constructed on or after 1 January 2024 means:

.1 for which the building contract is placed on or after 1 January 2024; or
.2 in the absence of a building contract, the keels of which are laid or which are at a similar stage of construction on or after 1 July 2024; or
.3 the delivery of which is on or after 1 January 2028.

C2.2.43 ***Accommodation spaces*** *are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, game and hobby rooms, barber shops, pantries containing no cooking appliances and similar spaces.*

C2.2.44 ***Explosive gas atmosphere*** *is a mixture with air, under atmospheric conditions, of flammable substances in the form of gas or vapour that, after ignition, permits self-sustaining flame propagation.*

C2.2.45 ***Flash gas*** *means boil-off gas instantly generated during LNG transfer due to the warmer temperature of the receiving ship tanks, sudden pressure drop or friction.*

C2.2.46 ***Gas Combustion Unit (or "Thermal Oxidizer")*** *means a system used for controlling the pressure in the LNG storage tanks by burning the excess boil-off gas from the tanks inside an enclosed combustion chamber under controlled and safe conditions.*

[3)] Refer also to IEC 60092-502:1999 Electrical Installations in Ships – Tankers – Special Features

C2.2.47 ***Gas control systems*** *means systems providing control and monitoring for bunkering, gas storage and gas supply to machinery.*

C2.2.48 ***Gas safety systems*** *means the safety systems for bunkering, gas storage and gas supply to machinery.*

C2.2.49 ***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.*

NOTE: The gas valve unit is by different suppliers also called for instance GVU, gas regulating unit, GRU or gas train, or gas valve train (GVT)

C2.2.50 ***Gas valve unit spaces*** *are spaces or boxes containing valves for control and regulation of gas supply before the consume.*

C2.2.51 ***Master gas fuel valve*** *means an automatic valve in the gas supply line to each engine located outside the machinery space.*

C2.2.52 ***Primary Barrier*** *means the inner element designed to contain the fuel when the fuel containment system includes two boundaries.*

C2.2.53 ***Secondary enclosure*** *means the enclosure around fuel piping designed to prevent liquefied and/or gaseous fuel leaking from the fuel piping system.*

C2.2.54 ***Service spaces*** *are spaces used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, storerooms, work-shops other than those forming part of the machinery spaces, and similar spaces and trunks to such spaces. For further clarification regarding distinguishing between galleys and pantries, regarding applicable fire protection requirements, see MSC.1/Circ.1436.*

C.2.55 ***Vapour return line*** *means connection between the bunkering facility and the receiving ship to allow excess vapour generated during the bunkering operation to be returned to the bunkering facility and remove any need to vent to atmosphere.*

C2.2.56 ***Vent mast*** *is a venting system to which fuel tank pressure relief valves are connected and which complies with 6.7.2.7.*

2.3 ALTERNATIVE DESIGN

2.3.1 This Rules 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 Rules, or
.2 be designed for use of a fuel not specifically addressed in this Rules.

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 Reg. 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 Rules.

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.*

C2.4 CLASS NOTATIONS

For ships complying with the requirements of this Rules class notation for machinery installation should be assigned with additional character of class ***GF****.*

Reference is also to be made to the requirements of the Rules for the classification of ships, Part 1 – General requirements, Chapter 1 – General information, Section 4.

For ships with assigned ***GF*** *additional character of class, the following additional descriptive note(s) may be assigned:*

.1 Dual fuelled, or
.2 Gas only fuelled

For ships for which ***GF*** *additional character of class has not been assigned, but when parts of the systems are installed with the detailed design in addition to the generic design according to the provisions of this Rules, the following additional descriptive note(s) may be assigned:*

.3 Gas fuel ready, or
.4 Dual fuel ready

C2.5 TECHNICAL DOCUMENTATION REQUIREMENTS

With reference to C2.1, for ships to be assigned the additional character of class ***GF****, the documents to be submitted are listed in Table C2-1:*

Table C2-1
Documents to be submitted

No.	**I/A** (1)	**Documentation type**	**Additional description**	**System / object**
1.	***I***	*Design philosophy*	*Including information on the machinery configuration, machinery space arrangements, fuel arrangements, redundancy considerations, shut down philosophy, boil off handling, etc.* *To be submitted before other documentation, as a support for its approval.*	*Propulsion, electrical generation and distribution, and steering general arrangements*
2.	***A***	*Failure mode and effect analysis (FMEA)*	*Failure modes and effects of single failure for electrical generation and distribution systems as requested in 14.3.4.* *For non-conventional gas fueled propulsion machinery arrangements, covering single failure in active components or systems (see C9.3.4).*	
3.	***A***	*Test procedure for quay and sea trial*	*For non-conventional gas fueled propulsion machinery arrangements:* - *redundancy and failure modes based on FMEA*	
4.	***I***	*Tank(s) arrangement plan*	*Overview of tanks with all tank connections and tank connection space.*	*Fuel gas tanks*
5.	***A***	*Detailed drawing*	- *tanks* - *tank domes (if any)* - *secondary barriers (if any)* - *supports and stays* - *thermal insulation* - *tank connection space* - *tank hatches, pipes and any openings to the gas tanks* - *marking plates*	
6.	***I***	*Design analysis*	- *design loads and structural analysis of fuel tanks* - *complete stress analysis for independent tanks type B and type C*	
7.	***I***	*Pipe strength analysis*	*Strength analysis of piping inside outer tank (vacuum insulated double shell tank).*	
8	***I***	*Filling limit calculation report*	*Filling limit curve.*	

No.	I/A [1]	Documentation type	Additional description	System / object
9.	***I***	*Boil-off gas handling calculation report*	- *Holding time calculation when pressure accumulation is used as boil-off gas handling method, including calculation of the thermal insulation suitability* - *Boil-off gas rate and refrigeration plant capability (if any) when pressure accumulation is not used as boil-off gas handling method, including calculation of the thermal insulation suitability*	*Fuel gas tanks*
10.	***A***	*Interbarrier space drainage, inerting and pressurisation systems, if fitted*		
11.	***A***	*Hull ship motion analysis*	*Where a direct analysis is preferred to the methods indicated in 6.4*	
12.	***A***	*Sloshing calculation report*	*Where relevant*	
13.	***A***	*Procedure*	*Cooling down*	
14	***I***	*Procedure*	*Fuel containment system gas freeing procedure, including emptying, inerting and aerating*	
15.	***A***	*Detailed drawing*	*Safety relief valves and associated vent piping, with specification*	
16.	***A***	*Capacity analysis*	*Safety relief valves and associated vent piping, including back pressure*	
17.	***I***	*Procedure*	*Bunkering*	
18.	***A***	*Inspection manual*	*Inspection/survey plan for the liquefied gas fuel containment system (see 6.4.1.8)*	
19.	***A***	*Arrangement plan(s)*	*Including:* - *machinery spaces containing the gas utilization units (engines, gas turbines, boilers and gas combustion units), GVU spaces/enclosures, accommodation, service and control station spaces* - *fuel containment systems* - *location of fuel tank(s) with distances related to fire protection and inspection* - *fuel bunkering station(s) with shore connections* - *fuel preparation rooms and tank connection spaces with regard to protection of the ship structure against cryogenic temperatures (see 5.8 and 6.3).*	*Fuel gas system*
20.	***A***	*Piping and instrumentation diagram(s) (P&ID), with details about material, thickness and joints of the gas pipes*	*Including* - *secondary enclosures for fuel pipes including pressure relief arrangements* - *vent lines for safety relief valves* - *bunkering lines (including vapour return lines, if any)* - *gas supply system for each gas consumer including details of gas fuel pumps and compressors (if any)* - *gas freeing and purging system* - *details of process pressure vessels and respective valving arrangement*	*Fuel gas piping system*
21.	***I***	*Pipe routing sketch*		
22.	***I***	*Thermal stress analysis*	*For design temperature below -110°C.*	
23.	***I***	*Calculation report*	*Stress analysis for high pressure fuel piping.*	
24	***I***	*Specification of valves, fittings, and flanges*	*Including offsets, loops, bends, expansion elements such as bellows and slip joints (only inside tanks). For valves intended for service with a design temperature below -55°C, documentation of leak test and functional test at design temperature (type test) shall be included.*	

No.	***I/A*** [(1)]	***Documentation type***	***Additional description***	***System / object***
25.	***A***	*Arrangement plan*	*Vent masts, including location and details of outlets from fuel tanks safety relief valves.*	*Fuel gas piping system*
26.	***A***	*Control and monitoring system documentation*	*Functionality as required by 15*	*Fuel gas control and monitoring system*
27.	***A***	*Control and monitoring system documentation*	*Functionality as required by Table 1, including emergency shut down system*	*Fuel gas safety system*
28.	***A***	*Cause and effect diagram*	- *covering the safety functions as required by Table 15-1* - *interfaces to other safety and control systems are to be included.*	*Fuel gas safety system*
29.	***A***	*Arrangement plan*	*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, hull protection beneath piping for liquefied fuel where leakages may be anticipated, such as at shore connections and at pump seals, etc. Arrangement plan shall include specification.*	*Fuel gas drip trays and hull structure*
30.	***A***	*Piping and instrumentation diagram (P&ID)*		*Fuel gas cooling system*
31.	***A***	*Piping and instrumentation diagram (P&ID)*		*Fuel gas heating system*
32.	***A***	*Piping diagram (PD)*	*Including arrangement of explosion relief, or verification of strength of piping system (see 10.3, 10.4, 10.5).*	*Exhaust gas system*
33.	***A***	*Hazardous area classification drawing*		*Hazardous area classification*
34.	***A***	*Arrangement plan*	*Location and construction details, including alarm equipment.*	*Air lock arrangements*
35.	***A***	*Ventilation ducting diagram*	*Including capacity and location of fans and their motors.*	*Ventilation systems for gas fuel system spaces*
36.	***A***	*Control and monitoring system documentation*	*Including detection of ventilation function, arrangement of powering of fans, safety actions and sequences, etc.*	*Ventilation control and monitoring system*
37.	***I***	*Arrangement plan of electric equipment including lighting system*	*Based on an approved "hazardous area classification drawing" where location of electric equipment in hazardous area is added (except paint stores, gas bottle store, and battery room).*	*Explosion (Ex) protection*
38.	***A***	*Electrical schematic drawing*	*Single line electrical wiring diagrams in hazardous areas for all intrinsically safe circuits, including data for verification of the compatibility between the barrier and the field components for each circuit.*	
39.	***I***	*Specification*	*List of non-certified safe electrical equipment that shall be disconnected (ESD protected machinery spaces, spaces protected by air lock), and certified safe electrical equipment*	
40.	***A***	*Failure mode and effect analysis (FMEA)*	*Where required in 14.*	
41.	***I***	*Maintenance manual*	*Electrical equipment in hazardous areas.*	
42.	***A***	*Control and monitoring system documentation*		*Hydrocarbon gas detection and alarm system, fixed*
43.	***A***	*Arrangement plan*		

No.	I/A (1)	Documentation type	Additional description	System / object
44.	**A**	*Fixed fire extinguishing appliances and systems documentation*	*Details of fire-extinguishing appliances and systems related to gas installation: Water spray system when required to be fitted, Dry chemical powder, Fire Main*	*Bunkering station and fuel preparation room fire extinguishing system*
45.	**A**	*Fixed fire extinguishing system documentation*		*External surface protection water spraying system*
46.	**A**	*Arrangement plan*		*Mobile fire extinguishing equipment*
47.	**A**	*Risk analysis*	*Risk analysis as per 4.2 and follow-up report of the recommendations*	*Where required as per 4.2*
48.	**A**	*Bilge system of the spaces related to fuel gas storage and preparation*		*Bilge*
49.	**A**	*Hull structure heating system, if any*		*Hull*

*(1) **A** = to be submitted for approval; **I** = to be submitted for information*

(2) As far as applicable, the diagrams are to include relevant indication/information about the (local and remote) control, monitoring and automation systems.

(3) Specific requirements for documentation submission may be additionally agreed for a particular project.

C2.6 CERTIFICATION REQUIREMENTS FOR THE EQUIPMENT SPECIFIC TO THE FUELS COVERED BY THIS RULES

Products shall be certified as required by Table C2-2:

Table C 2-2
Certificates required

Object	Certificate type	Issued by	Additional description
Gas/Dual Fuel Engines	*Product*	*Class Society*	*In accordance with IACS UR M78 (Rev.2, Mar 2023) and the Rules for the classification of ships, Part 9 - Machines*
Process pressure vessels	*Product*	*Class Society*	*Shall be certified as class I pressure vessels in accordance with the Rules for the classification of ships, Part 10 – Boilers, heat exchangers and pressure vessels*
Pumps	*Product*	*Class Society*	*In accordance with the Rules for the classification of ships, Part 9 - Machines*
Compressors	*Product*	*Class Society*	*In accordance with the Rules for the classification of ships, Part 9 - Machines*
Valves in fuel system	*Product*	*Class Society*	*For valves with design temperature below 0°C, and with design pressure above 10 bar In accordance with the Rules for the classification of ships, Part 8 - Piping (irrespective of size)*
	Product	*Manufacturer*	*For valves with design pressure equal to or lower than 10 bar, and design temperature equal to or above 0°C In accordance with the Rules for the classification of ships, Part 8 - Piping (irrespective of size)*
Expansion bellows	*Type approval*	*Class Society*	*In accordance with the Rules for the classification of ships, Part 8 - Piping*
Flexible hoses with couplings	*Type approval*	*Class Society*	*In accordance with the Rules for the classification of ships, Part 8 - Piping*
Fuel gas control and monitoring systems	*Product*	*Class Society*	*Shall be certified in accordance with the Rules for the classification of ships, Part 13 - Automation*
Fuel gas safety system	*Product*	*Class Society*	*Shall be certified in accordance with the Rules for the classification of ships, Part 13 - Automation*
Hydrocarbon gas detection and alarm system, fixed	*Product*	*Class Society*	*Shall be certified in accordance with the Rules for the classification of ships, Part 13 - Automation*

Object	***Certificate type***	***Issued by***	***Additional description***
Electric motors	*Product*	*Class Society*	*Shall be certified in accordance with the Rules for the classification of ships, Part 12 – Electrical equipment when used in gas supply systems and ventilation systems*
Electric motor starters	*Product*	*Class Society*	*Shall be certified in accordance with the Rules for the classification of ships, Part 12 – Electrical equipment when used in gas supply systems and ventilation systems*
Ventilation fans for hazardous spaces	*Product*	*Class Society*	*Shall be certified in accordance with the Rules for the classification of ships, Part 9 - Machines*

3 GOAL AND FUNCTIONAL REQUIREMENTS

3.1 GOAL

The goal of this Rules 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.

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

C3.2.13 *This applies in particular to ESD protected machinery spaces. A "source that might release gas" is to be considered as a "source of release" as defined in 2.2.39.*

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 chapters 5 through 15 applies, the risk assessment required by 4.2.1 need only be conducted where explicitly required by paragraphs 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 paragraphs 4.4 and 6.8 of the annex 1.

C4.2.2 *Recommendation for performance of risk assessment is explained in IACS Rec. 146 (Aug 2016).*

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 Flag State Administration.

4.3 LIMITATION OF EXPLOSION CONSEQUENCES

An explosion in any space containing any potential sources of release [4)] 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 ship in such a way that chain reactions involving, inter alia, cargo, gas and bunker oil may arise; or
.8 prevent persons access to life-saving appliances or impede escape routes.

[4)] Double wall fuel pipes are not considered as potential sources of release.

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 Section 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 Section 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

.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

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 is 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 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.
- .2 For cargo ships:
  - .1 for Vc below or equal 1,000 m^3, 0.8 m;
  - .2 for 1,000 m3 < Vc < 5,000 m^3, 0.75 + Vc x 0.2/4,000 m;
  - .3 for 5,000 m3 ≤ Vc < 30,000 m^3, 0.8 + Vc/25,000 m; and
  - .4 for Vc ≥ 30,000 m3, 2 m,

  where:
  Vc 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 centerline.

.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 is the 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 above, 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)]

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

$$fCN = fl \times ft \times fv$$

where:
ft is 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.
ft is calculated by use of the formulations for factor r contained in SOLAS regulation II-1/7-1.1.2, and reflects the probability that the damage penetrates beyond the outer boundary of the fuel tank. The formulation is:

$$ft = 1 - (x1, x2, b)$$ [6)]

fv is 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:

$$fv = 1.0 - 0.8 \cdot ((H - d)/7.8)$$

if $(H - d)$ is less than or equal to 7.8 m fv shall not be taken greater than 1

$fv = 0.2 - 0.2 \cdot ((H - d) - 7.8)/4.7)$, in all other cases fv shall not be taken less than 0

where:
H is the distance from baseline, in meters, to the lowermost boundary of the fuel tank; and
d is the 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 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 below or equal 1,000 m^3, 0.8 m;
    .2 for 1,000 m^3 < V_c < 5,000 m^3, 0.75 + V_c x 0.2 / 4,000 m;
    .3 for 5,000 m^3 ≤ V_c < 30,000 m^3, 0.8 + V_c / 25,000 m; and
    .4 for V_c ≥ 30,000 m^3, 2 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 paragraph 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 centerline 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 paragraph 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 section 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.

5.4 MACHINERY SPACE CONCEPTS

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

.1 Gas safe machinery spaces: Arrangements in machinery spaces are such that the spaces

[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.

[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.

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 *(UI GF5, Dec 2017) Premixed engines using fuel gas mixed with air before the turbocharger shall be located in ESD protected machinery spaces.*

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.

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.

C5.6.1 *Machinery spaces that are certified for periodically unattended operation shall be arranged in accordance with the requirements for automation class notation AUT1, AUT2 or AUT3.*

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 shutoff 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 shutdown the gas supply, and disconnect all electrical equipment or installations not of a certified safe type, shall be fitted.

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.

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.

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 *Fuel piping is considered as any piping system that may contain liquid or gaseous fuel including vent piping.*

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

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.

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

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 Rules for tank connection spaces.

C5.8.1 *(UI GF6, Dec 2017) Fuel preparation rooms, regardless of location, shall be arranged to safely contain cryogenic leakages.*

C5.8.2 *The material of the boundaries of the fuel preparation room shall have a design temperature corresponding with the lowest temperature it can be subjected to in a probable maximum leakage scenario unless the boundaries of the space, i.e. bulkheads and decks, are provided with suitable thermal protection.*

C5.8.3 *The fuel preparation room shall be arranged to prevent surrounding hull structure from being exposed to unacceptable cooling, in case of leakage of cryogenic liquids.*

C5.8.4 *The fuel preparation room 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.*

5.9 REGULATIONS FOR BILGE SYSTEMS

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

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 affected from a spill is necessary.

C5.10.1 *Drip trays are to be fitted in particular where liquid piping is dismantled regularly as bunkering station or 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 (e.g. stainless steel) is to ensure any leakage cannot come into contact with other equipment/structures and is safely collected. Integrity of the drip tray is to be maintained if subjected to cryogenic temperatures associated with fuel leakages.*

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.

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

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 Register.*

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.

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.

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.

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.

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 m^2. 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 underpressure 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 shall be provided in order 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.

6 FUEL CONTAINMENT SYSTEM

6.1 GOAL

The goal of this Section 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 fueled ship.

6.2 FUNCTIONAL REQUIREMENTS

This Section 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 Section.

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.

C6.3.1 *Tanks for liquefied fuel with a design pressure of 10 bar or less may be stored in enclosed spaces in accordance with the requirements in this Rules.*

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.

C6.3.3 *For fuel gas containment systems where leakage through the primary barrier is part of the design assumptions, the gas tight barrier will be the secondary barrier, or in case of partial secondary barriers, will be the fuel storage hold space.*

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 *For fuel tanks not located in enclosed spaces, tank connection spaces need not be arranged if other measures are in place to fulfil the functional requirements in 6.2 and 7.2.*

(UI GF3, Dec 2017):

A tank connection space may be required also for tanks on open deck. This may apply for ships were restriction of hazardous areas is safety critical. This 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.

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.

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 tank connection space is to be isolated thermally so that the surrounding hull is not exposed to unacceptable cooling in case of leakage of the liquid or compressed gas.*

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

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.

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 *Drip trays shall be thermally insulated from the ship's structure to prevent unacceptable cooling in case of leakage of liquefied gas.*

(*UI GF2, Sep 2017):*

1. *When the tank is located on the open deck, drip trays are to 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 are to be provided to protect the deck from leakages from tank connections and other sources of leakage.

3. When the tank and the tank connections are located below the deck, all tank connections are to be located in a tank connection space. Drip trays in this case are not required.

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.*

C6.3.13 *Design principles*

.1 Fuel containment systems shall be located in such a way that the risk of excessive heat input from a fire is minimized.

.2 Fuel containment systems shall be located and arranged in such a way that the risk of mechanical damage from ship operations, cargo operations and green seas is minimized, either by locating the fuel tanks away from such hazards, or by providing mechanical protection.

.3 Fuel containment systems shall be located in such a way that the risk of mechanical damage from explosions is minimized, either by locating the fuel tanks away from areas of explosion risks by providing mechanical protection, or by reducing the risk of explosions.

.4 Fuel containment systems shall be designed and arranged not to cause damage to other structures due to low temperature leakages.

.5 Fuel containment systems on open deck shall be designed and arranged to minimize, as far as practicable, the extent of hazardous areas and potential sources of release.

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 ship's liquefied gas fuel containment system, and may lead to additional safety measures for integration into the overall vessel design.

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)]

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;

---

7) Refer to IACS Rec.34

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.

.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 Rules:

.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.

C6.4.1.9 *Access for external inspection of fuel tanks shall be provided in accordance with IGC Code Chapter 3.5.*

Access for internal inspection of fuel tanks shall be provided, except for vacuum insulated type C tanks which may be accepted without access openings.

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°.

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, nitrogen 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

6.4.9.1 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.

6.4.9 Design loads

6.4.9.1 General

6.4.9.1.1 This section defines the design loads that shall be considered with regard to regulations in 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:

a) internal pressure
b) external pressure
c) thermally induced loads
d) vibration
e) interaction loads
f) loads associated with construction and installation
g) test loads
h) static heel loads
i) weight of liquefied gas fuel
j) sloshing
k) 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 $(P_{gdsite})_{max}$ is the associated liquid pressure determined using site specific accelerations.

.3 P_{eq} should be the greater of P_{eq1} and P_{eq2} calculated as follows:

$P_{eq1} = P_0 + (P_{gd})_x$ (MPa),

$P_{eq2} = P_h + (P_{gdsite})_{max}$ (MPa).

.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 Pgd resulting from combined effects of gravity and dynamic accelerations shall be calculated as follows:

$P_{gd} = \alpha_\beta Z_\beta (\rho/(1.02 \times 105))$ (MPa)

where:

α = dimensionless acceleration (i.e. relative to the acceleration of gravity), resulting from gravitational and dynamic loads, in an arbitrary direction β; (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:

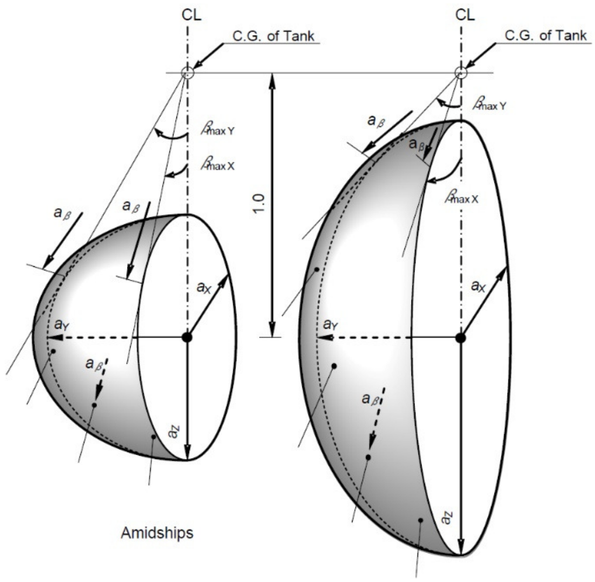
$$V_d = V_t \left(\frac{100-FL}{FL}\right)$$

where:

V_t = tank volume without any domes; and
FL = filling limit according to 6.8.
ρ = maximum liquefied gas fuel density (kg/m^3) at the design temperature.

The direction that gives the maximum value $(P_{gd})_{max}$ or $(P_{gdsite})_{max}$ 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.



At 0.05L from FP

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 6.4.1
Acceleration ellipsoid

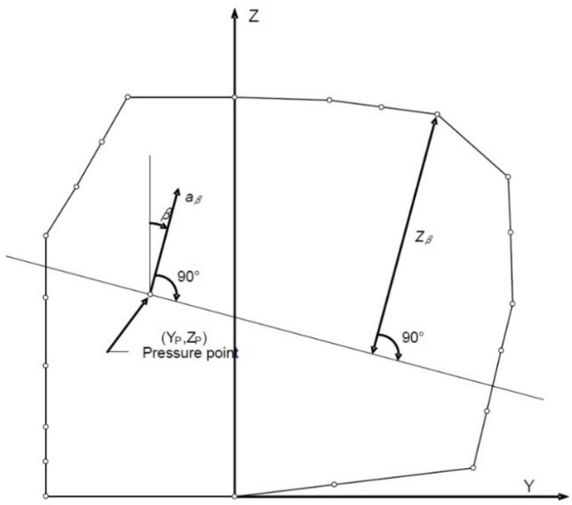


Figure 6.4.2
Determination of internal pressure heads

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.

6.4.9.3.3.2 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 paragraph 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.

6.4.9.3.3.9 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 Administration. [9)]

Ships for restricted service may be given special consideration.

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.

6.4.9.4.1.4 Snow and ice loads

Snow and icing shall be considered, if relevant.

6.4.9.4.1.5 Loads due to navigation in ice

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

6.4.9.4.1.6 Green sea loading

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

6.4.9.4.1.7 Wind loads

Account shall be taken to wind generated loads 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 its 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 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	2g

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

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.

[9)] Refer to section 4.28.2.1 of the IGC Code for guidance formulae for acceleration components

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.

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

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

6.4.11.2 Load scenarios

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

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

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

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

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

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

$$t_{xy} = t_{xy.st} \pm \sqrt{\Sigma(t_{xy.dyn})^2}$$

$$t_{xz} = t_{xz.st} \pm \sqrt{\Sigma(t_{xz.dyn})^2}$$

$$t_{yz} = t_{yz.st} \pm \sqrt{\Sigma(t_{yz.dyn})^2}$$

where:

$\sigma_{x.st}$, $\sigma_{y.st}$, $\sigma_{z.st}$, $t_{xy.st}$, $t_{xz.st}$ and $t_{yz.st}$ are static stresses; and

$\sigma_{x.dyn}$, $\sigma_{y.dyn}$, $\sigma_{z.dyn}$, $t_{xy.dyn}$, $t_{xz.dyn}$ and $t_{yz.dyn}$ are dynamic stresses,

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

6.4.12 Design conditions

All relevant failure modes shall be considered in the design for all relevant load scenarios and design conditions. The design conditions are given in the earlier part of this Section, and the load scenarios are covered by 6.4.11.2.

6.4.12.1 Ultimate design condition

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

.1 Plastic deformation and buckling shall be considered.

.2 Analysis shall be based on characteristic load values as follows:

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

.3 For the purpose of ultimate strength assessment the following material parameters apply:

.1 R_e = specified minimum yield stress at room temperature (N/mm^2). If the stress-strain curve does not show a defined yield stress, the 0.2% proof stress applies.

.2 R_m = specified minimum tensile strength at room temperature (N/mm^2).

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

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

.4 The equivalent stress σc (von Mises, Huber) shall be determined by:

$$\sigma_c = \sqrt{\sigma_x{}^2 + \sigma_y{}^2 + \sigma_Z{}^2 - \sigma_x\sigma_y - \sigma_x\sigma_z - \sigma_y\sigma_z + 3\left(\tau_{xy}{}^2 + \tau_{xz}{}^2 + \tau_{yz}{}^2\right)}$$

where:

σ_x = total normal stress in x-direction;

σ_y = total normal stress in y-direction;

σ_z = total normal stress in z-direction;

τ_{xy} = total shear stress in x-y plane;

τ_{xz} = total shear stress in x-z plane; and

τ_{yz} = total shear stress in y-z plane.

The above values shall be calculated as described in 6.4.11.2.3.

.5 Allowable stresses for materials other than those covered by 7.4 shall be subject to approval by the Administration in each case.

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

6.4.12.2 Fatigue Design Condition

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

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

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

where:

n_i = number of stress cycles at each stress level during the life of the tank;

N_i = number of cycles to fracture for the respective stress level according to the Wohler (S-N) curve;

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

$N_{Loading}$ = number of cycles to fracture for the fatigue loads due to loading and unloading; and

C_w = maximum allowable cumulative fatigue damage ratio.

The fatigue damage shall be based on the design life of the tank but not less than 10^8 wave encounters.

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

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

The S-N curves shall be based on a 97.6% probability of survival corresponding to the mean-minus-two-standard-deviation curves of relevant experimental data up to final failure. Use of S-N curves derived in a different way requires adjustments to the acceptable Cw values specified in 6.4.12.2.7 to 6.4.12.2.9.

.5 Analysis shall be based on characteristic load values as follows:

Permanent loads	Expected values
Functional loads	Specified values or specified history
Environmental loads	Expected load history, but not less than 108 cycles

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

.6 Where the size of the secondary barrier is reduced, as is provided for in 6.4.2.3, fracture mechanics analyses of fatigue crack growth shall be carried out to determine:

.1 crack propagation paths in the structure, where necessitated by 6.4.12.2.7 to 6.4.12.2.9, as applicable;

.2 crack growth rate;

.3 the time required for a crack to propagate to cause a leakage from the tank;

.4 the size and shape of through thickness cracks; and

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

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

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

Crack propagation analysis specified in 6.4.12.2.7 the simplified load distribution and sequence over a period of 15 days may be used. Such distributions may be obtained as indicated in figure 6.4.3. Load distribution and sequence for longer periods, such as in 6.4.12.2.8 and 6.4.12.2.9 shall be approved by the Administration.

The arrangements shall comply with 6.4.12.2.7 to 6.4.12.2.9 as applicable.

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

C_w shall be less than or equal to 0.5.
Predicted remaining failure development time, from the point of detection of leakage till reaching a critical state, shall not be less than 15 days unless different regulations apply for ships engaged in particular voyages.

.8 For failures that cannot be detected by leakage but that can be reliably detected at the time of in-service inspections:
C_w shall be less than or equal to 0.5.
Predicted remaining failure development time, from the largest crack not detectable by in-service inspection methods until reaching a critical state, shall not be less than three (3) times the inspection interval.

.9 In particular locations of the tank where effective defect or crack development detection cannot be assured, the following, more stringent, fatigue acceptance criteria shall be applied as a minimum:
C_w shall be less than or equal to 0.1.
Predicted failure development time, from the assumed initial defect until reaching a critical state, shall not be less than three (3) times the lifetime of the tank.

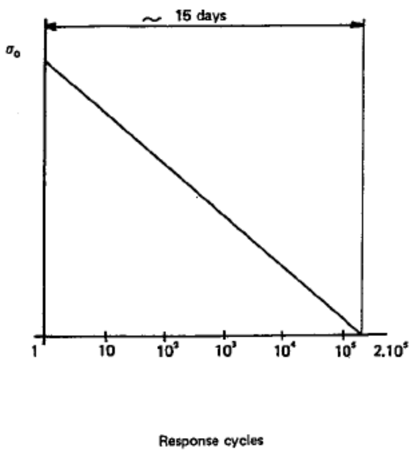


Figure 6.4.3
Simplified load distribution

6.4.12.3 Accidental design condition

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

6.4.12.3.2 Analysis shall be based on the characteristic values as follows:

Permanent loads	Expected values
Functional loads	Specified values
Environmental loads	Specified values
Accidental loads	Specified values or expected values

Loads mentioned in 6.4.9.3.3.8 and 6.4.9.5 need not be combined with each other or with wave-induced loads.

6.4.13 Materials and construction

6.4.13.1 Materials

6.4.13.1.1 Materials forming ship structure

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

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

.2 In addition to .1 above, where a complete or partial secondary barrier is required it shall be assumed to be at the liquefied gas fuel temperature at atmospheric pressure for any one tank only.

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

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

.5 Degradation of the thermal insulation properties over the life of the ship due to factors such as thermal and mechanical ageing, compaction, ship motions and tank vibrations as defined in 6.4.13.3.6 and 6.4.13.3.7 shall be assumed.

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

.7 Credit for hull heating may be taken in accordance with 6.4.13.1.1.3, provided the heating arrangements are in compliance with 6.4.13.1.1.4.

.8 No credit shall be given for any means of heating, except as described in 6.4.13.1.1.3.

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

6.4.13.1.1.2 The materials of all hull structures for which the calculated temperature in the design condition is below 0°C, due to the influence of liquefied gas fuel temperature, shall be in accordance with table 7.5. This includes hull structure supporting the liquefied gas fuel tanks, inner bottom plating, longitudinal bulkhead plating, transverse bulkhead plating, floors, webs, stringers and all attached stiffening members.

6.4.13.1.1.3 Means of heating structural materials may be used to ensure that the material temperature does not fall below the minimum allowed for the grade of material specified in table 7.5. In the calculations required in 6.4.13.1.1.1, credit for such heating may be taken in accordance with the following principles:

.1 for any transverse hull structure;
.2 for longitudinal hull structure referred to in 6.4.13.1.1.2 where colder ambient temperatures are specified, provided the material remains suitable for the ambient temperature conditions of plus 5°C for air and 0°C for seawater with no credit taken in the calculations for heating; and
.3 as an alternative to 6.4.13.1.1.3.2, for longitudinal bulkhead between liquefied gas fuel tanks, credit may be taken for heating provided the material remain suitable for a minimum design temperature of minus 30°C, or a temperature 30°C lower than that determined by 6.4.13.1.1.1 with the heating considered, whichever is less. In this case, the ship's longitudinal strength shall comply with SOLAS regulation II-1/3-1 for both when those bulkhead(s) are considered effective and not.

6.4.13.1.1.4 The means of heating referred to in 6.4.13.1.1.3 shall comply with the following:
.1 the heating system shall be arranged so that, in the event of failure in any part of the system, standby heating can be maintained equal to no less than 100% of the theoretical heat requirement;
.2 the heating system shall be considered as an essential auxiliary. All electrical components of at least one of the systems provided in accordance with 6.4.13.1.1.3.1 shall be supplied from the emergency source of electrical power; and
.3 the design and construction of the heating system shall be included in the approval of the containment system by the Administration.

6.4.13.2 Materials of primary and secondary barriers

6.4.13.2.1 Metallic materials used in the construction of primary and secondary barriers not forming the hull, shall be suitable for the design loads that they may be subjected to, and be in accordance with table 7.1, 7.2 or 7.3.

6.4.13.2.2 Materials, either non-metallic or metallic but not covered by tables 7.1, 7.2 and 7.3, used in the primary and secondary barriers may be approved by the Administration considering the design loads that they may be subjected to, their properties and their intended use.

6.4.13.2.3 Where non-metallic materials, [10)] including composites, are used for or incorporated in the primary or secondary barriers, they shall be tested for the following properties, as applicable, to ensure that they are adequate for the intended service:
.1 compatibility with the liquefied gas fuels;
.2 ageing;
.3 mechanical properties;
.4 thermal expansion and contraction;
.5 abrasion;
.6 cohesion;
.7 resistance to vibrations;
.8 resistance to fire and flame spread; and
.9 resistance to fatigue failure and crack propagation.

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

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

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

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

C6.4.13.3 The materials for insulation are to be approved by the Register. The approval of bonding materials, sealing materials, lining constituting a vapour barrier or mechanical protection is to be considered by the Register on a case-by-case basis. In any event, these materials are to be chemically compatible with the insulation material. A particular attention is to be paid to the continuity of the insulation in way of tank supports. Before applying the insulation, the surfaces of the tank structures or of the hull are to be carefully cleaned. When the insulation is sprayed or foamed, the minimum steel temperature at the time of application is to be not less than the temperature given in the specification of the insulation. Where applicable, the insulation system is to be suitable to be visually examined at least on one side.

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

6.4.13.3.2 Thermal insulation and other materials used in liquefied gas fuel containment systems shall have the following properties, as applicable, to ensure that they are adequate for the intended service:
.1 compatibility with the liquefied gas fuels;
.2 solubility in the liquefied gas fuel;
.3 absorption of the liquefied gas fuel;
.4 shrinkage;
.5 ageing;
.6 closed cell content;
.7 density;
.8 mechanical properties, to the extent that they are subjected to liquefied gas fuel and other loading effects, thermal expansion and contraction;
.9 abrasion;
.10 cohesion;
.11 thermal conductivity;
.12 resistance to vibrations;
.13 resistance to fire and flame spread; and
.14 resistance to fatigue failure and crack propagation.

6.4.13.3.3 The above properties, where applicable, shall be tested for the range between the expected maximum

[10)] Refer to section 6.4.16.

temperature in service and 5°C below the minimum design temperature, but not lower than minus 196°C.

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

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

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

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

6.4.14 Construction processes

6.4.14.1 Weld joint design

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

C6.4.14.1.1 *Small penetrations are those intended for instrumentation lines and accessory lines with a diameter of less than 25 mm.*

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

.1 All longitudinal and circumferential joints shall be of butt welded, full penetration, double vee or single vee type. Full penetration butt welds shall be obtained by double welding or by the use of backing rings. If used, backing rings shall be removed except from very small process pressure vessels. [11)] Other edge preparations may be permitted, depending on the results of the tests carried out at the approval of the welding procedure. For connections of tank shell to a longitudinal bulkhead of type C bilobe tanks, tee welds of the full penetration type may be accepted.

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

6.4.14.2 Design for gluing and other joining processes

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

6.4.15 Tank types

6.4.15.1 Type A independent tanks

6.4.15.1.1 Design basis

6.4.15.1.1.1 Type A independent tanks are tanks primarily designed using classical ship-structural analysis procedures in accordance with the requirements of the Administration. Where such tanks are primarily constructed of plane surfaces, the design vapour pressure P_0 shall be less than 0.07 MPa.

6.4.15.1.1.2 A complete secondary barrier is required as defined in 6.4.3. The secondary barrier shall be designed in accordance with 6.4.4.

6.4.15.1.2 Structural analysis

6.4.15.2.1 A structural analysis shall be performed taking into account the internal pressure as indicated in 6.4.9.3.3.1, and the interaction loads with the supporting and keying system as well as a reasonable part of the ship's hull.

6.4.15.2.2 For parts, such as structure in way of supports, not otherwise covered by the regulations in this Rules, stresses shall be determined by direct calculations, taking into account the loads referred to in 6.4.9.2 to 6.4.9.5 as far as applicable, and the ship deflection in way of supports.

6.4.15.2.3 The tanks with supports shall be designed for the accidental loads specified in 6.4.9.5. These loads need not be combined with each other or with environmental loads.

6.4.15.1.3 Ultimate design condition

6.4.15.1.3.1 For tanks primarily constructed of plane surfaces, the nominal membrane stresses for primary and secondary members (stiffeners, web frames, stringers, girders), when calculated by classical analysis procedures, shall not exceed the lower of $R_m/2.66$ or $R_e/1.33$ for nickel steels, carbon-manganese steels, austenitic steels and aluminium alloys, where Rm and Re are defined in 6.4.12.1.1.3. However, if detailed calculations are carried out for the primary members, the equivalent stress σc, as defined in 6.4.12.1.1.4, may be increased over that indicated above to a stress acceptable to the Administration. Calculations shall take into account the effects of bending, shear, axial and torsional deformation as well as the hull/liquefied gas fuel tank interaction forces due to the deflection of the hull structure and liquefied gas fuel tank bottoms.

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

6.4.15.1.3.2 Tank boundary scantlings shall meet at least the requirements of the Administration for deep tanks taking into account the internal pressure as indicated in 6.4.9.3.3.1 and any corrosion allowance required by 6.4.1.7.

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

6.4.15.1.4 Accidental design condition

6.4.15.1.4.1 The tanks and the tank supports shall be designed for the accidental loads and design conditions specified in 6.4.9.5 and 6.4.1.6.3 as relevant.

6.4.15.1.4.2 When subjected to the accidental loads specified in 6.4.9.5, the stress shall comply with the acceptance criteria specified in 6.4.15.1.3, modified as appropriate taking into account their lower probability of occurrence.

6.4.15.2 Type B independent tanks

6.4.15.2.1 Design basis

6.4.15.2.1.1 Type B independent tanks are tanks designed using model tests, refined analytical tools and analysis methods to determine stress levels, fatigue life and crack propagation characteristics. Where such tanks are primarily constructed of plane surfaces (prismatic tanks) the design vapour pressure P_0 shall be less than 0.07 MPa.

6.4.15.2.1.2 A partial secondary barrier with a protection system is required as defined in 6.4.3. The small leak protection system shall be designed according to 6.4.5.

6.4.15.2.2 Structural analysis

6.4.15.2.2.1 The effects of all dynamic and static loads shall be used to determine the suitability of the structure with respect to:

.1 plastic deformation;
.2 buckling;
.3 fatigue failure; and
.4 crack propagation.

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

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

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

6.4.15.2.3 Ultimate design condition

6.4.15.2.3.1 Plastic deformation

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

$\sigma_m \leq f$

$\sigma_L \leq 1.5f$

$\sigma_b \leq 1.5F$

$\sigma_L+\sigma_b \leq 1.5F$

$\sigma_m+\sigma_b \leq 1.5F$

$\sigma_m+\sigma_b+\sigma_g \leq 3.0F$

$\sigma_L+\sigma_b+\sigma_g \leq 3.0F$

where:

σ_m = equivalent primary general membrane stress;

σ_L = equivalent primary local membrane stress;

σ_b = equivalent primary bending stress;

σ_g = equivalent secondary stress;

f = the lesser of (R_m / A) or (R_e / B); and

F = the lesser of (R_m / C) or (R_e / D),

with R_m and R_e as defined in 6.4.12.1.1.3. With regard to the stresses σ_m, σ_L, σ_g and σ_b see also the definition of stress categories in 6.4.15.2.3.6

The values A and B shall have at least the following minimum values:

	Nickel steels and carbon manganese steels	Austenitic steels	Aluminium alloys
A	3	3.5	4
B	2	1.6	1.5
C	3	3	3
D	1.5	1.5	1.5

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

.1 for nickel steels and carbon-manganese steels, the lesser of R_m / 2 or R_e /1.2;
.2 for austenitic steels, the lesser of R_m / 2.5 or R_e / 1.2; and
.3 for aluminium alloys, the lesser of R_m / 2.5 or R_e / 1.2.

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

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

6.4.15.2.3.2 Buckling

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

6.4.15.2.3.3 Fatigue design condition

6.4.15.2.3.3.1 Fatigue and crack propagation assessment shall be performed in accordance with the provisions of 6.4.12.2. The acceptance criteria shall comply with 6.4.12.2.7, 6.4.12.2.8 or 6.4.12.2.9, depending on the detectability of the defect.

6.4.15.2.3.3.2 Fatigue analysis shall consider construction tolerances.

6.4.15.2.3.3.3 Where deemed necessary by the Administration, model tests may be required to determine stress concentration factors and fatigue life of structural elements.

6.4.15.2.3.4 Accidental design condition

6.4.15.2.3.4.1 The tanks and the tank supports shall be designed for the accidental loads and design conditions specified in 6.4.9.5 and 6.4.1.6.3, as relevant.

6.4.15.2.3.4.2 When subjected to the accidental loads specified in 6.4.9.5, the stress shall comply with the acceptance criteria specified in 6.4.15.2.3, modified as appropriate, taking into account their lower probability of occurrence.

6.4.15.2.3.5 Marking

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

6.4.15.2.3.6 Stress categories

For the purpose of stress evaluation, stress categories are defined in this section as follows:

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

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

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

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

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

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

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

$S_1 \leq 0.5\sqrt{Rt}$; and

$S_2 \geq 2.5\sqrt{Rt}$

where:

S_1 = distance in the meridional direction over which the equivalent stress exceeds 1.1 f;

S_2 = distance in the meridional direction to another region where the limits for primary general membrane stress are exceeded;

R = mean radius of the vessel;

t = wall thickness of the vessel at the location where the primary general membrane stress limit is exceeded; and

f = allowable primary general membrane stress.

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

6.4.15.3 Type C independent tanks

6.4.15.3.1 Design basis

6.4.15.3.1.1 The design basis for type C independent tanks is based on pressure vessel criteria modified to include fracture mechanics and crack propagation criteria. The minimum design pressure defined in 6.4.15.3.1.2 is intended to ensure that the dynamic stress is sufficiently low so that an initial surface flaw will not propagate more than half the thickness of the shell during the lifetime of the tank.

C6.4.15.3.1.1 *The requirements in UR G2 apply to type C independent tanks and to process pressure vessels.*

6.4.15.3.1.2 The design vapour pressure shall not be less than:

where:

$$A = 0.00185\left(\frac{\sigma_m}{\Delta\sigma_A}\right)^2$$

with:

σ_m = design primary membrane stress;

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

- 55 N/mm^2 for ferritic-perlitic, martensitic and austenitic steel;
- 25 N/mm^2 for aluminium alloy (5083-O);

C = a characteristic tank dimension to be taken as the greatest of the following:

h, 0.75b or 0.45ℓ,

with:

h = height of tank (dimension in ship's vertical direction) (m);

b = width of tank (dimension in ship's transverse direction) (m);

ℓ = length of tank (dimension in ship's longitudinal direction) (m);

ρ_r = the relative density of the cargo (ρ_r = 1 for fresh water) at the design temperature.

C6.4.15.3.1.2 *If other materials than those specified above are used, the allowable dynamic membrane stress $\Delta\sigma_A$ shall be agreed with the Register.*

C6.4.15.3.1.3 *Tank test load*

Tank test shall be done at a pressure of not less than 1.5 P_0. For vacuum insulated tanks the vacuum pressure shall be included, i.e. 1.5 (P_0 + P_{vacuum}).

C6.4.15.3.1.4 *Acceptance criteria for tank test condition*

In connection with the hydrostatic test, the membrane stress σ_t shall at any point not exceed $\sigma_t \leq 0.9\ R_{eH}$. It shall be ensured that any compression stresses in the tank during filling do not cause any instability of the tank shell.

C6.4.15.3.1.5 *For ultimate (ULS) design conditions, accidental (ALS) design conditions and test conditions, the following loads shall be considered for scantling control of tank structure and ring support:*

Table C6.4.15.3.1.5
Design conditions

<table>
<tr><th></th><th>Condition</th><th>Location</th><th>Reference</th><th>Load components</th></tr>
<tr><td rowspan="12">ULS</td><td rowspan="5">DC 1
yield check</td><td>cylindrical shell</td><td>Rules for the classification of ships, Part 10 – Boilers, heat exchangers and pressure vessels, Sec. 2, 2.2.1</td><td rowspan="5">- tank system self-weight
- internal static and dynamic cargo pressure
- internal vapour pressure</td></tr>
<tr><td>spherical shell</td><td>Rules for the classification of ships, Part 10 – Boilers, heat exchangers and pressure vessels, Sec. 2, 2.5.1</td></tr>
<tr><td>dished ends</td><td>Rules for the classification of ships, Part 10 – Boilers, heat exchangers and pressure vessels, Sec. 2, 2.5.2</td></tr>
<tr><td>shell in way of support</td><td>as described in C6.4.15.3.2.5.1</td></tr>
<tr><td>openings and reinforcements</td><td>Rules for the classification of ships, Part 10 – Boilers, heat exchangers and pressure vessels, Sec. 2, 2.2.1.4 and 2.5.2.4</td></tr>
<tr><td>DC 2
yield check</td><td>swash bulkhead</td><td>Rules for the classification of ships, Part 2 - Hull, Sec. 11, 11.5</td><td>- sloshing pressure</td></tr>
<tr><td rowspan="2">DC 3
yield and buckling check</td><td>tank</td><td>as for DC 1</td><td rowspan="2">- tank system self-weight
- max. acceleration or static cargo pressure at 30° inclination as relevant
- internal vapour pressure</td></tr>
<tr><td>in way of supports</td><td>as described in C6.4.15.3.2.5.2</td></tr>
<tr><td rowspan="3">DC 4
buckling check</td><td>cylindrical shell</td><td>C6.4.15.3.3.2.1</td><td rowspan="3">- design external pressure</td></tr>
<tr><td>spherical shell</td><td>C6.4.15.3.3.2.2</td></tr>
<tr><td>dished ends</td><td>C6.4.15.3.3.2.3</td></tr>
<tr style="display:none"></tr>
<tr><td rowspan="3">ALS</td><td>DC 5
forward collision</td><td>tank ends and supports</td><td>as described in C6.4.15.3.2.5.2</td><td>- tank system self-weight
- static cargo pressure
- longitudinal dynamic cargo pressure of “a” in forward direction</td></tr>
<tr><td>DC 6
aft collision</td><td>tank ends and supports</td><td>as described in C6.4.15.3.2.5.2</td><td>- tank system self-weight
- static cargo pressure
- longitudinal dynamic cargo pressure of “a/2” in aftward direction</td></tr>
<tr><td>DC 7
flooding condition</td><td>flotation supports (tanks located below waterline)</td><td>as described in C6.4.15.3.2.5.2</td><td>- empty tank
- external liquid height in cargo hold up to design water line</td></tr>
<tr><td>tank test</td><td>DC 8
tank test</td><td>tank and support</td><td>16.5.4.1</td><td>- full tank filled with fresh water</td></tr>
</table>

6.4.15.3.2 Shell thickness

6.4.15.3.2.1 In considering the shell thickness the following apply:

.1 for pressure vessels, the thickness calculated according to 6.4.15.3.2.4 shall be considered as a minimum thickness after forming, without any negative tolerance;

.2 for pressure vessels, the minimum thickness of shell and heads including corrosion allowance, after forming, shall not be less than 5 mm for carbon manganese steels and nickel steels, 3 mm for austenitic steels or 7 mm for aluminium alloys; and

.3 the welded joint efficiency factor to be used in the calculation according to 6.4.15.3.2.4 shall be 0.95 when the inspection and the non-destructive testing referred to in 16.3.6.4 are carried out. This figure may be increased up to 1.0 when account is taken of other considerations, such as the material used, type of joints, welding procedure and type of loading. For process pressure vessels the Administration may accept partial non-destructive examinations, but not less than those of 16.3.6.4, depending on such factors as the material used, the design temperature, the nil ductility transition temperature of the material as fabricated and the type of joint and welding procedure, but in this case an efficiency factor of not more than 0.85 shall be adopted. For special materials the above-mentioned factors shall be reduced, depending on the specified mechanical properties of the welded joint.

C6.4.15.3.2.1 *Corrosion addition*

Corrosion addition to be considered for the fuel tank is in general according to 6.4.1.7 and UR G2.3.5. For deck tanks exposed to the weather a corrosion addition of 1.0 mm shall be added to the calculated thickness.

6.5.1.5.3.2.2 The design liquid pressure defined in 6.4.9.3.3.1 shall be taken into account in the internal pressure calculations.

6.5.1.5.3.2.3 The design external pressure P_e, used for verifying the buckling of the pressure vessels, shall not be less than that given by:

$P_e = P_1 + P_2 + P_3 + P_4$ (MPa)

where:

P_1 = setting value of vacuum relief valves. For vessels not fitted with vacuum relief valves P_1 shall be specially considered, but shall not in general be taken as less than 0.025 MPa.

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

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

P_4 = external pressure due to head of water for pressure vessels or part of pressure vessels on exposed decks; elsewhere $P_4 = 0$

C6.4.15.3.2.3 *External overpressure shall be applied to the tank shell for empty and partially filled tank conditions to ensure that the buckling capacity of the tank is sufficient to withstand the maximum pressure difference between the minimum internal pressure (maximum vacuum) and the maximum external pressure to which any portion of the tank may be subjected simultaneously.*

6.4.15.3.2.4 Scantlings based on internal pressure shall be calculated as follows:

The thickness and form of pressure-containing parts of pressure vessels, under internal pressure, as defined in 6.4.9.3.3.1, including flanges, shall be determined. These calculations shall in all cases be based on accepted pressure vessel design theory. Openings in pressure-containing parts of pressure vessels shall be reinforced in accordance with a recognized standard acceptable to the Administration.

C6.4.15.3.2.4 *Scantlings based on internal pressure*

.1 Minimum plate thickness calculation based on allowable stress
The minimum thickness of a cylindrical, conical and spherical shell for pressure loading only shall be determined from the formulae in the Rules for the classification of ships, Part 10 – Boilers, heat exchangers and pressure vessels, Section 2: pressure vessel class I shall apply. The design pressure is given in 6.4.9.3.3.1.
The nominal design allowable stress, f, is given in 6.4.15.3.3.1.

.2 The requirements to reinforcements of openings and the dimensioning of attachments related to openings are given in Rules for the classification of ships, Part 10 – Boilers, heat exchangers and pressure vessels, Section 2. This includes openings related to, e.g. tank domes, sumps, manholes and pipe penetrations.

6.4.15.3.2.5 Stress analysis in respect of static and dynamic loads shall be performed as follows:

.1 pressure vessel scantlings shall be determined in accordance with 6.4.15.3.2.1 to 6.4.15.3.2.4 and 6.4.15.3.3.

C6.4.15.3.2.5.1 *Longitudinal stresses in the cylindrical shell*

.1 Longitudinal stresses in the cylindrical shell

The longitudinal stress in a cylindrical shell shall be calculated from the following formula:

$$\sigma_z = \frac{P_0 R^2}{(2R+t)t} + \frac{W}{\pi(2R+t)t} + \frac{4M \cdot 10^3}{\pi(2R+t)^2 t}$$

where:

P_0 = internal vapour pressure, in MPa, as defined in 6.4.15.3.1.2
R = inside radius of shell in mm
t = minimum net required shell thickness in mm
W = axial force (tension is positive) due to static and dynamic weight of cargo in N, excluding P_0
M = longitudinal bending moment in Nm, e.g. due to:

- *mass loads in a horizontal vessel*
- *eccentricities of the centre of working pressure relative to the neutral axis of the vessel*
- *friction forces between the vessel and a saddle support.*

If applicable, σ_Z is also to be checked for $P_0 = 0$
Tank test condition need to be taken into account considering for P_0 the test pressure described in C6.4.15.3.1.3.
The allowable longitudinal stress in the cylindrical tank is given in C 6.4.15.3.2.5.1.2 against P_0 and C6.4.15.3.1.4 for tank test load.
The longitudinal stresses are normally to be checked at tank mid-span and at the saddles.

.2 Acceptance criteria for longitudinal stresses in the cylindrical shell
For design against excessive plastic deformation, σ_Z according to C6.4.15.3.2.5.1.1 shall not exceed $0.8f \cdot e$ where:
e = efficiency factor for welded joints as given in 6.4.15.3.2.1.3, expressed as a fraction.
The value for f, shall be based on values for R_m and R_{eH} in cold worked or tempered condition.
For design against buckling, the longitudinal compressive stress, σ_Z shall not exceed:

$$\sigma_z = \frac{0.2 \cdot E \cdot \frac{t}{R}}{1 + 0.004 \cdot \frac{E}{R_{eH}}}$$

.2 calculations of the loads and stresses in way of the supports and the shell attachment of the support shall be made. Loads referred to in 6.4.9.2 to 6.4.9.5 shall be used, as applicable. Stresses in way of the supports shall be to a recognized standard acceptable to the Administration. In special cases a fatigue analysis may be required by the Administration; and

***C6.4.15.3.2.5.2** Supports*

.1 The supporting members shall be arranged in such a way as to provide for the maximum imposed design loads in 6.4.9.
In designs where significant compressive stresses are present, the possibility of buckling shall be investigated. The tank shall be able to expand and contract due to temperature changes without undue restrains.

.2 Horizontal tanks supported by saddles should preferably be supported by two saddle supports only.
Where more than two supports are used the deflection of the hull girder shall be considered.
For tanks supported in such a way that deflections of the hull transfer significant stresses to the tank, a three-dimensional analysis for the evaluation of the overall structural response of the tank may have to be carried out.
In cases where hull interaction loads are significant, separate fatigue evaluations shall be carried out.

.3 Saddles shall afford bearing over at least 140° of the circumference.

.4 Calculation of stresses in a cylindrical tank shall include:

- *longitudinal stresses at mid-span and at supports*
- *tangential shear stress at supports and in dished ends, if applicable*
- *circumferential stresses at supports.*

.5 The circumferential stresses at supports shall be calculated by a procedure acceptable to the Register for a sufficient number of design load cases in 6.4.9.
Calculations based on methods given in standard EN 13445-3 item 16.8- Horizontal vessels on saddle supports, or in ASME BPVC VIII Div.2 item 4.15.3- Saddle supports for horizontal vessels, may be carried out.

.6 For saddle-supported tanks, the supports are also to be calculated for the most severe resulting acceleration. The most probable resulting acceleration in a given direction β may be found as shown in Figure 6.4.1. The half axes in the acceleration ellipse may be found from the formulae given in Sec.4.28.2.1 of the IGC Code.

.3 if required by the Administration, secondary stresses and thermal stresses shall be specially considered.

***C6.4.15.3.2.5.3** Thermal loads*

Separate thermal analysis may be required if it is assumed that large temperature gradients are present in the tank, or if constraints in the tank impose large stresses in the tank structure due to contraction of the tank. Thermal stresses are normally classified as secondary stresses.

For selection of hull material grades stationary temperature analysis need to be carried out for the part of the hull supporting the cargo tank and the adjacent structure. These temperature calculations shall be according to 6.4.13.1.1.

***C6.4.15.3.2.5.4** Swash bulkheads*

The plates and stiffeners of the swash bulkhead shall as far as practicable be calculated according to the Rules for the classification of ships, Part 2 – Hull, Section 11.5.

Sloshing requirements for inertia sloshing loads and liquid impact loads shall be satisfied as a minimum requirement. In addition, numerical analyses and/or model testing may be required by the Register if found necessary.

Acceptance criteria for evaluation of swash bulkhead

The formulations given in the Rules for the classification of ships, Part 2 -Hull, 11.5.2 and 11.5.3 generally apply for the structural members of the swash bulkheads, provided that the bulkhead is not part of the strength of the tank.

6.4.15.3.3 Ultimate design condition

6.4.15.3.3.1 Plastic deformation

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

$\sigma_m \le f$

$\sigma_L \le 1.5f$

$\sigma_b \le 1.5f$

$\sigma_L+\sigma_b \le 1.5f$

$\sigma_m+\sigma_b \le 1.5f$

$\sigma_m+\sigma_b+\sigma_g \le 3.0f$

$\sigma_L+\sigma_b+\sigma_g \le 3.0f$

where:

σ_m = equivalent primary general membrane stress;

σ_L = equivalent primary local membrane stress;

σ_b = equivalent primary bending stress;

σ_g = equivalent secondary stress; and

f = the lesser of R_m /A or R_e /B,

with R_m and R_e as defined in 6.4.12.1.1.3. With regard to the stresses σ_m, σ_L, σ_g and σ_b see also the definition of stress categories in 6.4.15.2.3.6. The values A and B shall have at least the following minimum values:

	Nickel steels and carbon manganese steels	**Austenitic steels**	**Aluminium alloys**
A	3	3.5	4
B	1.5	1.5	1.5

C6.4.15.3.3.1 *Allowable stresses for materials other than those referred to in 7, will be subject to approval in each separate case.*

6.4.15.3.3.2 Buckling criteria shall be as follows:

The thickness and form of pressure vessels subject to external pressure and other loads causing compressive stresses shall be based on calculations using accepted pressure vessel buckling theory and shall adequately account for the difference in theoretical and actual buckling stress as a result of plate edge misalignment, ovality and deviation from true circular form over a specified arc or chord length.

C6.4.15.3.3.2 *Buckling*

.1 Cylindrical shell

The cylindrical shell shall be checked so that elastic instability or membrane yield does not occur. The allowable design pressure shall be complied with the requirement in C6.4.15.3.3.2.5.

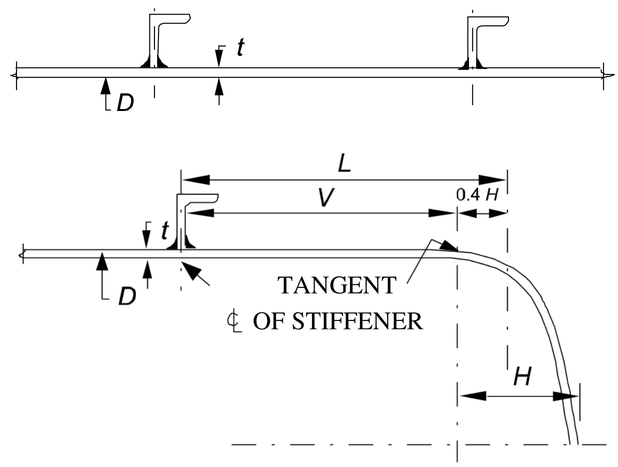


Figure 6.4.15-1
Effective length of cylinders subject to external pressure

Calculation of elastic instability

The pressure P_c, in MPa, corresponding to elastic instability of an ideal cylinder, shall be determined from the following formula:

$$P_c = \frac{2E}{(n^2-1)\left[1+\left(\frac{n}{Z}\right)^2\right]^2}\cdot\frac{t}{D} + \frac{2E}{3(1-\mathrm{n}^2)}\left[n^2-1+\frac{2n^2-1-\mathrm{n}}{\left(\frac{n}{Z}\right)^2-1}\right]\left(\frac{t}{D}\right)^3$$

where n is chosen to minimise P_c which means that the critical pressure is found by

an iteration process over the range n, where n > Z. The formula is only applicable when n > Z.
D = outside diameter in mm
t = net thickness of plate, in mm, exclusive of corrosion allowance
E = Young's modus in N/mm2
n = integral number of waves (≥ 2) for elastic instability
Z = coefficient equal to 0.5πD/L
L = effective length between stiffeners in mm, see Figure 6.4.15-1

Calculation of membrane yield

The pressure P_y, in MPa, corresponding to a general membrane yield, shall be determined from the following formula:

$$P_y = \frac{R_{eH} \cdot t}{R}$$

.2 *Spherical shells*
The spherical shell shall be checked so that elastic instability or membrane yield does not occur. The allowable design pressure shall be complied with the requirement in C6.4.15.3.3.2.5.

Calculation of elastic instability

The pressure P_c, in MPa, corresponding to elastic instability of a spherical shell, shall be determined from the following formula:

$$P_c = 0.24 \cdot E \cdot \left(\frac{t}{R}\right)^2$$

where:
R = outside radius of sphere in mm.

Calculation of membrane yield

For membrane check, the external pressure in MPa causing yield in the sphere will be:

$$P_y = 2 \cdot \frac{R_{eH} \cdot t}{R}$$

.3 *Dished ends*
Hemispherical ends shall be designed as spherical shells as given in C6.4.15.3.3.2.2.
Torispherical ends shall be designed as spherical shells as given in C6.4.15.3.3.2.2, taking the crown radius as the spherical radius, and in addition, the thickness shall not be less than 1.2 times the thickness required for an end of the same shape subject to internal pressure.
Ellipsoidal ends shall be designed as spherical shells as given in C6.4.15.3.3.2.2, taking the maximum radius of the crown as the equivalent spherical radius, and in addition, the thickness shall not be less than 1.2 times the thickness required for an end of the same shape subject to internal pressure.

.4 *Stiffening rings*
The requirements for scantling of stiffening rings are given in terms of minimum moment of inertia for the member, in mm^4.

$$I_x = \frac{0.18 \cdot D \cdot P_{ed} \cdot L \cdot D_S^2}{E}$$

D_S = diameter to the neutral axis of stiffener in mm
P_{ed} = external design pressure in MPa defined in 6.4.15.3.2.3.
The length of the shell in mm contributing to the moment of inertia is limited by:

$$L_S = 0.75\sqrt{Dt}$$

where:
Stiffening rings shall extent completely around the circumference of the shell.

.5 *Acceptance criteria for buckling strength assessment*
A membrane stress check shall be carried out for the cylindrical and spherical shells to ensure that elastic instability or membrane yield do not occur under external pressure. The external pressure shall in general not exceed a critical pressure, Pc, which is determined based on an evaluation of the buckling strength of the member, including a general safety factor. The critical pressure, including safety factor, is not allowed to exceed the yield strength of the material. The requirements are given in the following general format:

for cylindrical shell

$$\frac{P_c}{P_{ed}} \geq 4$$

for spherical shell

$$\frac{P_c}{P_{ed}} \geq 3$$

for cylindrical and spherical shells

$$\frac{P_y}{P_{ed}} \geq 3$$

where:
P_c = external pressure in MPa corresponding to elastic instability of cylindrical or spherical shell
P_y = external pressure in MPa corresponding to membrane yield of the material
P_{ed} = external design pressure in MPa as given in 6.4.15.3.2.3.

6.4.15.3.4 Fatigue design condition

6.4.15.3.4.1 For type C independent tanks where the liquefied gas fuel at atmospheric pressure is below minus 55°C, the Administration may require additional verification to check their compliance with 6.4.15.3.1.1, regarding static and dynamic stress depending on the tank size, the configuration of the tank and arrangement of its supports and attachments.

C6.4.15.3.4.1 *The analysis shall be carried out for parent material and welded connections at areas where high dynamic stresses or large stress concentrations may be expected, e.g. at tank supports, penetrations and attachments. Static and dynamic membrane and bending stresses shall be determined for use in the fatigue strength assessment, in 6.4.12.2.9.*

6.4.15.3.4.2 For vacuum insulated tanks, special attention shall be made to the fatigue strength of the support design and special considerations shall also be made to the limited inspection possibilities between the inside and outer shell.

6.4.15.3.5 Accidental design condition

6.4.15.3.5.1 The tanks and the tank supports shall be designed for the accidental loads and design conditions specified in 6.4.9.5 and 6.4.1.6.3, as relevant.

6.4.15.3.5.2 When subjected to the accidental loads specified in 6.4.9.5, the stress shall comply with the acceptance criteria specified in 6.4.15.3.3.1, modified as appropriate taking into account their lower probability of occurrence.

C6.4.15.3.5.2 *Acceptance criteria for accidental condition*

For the accidental load cases, the nominal equivalent von Mises stress in N/mm² shall satisfy the following:

$$\sigma_m \leq R_{eH}$$

For fine mesh strength assessment with maximum mesh size 50 mm x 50 mm, the acceptance criteria may be increased to $1.5R_{eH}$*, but not larger than* R_m*.*

6.4.15.3.6 Marking

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

6.4.15.4 Membrane tanks

6.4.15.4.1 Design basis

6.4.15.4.1.1 The design basis for membrane containment systems is that thermal and other expansion or contraction is compensated for without undue risk of losing the tightness of the membrane.

6.4.15.4.1.2 A systematic approach, based on analysis and testing, shall be used to demonstrate that the system will provide its intended function in consideration of the identified in service events as specified in 6.4.15.4.2.1.

6.4.15.4.1.3 A complete secondary barrier is required as defined in 6.4.3. The secondary barrier shall be designed according to 6.4.4.

6.4.15.4.1.4 The design vapour pressure P_0 shall not normally exceed 0.025 MPa. If the hull scantlings are increased accordingly and consideration is given, where appropriate, to the strength of the supporting thermal insulation, P_0 may be increased to a higher value but less than 0.070 MPa.

6.4.15.4.1.5 The definition of membrane tanks does not exclude designs such as those in which non-metallic membranes are used or where membranes are included or incorporated into the thermal insulation.

6.4.15.4.1.6 The thickness of the membranes shall normally not exceed 10 mm.

6.4.15.4.1.7 The circulation of inert gas throughout the primary and the secondary insulation spaces, in accordance with 6.11.1 shall be sufficient to allow for effective means of gas detection.

6.4.15.4.2 Design considerations

6.4.15.4.2.1 Potential incidents that could lead to loss of fluid tightness over the life of the membranes shall be evaluated. These include, but are not limited to:

- .1 Ultimate design events:
  - .1 tensile failure of membranes;
  - .2 compressive collapse of thermal insulation;
  - .3 thermal ageing;
  - .4 loss of attachment between thermal insulation and hull structure;
  - .5 loss of attachment of membranes to thermal insulation system;
  - .6 structural integrity of internal structures and their associated supporting structures; and
  - .7 failure of the supporting hull structure.
- .2 Fatigue design events:
  - .1 fatigue of membranes including joints and attachments to hull structure;
  - .2 fatigue cracking of thermal insulation;
  - .3 fatigue of internal structures and their associated supporting structures; and
  - .4 fatigue cracking of inner hull leading to ballast water ingress.
- .3 Accident design events:
  - .1 accidental mechanical damage (such as dropped objects inside the tank while in service);
  - .2 accidental over pressurization of thermal insulation spaces;
  - .3 accidental vacuum in the tank; and
  - .4 water ingress through the inner hull structure.

Designs where a single internal event could cause simultaneous or cascading failure of both membranes are unacceptable.

6.4.15.4.2.2 The necessary physical properties (mechanical, thermal, chemical, etc.) of the materials used in the construction of the liquefied gas fuel containment system shall be established during the design development in accordance with 6.4.15.4.1.2.

6.4.15.4.3 Loads, load combinations

Particular consideration shall be paid to the possible loss of tank integrity due to either an overpressure in the interbarrier space, a possible vacuum in the liquefied gas fuel tank, the sloshing effects, to hull vibration effects, or any combination of these events.

6.4.15.4.4 Structural analyses

6.4.15.4.4.1 Structural analyses and/or testing for the purpose of determining the ultimate strength and fatigue assessments of the liquefied gas fuel containment and associated structures and equipment noted in 6.4.7 shall be performed. The structural analysis shall provide the data required to assess each failure mode that has been identified as critical for the liquefied gas fuel containment system.

6.4.15.4.4.2 Structural analyses of the hull shall take into account the internal pressure as indicated in 6.4.9.3.3.1. Special attention shall be paid to deflections of the hull and their compatibility with the membrane and associated thermal insulation.

6.4.15.4.4.3 The analyses referred to in 6.4.15.4.4.1 and 6.4.15.4.4.2 shall be based on the particular motions, accelerations and response of ships and liquefied gas fuel containment systems.

6.4.15.4.5 Ultimate design condition

6.4.15.4.5.1 The structural resistance of every critical component, sub-system, or assembly, shall be established, in accordance with 6.4.15.4.1.2, for in-service conditions.

6.4.15.4.5.2 The choice of strength acceptance criteria for the failure modes of the liquefied gas fuel containment system, its attachments to the hull structure and internal tank structures, shall reflect the consequences associated with the considered mode of failure.

6.4.15.4.5.3 The inner hull scantlings shall meet the regulations for deep tanks, taking into account the internal pressure as indicated in 6.4.9.3.3.1 and the specified appropriate regulations for sloshing load as defined in 6.4.9.4.1.3.

6.4.15.4.6 Fatigue design condition

6.4.15.4.6.1 Fatigue analysis shall be carried out for structures inside the tank, i.e. pump towers, and for parts of membrane and pump tower attachments, where failure development cannot be reliably detected by continuous monitoring.

6.4.15.4.6.2 The fatigue calculations shall be carried out in accordance with 6.4.12.2, with relevant regulations depending on:

.1 the significance of the structural components with respect to structural integrity; and

.2 availability for inspection.

6.4.15.4.6.3 For structural elements for which it can be demonstrated by tests and/or analyses that a crack will not develop to cause simultaneous or cascading failure of both membranes, C_w shall be less than or equal to 0.5.

6.4.15.4.6.4 Structural elements subject to periodic inspection, and where an unattended fatigue crack can develop to cause simultaneous or cascading failure of both membranes, shall satisfy the fatigue and fracture mechanics regulations stated in 6.4.12.2.8.

6.4.15.4.6.5 Structural element not accessible for in-service inspection, and where a fatigue crack can develop without warning to cause simultaneous or cascading failure of both membranes, shall satisfy the fatigue and fracture mechanics regulations stated in 6.4.12.2.9.

6.4.15.4.7 Accidental design condition

6.4.15.4.7.1 The containment system and the supporting hull structure shall be designed for the accidental loads specified in 6.4.9.5. These loads need not be combined with each other or with environmental loads.

6.4.15.4.7.2 Additional relevant accidental scenarios shall be determined based on a risk analysis. Particular attention shall be paid to securing devices inside of tanks.

6.4.16 Limit state design for novel concepts

6.4.16.1 Fuel containment systems that are of a novel configuration that cannot be designed using section 6.4.15 shall be designed using this section and 6.4.1 to 6.4.14, as applicable. Fuel containment system design according to this section shall be based on the principles of limit state design which is an approach to structural design that can be applied to established design solutions as well as novel designs. This more generic approach maintains a level of safety similar to that achieved for known containment systems as designed using 6.4.15.

6.4.16.2 The following shall apply:

.1 The limit state design is a systematic approach where each structural element is evaluated with respect to possible failure modes related to the design conditions identified in 6.4.1.6. A limit state can be defined as a condition beyond which the structure, or part of a structure, no longer satisfies the regulations.

.2 For each failure mode, one or more limit states may be relevant. By consideration of all relevant limit states, the limit load for the structural element is found as the minimum limit load resulting from all the relevant limit states. The limit states are divided into the three following categories:

- .1 Ultimate limit states (ULS), which correspond to the maximum load-carrying capacity or, in some cases, to the maximum applicable strain or deformation; under intact (undamaged) conditions.
- .2 Fatigue limit states (FLS), which correspond to degradation due to the effect of time varying (cyclic) loading.
- .3 Accident limit states (ALS), which concern the ability of the structure to resist accidental situations.

6.4.16.3 The procedure and relevant design parameters of the limit state design shall comply with the Standards for the Use of limit state methodologies in the design of fuel containment systems of novel configuration (LSD Standard), as set out in the annex to part A-1.

C6.4.17 Additional requirements for vacuum insulated tanks

C6.4.17.1 *Vacuum insulated tanks and their supporting structures shall be designed to withstand the temperatures that may arise as a result of loss of insulating vacuum between the inner and outer tank.*

C6.4.17.2 *Vacuum insulated type C independent tanks shall have an outer shell that is able to function as a secondary barrier against leakages from pipes releasing gaseous fuel in case of leakage, to compensate for not having closable tank valves at the tank boundary. The outer shell shall be able to withstand the temperatures and the pressure build-up due to gaseous pipe leakages.*

C6.4.17.3 *Pipes releasing liquefied fuel in case of leakage shall be protected by a secondary enclosure up to the first valve. The secondary enclosure shall be able to withstand the pressure build-up due to evaporating liquefied fuel, but the design pressure shall be not less than the design pressure of the inner tank. Leakage detection shall be provided for both the inner pipe and the secondary enclosure.*

C6.4.17.4 *Pipes in the vacuum space shall have no branch connections.*

C6.4.17.5 *Pipes and secondary enclosures in the vacuum space shall be fully welded.*

C6.4.17.6 *A pipe stress analysis is required for the pipes and the secondary enclosures in the vacuum space.*

C6.4.17.7 *Pipe routing shall compensate for expansion and contractions due to changes in temperature. The use of expansion elements is not accepted for this purpose.*

C6.4.17.8 *Vacuum insulated type C independent tanks shall have their vacuum space protected by a pressure relief device connected to a vent system discharging to a safe location in open air. For tanks on open deck, a direct release into the atmosphere may be accepted.*

C6.4.17.9 *Alternatives to having an outer shell secondary barrier as required by C6.4.17.2 might be considered on a case-by-case basis. Alternative solutions shall as a minimum provide the following:*

- *Secondary enclosures as required by C6.4.17.3 shall be provided also for pipes in the vacuum space releasing gaseous fuel in case of leakage.*
- *The outer shell and the support structure shall be made from material with a design temperature corresponding to the equilibrium temperature resulting from a loss of vacuum between inner and outer tank.*
- *Any part of the outer tank shell having common boundaries with a tank connection space shall be made of material resistant to cryogenic temperatures.*

6.5 REGULATIONS FOR PORTABLE LIQUEFIED GAS FUEL TANKS

6.5.1 The design of the tank shall comply with 6.4.15.3. The tank support (container frame or truck chassis) shall be designed for the intended purpose.

C6.5.1 Portable fuel tanks shall be certified by the Register and comply with the requirements for type C tanks in 6.4.15.3 and/ or comply with relevant provisions of IMDG Code chapter 6.7 for portable tanks.

6.5.2 Portable fuel tanks shall be located in dedicated areas fitted with:

.1 mechanical protection of the tanks depending on location and cargo operations;
.2 if located on open deck: spill protection and water spray systems for cooling; and
.3 if located in an enclosed space: the space is to be considered as a tank connection space.

6.5.3 Portable fuel tanks shall be secured to the deck while connected to the ship systems. The arrangement for supporting and fixing the tanks shall be designed for the maximum expected static and dynamic inclinations, as well as the maximum expected values of acceleration, taking into account the ship characteristics and the position of the tanks.

6.5.4 Consideration shall be given to the strength and the effect of the portable fuel tanks on the ship's stability.

6.5.5 Connections to the ship's fuel piping systems shall be made by means of approved flexible hoses or other suitable means designed to provide sufficient flexibility.

6.5.6 Arrangements shall be provided to limit the quantity of fuel spilled in case of inadvertent disconnection or rupture of the non-permanent connections.

6.5.7 The pressure relief system of portable tanks shall be connected to a fixed venting system.

6.5.8 Control and monitoring systems for portable fuel tanks shall be integrated in the ship's control and monitoring system. Safety system for portable fuel tanks shall be integrated in the ship's safety system (e.g. shutdown systems for tank valves, leak/gas detection systems).

6.5.9 Safe access to tank connections for the purpose of inspection and maintenance shall be ensured.

6.5.10 After connection to the ship's fuel piping system,

.1 with the exception of the pressure relief system in 6.5.6 each portable tank shall be capable of being isolated at any time;
.2 isolation of one tank shall not impair the availability of the remaining portable tanks; and
.3 the tank shall not exceed its filling limits as given in 6.8.

C6.5 *The deck and any structure under or near to the portable tank connection hoses is to be protected from potential leakage by the provision of adequate drip trays and spray shields.*

6.6 REGULATIONS FOR CNG FUEL CONTAINMENT

6.6.1 The storage tanks to be used for CNG shall be certified and approved by the Administration.

C6.6.1 *Tanks for compressed natural gas (CNG) shall be certified as class I pressure vessels in accordance with the Rules for the classification of ships, Part 10 – Boilers, heat exchangers and pressure vessels.*

6.6.2 Tanks for CNG shall be fitted with pressure relief valves with a set point below the design pressure of the tank and with outlet located as required in 6.7.2.7 and 6.7.2.8.

6.6.3 Adequate means shall be provided to depressurize the tank in case of a fire which can affect the tank.

6.6.4 Storage of CNG in enclosed spaces is normally not acceptable, but may be permitted after special consideration and approval by the Administration provided the following is fulfilled in addition to 6.3.4 to 6.3.6:

.1 adequate means are provided to depressurize and inert the tank in case of a fire which can affect the tank;
.2 all surfaces within such enclosed spaces containing the CNG storage are provided with suitable thermal protection against any lost high-pressure gas and resulting condensation unless the bulkheads are

designed for the lowest temperature that can arise from gas expansion leakage; and

.3 a fixed fire-extinguishing system is installed in the enclosed spaces containing the CNG storage. Special consideration should be given to the extinguishing of jet-fires.

6.7 REGULATIONS FOR PRESSURE RELIEF SYSTEM

6.7.1 General

6.7.1.1 All fuel storage tanks shall be provided with a pressure relief system appropriate to the design of the fuel containment system and the fuel being carried. Fuel storage hold spaces, interbarrier spaces and tank connection spaces, which may be subject to pressures beyond their design capabilities, shall also be provided with a suitable pressure relief system. Pressure control systems specified in 6.9 shall be independent of the pressure relief systems.

6.7.1.2 Fuel storage tanks which may be subject to external pressures above their design pressure shall be fitted with vacuum protection systems.

C6.7.1.2 *Vacuum protection systems shall be in accordance with IGC Code, Chapter 8.3.*

6.7.2 Pressure relief systems for liquefied gas fuel tanks

6.7.2.1 If fuel release into the vacuum space of a vacuum insulated tank cannot be excluded, the vacuum space shall be protected by a pressure relief device which shall be connected to a vent system if the tanks are located below deck. On open deck a direct release into the atmosphere may be accepted by the Administration for tanks not exceeding the size of a 40 ft container if the released gas cannot enter safe areas.

6.7.2.2 Liquefied gas fuel tanks shall be fitted with a minimum of 2 pressure relief valves (PRVs) allowing for disconnection of one PRV in case of malfunction or leakage.

C6.7.2.2 *Pressure relief valves shall comply with IGC Code, Chapter 8.2 and be tested in accordance with applicable parts of IGC Code, Chapter 8.2.5.*

6.7.2.3 Interbarrier spaces shall be provided with pressure relief devices. [12)] For membrane systems, the designer shall demonstrate adequate sizing of interbarrier space PRVs.

6.7.2.4 The setting of the PRVs shall not be higher than the vapour pressure that has been used in the design of the tank. Valves comprising not more than 50% of the total relieving capacity may be set at a pressure up to 5% above MARVS to allow sequential lifting, minimizing unnecessary release of vapour.

6.7.2.5 The following temperature regulations apply to PRVs fitted to pressure relief systems:

.1 PRVs on fuel tanks with a design temperature below 0 °C shall be designed and arranged to prevent their becoming inoperative due to ice formation;

.2 the effects of ice formation due to ambient temperatures shall be considered in the construction and arrangement of PRVs;

.3 PRVs shall be constructed of materials with a melting point above 925°C. Lower melting point materials for internal parts and seals may be accepted provided that fail-safe operation of the PRV is not compromised; and

.4 sensing and exhaust lines on pilot operated relief valves shall be of suitably robust construction to prevent damage.

6.7.2.6 In the event of a failure of a fuel tank PRV a safe means of emergency isolation shall be available.

.1 procedures shall be provided and included in the operation manual (refer to Section 18);

.2 the procedures shall allow only one of the installed PRVs for the liquefied gas fuel tanks to be isolated, physical interlocks shall be included to this effect; and

.3 isolation of the PRV shall be carried out under the supervision of the master. This action shall be recorded in the ship's log, and at the PRV.

C6.7.2.6 *Stop valves shall be fitted before and after the pressure relief valves.*

This shall enable in-service maintenance, to stop gas from escaping in case of a leaking pressure relief valve and to be able to maintain tank pressure in cases where this is used to drive gas supply to the engine.

In case the pressure relief valves are located in open air, stop valve only at the inlet of the pressure relief valve is accepted. The outlet of the pressure relief valve shall then be fitted with a blind flange.

Stop valves shall be arranged to minimize the possibility that all pressure relief valves for one tank are isolated simultaneously.

6.7.2.7 Each pressure relief valve installed on a liquefied gas fuel tank shall be connected to a venting system, which shall be:

.1 so constructed that the discharge will be unimpeded and normally be directed vertically upwards at the exit;

.2 arranged to minimize the possibility of water or snow entering the vent system; and

.3 arranged such that the height of vent exits shall normally not be less than B/3 or 6 m, whichever is the greater, above the weather deck and 6 m above working areas and walkways. However, vent mast height could be limited to lower value according to special consideration by the Administration.

6.7.2.8 The outlet from the pressure relief valves shall normally be located at least 10 m from the nearest:

12) Refer to IACS Unified Interpretation GC9 entitled Guidance for sizing pressure relief systems for interbarrier spaces, 1988

.1 air intake, air outlet or opening to accommodation, service and control spaces, or other non-hazardous area; and
.2 exhaust outlet from machinery installations.

C6.7.2.7.3** and **C6.7.2.8

For small ships and ship types where the operation limits the possible location of the outlet, lesser heights than given above may be accepted.

6.7.2.9 All other fuel gas vent outlets shall also be arranged in accordance with 6.7.2.7 and 6.7.2.8. Means shall be provided to prevent liquid overflow from gas vent outlets, due to hydrostatic pressure from spaces to which they are connected.

6.7.2.10 In the vent piping system, means for draining liquid from places where it may accumulate shall be provided. The PRVs and piping shall be arranged so that liquid can, under no circumstances, accumulate in or near the PRVs.

6.7.2.11 Suitable protection screens of not more than 13 mm square mesh shall be fitted on vent outlets to prevent the ingress of foreign objects without adversely affecting the flow.

6.7.2.12 All vent piping shall be designed and arranged not to be damaged by the temperature variations to which it may be exposed, forces due to flow or the ship's motions.

6.7.2.13 PRVs shall be connected to the highest part of the fuel tank. PRVs shall be positioned on the fuel tank so that they will remain in the vapour phase at the filling limit (FL) as given in 6.8, under conditions of 15° list and 0.015L trim, where L is defined in 2.2.25.

6.7.3 Sizing of pressure relieving system

6.7.3.1 Sizing of pressure relief valves

6.7.3.1.1 PRVs shall have a combined relieving capacity for each liquefied gas fuel tank to discharge the greater of the following, with not more than a 20% rise in liquefied gas fuel tank pressure above the MARVS:

.1 the maximum capacity of the liquefied gas fuel tank inerting system if the maximum attainable working pressure of the liquefied gas fuel tank inerting system exceeds the MARVS of the liquefied gas fuel tanks; or
.2 vapours generated under fire exposure computed using the following formula:

$Q = FGA^{0.82}$ (m^3/s)

where:

Q = minimum required rate of discharge of air at standard conditions of 273.15 Kelvin (K) and 0.1013 MPa.

F = fire exposure factor for different liquefied gas fuel types:

F = 1.0 for tanks without insulation located on deck;

F = 0.5 for tanks above the deck when insulation is approved by the Administration. (Approval will be based on the use of a fireproofing material, the thermal conductance of insulation, and its stability under fire exposure);

F = 0.5 for uninsulated independent tanks installed in holds;

F = 0.2 for insulated independent tanks in holds (or uninsulated independent tanks in insulated holds);

F = 0.1 for insulated independent tanks in inerted holds (or uninsulated independent tanks in inerted, insulated holds); and

F = 0.1 for membrane tanks.

For independent tanks partly protruding through the weather decks, the fire exposure factor shall be determined on the basis of the surface areas above and below deck.

G = gas factor according to formula:

$$G = \frac{12.4}{LD}\sqrt{\frac{ZT}{M}}$$

where:

T = temperature in Kelvin at relieving conditions, i.e. 120% of the pressure at which the pressure relief valve is set;

L = latent heat of the material being vaporized at relieving conditions, in kJ/kg;

D = a constant based on relation of specific heats k and is calculated as follows:

$$D = \sqrt{k\left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}}$$

where:

k = ratio of specific heats at relieving conditions, and the value of which is between 1.0 and 2.2. If k is not known, D = 0.606 shall be used;

Z = compressibility factor of the gas at relieving conditions; if not known, Z = 1.0 shall be used;

M = molecular mass of the product.

The gas factor of each liquefied gas fuel to be carried is to be determined and the highest value shall be used for PRV sizing.

A = external surface area of the tank (m2), as for different tank types, as shown in Figure 6.7.1.

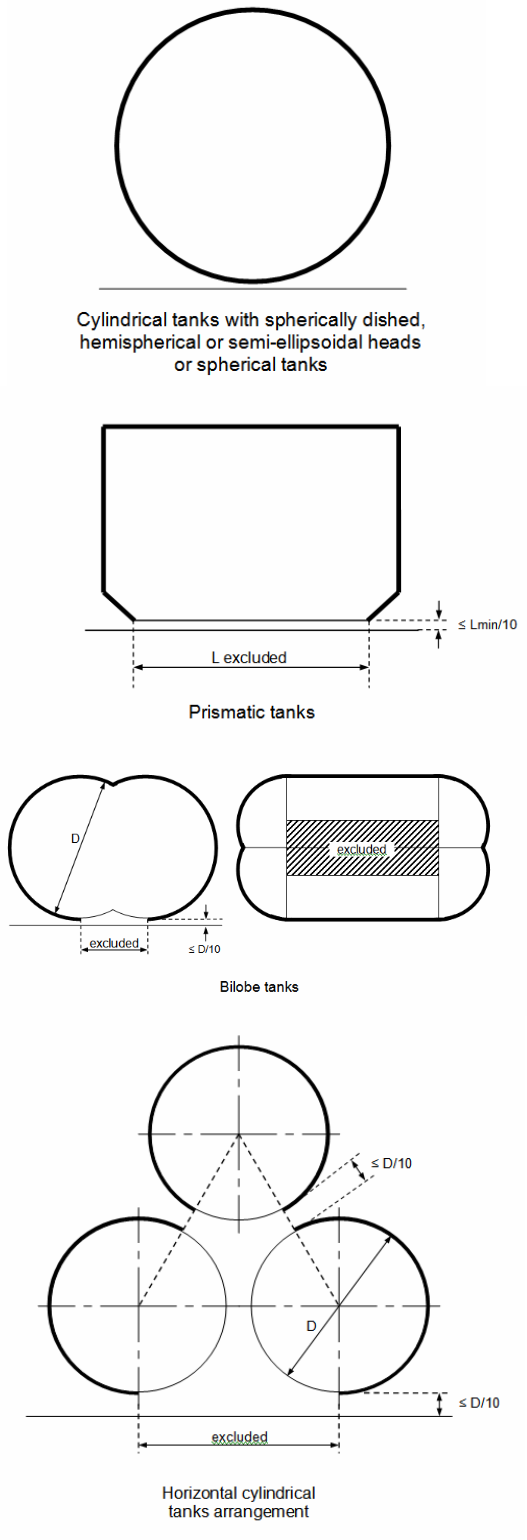

Cylindrical tanks with spherically dished,
hemispherical or semi-ellipsoidal heads
or spherical tanks
≤ Lmin/10
L excluded
Prismatic tanks
D
excluded
≤ D/10
excluded
Bilobe tanks
≤ D/10
D
≤ D/10
excluded
Horizontal cylindrical
tanks arrangement

Figure 6.7.1

C6.7.3.1.1.2 *(UI GF 7, Dec 2017)*

For prismatic tanks:

.1 Lmin, for non-tapered tanks, is the smaller of the horizontal dimensions of the flat bottom of the tank. For tapered tanks, as would be used for the forward tank, Lmin is the smaller of the length and the average width.

.2 For prismatic tanks whose distance between the flat bottom of the tank and bottom of the hold space is equal to or less than Lmin/10:
A = external surface area minus flat bottom surface area.

.3 For prismatic tanks whose distance between the flat bottom of the tank and bottom of the hold space is greater than Lmin/10:
A = external surface area.

6.7.3.1.2 For vacuum insulated tanks in fuel storage hold spaces and for tanks in fuel storage hold spaces separated from potential fire loads by coffer dams or surrounded by ship spaces with no fire load the following applies:

If the pressure relief valves have to be sized for fire loads the fire factors according may be reduced to the following values:

$F = 0.5$ to $F = 0.25$

$F = 0.2$ to $F = 0.1$

The minimum fire factor is $F = 0.1$

6.7.3.1.3 The required mass flow of air at relieving conditions is given by:

$M_{air} = Q * \rho_{air}$ (kg/s)

where density of air (ρ_{air}) = 1.293 kg/m^3 (air at 273.15 K, 0.1013 MPa).

6.7.3.2 Sizing of vent pipe system

6.7.3.2.1 Pressure losses upstream and downstream of the PRVs, shall be taken into account when determining their size to ensure the flow capacity required by 6.7.3.1.

6.7.3.2.2 Upstream pressure losses

.1 the pressure drop in the vent line from the tank to the PRV inlet shall not exceed 3% of the valve set pressure at the calculated flow rate, in accordance with 6.7.3.1;

.2 pilot-operated PRVs shall be unaffected by inlet pipe pressure losses when the pilot senses directly from the tank dome; and

.3 pressure losses in remotely sensed pilot lines shall be considered for flowing type pilots.

6.7.3.2.3 Downstream pressure losses

.1 Where common vent headers and vent masts are fitted, calculations shall include flow from all attached PRVs.

.2 The built-up back pressure in the vent piping from the PRV outlet to the location of discharge to the atmosphere, and including any vent pipe interconnections that join other tanks, shall not exceed the following values:

.1 for unbalanced PRVs: 10% of MARVS;
.2 for balanced PRVs: 30% of MARVS; and
.3 for pilot operated PRVs: 50% of MARVS

Alternative values provided by the PRV manufacturer may be accepted.

6.7.3.2.4 To ensure stable PRV operation, the blow-down shall not be less than the sum of the inlet pressure loss and 0.02 MARVS at the rated capacity.

6.8 REGULATIONS ON LOADING LIMIT FOR LIQUEFIED GAS FUEL TANKS

6.8.1 Storage tanks for liquefied gas shall not be filled to more than a volume equivalent to 98% full at the reference temperature as defined in 2.2.36.

A loading limit curve for actual fuel loading temperatures shall be prepared from the following formula:

$LL = FL\ \rho_R/\rho_L$

where:

LL = loading limit as defined in 2.2.27, expressed in per cent;

FL = filling limit as defined in 2.2.16 expressed in per cent, here 98%;

ρ_R = relative density of fuel at the reference temperature; and

ρ_L = relative density of fuel at the loading temperature.

6.8.2 In cases where the tank insulation and tank location make the probability very small for the tank contents to be heated up due to an external fire, special considerations may be made to allow a higher loading limit than calculated using the reference temperature, but never above 95%. This also applies in cases where a second system for pressure maintenance is installed, (refer to 6.9). However, if the pressure can only be maintained / controlled by fuel consumers, the loading limit as calculated in 6.8.1 shall be used.

C6.8.2 *(UI GF 16, Dec 2018)*

The alternative loading limit option given under 6.8.2 is understood to be an alternative to 6.8.1 and should only be applicable when the calculated loading limit using the formulae in 6.8.1 gives a lower value than 95%.

6.8.3 For ships constructed on or after 1 January 2024, in cases where the tank insulation and tank location make the probability very small for the tank contents to be heated up due to an external fire, special considerations may be made to allow a higher loading limit than calculated using the reference temperature, but never above 95%.

6.9 REGULATIONS FOR THE MAINTAINING OF FUEL STORAGE CONDITION

6.9.1 Control of tank pressure and temperature

6.9.1.1 With the exception of liquefied gas fuel tanks designed to withstand the full gauge vapour pressure of the fuel under conditions of the upper ambient design temperature, liquefied gas fuel tanks' pressure and temperature shall be maintained at all times within their design range by means acceptable to the Administration, e.g. by one of the following methods:

.1 re-liquefaction of vapours;
.2 thermal oxidation of vapours;
.3 pressure accumulation; or
.4 liquefied gas fuel cooling.

The method chosen shall be capable of maintaining tank pressure below the set pressure of the tank pressure relief valves for a period of 15 days assuming full tank at normal service pressure and the ship in idle condition, i.e. only power for domestic load is generated.

6.9.1.2 Venting of fuel vapour for control of the tank pressure is not acceptable except in emergency situations.

C6.9.1.2 *(UI GF 8, Dec 2017)*

Liquefied gas fuel tanks pressure and temperature shall be controlled and maintained within the design range at all times including after activation of the safety system required in 15.2.2 for a period of minimum 15 days. The activation of the safety system alone is not deemed as an emergency situation.

6.9.2 Design of systems

6.9.2.1 For worldwide service, the upper ambient design temperature shall be sea 32ºC and air 45ºC. For service in particularly hot or cold zones, these design temperatures shall be increased or decreased, to the satisfaction of the Administration.

6.9.2.2 The overall capacity of the system shall be such that it can control the pressure within the design conditions without venting to atmosphere.

6.9.3 Re-liquefaction systems

6.9.3.1 The re-liquefaction system shall be designed and calculated according to 6.9.3.2. The system has to be sized in a sufficient way also in case of no or low consumption.

6.9.3.2 The re-liquefaction system shall be arranged in one of the following ways:

.1 a direct system where evaporated fuel is compressed, condensed and returned to the fuel tanks;
.2 an indirect system where fuel or evaporated fuel is cooled or condensed by refrigerant without being compressed;
.3 a combined system where evaporated fuel is compressed and condensed in a fuel/refrigerant heat exchanger and returned to the fuel tanks; or
.4 if the re-liquefaction system produces a waste stream containing methane during pressure control operations within the design conditions, these waste gases shall, as far as reasonably practicable, be disposed of without venting to atmosphere.

6.9.4 Thermal oxidation systems

6.9.4.1 Thermal oxidation can be done by either consumption of the vapours according to the regulations for consumers described in this Rules or in a dedicated gas combustion unit (GCU). It shall be demonstrated that the capacity of the oxidation system is sufficient to consume the required quantity of vapours. In this regard, periods of slow steaming and/or no consumption from propulsion or other services of the ship shall be considered.

6.9.5 Compatibility

6.9.5.1 Refrigerants or auxiliary agents used for refrigeration or cooling of fuel shall be compatible with the fuel they may come in contact with (not causing any hazardous reaction or excessively corrosive products). In addition, when several refrigerants or agents are used, these shall be compatible with each other.

6.9.6 Availability of systems

6.9.6.1 The availability of the system and its supporting auxiliary services shall be such that in case of a single failure (of mechanical non-static component or a component of the control systems) the fuel tank pressure and temperature can be maintained by another service/system.

6.9.6.2 Heat exchangers that are solely necessary for maintaining the pressure and temperature of the fuel tanks within their design ranges shall have a standby heat exchanger unless they have a capacity in excess of 25% of the largest required capacity for pressure control and they can be repaired on board without external sources.

6.10 REGULATIONS ON ATMOSPHERIC CONTROL WITHIN THE FUEL CONTAINMENT SYSTEM

6.10.1 A piping system shall be arranged to enable each fuel tank to be safely gas-freed, and to be safely filled with fuel from a gas-free condition. The system shall be arranged to minimize the possibility of pockets of gas or air remaining after changing the atmosphere.

6.10.2 The system shall be designed to eliminate the possibility of a flammable mixture existing in the fuel tank during any part of the atmosphere change operation by utilizing an inerting medium as an intermediate step.

6.10.3 Gas sampling points shall be provided for each fuel tank to monitor the progress of atmosphere change.

6.10.4 Inert gas utilized for gas freeing of fuel tanks may be provided externally to the ship.

6.11 REGULATIONS ON ATMOSPHERE CONTROL WITHIN FUEL STORAGE HOLD SPACES (fuel containment systems other than type C independent tanks)

6.11.1 Interbarrier and fuel storage hold spaces associated with liquefied gas fuel containment systems requiring full or partial secondary barriers shall be inerted with a suitable dry inert gas and kept inerted with make-up gas provided by a shipboard inert gas generation system, or by shipboard storage, which shall be sufficient for normal consumption for at least 30 days. Shorter periods may be considered by the Administration depending on the ship's service.

6.11.2 Alternatively, the spaces referred to in 6.11.1 requiring only a partial secondary barrier may be filled with dry air provided that the ship maintains a stored charge of inert gas or is fitted with an inert gas generation system sufficient to inert the largest of these spaces, and provided that the configuration of the spaces and the relevant vapour detection systems, together with the capability of the inerting arrangements, ensures that any leakage from the liquefied gas fuel tanks will be rapidly detected and inerting effected before a dangerous condition can develop. Equipment for the provision of sufficient dry air of suitable quality to satisfy the expected demand shall be provided.

6.12 REGULATIONS ON ENVIRONMENTAL CONTROL OF SPACES SURROUNDING TYPE C INDEPENDENT TANKS

6.12.1 Spaces surrounding liquefied gas fuel tanks shall be filled with suitable dry air and be maintained in this condition with dry air provided by suitable air drying equipment. This is only applicable for liquefied gas fuel tanks where condensation and icing due to cold surfaces is an issue.

6.13 REGULATIONS ON INERTING

C6.13 *An arrangement for purging fuel bunkering lines and supply lines with nitrogen shall be provided.*

6.13.1 Arrangements to prevent back-flow of fuel vapour into the inert gas system shall be provided as specified below.

6.13.2 To prevent the return of flammable gas to any non-hazardous spaces, the inert gas supply line shall be fitted with two shutoff valves in series with a venting valve in between (double block and bleed valves). In addition, a closable non-return valve shall be installed between the double block and bleed arrangement and the fuel system. These valves shall be located outside non-hazardous spaces.

C6.13.2 *The double block and bleed valves shall comply with the following requirements:*

- *The operation of the valves shall be automatically executed. Signals for opening and closing shall be taken from the process directly, e.g. differential pressure.*
- *An alarm for faulty operation of the valves shall be provided.*

6.13.3 Where the connections to the fuel piping systems are non-permanent, two non-return valves may be substituted for the valves required in 6.13.2.

6.13.4 The arrangements shall be such that each space being inerted can be isolated and the necessary controls and relief valves, etc. shall be provided for controlling pressure in these spaces.

6.13.5 Where insulation spaces are continually supplied with an inert gas as part of a leak detection system, means shall be provided to monitor the quantity of gas being supplied to individual spaces.

6.14 REGULATIONS ON INERT GAS PRODUCTION AND STORAGE ON BOARD

6.14.1 The equipment shall be capable of producing inert gas with oxygen content at no time greater than 5% by volume. A continuous-reading oxygen content meter shall be fitted to the inert gas supply from the equipment and shall be fitted with an alarm set at a maximum of 5% oxygen content by volume.

C6.14.1 *Inert gas systems shall comply with the requirements in IGC Code, Chapter 9.5.*

6.14.2 An inert gas system shall have pressure controls and monitoring arrangements appropriate to the fuel containment system.

6.14.3 Where a nitrogen generator or nitrogen storage facilities are installed in a separate compartment outside of the engine-room, the separate compartment shall be fitted with an independent mechanical extraction ventilation system, providing a minimum of 6 air changes per hour. A low oxygen alarm shall be fitted.

C6.14.3 *Such separate compartments shall be treated as other machinery spaces, with respect to fire protection.*

The compartment shall have no direct access to accommodation spaces, service spaces or control stations.

The nitrogen generator shall be fitted with automatic means to discharge off-specification gas to the atmosphere during start-up and abnormal operation.

A feed air treatment system shall be fitted to remove water, particles and traces of oil from the compressed air.

The oxygen-enriched air from the nitrogen generator and the nitrogen-product enriched gas from the protective devices of the nitrogen receiver shall be discharged to a safe location on the open deck.

Safe locations on the open deck are:

.1 outside of hazardous area (for oxygen-enriched air)
.2 not within 3 m of areas traversed by personnel
.3 not within 6 m of air intakes for machinery (engines and boilers) and all ventilation inlets.

6.14.4 Nitrogen pipes shall only be led through well ventilated spaces. Nitrogen pipes in enclosed spaces shall:

.1 be fully welded;

.2 have only a minimum of flange connections as needed for fitting of valves; and

.3 be as short as possible.

C6.14.4 *The need for other precautions to prevent suffocation of personnel in case of leakage should be considered in each case.*

7 MATERIAL AND GENERAL PIPE DESIGN

7.1 GOAL

7.1.1 The goal of this Section is to ensure the safe handling of fuel, under all operating conditions, to minimize the risk to the ship, personnel and to the environment, having regard to the nature of the products involved.

7.2 FUNCTIONAL REQUIREMENTS

7.2.1 This Section relates to functional requirements in 3.2.1, 3.2.5, 3.2.6, 3.2.8, 3.2.9 and 3.2.10. In particular the following apply:

.1 Fuel piping shall be capable of absorbing thermal expansion or contraction caused by extreme temperatures of the fuel without developing substantial stresses.

.2 Provision shall be made to protect the piping, piping system and components and fuel tanks from excessive stresses due to thermal movement and from movements of the fuel tank and hull structure.

.3 If the fuel gas contains heavier constituents that may condense in the system, means for safely removing the liquid shall be fitted.

.4 Low temperature piping shall be thermally isolated from the adjacent hull structure, where necessary, to prevent the temperature of the hull from falling below the design temperature of the hull material.

7.3 REGULATIONS FOR GENERAL PIPE DESIGN

7.3.1 General

7.3.1.1 Fuel pipes and all the other piping needed for a safe and reliable operation and maintenance shall be colour marked in accordance with a standard at least equivalent to those acceptable to the Organization. [13)]

7.3.1.2 Where tanks or piping are separated from the ship's structure by thermal isolation, provision shall be made for electrically bonding to the ship's structure both the piping and the tanks. All gasketed pipe joints and hose connections shall be electrically bonded.

7.3.1.3 All pipelines or components which may be isolated in a liquid full condition shall be provided with relief valves.

C7.3.1.3 *For pressure relief valves in the bunkering lines, the set pressure shall be equal to the design pressure.*

7.3.1.4 Pipework, which may contain low temperature fuel, shall be thermally insulated to an extent which will minimize condensation of moisture.

7.3.1.5 Piping other than fuel supply piping and cabling may be arranged in the double wall piping or duct provided that they do not create a source of ignition or compromise the integrity of the double pipe or duct. The double wall piping or duct shall only contain piping or cabling necessary for operational purposes.

C7.3.1.6 *Fuel piping shall be located in such a way that the risk of mechanical damage from ship operations, cargo operations and green seas is minimized, either by locating the fuel piping systems away from such hazards, or by providing mechanical protection.*

C7.3.1.7 *Leakages in the fuel piping shall not cause damage to other structures due to the low temperature, and the design shall prevent gas spreading to non-hazardous spaces.*

C7.3.1.8 *Fuel piping shall be designed and arranged to minimize as far as practicable the extent of hazardous areas and potential sources of release.*

C7.3.1.9 *It shall be possible to detect leakages in a fuel piping, and automatically isolate the leakage from the source.*

C7.3.1.10 *It shall be possible to automatically isolate the piping for fuel at the tank boundary.*

C7.3.1.11 *High-pressure gas lines shall be installed and protected to minimize the risk of injury to personnel in case of rupture.*

C7.3.1.12 *Components in the fuel containment systems and piping systems with low surface temperatures shall be so installed and protected as to reduce to a minimum any danger to persons on board, and to prevent operational problems due to icing.*

C7.3.1.13 *For other requirements for piping not covered by this part of the Rules, see the Rules for the classification of ships, Part 8 - Piping.*

7.3.2 Wall thickness

7.3.2.1 The minimum wall thickness shall be calculated as follows:

$t = (t_0 + b + c) / (1 - a/100)$ (mm)

where:

t_0 = theoretical thickness

t_0 = $PD / (2.0Ke + P)$ (mm)

with:

P = design pressure (MPa) referred to in 7.3.3;

D = outside diameter (mm);

K = allowable stress (N/mm²) referred to in 7.3.4; and

e = efficiency factory equal to 1.0 for seamless pipes and for longitudinally or spirally welded pipes, delivered by approved manufacturers of welded pipes, that are considered equivalent to seamless pipes when non-destructive testing on welds is carried out in accordance with recognized standards. In other cases an efficiency factor of less than 1.0, in accordance with recognized standards, may be

[13)] Refer to EN ISO 14726:2008 Ships and marine technology – Identification colours for the content of piping systems required depending on the manufacturing process;

b = allowance for bending (mm). The value of b shall be chosen so that the calculated stress in the bend, due to internal pressure only, does not exceed the allowable stress. Where such justification is not given, b shall be:

$b = D \cdot t_0 / 2.5r$ (mm)

with:

r = mean radius of the bend (mm);

c = corrosion allowance (mm). If corrosion or erosion is expected the wall thickness of the piping shall be increased over that required by other design regulations. This allowance shall be consistent with the expected life of the piping; and

a = negative manufacturing tolerance for thickness (%).

7.3.2.2 The absolute minimum wall thickness shall be in accordance with a standard acceptable to the Administration.

7.3.3 Design condition

7.3.3.1 The greater of the following design conditions shall be used for piping, piping system and components as appropriate: [14) 15)]

.1 for systems or components which may be separated from their relief valves and which contain only vapour at all times, vapour pressure at 45°C assuming an initial condition of saturated vapour in the system at the system operating pressure and temperature; or
.2 the MARVS of the fuel tanks and fuel processing systems; or
.3 the pressure setting of the associated pump or compressor discharge relief valve; or
.4 the maximum total discharge or loading head of the fuel piping system; or
.5 the relief valve setting on a pipeline system.

7.3.3.2 Piping, piping systems and components shall have a minimum design pressure of 1.0 MPa except for open ended lines where it is not to be less than 0.5 MPa.

7.3.4 Allowable stress

7.3.4.1 For pipes made of steel including stainless steel, the allowable stress to be considered in the formula of the strength thickness in 7.3.2.1 shall be the lower of the following values:

$R_m/2.7$ or $R_e/1.8$

where:

R_m = specified minimum tensile strength at room temperature (N/mm²); and

R_e = specified minimum yield stress at room temperature (N/mm²). If the stress strain curve does not show a defined yield stress, the 0.2% proof stress applies.

7.3.4.2 Where necessary for mechanical strength to prevent damage, collapse, excessive sag or buckling of pipes due to superimposed loads, the wall thickness shall be increased over that required by 7.3.2 or, if this is impracticable or would cause excessive local stresses, these loads shall be reduced, protected against or eliminated by other design methods. Such superimposed loads may be due to; supports, ship deflections, liquid pressure surge during transfer operations, the weight of suspended valves, reaction to loading arm connections, or otherwise.

7.3.4.3 For pipes made of materials other than steel, the allowable stress shall be considered by the Administration.

7.3.4.4 High pressure fuel piping systems shall have sufficient constructive strength. This shall be confirmed by carrying out stress analysis and taking into account:

.1 stresses due to the weight of the piping system;
.2 acceleration loads when significant; and
.3 internal pressure and loads induced by hog and sag of the ship.

C7.3.4.4.2 *NOTE: Significant acceleration loads imply in this context acceleration loads that give a stress equal to more than 20% of the stress from the internal pressure in the pipe.*

7.3.4.5 When the design temperature is minus 110°C or colder, a complete stress analysis, taking into account all the stresses due to weight of pipes, including acceleration loads if significant, internal pressure, thermal contraction and loads induced by hog and sag of the ship shall be carried out for each branch of the piping system.

7.3.5 Flexibility of piping

7.3.5.1 The arrangement and installation of fuel piping shall provide the necessary flexibility to maintain the integrity of the piping system in the actual service situations, taking potential for fatigue into account.

7.3.6 Piping fabrication and joining details

7.3.6.1 Flanges, valves and other fittings shall comply with a standard acceptable to the Administration, taking into account the design pressure defined in 7.3.3.1. For bellows and expansion joints used in vapour service, a lower minimum design pressure than defined in 7.3.3.1 may be accepted.

7.3.6.2 All valves and expansion joints used in high pressure fuel piping systems shall be approved according to a standard acceptable to the Administration.

7.3.6.3 The piping system shall be joined by welding with a minimum of flange connections. Gaskets shall be protected against blow-out.

---

14) Lower values of ambient temperature regarding design condition in 7.3.3.1.1 may be accepted by the Administration for ships operating in restricted areas. Conversely, higher values of ambient temperature may be required

15) For ships on voyages of restricted duration, P_0 may be calculated based on the actual pressure rise during the voyage and account may be taken of any thermal insulation of the tank. Reference is made to the *Application of amendments to gas carrier codes concerning type C tank loading limits (SIGTTO/IACS)*

7.3.6.4 Piping fabrication and joining details shall comply with the following:

7.3.6.4.1 Direct connections

.1 Butt-welded joints with complete penetration at the root may be used in all applications. For design temperatures colder than minus 10°C, butt welds shall be either double welded or equivalent to a double welded butt joint. This may be accomplished by use of a backing ring, consumable insert or inert gas back-up on the first pass. For design pressures in excess of 1.0 MPa and design temperatures of minus 10°C or colder, backing rings shall be removed.

.2 Slip-on welded joints with sleeves and related welding, having dimensions in accordance with recognized standards, shall only be used for instrument lines and open-ended lines with an external diameter of 50 mm or less and design temperatures not colder than minus 55°C.

.3 Screwed couplings complying with recognized standards shall only be used for accessory lines and instrumentation lines with external diameters of 25 mm or less.

C7.3.6.4.1.2 *Slip-on welded joints may be accepted for open ended piping above 50 mm diameter, given that the strength of the piping with such a joint is sufficient for the maximum pressure it will be subjected to, and that NDT is carried out to verify the integrity.*

7.3.6.4.2 Flanged connections

.1 Flanges in flange connections shall be of the welded neck, slip-on or socket welded type; and

.2 For all piping except open ended, the following restrictions apply:

  .1 For design temperatures colder than minus 55°C, only welded neck flanges shall be used; and

  .2 For design temperatures colder than minus 10°C, slip-on flanges shall not be used in nominal sizes above 100 mm and socket welded flanges shall not be used in nominal sizes above 50 mm.

7.3.6.4.3 Expansion joints

Where bellows and expansion joints are provided in accordance with 7.3.6.1 the following apply:

.1 if necessary, bellows shall be protected against icing;

.2 slip joints shall not be used except within the liquefied gas fuel storage tanks; and

.3 bellows shall normally not be arranged in enclosed spaces.

C7.3.6.4.3.4 *If accepted, bellows in piping containing gaseous fuel shall only be installed in fuel preparation rooms or tank connection spaces, while bellows in piping containing cryogenic liquids shall only be installed in spaces designed to withstand cryogenic leakages.*

C7.3.6.4.3.5 *Bellows shall only be installed where they are readily accessible for inspection.*

7.3.6.4.4 Other connections

Piping connections shall be joined in accordance with 7.3.6.4.1 to 7.3.6.4.3 but for other exceptional cases the Administration may consider alternative arrangements.

7.4 REGULATIONS FOR MATERIALS

C7.4 *Metallic materials in general are to comply with the requirements of the Rules for the classification of ships, Part 25 - Metallic materials, and the Rules for the classification of ships, Part 26 - Welding.*

Materials used in gas tanks, gas piping, process pressure vessels and other components in contact with cryogenic liquids or gases are to be in compliance with this Section.

7.4.1 Metallic materials

7.4.1.1 Materials for fuel containment and piping systems shall comply with the minimum regulations given in the following tables:

Table 7.1: Plates, pipes (seamless and welded), sections and forgings for fuel tanks and process pressure vessels for design temperatures not lower than 0°C (for additional requirements see the Note below).

Table 7.2: Plates, sections and forgings for fuel tanks, secondary barriers and process pressure vessels for design temperatures below 0°C and down to minus 55°C (for additional requirements see the Note below).

Table 7.3: Plates, sections and forgings for fuel tanks, secondary barriers and process pressure vessels for design temperatures below minus 55°C and down to minus 165°C (for additional requirements see the Note below).

Table 7.4: Pipes (seamless and welded), forgings and castings for fuel and process piping for design temperatures below 0°C and down to minus 165°C.

Table 7.5: Plates and sections for hull structures required by 6.4.13.1.1.2.

C7.4.1.1 *NOTE: For material requirements additional to the ones given in tables 7.1, 7.2, 7.3, see UR W1 (Rev.4, Apr 2021).*

Table 7.1

PLATES, PIPES (SEAMLESS AND WELDED) (1), (2), SECTIONS AND FORGINGS FOR FUEL TANKS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES NOT LOWER THAN 0°C		
CHEMICAL COMPOSITION AND HEAT TREATMENT		
► Carbon-manganese steel		
► Fully killed fine grain steel		
► Small additions of alloying elements by agreement with the Administration		
► Composition limits to be approved by the Administration		
► Normalized, or quenched and tempered (4)		
TENSILE AND TOUGHNESS (IMPACT) TEST REGULATIONS		
Sampling frequency		
► Plates	Each "piece" to be tested	
► Sections and forgings	Each "batch" to be tested.	
Mechanical properties		
► Tensile properties	Specified minimum yield stress not to exceed 410 N/mm (2), (5)	
Toughness (Charpy V-notch test)		
► Plates	Transverse test pieces. Minimum average energy value (KV) 27J	
► Sections and forgings	Longitudinal test pieces. Minimum average energy value (KV) 41J	
► Test temperature	Thickness t (mm)	Test temperature (°C)
	T $\leq$ 20	0
	20 < t $\leq$40 (3)	-20

NOTES:

(1) For seamless pipes and fittings normal practice applies. The use of longitudinally and spirally welded pipes shall be specially approved by the Administration.

(2) Charpy V-notch impact tests are not required for pipes.

(3) This Table is generally applicable for material thicknesses up to 40 mm. Proposals for greater thicknesses shall be approved by the Administration.

(4) A controlled rolling procedure or thermo-mechanical controlled processing (TMCP) may be used as an alternative.

(5) Materials with specified minimum yield stress exceeding 410 N/mm^2 may be approved by the Administration. For these materials, particular attention shall be given to the hardness of the welded and heat affected zones.

Table 7.2

PLATES, SECTIONS AND FORGINGS [1] FOR FUEL TANKS, SECONDARY BARRIERS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES BELOW 0°C AND DOWN TO MINUS 55°C Maximum thickness 25 mm [2]				
CHEMICAL COMPOSITION AND HEAT TREATMENT				
► Carbon-manganese steel				
► Fully killed, aluminium treated fine grain steel				
► Chemical composition (ladle analysis)				
C	Min	Si	S	P
0.16% max. [3]	0.70-1.60%	0.10-0.50%	0.025% max.	0.025% max.
Optional additions: Alloys and grain refining elements may be generally in accordance with the following:				
Ni	Cr	Mo	Cu	Nb
0.80% max.	0.25% max.	0.08% max.	0.35% max	0.05% max.
V				
0.10 max.				
Al content total 0.020% min. (Acid soluble 0.015% min.)				
► Normalized, or quenched and tempered [4]				
TENSILE AND TOUGHNESS (IMPACT) TEST REGULATIONS				
Sampling frequency				
► Plates	Each 'piece' to be tested			
► Sections and forgings	Each 'batch' to be tested			
Mechanical properties				
► Tensile properties	Specified minimum yield stress not to exceed 410 N/mm^2 [5]			
Toughness (Charpy V-notch test)				
► Plates	Transverse test pieces. Minimum average energy value (KV) 27J			
► Sections and forgings	Longitudinal test pieces. Minimum average energy value (KV) 41J			
► Test temperature	5°C below the design temperature or -20°C whichever is lower			

Notes

[1] The Charpy V-notch and chemistry regulations for forgings may be specially considered by the Administration.

[2] For material thickness of more than 25 mm, Charpy V-notch tests shall be conducted as follows:

Material thickness (mm)	Test temperature (°C)
$25 < t \leq 30$	10°C below design temperature or -20°C whichever is lower
$30 < t \leq 35$	15°C below design temperature or -20°C whichever is lower
$35 < t \leq 40$	20°C below design temperature
$40 < t$	Temperature approved by the Administration

The impact energy value shall be in accordance with the table for the applicable type of test specimen. Materials for tanks and parts of tanks which are completely thermally stress relieved after welding may be tested at a temperature 5°C below design temperature or -20°C whichever is lower.

For thermally stress relieved reinforcements and other fittings, the test temperature shall be the same as that required for the adjacent tank-shell thickness.

[3] By special agreement with the Administration, the carbon content may be increased to 0.18% maximum provided the design temperature is not lower than -40°C

[4] A controlled rolling procedure or thermo-mechanical controlled processing (TMCP) may be used as an alternative.

[5] Materials with specified minimum yield stress exceeding 410 N/mm^2 may be approved by the Administration. For these materials, particular attention shall be given to the hardness of the welded and heat affected zones.

GUIDANCE:
For materials exceeding 25 mm in thickness for which the test temperature is -60°C or lower, the application of specially treated steels or steels in accordance with table 7.3 may be necessary.

Table 7.3

PLATES, SECTIONS AND FORGINGS [1] FOR FUEL TANKS, SECONDARY BARRIERS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES BELOW MINUS 55°C AND DOWN TO MINUS 165°C [2] Maximum thickness 25 mm [3], [4]		
Minimum design temperature (°C)	Chemical composition [5] and heat treatment	Impact test temperature (°C)
-60	1.5% nickel steel – normalized or normalized and tempered or quenched and tempered or TMCP (see note [6])	-65
-65	2.25% nickel steel – normalized or normalized and tempered or quenched and tempered or TMCP [6], [7]	-70
-90	3.5% nickel steel – normalized or normalized and tempered or quenched and tempered or TMCP [6], [7]	-95
-105	5% nickel steel – normalized or normalized and tempered or quenched and tempered [6], [7], [8]	-110
-165	9% nickel steel – double normalized and tempered or quenched and tempered [6]	-196
-165	Austenitic steels, such as types 304, 304L, 316, 316L, 321 and 347 solution treated [9]	-196
-165	Aluminium alloys; such as type 5083 annealed	Not required
-165	Austenitic Fe-Ni alloy (36% nickel) Heat treatment as agreed	Not required

TENSILE AND TOUGHNESS (IMPACT) TEST REGULATIONS	
Sampling frequency	
► Plates	Each 'piece' to be tested
► Sections and forgings	Each 'batch' to be tested
Toughness (Charpy V-notch test)	
► Plates	Transverse test pieces. Minimum average energy value (KV) 27J
► Sections and forgings	Longitudinal test pieces. Minimum average energy value (KV) 41J

NOTES:

(1) The impact test required for forgings used in critical applications shall be subject to special consideration by the Administration.

(2) The regulations for design temperatures below –165°C shall be specially agreed with the Administration.

(3) For materials 1.5% Ni, 2.25% Ni, 3.5% Ni and 5% Ni, with thicknesses greater than 25 mm, the impact tests shall be conducted as follows:

Material thickness (mm)	Test temperature (°C)
$25 < t \leq 30$	10°C below design temperature or -20°C whichever is lower
$30 < t \leq 35$	15°C below design temperature or -20°C whichever is lower
$35 < t \leq 40$	20°C below design temperature

The energy value shall be in accordance with the table for the applicable type of test specimen. For material thickness of more than 40 mm, the Charpy V-notch values shall be specially considered.

(4) For 9% Ni steels, austenitic stainless steels and aluminium alloys, thickness greater than 25 mm may be used.

(5) The chemical composition limits shall be in accordance with recognized standards.

(6) Thermo-mechanical controlled processing (TMCP) nickel steels will be subject to acceptance by the Administration.

(7) A lower minimum design temperature for quenched and tempered steels may be specially agreed with the Administration.

(8) A specially heat-treated 5% nickel steel, for example triple heat treated 5% nickel steel, may be used down to –165°C, provided that the impact tests are carried out at –196°C.

(9) The impact test may be omitted subject to agreement with the Administration.

Table 7.4

PIPES (SEAMLESS AND WELDED) [(1)], FORGINGS [(2)] AND CASTINGS [(2)] FOR FUEL AND PROCESS PIPING FOR DESIGN TEMPERATURES BELOW 0°C AND DOWN TO MINUS 165°C [(3)] Maximum thickness 25 mm			
Minimum design temperature (°C)	Chemical composition [(5)] and heat treatment	Impact test	
		Test temperature (°C)	Minimum average energy (KV)
-55	Carbon-manganese steel. Fully killed fine grain. Normalized or as agreed [(6)]	See note [(4)]	27
-65	2.25% nickel steel. Normalized or normalized and tempered or quenched and tempered [(6)]	-70	34
-90	3.5% nickel steel. Normalized or normalized and tempered or quenched and tempered [(6)]	-95	34
-165	9% nickel steel [(7)]. Double normalized and tempered or quenched and tempered	-196	41
	Austenitic steels, such as types 304, 304L, 316, 316L, 321 and 347. Solution treated [(8)]	-196	41
	Aluminium alloys; such as type 5083 annealed		Not required
TENSILE AND TOUGHNESS (IMPACT) TEST REGULATIONS			
Sampling frequency			
► Each 'batch' to be tested			
Toughness (Charpy V-notch test)			
► Impact test: Longitudinal test pieces			

NOTES:

(1) The use of longitudinally or spirally welded pipes shall be specially approved by the Administration.

(2) The regulations for forgings and castings may be subject to special consideration by the Administration.

(3) The regulations for design temperatures below -165°C shall be specially agreed with the Administration.

(4) The test temperature shall be 5°C below the design temperature or -20°C whichever is lower.

(5) The composition limits shall be in accordance with Recognized Standards.

(6) A lower design temperature may be specially agreed with the Administration for quenched and tempered materials.

(7) This chemical composition is not suitable for castings.

(8) Impact tests may be omitted subject to agreement with the Administration.

Table 7.5

PLATES AND SECTIONS FOR HULL STRUCTURES REQUIRED BY 6.4.13.1.1.2								
Minimum design temperature of hull structure (°C)	Maximum thickness (mm) for steel grades							
	A	B	D	E	AH	DH	EH	FH
0 and above	Recognized Standards							
down to -5	15	25	30	50	25	45	50	50
down to -10	x	20	25	50	20	40	50	50
down to -20	x	x	20	50	x	30	50	50
down to -30	x	x	x	40	x	20	40	50
below -30	In accordance with table 7.2 except that the thickness limitation given in table 7.2 and in footnote 2 of that table does not apply.							

NOTE:

'x' means steel grade not to be used.

7.4.1.2 Materials having a melting point below 925°C shall not be used for piping outside the fuel tanks.

7.4.1.3 For CNG tanks, the use of materials not covered above may be specially considered by the Administration.

7.4.1.4 Where required the outer pipe or duct containing high pressure gas in the inner pipe shall as a minimum fulfil the material regulations for pipe materials with design temperature down to minus 55°C in table 7.4.

7.4.1.5 The outer pipe or duct around liquefied gas fuel pipes shall as a minimum fulfil the material regulations for pipe materials with design temperature down to minus 165°C in table 7.4.

C7.4.1.6 *The documentation required for the materials used in fuel gas piping systems shall be in accordance with Table C7.4.1:*

Table C7.4.1
Certification of material quality and testing

Item	*Material certificate type (1), (2), (3)*	*Material*	*Piping system*	*Nominal Diameter*	*Design pressure (bar)*	*Design temperature (°C)*
Pipes (including secondary enclosures)	*C*		*Pressurised*	*> 25*	*> 10*	*or < 0*
	W		*Pressurised*	*≤ 25*		
	W		*Open ended*			*< 0*
	W		*Pressurised*		*≤ 10*	*and ≥ 0*
	TR		*Open ended*			*≥ 0*
Flanges	*W*		*Pressurised*			
	W		*Open ended*			
Bodies of valves and fittings (4), pump housings, other pressure containing components not considered as pressure vessels	*C*	*Steel*				*< 0*
	W	*Steel*				
	W	*Copper alloys*				
Nuts and bolts	*TR*	*Steel*				

NOTES:
(1) C = Class certificate
(2) W = works' certificate (issued by the manufacturer)
(3) TR = test report (issued by the manufacturer)
(4) When fittings are made from plates or pipes, the certification requirements for pipes shall be applied also for the pipe fittings.

C7.4.1.7 *For the acceptance of alternative metallic materials (not listed in tables 7.2, 7.3 and 7.4 of this Rules) for cryogenic service in ships using gases or other low-flashpoint fuels, see referent Guidelines (MSC.1/Circ.1622/Rev.1).*

C7.4.1.8 *For the application of high manganese austenitic steel for cryogenic service on the design and construction of the fuel tanks in ships using gases or other low-flashpoint fuels see referent Guidelines (MSC.1/Circ.1599/Rev.3).*

8 BUNKERING

8.1 GOAL

8.1.1 The goal of this Section is to provide for suitable systems on board the ship to ensure that bunkering can be conducted without causing danger to persons, the environment or the ship.

8.2 FUNCTIONAL REQUIREMENTS

8.2.1 This Section relates to functional requirements in 3.2.1 to 3.2.11 and 3.2.13 to 3.2.17. In particular the following apply:

.1 The piping system for transfer of fuel to the storage tank shall be designed such that any leakage from the piping system cannot cause danger to personnel, the environment or the ship.

8.3 REGULATIONS FOR BUNKERING STATION

8.3.1 General

8.3.1.1 The bunkering station shall be located on open deck so that sufficient natural ventilation is provided. Closed or semi-enclosed bunkering stations shall be subject to special consideration within the risk assessment.

C8.3.1.1 *(as referred also in 13.7) Recommendation for performance of risk assessment is explained in IACS Rec. 146 (Aug 2016).*

(UI GF9, Dec 2017)

The special consideration shall as a minimum include, but not be restricted to, the following design features:

- *segregation towards other areas on the ship*
- *hazardous area plans for the ship*
- *requirements for forced ventilation*
- *requirements for leakage detection (e.g. gas detection and low temperature detection)*
- *safety actions related to leakage detection (e.g. gas detection and low temperature detection)*
- *access to bunkering station from non-hazardous areas through airlocks*
- *monitoring of bunkering station by direct line of sight or by CCTV.*

Enclosed or semi enclosed bunker stations and ducts around fuel gas bunker pipes are to be fitted with permanently installed gas detectors in accordance with 15.8.

8.3.1.2 Connections and piping shall be so positioned and arranged that any damage to the fuel piping does not cause damage to the ship's fuel containment system resulting in an uncontrolled gas discharge.

8.3.1.3 Arrangements shall be made for safe management of any spilled fuel.

C8.3.1.3 *Drip trays as per 5.10 are to be provided beneath bunkering connections to protect the hull structure from low temperatures. Where the damage to the hull structure from accidental spillage of LNG during bunkering operations cannot be precluded, additional measures are to be fitted under the bunkering station to provide for additional protection of the hull steel and the ship's side structure.*

8.3.1.4 Suitable means shall be provided to relieve the pressure and remove liquid contents from pump suctions and bunker lines. Liquid is to be discharged to the liquefied gas fuel tanks or other suitable location.

8.3.1.5 The surrounding hull or deck structures shall not be exposed to unacceptable cooling, in case of leakage of fuel.

8.3.1.6 For CNG bunkering stations, low temperature steel shielding shall be considered to determine if the escape of cold jets impinging on surrounding hull structure is possible.

8.3.2 Ships' fuel hoses

8.3.2.1 Liquid and vapour hoses used for fuel transfer shall be compatible with the fuel and suitable for the fuel temperature.

8.3.2.2 Hoses subject to tank pressure, or the discharge pressure of pumps or vapour compressors, shall be designed for a bursting pressure not less than five times the maximum pressure the hose can be subjected to during bunkering.

8.4 REGULATIONS FOR MANIFOLD

8.4.1 The bunkering manifold shall be designed to withstand the external loads during bunkering. The connections at the bunkering station shall be of dry-disconnect type equipped with additional safety dry break-away coupling/ self-sealing quick release. The couplings shall be of a standard type.

C8.4.1 *(as referred in ISO 21593 for Emergency Release Coupling, or ISO 16904 for Quick connect / disconnect coupling).*

8.5 REGULATIONS FOR BUNKERING SYSTEM

8.5.1 An arrangement for purging fuel bunkering lines with inert gas shall be provided.

8.5.2 The bunkering system shall be so arranged that no gas is discharged to the atmosphere during filling of storage tanks.

8.5.3 A manually operated stop valve and a remote operated shutdown valve in series, or a combined manually operated and remote valve shall be fitted in every bunkering line close to the connecting point. It shall be possible to operate the remote valve in the control location for bunkering operations and/or from another safe location.

C8.5.3 *The remote operated valve is to be of the fail to close type (closed on loss of actuating power), and have indication of the actual valve position.*

8.5.4 Means shall be provided for draining any fuel from the bunkering pipes upon completion of operation.

8.5.5 Bunkering lines shall be arranged for inerting and gas freeing. When not engaged in bunkering, the bunkering pipes shall be free of gas, unless the consequences of not gas freeing is evaluated and approved.

8.5.6 In case bunkering lines are arranged with a cross-over it shall be ensured by suitable isolation arrangements that no fuel is transferred inadvertently to the ship side not in use for bunkering.

8.5.7 A ship-shore link (SSL) or an equivalent means for automatic and manual ESD communication to the bunkering source shall be fitted.

8.5.8 If not demonstrated to be required at a higher value due to pressure surge considerations a default time as calculated in accordance with 16.7.3.7 from the trigger of the alarm to full closure of the remote operated valve required by 8.5.3 shall be adjusted.

C8.5.8 *This requirement also applies to tank filling valves if automatic operation is initiated by high tank level during transfer operation between liquified gas fuel tanks.*

C8.5.9 *Bunkering lines shall in general be arranged as self-draining towards the fuel containment system. If the bunkering station need to be located lower than the fuel containment system, other suitable means should be provided to relieve the pressure and remove liquid contents from the bunker lines.*

C8.5.10 *Bunkering connections and bunkering lines shall be supported and arranged in such a way that in case of mechanical damage to the piping on open deck, the risk of damage to the ship's fuel containment system and tank valves are minimized.*

C8.5.11 Vapour return line

C8.5.11.1 *A vapour return line may be used to control the pressure in the receiving tank due to the liquid transfer, flash gas and boil-off gas generation.*

C8.5.11.2 *Whether vapour return is needed or not will depend on:*

1. The ability of the vessel to cope with boil-off gas (BOG) pressure
.2 BOG management system on vessels side
.3 LNG spraying on vessel side to cool-down BOG

NOTE: A bunkering system may be designed with a vapour return line and associated equipment to manage the returned vapour, in order to control the pressure in the receiving tank, or to reduce the time required for bunkering. This is particularly applicable to atmospheric pressure fuel storage tanks (type A, prismatic type B or membrane tanks). An alternative practice of LNG bunkering widely used when no vapour return line is available (especially in a truck-to-ship bunkering situation), is to spray LNG into the top of the receiving tank through diffusers in order to cool the vapour space. As a result, the tank pressure will be reduced and therefore the pressure increase due to flash gas can be contained and managed for the duration of the LNG bunkering.

For transfers with smaller capacities (range of around 50-200 m^3/h), and where the receiving tank is a type C tank with the possibility of sequential filling and LNG spraying, a vapour return line may generally not be needed.

C8.5.11.3 *Vapor return lines are to be arranged for inerting and gas freeing as described for bunkering lines in 8.5.5.*

C8.5.12 Technical requirements for bunkering systems

8.5.1.2.1 *Technical requirements for bunkering systems may be applied as stated in IACS Rec. 142 (June C2016), Chapter 1, Section 5.*

9 FUEL SUPPLY TO CONSUMERS

9.1 GOAL

The goal of this Section is to ensure safe and reliable distribution of fuel to the consumers.

9.2 FUNCTIONAL REQUIREMENTS

This Section is related to functional requirements in 3.2.1 to 3.2.6, 3.2.8 to 3.2.11 and 3.2.13 to 3.2.17. In particular the following apply:

.1 the fuel supply system shall be so arranged that the consequences of any release of fuel will be minimized, while providing safe access for operation and inspection;

.2 the piping system for fuel transfer to the consumers shall be designed in a way that a failure of one barrier cannot lead to a leak from the piping system into the surrounding area causing danger to the persons on board, the environment or the ship (see note below); and

.3 fuel lines outside the machinery spaces shall be installed and protected so as to minimize the risk of injury to personnel and damage to the ship in case of leakage.

NOTE: (UI GF19, Dec 2023) To comply with part A-1, paragraphs 9.2.2, 9.6.1 and 7.3.6.3 of the IGF Code, two independent safety barriers shall be in place, while, as far as practicable, using a minimum of flange connections. There shall be, no single common flange or other component where one single failure itself may overcome both primary and secondary barriers and may result in a gas leak into the surrounding area causing danger to the persons on board, the environment or the ship.

A single common flange (with two sealing systems) may be accepted at the fuel connection to the gas consumers including GCUs, boilers and components on the engine, such as gas regulating units

9.3 REGULATIONS ON REDUNDANCY OF FUEL SUPPLY

9.3.1 For single fuel installations the fuel supply system shall be arranged with full redundancy and segregation all the way from the fuel tanks to the consumer, so that a leakage in one system does not lead to an unacceptable loss of power.

9.3.2 For single fuel installations, the fuel storage shall be divided between two or more tanks. The tanks shall be located in separate compartments.

9.3.3 For type C tank only, one tank may be accepted if two completely separate tank connection spaces are installed for the one tank.

C9.3.3 For non-conventional gas fuelled propulsion *machinery arrangements, a failure mode and effect analysis (FMEA) shall be made covering any single failure in active components or systems.*

Documentation of calculation methods and computer programs shall be submitted upon request.

When numerical calculations cannot be performed due to insufficient data, other redundancy principles may be accepted on the basis of qualitative failure analyses of the component or system.

NOTE: Non-conventional gas fuelled propulsion machinery arrangements in this respect implies machinery arrangement where the propulsion machinery is based on other redundancy principles than duplication of the propulsion line with separate gas supply systems. The requirement does in general not apply to dual-fuel engines.

9.4 REGULATIONS ON SAFETY FUNCTIONS OF GAS SUPPLY SYSTEM

9.4.1 Fuel storage tank inlets and outlets shall be provided with valves located as close to the tank as possible. Valves required to be operated during normal operation [16] which are not accessible shall be remotely operated. Tank valves whether accessible or not shall be automatically operated when the safety system required in 15.2.2 is activated.

C9.4.1 *All automatic and remotely operated valves shall be provided with indications for open and closed valve positions at the location where the valves are remotely operated.*

Normally closed valves not operated during normal service that are not easily accessible need not be remotely operated.

9.4.2 The main gas supply line to each gas consumer or set of consumers shall be equipped with a manually operated stop valve and an automatically operated "master gas fuel valve" coupled in series or a combined manually and automatically operated valve. The valves shall be situated in the part of the piping that is outside the machinery space containing gas consumers, and placed as near as possible to the installation for heating the gas, if fitted. The master gas fuel valve shall automatically cut off the gas supply when activated by the safety system required in 15.2.2.

9.4.3 The automatic master gas fuel valve shall be operable from safe locations on escape routes inside a machinery space containing a gas consumer, the engine control room, if applicable; outside the machinery space, and from the navigation bridge.

9.4.4 Each gas consumer shall be provided with "double block and bleed" valves arrangement. These valves shall be arranged as outlined in .1 or .2 so that when the safety system required in 15.2.2 is activated this will cause the shutoff valves that are in series to close automatically and the bleed valve to open automatically and:

.1 the two shutoff valves shall be in series in the gas fuel pipe to the gas consuming equipment. The bleed valve shall be in a pipe that vents to a safe location in the open air that portion of the gas fuel piping that is between the two valves in series; or

[16]) Normal operation in this context is when gas is supplied to consumers and during bunkering operations.

.2 the function of one of the shutoff valves in series and the bleed valve can be incorporated into one valve body, so arranged that the flow to the gas utilization unit will be blocked and the ventilation opened.

9.4.5 The two valves shall be of the fail-to-close type, while the ventilation valve shall be fail-to-open.

9.4.6 The double block and bleed valves shall also be used for normal stop of the engine.

9.4.7 In cases where the master gas fuel valve is automatically shutdown, the complete gas supply branch downstream of the double block and bleed valve shall be automatically ventilated assuming reverse flow from the engine to the pipe.

9.4.8 There shall be one manually operated shutdown valve in the gas supply line to each engine upstream of the double block and bleed valves to assure safe isolation during maintenance on the engine.

9.4.9 For single-engine installations and multi-engine installations, where a separate master valve is provided for each engine, the master gas fuel valve and the double block and bleed valve functions can be combined.

9.4.10 For each main gas supply line entering an ESD protected machinery space, and each gas supply line to high pressure installations means shall be provided for rapid detection of a rupture in the gas line in the engine-room. When rupture is detected a valve shall be automatically shut off. [17)] This valve shall be located in the gas supply line before it enters the engine-room or as close as possible to the point of entry inside the engine-room. It can be a separate valve or combined with other functions, e.g. the master valve.

C9.4.10 *NOTE: If a differential pressure measurement is used to detect a pipe rupture, the shutdown should be time delayed to prevent shutdown due to transient load variations.*

C9.4.11 *Emergency shut down valves (as provided for safety functions) shall fail to a safe position upon loss of actuation power or control signals.*

C9.4.12 *Closure time of emergency shutdown valves shall be in accordance with 16.7.3.6.*

C9.4.13 *Provision is to be made for inerting and gas-freeing the gas fuel supply piping system. Discharges are to be led to a safe location in the open air.*

C9.4.14 *The transient response characteristics of the fuel gas supply and control systems are to be such that transient variations in fuel gas demand would not cause unintended shutdown of the fuel gas supply system.*

9.5 REGULATIONS FOR FUEL DISTRIBUTION OUTSIDE OF MACHINERY SPACE

9.5.1 Where fuel pipes pass through enclosed spaces in the ship, they shall be protected by a secondary enclosure. This enclosure can be a ventilated duct or a double wall piping system. The duct or double wall piping system shall be mechanically underpressure (extraction) ventilated with 30 air changes per hour, and gas detection as required in 15.8 shall be provided. Other solutions providing an equivalent safety level may also be accepted by the Administration (see also C 13.3.10).

9.5.2 The requirement in 9.5.1 need not be applied for fully welded fuel gas vent pipes led through mechanically ventilated spaces.

9.5.3 The requirements in 9.5.4 to 9.5.6 shall apply to ships constructed on or after 1 January 2024 in lieu of the requirements in 9.5.1 and 9.5.2.

9.5.4 Where gaseous fuel pipes pass through enclosed spaces in the ship, they shall be protected by a secondary enclosure. This enclosure can be a ventilated duct or a double wall piping system. The duct or double wall piping system shall be mechanically under pressure ventilated with 30 air changes per hour, and gas detection as required in 15.8 shall be provided. Other solutions providing an equivalent safety level may also be accepted by the Administration.

9.5.5 The requirement in 9.5.4 need not be applied for fully welded fuel gas vent pipes led through mechanically ventilated spaces.

9.5.6 Liquefied fuel pipes shall be protected by a secondary enclosure able to contain leakages. If the piping system is in a fuel preparation room or a tank connection space, the Administration may waive this requirement. Where gas detection as required in 15.8.1.2 is not fit for purpose, the secondary enclosures around liquefied fuel pipes shall be provided with leakage detection by means of pressure or temperature monitoring systems, or any combination thereof. The secondary enclosure shall be able to withstand the maximum pressure that may build up in the enclosure in case of leakage from the fuel piping. For this purpose, the secondary enclosure may need to be arranged with a pressure relief system that prevents the enclosure from being subjected to pressures above their design pressures.

C9.5.7 *The secondary enclosure for the piping contains cryogenic liquified fuel shall be made of a material that can withstand cryogenic temperatures.*

C9.5.8 *The requirement for secondary enclosure need not be applied for fully welded gaseous fuel pipes on open deck, and for liquefied fuel pipes without fittings or valves on open deck.*

C9.5.9 *Fuel piping including vent lines shall not be routed through tanks.*

9.6 REGULATIONS FOR FUEL SUPPLY TO CONSUMERS IN GAS-SAFE MACHINERY SPACES

9.6.1 Fuel piping in gas-safe machinery spaces shall be completely enclosed by a double pipe or duct fulfilling one of the following conditions:

[17)] The shutdown shall be time delayed to prevent shutdown due to transient load variations.

.1 the gas piping shall be a double wall piping system with the gas fuel contained in the inner pipe. The space between the concentric pipes shall be pressurized with inert gas at a pressure greater than the gas fuel pressure. Suitable alarms shall be provided to indicate a loss of inert gas pressure between the pipes. When the inner pipe contains high pressure gas, the system shall be so arranged that the pipe between the master gas valve and the engine is automatically purged with inert gas when the master gas valve is closed; or

.2 the gas fuel piping shall be installed within a ventilated pipe or duct. The air space between the gas fuel piping and the wall of the outer pipe or duct shall be equipped with mechanical ventilation of the extraction type having a capacity of at least 30 air changes per hour. This ventilation capacity may be reduced to 10 air changes per hour provided automatic filling of the duct with nitrogen upon detection of gas is arranged for. The fan motors shall comply with the required explosion protection in the installation area. The ventilation outlet shall be covered by a protection screen and placed in a position where no flammable gas-air mixture may be ignited; or

.3 other solutions providing an equivalent safety level may also be accepted by the Administration.

9.6.2 The connecting of gas piping and ducting to the gas injection valves shall be completely covered by the ducting. The arrangement shall facilitate replacement and/or overhaul of injection valves and cylinder covers. The double ducting is also required for all gas pipes on the engine itself, until gas is injected into the chamber. [18)]

9.7 REGULATIONS FOR GAS FUEL SUPPLY TO CONSUMERS IN ESD-PROTECTED MACHINERY SPACES

9.7.1 The pressure in the gas fuel supply system shall not exceed 1.0 MPa.

9.7.2 The gas fuel supply lines shall have a design pressure not less than 1.0 MPa.

9.8 REGULATIONS FOR THE DESIGN OF VENTILATED DUCT, OUTER PIPE AGAINST INNER PIPE GAS LEAKAGE

9.8.1 The design pressure of the outer pipe or duct of fuel systems shall not be less than the maximum working pressure of the inner pipe. Alternatively for fuel piping systems with a working pressure greater than 1.0 MPa, the design pressure of the outer pipe or duct shall not be less than the maximum built-up pressure arising in the annular space considering the local instantaneous peak pressure in way of any rupture and the ventilation arrangements.

9.8.2 For high-pressure fuel piping the design pressure of the ducting shall be taken as the higher of the following:

.1 the maximum built-up pressure: static pressure in way of the rupture resulting from the gas flowing in the annular space;

.2 local instantaneous peak pressure in way of the rupture: this pressure shall be taken as the critical pressure given by the following expression:

$$p = p_0 \left(\frac{2}{k+1}\right)^{\frac{k}{k-1}}$$

where:

p_0 = maximum working pressure of the inner pipe

k = C_p/C_v constant pressure specific heat divided by the constant volume specific heat

k = 1.31 for CH_4

The tangential membrane stress of a straight pipe shall not exceed the tensile strength divided by 1.5 (R_m/1.5) when subjected to the above pressures. The pressure ratings of all other piping components shall reflect the same level of strength as straight pipes.

As an alternative to using the peak pressure from the above formula, the peak pressure found from representative tests can be used. Test reports shall then be submitted.

9.8.3 Verification of the strength shall be based on calculations demonstrating the duct or pipe integrity. As an alternative to calculations, the strength can be verified by representative tests.

9.8.4 For low pressure fuel piping the duct shall be dimensioned for a design pressure not less than the maximum working pressure of the fuel pipes. The duct shall be pressure tested to show that it can withstand the expected maximum pressure at fuel pipe rupture.

C9.8.5 *Parts of the secondary enclosure extending to air inlets and outlets on open deck shall be dimensioned for a design pressure corresponding to the requirements in 9.8.2 and 9.8.4 unless a lower design pressure may be justified by back pressure calculations.*

9.9 REGULATIONS FOR COMPRESSORS AND PUMPS

9.9.1 If compressors or pumps are driven by shafting passing through a bulkhead or deck, the bulkhead penetration shall be of gastight type.

9.9.2 Compressors and pumps shall be suitable for their intended purpose. All equipment and machinery shall be such as to be adequately tested to ensure suitability for use within a marine environment. Such items to be considered would include, but not be limited to:

.1 environmental;

.2 shipboard vibrations and accelerations;

[18)] If gas is supplied into the air inlet directly on each individual cylinder during air intake to the cylinder on a low pressure engine, such that a single failure will not lead to release of fuel gas into the machinery space, double ducting may be omitted on the air inlet pipe.

.3 effects of pitch, heave, and roll motions, etc.; and
.4 gas composition.

9.9.3 Arrangements shall be made to ensure that under no circumstances liquefied gas can be introduced in the gas control section or gas-fuelled machinery, unless the machinery is designed to operate with gas in liquid state.

9.9.4 Compressors and pumps shall be fitted with accessories and instrumentation necessary for efficient and reliable function.

C9.9.5 *Circulation pumps for the heating fluid intended to heat liquified gas in heat exchangers, shall be arranged with redundancy. In case that circulation of heating fluid is necessary to prevent freezing in the heating circuit, power supply of circulation pumps shall be from an uninterruptible power supply (UPS), or alternative means for maintaining circulation for a sufficiently long period in case of loss of electric power supply. Heating circuit shall also satisfy following requirements:*

.1 The heating circuit expansion tank fitted with a gas detector as per 15.8.1.8, shall be vented to open air.
.2 To prevent freezing of the heating medium, the following arrangement shall be provided:
- *alarm for low temperature at heating medium outlet*
- *automatic stop of liquefied gas feed pump (if fitted) and closing of liquified gas storage tank valve at stop of circulation of heating fluid.*

C9.9.6 *For other requirements for pumps and compressors not covered by this part of the Rules, see the Rules for the classification of ships, Part 9 - Machines.*

C9.10 HEAT EXCHANGERS AND PROCESS PRESSURE VESSELS

C9.10.1 *Heat exchangers used for heating or vaporizing fuel gas, and process pressure vessels used to store or treat fuel gas supply liquids or vapors, shall comply with the requirements in 6.4.15.3 and IGC Code Chapter 5, as applicable.*

C9.10.2 *For pressure and temperature measurements and controls, see Section 15.*

C9.10.3 *For other requirements for heat exchangers and pressure vessels not covered by this part of the Rules, see the Rules for the classification of ships, Part 10 - Boilers, heat exchangers and pressure vessels.*

C9.11 GAS VALVE UNIT

C9.11.1 *Where the gas valve unit is located in a dedicated compartment or space, the safety principles and arrangements of that compartment are to be the same as those required for an ESD-protected machinery space detailed in 5.4.1.2, 5.6, 5.11.4, 12.3.3, 13.5.2, 13.5.3, and 13.5.4.*

C9.11.2 *Where the gas valve unit components are enclosed in a gas tight box or enclosure of minimum volume, for the purpose of being located in a non-hazardous space, the safety principles and arrangements of that gas tight box or enclosure are to be the same as those required for an ESD-protected machinery space detailed in 12.3.3, 13.5.2, 13.5.3, and 13.5.4.*

C9.11.3 *Gas valve unit enclosures detailed in C 9.11.1 are to be designed to a recognized standard acceptable to Register for the design pressure as per 9.8.2 or 9.8.4, as applicable. The hydrostatic test pressure of the gas valve unit enclosure is to be not less than the design pressure of the fuel gas for low pressure systems. For high pressure fuel gas systems, the hydrostatic test pressure of the gas valve unit enclosure is to be not less than the design pressure of the duct as per 9.8.2.*

C9.12 PERIODIC SURVEY OF FUEL INSTALLATIONS ON SHIPS OTHER THAN LIQUEFIED GAS CARRIERS UTILIZING GAS OR OTHER LOW FLASH POINT FUELS

C9.12.1 *For the requirements for periodic survey of fuel installations on ships other than liquefied gas carriers utilizing gas or other low flash point fuels, see IACS UR Z25 (Rev.1, Sep 2017).*

10 POWER GENERATION INCLUDING PROPULSION AND OTHER GAS CONSUMERS

10.1 GOAL

10.1.1 The goal of this Section is to provide safe and reliable delivery of mechanical, electrical or thermal energy.

10.2 FUNCTIONAL REQUIREMENTS

This Section is related to functional requirements in 3.2.1, 3.2.11, 3.2.13, 3.2.16 and 3.2.17. In particular the following apply:

.1 the exhaust systems shall be configured to prevent any accumulation of un-burnt gaseous fuel;

.2 unless designed with the strength to withstand the worst case over pressure due to ignited gas leaks, engine components or systems containing or likely to contain an ignitable gas and air mixture shall be fitted with suitable pressure relief systems. Dependent on the particular engine design this may include the air inlet manifolds and scavenge spaces;

.3 the explosion venting shall be led away from where personnel may normally be present; and

.4 all gas consumers shall have a separate exhaust system.

C10.2 *NOTE: The arrangement and location of the protective devices depends on both explosion impact and amount of potentially suffocating combustion gases. The danger to personnel and equipment from operation of the protective device shall be minimized, with discharge being directed to a safe location.*

The distance from a relief valve to passageways and working areas should generally be at least 3 meters unless efficient shielding is provided.

10.3 REGULATIONS FOR INTERNAL COMBUSTION ENGINES OF PISTON TYPE

10.3.1 General

10.3.1 The exhaust system shall be equipped with explosion relief ventilation sufficiently dimensioned to prevent excessive explosion pressures in the event of ignition failure of one cylinder followed by ignition of the unburned gas in the system.

10.3.1.1.1 For ships constructed on or after 1 January 2024, the exhaust system shall be equipped with explosion relief systems unless designed to accommodate the worst case overpressure due to ignited gas leaks or justified by the safety concept of the engine. A detailed evaluation of the potential for unburnt gas in the exhaust system is to be undertaken covering the complete system from the cylinders up to the open end. This detailed evaluation shall be reflected in the safety concept of the engine.

C10.3.1.1.2 *Explosion relief valves or other appropriate protective devices against explosion (e.g. bursting discs) as required in 10.3.1.1.1, shall be of an approved type. For type testing procedure see IACS UR M82 (Mar 2023).*

C10.3.1.1.3 *Protective devices that require dismantling or replacement upon it's activation (e.g. bursting discs) prior to continued engine operation, are not to be installed on single engine main propulsion exhaust system installations, nor in installations where any event, causing activation of such protective device, may compromise the exhaust system in extent that leads to an unacceptable loss of power.*

10.3.1.2 For engines where the space below the piston is in direct communication with the crankcase a detailed evaluation regarding the hazard potential of fuel gas accumulation in the crankcase shall be carried out and reflected in the safety concept of the engine.

10.3.1.3 Each engine other than two-stroke crosshead diesel engines shall be fitted with vent systems independent of other engines for crankcases and sumps.

10.3.1.4 Where gas can leak directly into the auxiliary system medium (lubricating oil, cooling water), an appropriate means shall be fitted after the engine outlet to extract gas in order to prevent gas dispersion. The gas extracted from auxiliary systems media shall be vented to a safe location in the atmosphere.

10.3.1.5 For engines fitted with ignition systems, prior to admission of gas fuel, correct operation of the ignition system on each unit shall be verified.

10.3.1.6 A means shall be provided to monitor and detect poor combustion or misfiring. In the event that it is detected, gas operation may be allowed provided that the gas supply to the concerned cylinder is shut off and provided that the operation of the engine with one cylinder cut-off is acceptable with respects to torsional vibrations.

10.3.1.7 For engines starting on fuels covered by this Rules, if combustion has not been detected by the engine monitoring system within an engine specific time after the opening of the fuel supply valve, the fuel supply valve shall be automatically shut off. Means to ensure that any unburnt fuel mixture is purged away from the exhaust system shall be provided.

C10.3.1.8 *For the engines operating in Otto cycle, when engine stops during the gas fuel mode of operation, the exhaust system is to be purged for a sufficient time to discharge the gas that may be present. The purge time is to be based on a minimum of four (4) air changes of the volume of the exhaust system. See also 10.3.1.7 for additional requirements regarding exhaust system purging.*

NOTE: The "engine specific time" referenced above is to be specified by the engine manufacturer.

C10.3.1.9 *For trunk piston engines operating in Otto cycle, a means is to be provided for inerting and aerating the crankcase before opening the crankcase doors for maintenance purposes. A connection, or other means, are to be provided for crankcase inerting and ventilating and gas concentration measuring.*

C10.3.1.10 *For other requirements for exhaust system of internal combustion engines not covered by this part of the*

Rules, see the Rules for the classification of ships, Part 8 - Piping.

C10.3.1.11 *For other requirements for internal combustion engines not covered by this part of the Rules, see the Rules for the classification of ships, Part 9 - Machines.*

C10.3.1.12 *For other requirements for marine reciprocating internal combustion engines supplied with natural gas as fuel, see IACS UR M78 (Rev.2, Mar 2023).*

10.3.2 Regulations for dual fuel engines

10.3.2.1 In case of shutoff of the gas fuel supply, the engines shall be capable of continuous operation by oil fuel only without interruption.

10.3.2.2 An automatic system shall be fitted to change over from gas fuel operation to oil fuel operation and vice versa with minimum fluctuation of the engine power. Acceptable reliability shall be demonstrated through testing. In the case of unstable operation on engines when gas firing, the engine shall automatically change to oil fuel mode. Manual activation of gas system shutdown shall always be possible.

C10.3.2.2 *Changeover to and from gas fuel operation is only to be possible at a power level and under conditions where it can be done with acceptable reliability and safety.*

10.3.2.3 In case of a normal stop or an emergency shutdown, the gas fuel supply shall be shut off not later than the ignition source. It shall not be possible to shut off the ignition source without first or simultaneously closing the gas supply to each cylinder or to the complete engine.

10.3.3 Regulations for gas-only engines

In case of a normal stop or an emergency shutdown, the gas fuel supply shall be shut off not later than the ignition source. It shall not be possible to shut off the ignition source without first or simultaneously closing the gas supply to each cylinder or to the complete engine.

10.3.4 Regulations for multi-fuel engines

10.3.4.1 In case of shutoff of one fuel supply, the engines shall be capable of continuous operation by an alternative fuel with minimum fluctuation of the engine power.

10.3.4.2 An automatic system shall be fitted to change over from one fuel operation to an alternative fuel operation with minimum fluctuation of the engine power. Acceptable reliability shall be demonstrated through testing. In the case of unstable operation on an engine when using a particular fuel, the engine shall automatically change to an alternative fuel mode. Manual activation shall always be possible.

	GAS ONLY		**DUAL FUEL**	**MULTI FUEL**
IGNITION MEDIUM	Spark	Pilot fuel	Pilot fuel	N/A
MAIN FUEL	Gas	Gas	Gas and/ or Oil fuel	Gas and/ or Liquid

C10.3.5 Pre-mixed engines

C10.3.5.1 *Pre-mixed engines, using fuel gas mixed with air before it enters the cylinder or cylinder head port, shall be located in ESD protected machinery spaces. Alternative arrangements may be considered on a case-by-case basis.*

C10.3.5.2 *The engine components containing the gas/air mixture, such as inlet manifold, turbo-charger, charge air cooler, etc., are to be considered as parts of the fuel gas supply system.*

10.4 REGULATIONS FOR MAIN AND AUXILIARY BOILERS

10.4.1 Each boiler shall have a dedicated forced draught system. A crossover between boiler force draught systems may be fitted for emergency use providing that any relevant safety functions are maintained.

10.4.2 Combustion chambers and uptakes of boilers shall be designed to prevent any accumulation of gaseous fuel.

10.4.3 Burners shall be designed to maintain stable combustion under all firing conditions.

10.4.4 On main/propulsion boilers an automatic system shall be provided to change from gas fuel operation to oil fuel operation without interruption of boiler firing.

10.4.5 Gas nozzles and the burner control system shall be configured such that gas fuel can only be ignited by an established oil fuel flame, unless the boiler and combustion equipment is designed and approved by the Administration to light on gas fuel.

10.4.6 There shall be arrangements to ensure that gas fuel flow to the burner is automatically cut off unless satisfactory ignition has been established and maintained.

10.4.7 On the fuel pipe of each gas burner a manually operated shutoff valve shall be fitted.

10.4.8 Provisions shall be made for automatically purging the gas supply piping to the burners, by means of an inert gas, after the extinguishing of these burners.

10.4.9 The automatic fuel changeover system required by 10.4.4 shall be monitored with alarms to ensure continuous availability.

10.4.10 Arrangements shall be made that, in case of flame failure of all operating burners, the combustion chambers of the boilers are automatically purged before relighting.

10.4.11 Arrangements shall be made to enable the boilers purging sequence to be manually activated.

C10.4.12 *For other requirements for exhaust system of main and auxiliary boilers not covered by this part of the Rules, see the Rules for the classification of ships, Part 8 - Piping.*

C10.4.13 *For other requirements for main and auxiliary boilers not covered by this part of the Rules, see the Rules for the classification of ships, Part 10 - Boilers, heat exchangers and pressure vessels.*

10.5 REGULATIONS FOR GAS TURBINES

10.5.1 Unless designed with the strength to withstand the worst case over pressure due to ignited gas leaks, pressure relief systems shall be suitably designed and fitted to the exhaust system, taking into consideration of explosions due to gas leaks. Pressure relief systems within the exhaust uptakes shall be lead to a safe location, away from personnel.

10.5.2 The gas turbine may be fitted in a gas-tight enclosure arranged in accordance with the ESD principle outlined in 5.6 and 9.7, however a pressure above 1.0 MPa in the gas supply piping may be accepted within this enclosure.

10.5.3 Gas detection systems and shutdown functions shall be as outlined for ESD protected machinery spaces.

10.5.4 Ventilation for the enclosure shall be as outlined in Section 13 for ESD protected machinery spaces, but shall in addition be arranged with full redundancy (2 x 100% capacity fans from different electrical circuits).

10.5.5 For other than single fuel gas turbines, an automatic system shall be fitted to change over easily and quickly from gas fuel operation to oil fuel operation and vice-versa with minimum fluctuation of the engine power.

10.5.6 Means shall be provided to monitor and detect poor combustion that may lead to unburnt fuel gas in the exhaust system during operation. In the event that it is detected, the fuel gas supply shall be shutdown.

10.5.7 Each turbine shall be fitted with an automatic shutdown device for high exhaust temperatures.

C10.5.8 *For other requirements for gas turbines not covered by this part of the Rules, see the Rules for the classification of ships, Part 9 - Machines.*

11 FIRE SAFETY

11.1 GOAL

The goal of this Section is to provide for fire protection, detection and fighting for all system components related to the storage, conditioning, transfer and use of natural gas as ship fuel.

11.2 FUNCTIONAL REQUIREMENTS

This Section is related to functional requirements in 3.2.2, 3.2.4, 3.2.5, 3.2.7, 3.2.12, 3.2.14, 3.2.15 and 3.2.17.

11.3 REGULATIONS FOR FIRE PROTECTION

11.3.1 Any space containing equipment for the fuel preparation such as pumps, compressors, heat exchangers, vaporizers and pressure vessels shall be regarded as a machinery space of category A for fire protection purposes. See IACS UI GF13, at its latest revision.

11.3.2 Any boundary of accommodation spaces, service spaces, control stations, escape routes and machinery spaces, facing fuel tanks on open deck, shall be shielded by A-60 class divisions. The A-60 class divisions shall extend up to the underside of the deck of the navigation bridge. In addition, fuel tanks shall be segregated from cargo in accordance with the requirements of the International Maritime Dangerous Goods (IMDG) Code where the fuel tanks are regarded as bulk packaging. For the purposes of the stowage and segregation requirements of the IMDG Code, a fuel tank on the open deck shall be considered a class 2.1 package.

11.3.3 The space containing fuel containment system shall be separated from the machinery spaces of category A or other rooms with high fire risks. See IACS UI GF17. The separation shall be done by a cofferdam of at least 900 mm with insulation of A-60 class. When determining the insulation of the space containing fuel containment system from other spaces with lower fire risks, the fuel containment system shall be considered as a machinery space of category A, in accordance with SOLAS regulation II-2/9. For type C tanks, the fuel storage hold space may be considered as a cofferdam.

Notwithstanding the last sentence in above paragraph, for ships constructed on or after 1 January 2024, the fuel storage hold space may be considered as a cofferdam provided that:

.1 the type C tank is not located directly above machinery spaces of category A or other rooms with high fire risk; and

.2 the minimum distance to the A-60 boundary from the outer shell of the type C tank or the boundary of the tank connection space, if any, is not less than 900 mm.

11.3.4 The fuel storage hold space shall not be used for machinery or equipment that may have a fire risk.

11.3.5 The fire protection of fuel pipes led through ro-ro spaces shall be subject to special consideration by the Register depending on the use and expected pressure in the pipes.

11.3.6 The bunkering station shall be separated by A-60 class divisions towards machinery spaces of category A, accommodation, control stations and high fire risk spaces, except for spaces such as tanks, voids, auxiliary machinery spaces of little or no fire risk, sanitary and similar spaces where the insulation standard may be reduced to class A-0.

11.3.7 If an ESD protected machinery spaces is separated by a single boundary, the boundary shall be of A-60 class division.

C11.3.7 *The provisions of 11.3.7 apply to the separation between ESD protected machinery spaces and other ESD protected machinery spaces, machinery spaces of category A, accommodation spaces, control stations and high fire risk spaces, except for spaces such as tanks, voids, auxiliary machinery spaces of little or no fire risk, sanitary and similar spaces where the insulation standard may be reduced to class A-0.*

11.4 REGULATIONS FOR FIRE MAIN

11.4.1 The water spray system required below may be part of the fire main system provided that the required fire pump capacity and working pressure are sufficient for the operation of both the required numbers of hydrants and hoses and the water spray system simultaneously.

11.4.2 When the fuel storage tank(s) is located on the open deck, isolating valves shall be fitted in the fire main in order to isolate damaged sections of the fire main. Isolation of a section of fire main shall not deprive the fire line ahead of the isolated section from the supply of water.

11.5 REGULATIONS FOR WATER SPRAY SYSTEM

11.5.1 A water spray system shall be installed for cooling and fire prevention to cover exposed parts of fuel storage tank(s) located on open deck.

C11.5.1 *For tankers, interaction between fixed foam fire extinguishing system and water spray system shall be considered.*

11.5.2 The water spray system shall also provide coverage for boundaries of the superstructures, compressor rooms, pump-rooms, cargo control rooms, bunkering control stations, bunkering stations and any other normally occupied deck houses that face the storage tank on open decks unless the tank is located 10 metres or more from the boundaries.

11.5.3 The system shall be designed to cover all areas as specified above with an application rate of 10 l/min/m2 for the largest horizontal projected surfaces and 4 l/min/m2 for vertical surfaces.

11.5.4 Stop valves shall be fitted in the water spray application main supply line(s), at intervals not exceeding 40 metres, for the purpose of isolating damaged sections. Alternatively, the system may be divided into two or more sections that may be operated independently, provided the necessary controls are located together in a readily accessible position not likely to be inaccessible in case of fire in the areas protected.

11.5.5 The capacity of the water spray pump shall be sufficient to deliver the required amount of water to the hydraulically most demanding area as specified above in the areas protected.

11.5.6 If the water spray system is not part of the fire main system, a connection to the ship's fire main through a stop valve shall be provided.

11.5.7 Remote start of pumps supplying the water spray system and remote operation of any normally closed valves to the system shall be located in a readily accessible position which is not likely to be inaccessible in case of fire in the areas protected.

11.5.8 The nozzles shall be of an approved full bore type and they shall be arranged to ensure an effective distribution of water throughout the space being protected.

11.6 REGULATIONS FOR DRY CHEMICAL POWDER FIRE-EXTINGUISHING SYSTEM

11.6.1 A permanently installed dry chemical powder fire-extinguishing system shall be installed in the bunkering station area to cover all possible leak points. The capacity shall be at least 3.5 kg/s for a minimum of 45 s. The system shall be arranged for easy manual release from a safe location outside the protected area.

C11.6.1 *For tankers, possible interaction between fixed foam and powder fire extinguishing system shall be considered. Dry chemical powder shall be based on potassium bicarbonate.*

11.6.2 In addition to any other portable fire extinguishers that may be required elsewhere in Rules, one portable dry powder extinguisher of at least 5 kg capacity shall be located near the bunkering station.

11.7 REGULATIONS FOR FIRE DETECTION AND ALARM SYSTEM

11.7.1 A fixed fire detection and fire alarm system complying with the Fire Safety Systems Code shall be provided for the fuel storage hold spaces and the ventilation trunk for fuel containment system below deck, and for all other rooms of the fuel gas system where fire cannot be excluded.

11.7.2 Smoke detectors alone shall not be considered sufficient for rapid detection of a fire.

11.8 REGULATION FOR FUEL PREPARATION ROOM FIRE-EXTINGUISHING SYSTEMS

11.8.1 For ships constructed on or after 1 January 2024, fuel preparation rooms containing pumps, compressors or other potential ignition sources shall be provided with a fixed fire-extinguishing system complying with the provisions of SOLAS regulation II-2/10.4.1.1 and taking into account the necessary concentrations/application rate required for extinguishing gas fires.

12 EXPLOSION PREVENTION

12.1 GOAL

The goal of this Section is to provide for the prevention of explosions and for the limitation of effects from explosion.

12.2 FUNCTIONAL REQUIREMENTS

This Section is related to functional requirements in 3.2.2 to 3.2.5, 3.2.7, 3.2.8, 3.2.12 to 3.2.14 and 3.2.17. In particular the following apply:

The probability of explosions shall be reduced to a minimum by:

.1 reducing number of sources of ignition; and

.2 reducing the probability of formation of ignitable mixtures.

12.3 REGULATIONS – GENERAL

12.3.1 Hazardous areas on open deck and other spaces not addressed in this Section shall be decided based on a recognized standard. [19] The electrical equipment fitted within hazardous areas shall be according to the same standard.

12.3.2 Electrical equipment and wiring shall in general not be installed in hazardous areas unless essential for operational purposes based on a recognized standard. [20]

12.3.3 Electrical equipment fitted in an ESD-protected machinery space shall fulfil the following:

.1 in addition to fire and gas hydrocarbon detectors and fire and gas alarms, lighting and ventilation fans shall be certified safe for hazardous area zone 1; and

.2 all electrical equipment in a machinery space containing gas-fuelled engines, and not certified for zone 1 shall be automatically disconnected, if gas concentrations above 40% LEL is detected by two detectors in the space containing gas-fuelled consumers.

12.4 REGULATIONS ON AREA CLASSIFICATION

12.4.1 Area classification is a method of analysing and classifying the areas where explosive gas atmospheres may occur. The object of the classification is to allow the selection of electrical apparatus able to be operated safely in these areas.

12.4.2 In order to facilitate the selection of appropriate electrical apparatus and the design of suitable electrical installations, hazardous areas are divided into zones 0, 1 and 2. [21] See also 12.5 below.

12.4.3 Ventilation ducts shall have the same area classification as the ventilated space.

12.5 HAZARDOUS AREA ZONES

12.5.1 Hazardous area zone 0

This zone includes, but is not limited to the interiors of fuel tanks, any pipework for pressure- relief or other venting systems for fuel tanks, pipes and equipment containing fuel.

12.5.2 Hazardous area zone 1 [22]

This zone includes, but is not limited to:

.1 tank connection spaces, fuel storage hold spaces [23] and interbarrier spaces;

C12.5.2.1 *(UI GF14) For the purposes of hazardous area classification, fuel storage hold spaces containing type C tanks with all potential leakage sources in a tank connection space and having no access to any hazardous area, should be considered non-hazardous. Where the fuel storage hold spaces include potential leakage sources, e.g. tank connections, they shall be considered hazardous area zone 1. Where the fuel storage hold spaces include bolted access to the tank connection space, they shall be considered hazardous area zone 2.*

.2 fuel preparation room arranged with ventilation according to 13.6;

.3 areas on open deck, or semi-enclosed spaces on deck, within 3 m of any fuel tank outlet, gas or vapour outlet, [24] bunker manifold valve, other fuel valve, fuel pipe flange, fuel preparation room ventilation outlets and fuel tank openings for pressure release provided to permit the flow of small volumes of gas or vapour mixtures caused by thermal variation;

.4 areas on open deck or semi-enclosed spaces on deck, within 1.5 m of fuel preparation room entrances, fuel preparation room ventilation inlets and other openings into zone 1 spaces;

.5 areas on the open deck within spillage coamings surrounding gas bunker manifold valves and 3 m beyond these, up to a height of 2.4 m above the deck;

.6 enclosed or semi-enclosed spaces in which pipes containing fuel are located, e.g. ducts around fuel pipes, semi-enclosed bunkering stations;

---

19) Refer to IEC standard 60092-502, part 4.4: Tankers carrying flammable liquefied gases as applicable

20) Refer to IEC standard 60092-502: IEC 60092-502:1999 Electrical Installations in Ships – Tankers – Special Features and IEC 60079-10-1:2008 Explosive atmospheres – Part 10-1: Classification of areas – Explosive gas atmospheres, according to the area classification

21) Refer to standards IEC 60079-10-1:2008 Explosive atmospheres part 10-1: Classification of areas – Explosive gas atmospheres and guidance and informative examples given in IEC 60092-502:1999, Electrical Installations in Ships – Tankers – Special Features for tankers.

22) Instrumentation and electrical apparatus installed within these areas should be of a type suitable for zone 1

23) Fuel storage hold spaces for type C tanks are normally not considered as zone 1.

24) Such areas are, for example, all areas within 3 m of fuel tank hatches, ullage openings or sounding pipes for fuel tanks located on open deck and gas vapour outlets.

.7 the ESD-protected machinery space is considered a non-hazardous area during normal operation, but will require equipment required to operate following detection of gas leakage to be certified as suitable for zone 1;

.8 a space protected by an airlock is considered as non-hazardous area during normal operation, but will require equipment required to operate following loss of differential pressure between the protected space and the hazardous area to be certified as suitable for zone 1; and

.9 except for type C tanks, an area within 2.4 m of the outer surface of a fuel containment system where such surface is exposed to the weather.

12.5.3 Hazardous area zone 2 [25)]

12.5.3.1 This zone includes, but is not limited to areas within 1.5 m surrounding open or semi-enclosed spaces of zone 1.

12.5.3.2 Space containing bolted hatch to tank connection space.

25) Instrumentation and electrical apparatus installed within these areas should be of a type suitable for zone 2.

13 VENTILATION

13.1 GOAL

The goal of this Section is to provide for the ventilation required for safe operation of gas-fuelled machinery and equipment.

13.2 FUNCTIONAL REQUIREMENTS

This Section is related to functional requirements in 3.2.1, 3.2.2, 3.2.5, 3.2.6, 3.2.7, 3.2.8, 3.2.10, 3.2.11, 3.2.12 to 3.2.14 and 3.2.17.

13.3 REGULATIONS – GENERAL

13.3.1 Any ducting used for the ventilation of hazardous spaces shall be separate from that used for the ventilation of non-hazardous spaces. The ventilation shall function at all temperatures and environmental conditions the ship will be operating in. Ventilation ducts shall also fulfill the following:

C.1 *Where a ventilation duct passes through a space with a different hazardous zone classification, eventual leakages to the less hazardous zone shall be prevented by ensuring over-pressure of the less hazardous space or duct relative to the more hazardous space or duct. Such ventilation ducts shall be made of steel and have a mechanical integrity equivalent to that required for general piping systems in the Rules for the classification of ships, Part 8 - Piping, Table 1.3.4.3.*

C.2 *Ventilation ducts from spaces containing liquefied gas fuel leakage sources shall be constructed of materials having a design temperature corresponding to the minimum temperature that may arise when cold gas is ventilated out through the ducts.*

13.3.2 Electric motors for ventilation fans shall not be located in ventilation ducts for hazardous spaces unless the motors are certified for the same hazard zone as the space served.

13.3.3 Design of ventilation fans serving spaces containing gas sources shall fulfil the following:

.1 Ventilation fans shall not produce a source of vapour ignition in either the ventilated space or the ventilation system associated with the space. Ventilation fans and fan ducts, in way of fans only, shall be of non-sparking construction defined as:
  - .1 impellers or housings of non-metallic material, due regard being paid to the elimination of static electricity;
  - .2 impellers and housings of non-ferrous metals;
  - .3 impellers and housings of austenitic stainless steel;
  - .4 impellers of aluminium alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non-ferrous materials is fitted in way of the impeller, due regard being paid to static electricity and corrosion between ring and housing; or
  - .5 any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 mm tip design clearance.

.2 In no case shall the radial air gap between the impeller and the casing be less than 0.1 of the diameter of the impeller shaft in way of the bearing but not less than 2 mm. The gap need not be more than 13 mm.

.3 Any combination of an aluminium or magnesium alloy fixed or rotating component and a ferrous fixed or rotating component, regardless of tip clearance, is considered a sparking hazard and shall not be used in these places.

13.3.4 Ventilation systems required to avoid any gas accumulation shall consist of independent fans, each of sufficient capacity, unless otherwise specified in this Rules.

13.3.5 Air inlets for hazardous enclosed spaces shall be taken from areas that, in the absence of the considered inlet, would be non-hazardous. Air inlets for non-hazardous enclosed spaces shall be taken from non-hazardous areas at least 1.5 m away from the boundaries of any hazardous area. Where the inlet duct passes through a more hazardous space, the duct shall be gas-tight and have over-pressure relative to this space.

13.3.6 Air outlets from non-hazardous spaces shall be located outside hazardous areas.

13.3.7 Air outlets from hazardous enclosed spaces shall be located in an open area that, in the absence of the considered outlet, would be of the same or lesser hazard than the ventilated space.

13.3.8 The required capacity of the ventilation plant is normally based on the total volume of the room. An increase in required ventilation capacity may be necessary for rooms having a complicated form.

13.3.9 Non-hazardous spaces with access to the external hazardous area shall be arranged with an airlock and be maintained at overpressure relative to the external hazardous area. The overpressure ventilation shall be arranged according to the following:

.1 During initial start-up or after loss of overpressure ventilation, before energizing any electrical installations not certified safe for the space in the absence of pressurization, it shall be required to:
  - .1 proceed with purging (at least 5 air changes) or confirm by measurements that the space is non-hazardous; and
  - .2 pressurize the space.

.2 Operation of the overpressure ventilation shall be monitored and in the event of failure of the overpressure ventilation:
  - .1 an audible and visual alarm shall be given at a manned location; and
  - .2 if overpressure cannot be immediately restored, automatic or programmed, disconnection of electrical installations

according to a recognized standard [26)] shall be required.

13.3.10 Non-hazardous spaces with access to a hazardous enclosed space shall be arranged with an airlock and the hazardous space shall be maintained at underpressure relative to the non-hazardous space. Operation of the extraction ventilation in the hazardous space shall be monitored and in the event of failure of the extraction ventilation:

.1 an audible and visual alarm shall be given at a manned location; and

.2 if underpressure cannot be immediately restored, automatic or programmed, disconnection of electrical installations according to a recognized standard in the non-hazardous space shall be required.

C13.3.10 *For spaces or secondary enclosures where the ventilation may cause condensation and icing due to cold surfaces, other solutions providing an equivalent level of safety, may be considered on a case-by-case basis.*

C13.3.11 *For other requirements for ventilation system not covered by this part of the Rules, see the Rules for the classification of ships, Part 8 - Piping.*

13.4 REGULATIONS FOR TANK CONNECTION SPACE

13.4.1 The tank connection space shall be provided with an effective mechanical forced ventilation system of extraction type. A ventilation capacity of at least 30 air changes per hour shall be provided. The rate of air changes may be reduced if other adequate means of explosion protection are installed. The equivalence of alternative installations shall be demonstrated by a risk assessment.

C13.4.1 *Recommendation for performance of risk assessment is explained in IACS Rec. 146 (Aug 2016).*

13.4.2 Approved automatic fail-safe fire dampers shall be fitted in the ventilation trunk for the tank connection space.

C13.4.3 *Spaces containing access openings for tank connection spaces shall be arranged with separate ventilation, providing at least 8 air changes per hour.*

13.5 REGULATIONS FOR MACHINERY SPACES

13.5.1 The ventilation system for machinery spaces containing gas-fuelled consumers shall be independent of all other ventilation systems.

NOTE: (UI GF10, Dec 2017) Spaces enclosed in the boundaries of machinery spaces (such as purifier's room, engine room workshops and stores) are considered an integral part of machinery spaces containing gas-fuelled consumers and, therefore, their ventilation system does not need to be independent of the one of machinery spaces.

C13.5.1 *The ventilation system for an ESD-protected machinery space is to be always in operation when there is gas fuel in the piping in normal operation, as well as in purging operation prior to maintenance works.*

13.5.2 ESD protected machinery spaces shall have ventilation with a capacity of at least 30 air changes per hour. The ventilation system shall ensure a good air circulation in all spaces, and in particular ensure that any formation of gas pockets in the room are detected. As an alternative, arrangements whereby under normal operation the machinery spaces are ventilated with at least 15 air changes an hour is acceptable provided that, if gas is detected in the machinery space, the number of air changes will automatically be increased to 30 an hour.

13.5.3 For ESD protected machinery spaces the ventilation arrangements shall provide sufficient redundancy to ensure a high level of ventilation availability as defined in a standard acceptable to the Organization. [27)]

13.5.4 The number and power of the ventilation fans for ESD protected engine-rooms and for double pipe ventilation systems for gas safe engine-rooms shall be such that the capacity is not reduced by more than 50% of the total ventilation capacity if a fan with a separate circuit from the main switchboard or emergency switchboard or a group of fans with common circuit from the main switchboard or emergency switchboard, is inoperable.

13.6 REGULATIONS FOR FUEL PREPARATION ROOM

13.6.1 Fuel preparation rooms, shall be fitted with effective mechanical ventilation system of the extraction type, providing a ventilation capacity of at least 30 air changes per hour.

13.6.2 The number and power of the ventilation fans shall be such that the capacity is not reduced by more than 50%, if a fan with a separate circuit from the main switchboard or emergency switchboard or a group of fans with common circuit from the main switchboard or emergency switchboard, is inoperable.

13.6.3 Ventilation systems for fuel preparation rooms, shall be in operation when pumps or compressors are working.

13.7 REGULATIONS FOR BUNKERING STATION

Bunkering stations that are not located on open deck shall be suitably ventilated to ensure that any vapour being released during bunkering operations will be removed outside. If the natural ventilation is not sufficient, mechanical ventilation shall be provided in accordance with the risk assessment required by 8.3.1.1.

C13.7 *Recommendation for performance of risk assessment is explained in IACS Rec. 146 (Aug 2016).*

26) Refer to IEC 60092-502:1999 Electrical Installations in Ships – Tankers – Special Features, table 5.

27) Refer to IEC 60079-10-1

13.8 REGULATIONS FOR DUCTS AND DOUBLE PIPES

13.8.1 Ducts and double pipes containing fuel piping shall be fitted with effective mechanical ventilation system of the extraction type, providing a ventilation capacity of at least 30 air changes per hour. This is not applicable to double pipes in the engine-room if fulfilling 9.6.1.1.

13.8.2 The ventilation system for double piping and for gas valve unit spaces in gas safe engine-rooms shall be independent of all other ventilation systems.

NOTE: (UI GF11, Dec 2017) Double wall piping and gas valve unit spaces in gas safe engine-rooms are considered an integral part of the fuel supply systems and, therefore, their ventilation system does not need to be independent of other fuel supply ventilation systems provided such fuel supply systems contain only gaseous fuel.

C13.8.2 *Tank connection spaces and other spaces, where there is a potential for liquefied gas fuel leakages, shall have the ventilation system independent of ventilation systems for the double wall piping or duct.*

13.8.3 The ventilation inlet for the double wall piping or duct shall always be located in a non-hazardous area in open air away from ignition sources. The inlet opening shall be fitted with a suitable wire mesh guard and protected from ingress of water. (UIGF 12, Dec 2017)

C13.8.3 *The outlet opening shall be covered by a protection screen and placed in a position where no flammable gas-air mixture may be ignited.*

13.8.4 The capacity of the ventilation for a pipe duct or double wall piping may be below 30 air changes per hour if a flow velocity of minimum 3 m/s is ensured. The flow velocity shall be calculated for the duct with fuel pipes and other components installed.

14 ELECTRICAL INSTALLATIONS

14.1 GOAL

The goal of this Section is to provide for electrical installations that minimizes the risk of ignition in the presence of a flammable atmosphere.

14.2 FUNCTIONAL REQUIREMENTS

This Section is related to functional requirements in 3.2.1, 3.2.2, 3.2.4, 3.2.7, 3.2.8, 3.2.11, 3.2.13 and 3.2.16 to 3.2.18. In particular the following apply:

Electrical generation and distribution systems, and associated control systems, shall be designed such that a single fault will not result in the loss of ability to maintain fuel tank pressures and hull structure temperature within normal operating limits.

14.3 REGULATIONS – GENERAL

14.3.1 Electrical installations shall be in compliance with a standard at least equivalent to those acceptable to the Organization. [28)]

14.3.2 Electrical equipment or wiring shall not be installed in hazardous areas unless essential for operational purposes or safety enhancement.

14.3.3 Where electrical equipment is installed in hazardous areas as provided in 14.3.2 it shall be selected, installed and maintained in accordance with standards at least equivalent to those acceptable to the Organization. [29)]

Equipment for hazardous areas shall be evaluated and certified or listed by an accredited testing authority or notified body recognized by the Administration.

14.3.4 Failure modes and effects of single failure for electrical generation and distribution systems in 14.2 shall be analysed and documented to be at least equivalent to those acceptable to the Organization. [30)]

14.3.5 The lighting system in hazardous areas shall be divided between at least two branch circuits. All switches and protective devices shall interrupt all poles or phases and shall be located in a non-hazardous area.

14.3.6 The installation on board of the electrical equipment units shall be such as to ensure the safe bonding to the hull of the units themselves.

14.3.7 Arrangements shall be made to alarm in low-liquid level and automatically shutdown the motors in the event of low-liquid level. The automatic shutdown may be accomplished by sensing low pump discharge pressure, low motor current, or low-liquid level. This shutdown shall give an audible and visual alarm on the navigation bridge, continuously manned central control station or onboard safety centre.

14.3.8 Submerged fuel pump motors and their supply cables may be fitted in liquefied gas fuel containment systems. Fuel pump motors shall be capable of being isolated from their electrical supply during gas-freeing operations.

14.3.9 For non-hazardous spaces with access from hazardous open deck where the access is protected by an airlock, electrical equipment which is not of the certified safe type shall be de-energized upon loss of overpressure in the space.

14.3.10 Electrical equipment for propulsion, power generation, manoeuvring, anchoring, and mooring, as well as emergency fire pumps, that are located in spaces protected by airlocks, shall be of a certified safe type.

[28)] Refer to IEC 60092 series standards, as applicable.
[29)] Refer to the recommendation published by the International Electrotechnical Commission, in particular to publication IEC 60092-502:1999.
[30)] Refer to IEC 60812.

15 CONTROL, MONITORING AND SAFETY SYSTEMS

15.1 GOAL

The goal of this Section is to provide for the arrangement of control, monitoring and safety systems that support an efficient and safe operation of the gas-fuelled installation as covered in the other Sections of this Rules.

15.2 FUNCTIONAL REQUIREMENTS

This Section is related to functional requirements in 3.2.1, 3.2.2, 3.2.11, 3.2.13 to 3.2.15, 3.2.17 and 3.2.18. In particular the following apply:

.1 the control, monitoring and safety systems of the gas-fuelled installation shall be so arranged that the remaining power for propulsion and power generation is in accordance with 9.3.1 in the event of single failure;

.2 a gas safety system shall be arranged to close down the gas supply system automatically, upon failure in systems as described in table 1 and upon other fault conditions which may develop too fast for manual intervention;

.3 for ESD protected machinery configurations the safety system shall shutdown gas supply upon gas leakage and in addition disconnect all non-certified safe type electrical equipment in the machinery space;

.4 the safety functions shall be arranged in a dedicated gas safety system that is independent of the gas control system in order to avoid possible common cause failures. This includes power supplies and input and output signal;

.5 the safety systems including the field instrumentation shall be arranged to avoid spurious shutdown, e.g. as a result of a faulty gas detector or a wire break in a sensor loop; and

.6 where two or more gas supply systems are required to meet the regulations, each system shall be fitted with its own set of independent gas control and gas safety systems.

15.3 REGULATIONS – GENERAL

15.3.1 Suitable instrumentation devices shall be fitted to allow a local and a remote reading of essential parameters to ensure a safe management of the whole fuel-gas equipment including bunkering.

15.3.2 A bilge well in each tank connection space of an independent liquefied gas storage tank shall be provided with both a level indicator and a temperature sensor. Alarm shall be given at high level in the bilge well. Low temperature indication shall activate the safety system.

C15.3.2 *(UI GF18, Feb 2019) The level indicator required by 15.3.2 is understood to be required for the purposes of indicating an alarm status only; a level switch (float switch) is an instrument example considered to meet this requirement.*

15.3.3 For tanks not permanently installed in the ship a monitoring system shall be provided as for permanently installed tanks.

15.4 REGULATIONS FOR BUNKERING AND LIQUEFIED GAS FUEL TANK MONITORING

15.4.1 Level indicators for liquefied gas fuel tanks

.1 Each liquefied gas fuel tank shall be fitted with liquid level gauging device(s), arranged to ensure a level reading is always obtainable whenever the liquefied gas fuel tank is operational. The device(s) shall be designed to operate throughout the design pressure range of the liquefied gas fuel tank and at temperatures within the fuel operating temperature range.

.2 Where only one liquid level gauge is fitted it shall be arranged so that it can be maintained in an operational condition without the need to empty or gas-free the tank.

.3 Liquefied gas fuel tank liquid level gauges may be of the following types:

  .1 indirect devices, which determine the amount of fuel by means such as weighing or in-line flow metering; or

  .2 closed devices, which do not penetrate the liquefied gas fuel tank, such as devices using radio-isotopes or ultrasonic devices;

15.4.2 Overflow control

.1 Each liquefied gas fuel tank shall be fitted with a high liquid level alarm operating independently of other liquid level indicators and giving an audible and visual warning when activated.

.2 An additional sensor operating independently of the high liquid level alarm shall automatically actuate a shutoff valve in a manner that will both avoid excessive liquid pressure in the bunkering line and prevent the liquefied gas fuel tank from becoming liquid full.

.3 The position of the sensors in the liquefied gas fuel tank shall be capable of being verified before commissioning. At the first occasion of full loading after delivery and after each dry-docking, testing of high level alarms shall be conducted by raising the fuel liquid level in the liquefied gas fuel tank to the alarm point.

C15.4.2.3 *(UIGF 1, Dec 2017) The expression "each dry-docking" refers to:*

.1 the survey of the outside of the ship's bottom required for the renewal of the Cargo Ship Safety Construction Certificate and/or the

Cargo Ship Safety Certificate, for cargo ships.

.2 *the survey of the outside of the ship's bottom to be carried out every 60 months according to IMO Resolution A.1186(33), paragraphs 5.10.1 and 5.10.2), as may be amended, for passenger ships.*

.4 *All elements of the level alarms, including the electrical circuit and the sensor(s), of the high, and overfill alarms, shall be capable of being functionally tested. Systems shall be tested prior to fuel operation in accordance with 18.4.3.*

.5 *Where arrangements are provided for overriding the overflow control system, they shall be such that inadvertent operation is prevented. When this override is operated continuous visual indication is to be provided at the navigation bridge, continuously manned central control station or onboard safety centre.*

15.4.3 The vapour space of each liquefied gas fuel tank shall be provided with a direct reading gauge. Additionally, an indirect indication is to be provided on the navigation bridge, continuously manned central control station or onboard safety centre.

15.4.4 The pressure indicators shall be clearly marked with the highest and lowest pressure permitted in the liquefied gas fuel tank.

15.4.5 A high-pressure alarm and, if vacuum protection is required, a low-pressure alarm shall be provided on the navigation bridge and at a continuously manned central control station or onboard safety centre. Alarms shall be activated before the set pressures of the safety valves are reached.

15.4.6 Each fuel pump discharge line and each liquid and vapour fuel manifold shall be provided with at least one local pressure indicator.

15.4.7 Local-reading manifold pressure indicator shall be provided to indicate the pressure between ship's manifold valves and hose connections to the shore.

15.4.8 Fuel storage hold spaces and interbarrier spaces without open connection to the atmosphere shall be provided with pressure indicator.

15.4.9 At least one of the pressure indicators provided shall be capable of indicating throughout the operating pressure range.

15.4.10 For submerged fuel-pump motors and their supply cables, arrangements shall be made to alarm in low-liquid level and automatically shutdown the motors in the event of low-liquid level. The automatic shutdown may be accomplished by sensing low pump discharge pressure, low motor current, or low-liquid level. This shutdown shall give an audible and visual alarm on the navigation bridge, continuously manned central control station or onboard safety centre.

15.4.11 Except for independent tanks of type C supplied with vacuum insulation system and pressure build-up fuel discharge unit, each fuel tank shall be provided with devices to measure and indicate the temperature of the fuel in at least three locations; at the bottom and middle of the tank as well as the top of the tank below the highest allowable liquid level.

15.5 REGULATIONS FOR BUNKERING CONTROL

15.5.1 Control of the bunkering shall be possible from a safe location remote from the bunkering station. At this location the tank pressure, tank temperature if required by 15.4.11, and tank level shall be monitored. Remotely controlled valves required by 8.5.3 and 11.5.7 shall be capable of being operated from this location. Overfill alarm and automatic shutdown shall also be indicated at this location.

15.5.2 If the ventilation in the ducting enclosing the bunkering lines stops, an audible and visual alarm shall be provided at the bunkering control location, see also 15.8.

15.5.3 If gas is detected in the ducting around the bunkering lines an audible and visual alarm and emergency shutdown shall be provided at the bunkering control location.

15.6 REGULATIONS FOR GAS COMPRESSOR MONITORING

15.6.1 Gas compressors shall be fitted with audible and visual alarms both on the navigation bridge and in the engine control room. As a minimum the alarms shall include low gas input pressure, low gas output pressure, high gas output pressure and compressor operation.

15.6.2 Temperature monitoring for the bulkhead shaft glands and bearings shall be provided, which automatically give a continuous audible and visual alarm on the navigation bridge or in a continuously manned central control station.

15.7 REGULATIONS FOR GAS ENGINE MONITORING

In addition to the instrumentation provided in accordance with part C of SOLAS chapter II-1, indicators shall be fitted on the navigation bridge, the engine control room, and the manoeuvring platform for:

.1 operation of the engine in case of gas-only engines; or

.2 operation and mode of operation of the engine in the case of dual fuel engines.

15.8 REGULATIONS FOR GAS DETECTION

15.8.1 Permanently installed gas detectors shall be fitted in:

.1 the tank connection spaces;

.2 all ducts around fuel pipes;

.3 machinery spaces containing gas piping, gas equipment or gas consumers;

.4 compressor rooms and fuel preparation rooms;

.5 other enclosed spaces containing fuel piping or other fuel equipment without ducting;

.6 other enclosed or semi-enclosed spaces where fuel vapours may accumulate including interbarrier spaces and fuel storage hold spaces of independent tanks other than type C;

.7 airlocks;

.8 gas heating circuit expansion tanks;

.9 motor rooms associated with the fuel systems; and

.10 or at ventilation inlets to accommodation and machinery spaces if required based on the risk assessment required in 4.2.

15.8.2 In each ESD-protected machinery space, redundant gas detection systems shall be provided.

15.8.3 The number of detectors in each space shall be considered taking into account the size, layout and ventilation of the space.

15.8.4 The detection equipment shall be located where gas may accumulate and in the ventilation outlets. Gas dispersal analysis or a physical smoke test shall be used to find the best arrangement.

15.8.5 Gas detection equipment shall be designed, installed and tested in accordance with a recognized standard.[31)]

15.8.6 An audible and visible alarm shall be activated at a gas vapour concentration of 20% of the lower explosion limit (LEL). The safety system shall be activated at 40% of LEL at two detectors (see footnote 1 in Table 15-1).

15.8.7 For ventilated ducts around gas pipes in the machinery spaces containing gas-fuelled engines, the alarm limit can be set to 30% LEL. The safety system shall be activated at 60% of LEL at two detectors (see footnote 1 in Table 15-1).

15.8.8 Audible and visible alarms from the gas detection equipment shall be located on the navigation bridge or in the continuously manned central control station.

15.8.9 Gas detection required by this section shall be continuous without delay.

15.9 REGULATIONS FOR FIRE DETECTION

Required safety actions at fire detection in the machinery space containing gas-fuelled engines and rooms containing independent tanks for fuel storage hold spaces are given in Table 1 below.

15.10 REGULATIONS FOR VENTILATION

15.10.1 Any loss of the required ventilating capacity shall give an audible and visual alarm on the navigation bridge or in a continuously manned central control station or safety centre.

C15.10.1 *(UI GF15, July 2018) Acceptable means to confirm that the ventilation system has the required ventilating capacity in operation are:*

.1 monitoring of the ventilation electric motor or fan operation combined with underpressure indication; or

.2 monitoring of the ventilation electric motor or fan operation combined with ventilation flow indication; or

.3 monitoring of ventilation flow rate to indicate that the required air flow rate is established.

Alternative solutions are subject to special consideration by the Register in each particular case.

15.10.2 For ESD protected machinery spaces the safety system shall be activated upon loss of ventilation in engine-room.

15.11 REGULATIONS ON SAFETY FUNCTIONS OF FUEL SUPPLY SYSTEMS

15.11.1 If the fuel supply is shut off due to activation of an automatic valve, the fuel supply shall not be opened until the reason for the disconnection is ascertained and the necessary precautions taken. A readily visible notice giving instruction to this effect shall be placed at the operating station for the shutoff valves in the fuel supply lines.

15.11.2 If a fuel leak leading to a fuel supply shutdown occurs, the fuel supply shall not be operated until the leak has been found and dealt with. Instructions to this effect shall be placed in a prominent position in the machinery space.

15.11.3 A caution placard or signboard shall be permanently fitted in the machinery space containing gas-fuelled engines stating that heavy lifting, implying danger of damage to the fuel pipes, shall not be done when the engine(s) is running on gas.

15.11.4 Compressors, pumps and fuel supply shall be arranged for manual remote emergency stop from the following locations as applicable:

.1 navigation bridge;

.2 cargo control room;

.3 onboard safety centre;

.4 engine control room;

.5 fire control station; and

.6 adjacent to the exit of fuel preparation rooms.

The gas compressor shall also be arranged for manual local emergency stop.

[31)] Refer to IEC 60079-29-1 – Explosive atmospheres – Gas detectors – Performance requirements of detectors for flammable detectors.

Table 15-1
Monitoring of gas supply system to engines

Parameter	Alarm	Automatic shutdown of tank valve (6)	Automatic shutdown of gas supply to machinery space containing gas-fueled engines	Comments
Gas detection in tank connection space at 20% LEL	X			
Gas detection on two detectors (1) in tank connection space at 40% LEL	X	X		
Fire detection in fuel storage hold space	X			
Fire detection in ventilation trunk for fuel containment system below deck	X			
Bilge well high level in tank connection space	X			
Bilge well low temperature in tank connection space	X	X		
Gas detection in duct between tank and machinery space containing gas-fueled engines at 20% LEL	X			
Gas detection on two detectors (1) in duct between tank and machinery space containing gas-fueled engines at 40% LEL	X	X (2)		
Gas detection in fuel preparation room at 20% LEL	X			
Gas detection on two detectors (1) in fuel preparation room at 40% LEL	X	X (2)		
Gas detection in duct inside machinery space containing gas-fueled engines at 30% LEL	X			If double pipe fitted in machinery space containing gas-fueled engines
Gas detection on two detectors (1) in duct inside machinery space containing gas-fueled engines at 60% LEL	X		X (1)	If double pipe fitted in machinery space containing gas-fueled engines
Gas detection in ESD protected machinery space containing gas-fueled engines at 20% LEL	X			
Gas detection on two detectors1) in ESD protected machinery space containing gas-fueled engines at 40% LEL	X		X	It shall also disconnect non-certified safe electrical equipment in machinery space containing gas-fueled engines
Loss of ventilation in duct between tank and machinery space containing gas-fueled engines	X		X (2)	
Loss of ventilation in duct inside machinery space containing gas-fueled engines (5)	X		X (3)	If double pipe fitted in machinery space containing gas-fueled engines
Loss of ventilation in ESD protected machinery space containing gas-fueled engines	X		X	
Fire detection in machinery space containing gas-fueled engines	X			
Abnormal gas pressure in gas supply pipe	X			
Failure of valve control actuating medium	X		X (4)	Time delayed as found necessary

Parameter	**Alarm**	**Automatic shutdown of tank valve** (6)	**Automatic shutdown of gas supply to machinery space containing gas-fueled engines**	**Comments**
Automatic shutdown of engine (engine failure)	X		X (4)	
Manually activated emergency shutdown of engine	X		X	

(1) Two independent gas detectors located close to each other are required for redundancy reasons. If the gas detector is of self-monitoring type the installation of a single gas detector can be permitted.

(2) If the tank is supplying gas to more than one engine and the different supply pipes are completely separated and fitted in separate ducts and with the master valves fitted outside of the duct, only the master valve on the supply pipe leading into the duct where gas or loss of ventilation is detected shall close.

(3) If the gas is supplied to more than one engine and the different supply pipes are completely separated and fitted in separate ducts and with the master valves fitted outside of the duct and outside of the machinery space containing gas-fueled engines, only the master valve on the supply pipe leading into the duct where gas or loss of ventilation is detected shall close.

(4) Only double block and bleed valves to close.

(5) If the duct is protected by inert gas (see 9.6.1.1) then loss of inert gas overpressure shall lead to the same actions as given in this table.

(6) Valves referred to in 9.4.1.

ANNEX 1 - STANDARD FOR THE USE OF LIMIT STATE METHODOLOGIES IN THE DESIGN OF FUEL CONTAINMENT SYSTEMS OF NOVEL CONFIGURATION

1 GENERAL

1.1 The purpose of this standard is to provide procedures and relevant design parameters of limit state design of fuel containment systems of a novel configuration in accordance with section 6.4.16.

1.2 Limit state design is a systematic approach where each structural element is evaluated with respect to possible failure modes related to the design conditions identified in 6.4.1.6. A limit state can be defined as a condition beyond which the structure, or part of a structure, no longer satisfies the regulations.

1.3 The limit states are divided into the three following categories:

.1 Ultimate Limit States (ULS), which correspond to the maximum load-carrying capacity or, in some cases, to the maximum applicable strain, deformation or instability in structure resulting from buckling and plastic collapse; under intact (undamaged) conditions;

.2 Fatigue Limit States (FLS), which correspond to degradation due to the effect of cyclic loading; and

.3 Accident Limit States (ALS), which concern the ability of the structure to resist accident situations.

1.4 Section 6.4.1 through to section 6.4.14 shall be complied with as applicable depending on the fuel containment system concept.

2 DESIGN FORMAT

2.1 The design format in this standard is based on a Load and Resistance Factor Design format. The fundamental principle of the Load and Resistance Factor Design format is to verify that design load effects, *Ld*, do not exceed design resistance, *Rd*, for any of the considered failure modes in any scenario:

$Ld < Rd$

A design load *Fdk* is obtained by multiplying the characteristic load by a load factor relevant for the given load category:

$$F_{dk} = \gamma_f \cdot F_k$$

where:

γ_f is load factor; and

F_k is the characteristic load as specified in section 6.4.9 through to section 6.4.12.

A design load effect *Ld* (e.g. stresses, strains, displacements and vibrations) is the most unfavourable combined load effect derived from the design loads, and may be expressed by:

$$L_d = q(F_{d1}, F_{d2}, ..., F_{dN})$$

where q denotes the functional relationship between load and load effect determined by structural analyses.

The design resistance *Rd* is determined as follows:

$$R_d = \frac{R_k}{\gamma_R \cdot \gamma_C}$$

where:

R_k is the characteristic resistance. In case of materials covered by chapter 7, it may be, but not limited to, specified minimum yield stress, specified minimum tensile strength, plastic resistance of cross sections, and ultimate buckling strength;

γ_R is the resistance factor, defined as $\gamma_R = \gamma_m \cdot \gamma_s$;

γ_m is the partial resistance factor to take account of the probabilistic distribution of the material properties (material factor);

γ_s is the partial resistance factor to take account of the uncertainties on the capacity of the structure, such as the quality of the construction, method considered for determination of the capacity including accuracy of analysis; and

γ_C is the consequence class factor, which accounts for the potential results of failure with regard to release of fuel and possible human injury.

2.2 Fuel containment design shall take into account potential failure consequences. Consequence classes are defined in table 1, to specify the consequences of failure when the mode of failure is related to the Ultimate Limit State, the Fatigue Limit State, or the Accident Limit State.

Table 1
Consequence classes

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

3 REQUIRED ANALYSES

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

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

3.3 Fatigue and crack propagation analysis shall be carried out in accordance with paragraph 5.1 of this standard.

4 ULTIMATE LIMIT STATES

4.1 Structural resistance may be established by testing or by complete analysis taking account of both elastic and plastic material properties. Safety margins for ultimate strength shall be introduced by partial factors of safety taking account of the contribution of stochastic nature of loads and resistance (dynamic loads, pressure loads, gravity loads, material strength, and buckling capacities).

4.2 Appropriate combinations of permanent loads, functional loads and environmental loads including sloshing loads shall be considered in the analysis. At least two load combinations with partial load factors as given in table 2 shall be used for the assessment of the ultimate limit states.

Table 2
Partial load factors

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

The load factors for permanent and functional loads in load combination 'a' are relevant for the normally well-controlled and/or specified loads applicable to fuel containment systems such as vapour pressure, fuel weight, system self-weight, etc. Higher load factors may be relevant for permanent and functional loads where the inherent variability and/or uncertainties in the prediction models are higher.

4.3 For sloshing loads, depending on the reliability of the estimation method, a larger load factor may be required by the Administration.

4.4 In cases where structural failure of the fuel containment system are considered to imply high potential for human injury and significant release of fuel, the consequence class factor shall be taken as γ_C = 1.2. This value may be reduced if it is justified through risk analysis and subject to the approval by the Administration. The risk analysis shall take account of factors including, but not limited to, provision of full or partial secondary barrier to protect hull structure from the leakage and less hazards associated with intended fuel. Conversely, higher values may be fixed by the Administration, for example, for ships carrying more hazardous or higher pressure fuel. The consequence class factor shall in any case not be less than 1.0.

4.5 The load factors and the resistance factors used shall be such that the level of safety is equivalent to that of the fuel containment systems as described in sections 6.4.2.1 to 6.4.2.5. This may be carried out by calibrating the factors against known successful designs.

4.6 The material factor γ_m shall in general reflect the statistical distribution of the mechanical properties of the material and needs to be interpreted in combination with the specified characteristic mechanical properties. For the materials defined in Section 6, the material factor γ_m may be taken as:

1.1 when the characteristic mechanical properties specified by the Administration typically represents the lower 2.5% quantile in the statistical distribution of the mechanical properties; or

1.0 when the characteristic mechanical properties specified by the Administration represents a sufficiently small quantile such that the probability of lower mechanical properties than specified is extremely low and can be neglected.

4.7 The partial resistance factors γ_{si} shall in general be established based on the uncertainties in the capacity of the structure considering construction tolerances, quality of construction, the accuracy of the analysis method applied, etc.

4.7.1 For design against excessive plastic deformation using the limit state criteria given in paragraph 4.8 of this standard, the partial resistance factors γ_{si} shall be taken as follows:

$$\gamma_{s1} = 0.76\frac{B}{k_1}$$

$$\gamma_{s2} = 0.76\frac{D}{k_2}$$

$$k_1 = \mathrm{Min}\left(\frac{R_m}{R_e}\cdot\frac{B}{A};1.0\right)$$

$$k_2 = \mathrm{Min}\left(\frac{R_m}{R_e}\cdot\frac{D}{C};1.0\right)$$

Factors A, B, C and D are defined in 6.4.15.2.3.1. Rm and Re are defined in 6.4.12.1.1.3.

The partial resistance factors given above are the results of calibration to conventional type B independent tanks.

4.8 Design against excessive plastic deformation

4.8.1 Stress acceptance criteria given below refer to elastic stress analyses.

4.8.2 Parts of fuel containment systems where loads are primarily carried by membrane response in the structure shall satisfy the following limit state criteria:

$$\sigma_m \le f$$
$$\sigma_L \le 1.5f$$
$$\sigma_b \le 1.5F$$
$$\sigma_L + \sigma_b \le 1.5F$$

$\sigma_m + \sigma_b \leq 1.5F$

$\sigma_m + \sigma_b + \sigma_g \leq 3.0F$

$\sigma_L + \sigma_b + \sigma_g \leq 3.0F$

where:

σ_m = equivalent primary general membrane stress

σ_L = equivalent primary local membrane stress

σ_b = equivalent primary bending stress

σ_g = equivalent secondary stress

$$f = \frac{R_e}{\gamma_{s1} \cdot \gamma_m \cdot \gamma_C}$$

$$F = \frac{R_e}{\gamma_{s2} \cdot \gamma_m \cdot \gamma_C}$$

GUIDANCE NOTE:

The stress summation described above shall be carried out by summing up each stress component (σ_x, σ_y, τ_{xy}), and subsequently the equivalent stress shall be calculated based on the resulting stress components as shown in the example below.

$$\sigma_L + \sigma_b = \sqrt{(\sigma_{Lx} + \sigma_{bx})^2 - (\sigma_{Lx} + \sigma_{bx})(\sigma_{Ly} + \sigma_{by}) + (\sigma_{Ly} + \sigma_{by})^2 + 3(\tau_{Lxy} + \tau_{bxy})^2}$$

4.8.3 Parts of fuel containment systems where loads are primarily carried by bending of girders, stiffeners, and plates, shall satisfy the following limit state criteria:

$\sigma_{ms} + \sigma_{bp} \leq 1.25F$ (see notes 1, 2)

$\sigma_{ms} + \sigma_{bp} + \sigma_{bs} \leq 1.25F$ (see note 2)

$\sigma_{ms} + \sigma_{bp} + \sigma_{bs} + \sigma_{bt} + \sigma_g \leq 3.0F$

NOTE 1: The sum of equivalent section membrane stress and equivalent membrane stress in primary structure ($\sigma_{ms} + \sigma_{bp}$) will normally be directly available from three-dimensional finite element analyses.

NOTE 2: The coefficient, 1.25, may be modified by the Administration considering the design concept, configuration of the structure, and the methodology used for calculation of stresses.

where:

σ_{ms} = equivalent section membrane stress in primary structure

σ_{bp} = equivalent membrane stress in primary structure and stress in secondary and tertiary structure caused by bending of primary structure

σ_{bs} = section bending stress in secondary structure and stress in tertiary structure caused by bending of secondary structure

σ_{bt} = section bending stress in tertiary structure

σ_g = equivalent secondary stress

$$f = \frac{R_e}{\gamma_{s1} \cdot \gamma_m \cdot \gamma_C}$$

$$F = \frac{R_e}{\gamma_{s2} \cdot \gamma_m \cdot \gamma_C}$$

The stresses σ_{ms}, σ_{bp}, σ_{bs}, and σ_{bt} are defined in 4.8.4

GUIDANCE NOTE:

The stress summation described above shall be carried out by summing up each stress component (σ_x, σ_y, τ_{xy}), and subsequently the equivalent stress shall be calculated based on the resulting stress components.

Skin plates shall be designed in accordance with the requirements of the Administration. When membrane stress is significant, the effect of the membrane stress on the plate bending capacity shall be appropriately considered in addition.

4.8.4 Section stress categories

Normal stress is the component of stress normal to the plane of reference.

Equivalent section membrane stress is the component of the normal stress that is uniformly distributed and equal to the average value of the stress across the cross section of the structure under consideration. If this is a simple shell section, the section membrane stress is identical to the membrane stress defined in paragraph 4.8.2 of this standard.

Section bending stress is the component of the normal stress that is linearly distributed over a structural section exposed to bending action, as illustrated in Figure 1.

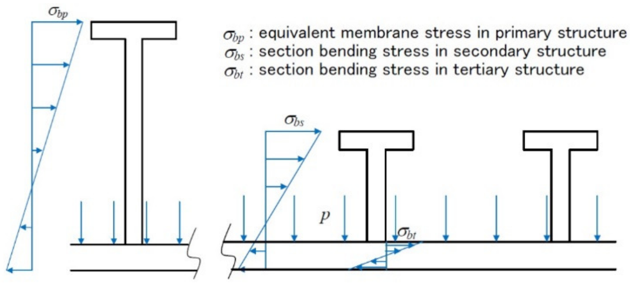


Figure 1

Definition of the three categories of section stress

(Stresses σ_{bp} and σ_{bs} are normal to the cross section shown)

4.9 The same factors γ_c, γ_m, γ_{si} shall be used for design against buckling unless otherwise stated in the applied recognized buckling standard. In any case the overall level of safety shall not be less than given by these factors.

5 FATIGUE LIMIT STATES

5.1 Fatigue design condition as described in 6.4.12.2 shall be complied with as applicable depending on the fuel containment system concept. Fatigue analysis is required for the fuel containment system designed under 6.4.16 and this standard.

5.2 The load factors for FLS shall be taken as 1.0 for all load categories.

5.3 Consequence class factor □c and resistance factor γ_R shall be taken as 1.0.

5.4 Fatigue damage shall be calculated as described in 6.4.12.2.2 to 6.4.12.2.2.5. The calculated cumulative fatigue damage ratio for the fuel containment systems shall be less than or equal to the values given in table 3.

Table 3
Maximum allowable cumulative fatigue damage ratio

	Consequence class		
C_W	Low	Medium	High
	1.0	0.5	0.5 *

* NOTE: Lower value shall be used in accordance with 6.4.12.2.7 to 6.4.12.2.9, depending on the detectability of defect or crack, etc.

5.5 Lower values may be fixed by the Administration.

5.6 Crack propagation analyses are required in accordance with 6.4.12.2.6 to 6.4.12.2.9. The analysis shall be carried out in accordance with methods laid down in a standard recognized by the Administration.

6 ACCIDENT LIMIT STATES

6.1 Accident design condition as described in 6.4.12.3 shall be complied with as applicable, depending on the fuel containment system concept.

6.2 Load and resistance factors may be relaxed compared to the ultimate limit state considering that damages and deformations can be accepted as long as this does not escalate the accident scenario.

6.3 The load factors for ALS shall be taken as 1.0 for permanent loads, functional loads and environmental loads.

6.4 Loads mentioned in 6.4.9.3.3.8 and 6.4.9.5 need not be combined with each other or with environmental loads, as defined in 6.4.9.4.

6.5 Resistance factor γ_R shall in general be taken as 1.0.

6.6 Consequence class factors γ_C shall in general be taken as defined in paragraph 4.4 of this standard, but may be relaxed considering the nature of the accident scenario.

6.7 The characteristic resistance R_k shall in general be taken as for the ultimate limit state, but may be relaxed considering the nature of the accident scenario.

6.8 Additional relevant accident scenarios shall be determined based on a risk analysis.

7 TESTING

7.1 Fuel containment systems designed according to this standard shall be tested to the same extent as described in 16.2, as applicable depending on the fuel containment system concept.

PART B-1

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

16 MANUFACTURE, WORKMANSHIP AND TESTING

16.1 GENERAL

16.1.1 The manufacture, testing, inspection and documentation shall be in accordance with recognized standards and the regulations given in this Rules.

16.1.1 Where post-weld heat treatment is specified or required, the properties of the base material shall be determined in the heat treated condition, in accordance with the applicable tables of Section 7, and the weld properties shall be determined in the heat treated condition in accordance with 16.3. In cases where a post-weld heat treatment is applied, the test regulations may be modified at the discretion of the Administration.

C16.1.2 *Stress relieving (UR G2, Dec 2018, G2.8)*

Tanks made of carbon and carbon-manganese steel shall be thermally stress-relieved after welding if the design temperature is below –10°C. The soaking temperature and holding time shall be according to standard EN 13445-4 Table 10.1-1, or in ASME BPVC VIII Div.1 UCS-56.

The heat treatment shall comply with the requirements in Part 10, Sec. 1.6.

For nickel alloy steels and austenitic stainless steel, the requirements for heat treatment will be considered in each case separately.

In the case of large pressure vessels of carbon or carbon-manganese steel for which it is difficult to perform the heat treatment, mechanical stress relieving by pressurizing may be carried out as an alternative to the heat treatment subject to the appropriate procedure is approved by the Register.

C16.1.3 *Piping manufacture and joining requirements (UR G3, Jan 2016, G3.7.2, G3.7.3 and G3.7.5)*

The requirements apply to piping that contains fuel in gaseous and liquefied state.

The piping system shall be joined by welding with a minimum of flange connections. Gaskets shall be of a type designed to prevent blow-out.

.1 The following types of connections may be considered for direct connection of pipe lengths (without flanges):

.1 Butt-welded joints with complete penetration at the root may be used in all applications.
For design temperatures lower than -10°C, butt welds shall be either double welded or equivalent to a double welded butt joint. This may be accomplished by use of a backing ring, consumable insert or inert gas back-up on the first pass.
For design pressures in excess of 10 bar and design temperatures lower than -10°C, backing rings shall be removed.

.2 Slip-on welded joints with sleeves and related welding, having dimensions in accordance with recognized standards, shall only be used for instrument lines and open-ended lines with an external diameter of 50 mm or less and design temperatures not lower than -55°C.
Slip-on welded joints may be accepted for open ended piping above 50 mm diameter, given that the strength of the piping with such a joint is sufficient for the maximum pressure it will be subjected to, and that NDT is carried out to verify the integrity.

.3 Screwed couplings complying with recognized standards shall only be used for accessory lines and instrumentation lines with external diameters of 25 mm or less.

.2 Flanges in fuel piping shall be of the welding neck, slip-on or socket welding type.
For all piping (except open ended lines), the following restrictions apply:

.1 For design temperatures < -55°C only welding neck flanges shall be used.

.2 For design pressure above 10 bar, only welding neck flanges shall be used.

.3 For design temperatures < -10°C slip-on flanges shall not be used in nominal sizes above 100 mm and socket welding flanges shall not be used in nominal sizes above 50 mm.

.3 Flanges in secondary enclosures for fuel piping shall be of the welding neck, slip-on or socket welding type.

.4 Bellows are to be protected against icing, if necessary.

.5 Slip joints are not to be used except within the tanks.

C16.1.4 *Tank manufacture (G2.7 and G2.9.1)*

The tanks shall be manufactured by works approved by the Register for manufacturing of class I pressure vessels.

The workmanship shall comply with the requirements in Part 10 Sec.1.5, for class I pressure vessels. Special precautions shall be taken to avoid notches as undercutting, excessive reinforcement, cracks, and arc flashes.

All longitudinal and circumferential welds, nozzle and flange welds included, shall be full penetration welds, unless specially approved for small nozzle diameters. Full penetration butt welds are to be obtained by double welding or by the use of backing rings. If used backing rings are to be removed except for very small process pressure vessels.

Shells for welded tanks shall be within the limits for out-of-roundness and local departure from circularity after heat treatment has been carried out as follows:

.1 the difference between the maximum and minimum diameter at any cross section of a shell welded longitudinally, shall not

exceed 1% of the nominal internal diameter, D, with a maximum of: (D + 1250) / 200 (mm).

.2 *Irregularities in profile shall not exceed the 5% of the plate thickness plus 3 mm, or 0.2% of D, whichever is the greater, with a maximum equal to the plate thickness. There shall be no flat or peak at joints, and any local departure from circularity shall be gradual. This maximum value may be increased by 25%, if the length of the irregularities does not exceed the lesser of 1 metre and one quarter of the length of the shell between two circumferential joints.*

16.2 GENERAL TEST REGULATIONS AND SPECIFICATIONS

16.2.1 Tensile test

16.2.1.1 Tensile testing shall be carried out in accordance with recognized standards.

16.2.1.2 Tensile strength, yield stress and elongation shall be to the satisfaction of the Administration. For carbon-manganese steel and other materials with definitive yield points, consideration shall be given to the limitation of the yield to tensile ratio.

16.2.2 Toughness test

16.2.2.1 Acceptance tests for metallic materials shall include Charpy V-notch toughness tests unless otherwise specified by the Administration. The specified Charpy V-notch regulations are minimum average energy values for three full size (10 mm × 10 mm) specimens and minimum single energy values for individual specimens. Dimensions and tolerances of Charpy V-notch specimens shall be in accordance with recognized standards. The testing and regulations for specimens smaller than 5.0 mm in size shall be in accordance with recognized standards. Minimum average values for sub-sized specimens shall be:

Charpy V-notch specimen size (mm)	Minimum average energy of three specimens
10 x 10	KV
10 x 7.5	5/6 KV
10 x 5.0	2/3 KV

where:

KV = the energy values (J) specified in tables 7.1 to 7.4.

Only one individual value may be below the specified average value, provided it is not less than 70% of that value.

16.2.2.2 For base metal, the largest size Charpy V-notch specimens possible for the material thickness shall be machined with the specimens located as near as practicable to a point midway between the surface and the centre of the thickness and the length of the notch perpendicular to the surface as shown in Figure 16.1.

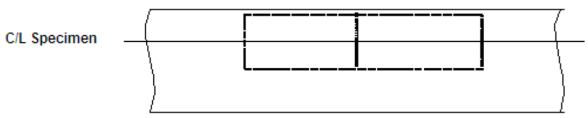


Figure 16.1
Orientation of base metal test specimen

16.2.2.3 For a weld test specimen, the largest size Charpy V-notch specimens possible for the material thickness shall be machined, with the specimens located as near as practicable to a point midway between the surface and the centre of the thickness. In all cases the distance from the surface of the material to the edge of the specimen shall be approximately 1 mm or greater. In addition, for double-V butt welds, specimens shall be machined closer to the surface of the second welded section. The specimens shall be taken generally at each of the following locations, as shown in figure 16.2, on the centreline of the welds, the fusion line and 1 mm, 3 mm and 5 mm from the fusion line.

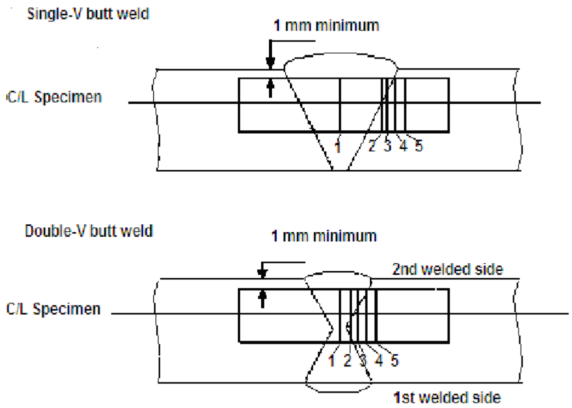


Figure 16.2
Orientation of weld test specimen

Notch locations in figure 16.2:

.1 centreline of the weld;
.2 on fusion line;
.3 in heat-affected zone (HAZ), 1 mm from fusion line;
.4 in HAZ, 3 mm from fusion line; and
.5 in HAZ, 5 mm from fusion line.

16.2.2.4 If the average value of the three initial Charpy V-notch specimens fails to meet the stated regulations, or the value for more than one specimen is below the required average value, or when the value for one specimen is below the minimum value permitted for a single specimen, three additional specimens from the same material may be tested and the results combined with those previously obtained to form a new average. If this new average complies with the regulations and if no more than two individual results are lower, than the required average and no more than one result is lower than the required value for a single specimen, the piece or batch may be accepted.

16.2.3 Bend test

16.2.3.1 The bend test may be omitted as a material acceptance test but is required for weld tests. Where a bend test is performed, this shall be done in accordance with recognized standards.

16.2.3.2 The bend tests shall be transverse bend tests, which may be face, root or side bends at the discretion of the Administration. However, longitudinal bend tests may be required in lieu of transverse bend tests in cases where the base material and weld metal have different strength levels.

16.2.4 Section observation and other testing

Macrosection, microsection observations and hardness tests may also be required by the Administration, and they shall be carried out in accordance with recognized standards, where required.

16.3 WELDING OF METALLIC MATERIALS AND NON-DESTRUCTIVE TESTING FOR THE FUEL CONTAINMENT SYSTEM

16.3.1 General

This section shall apply to primary and secondary barriers only, including the inner hull where this forms the secondary barrier. Acceptance testing is specified for carbon, carbon-manganese, nickel alloy and stainless steels, but these tests may be adapted for other materials. At the discretion of the Administration, impact testing of stainless steel and aluminium alloy weldments may be omitted and other tests may be specially required for any material.

16.3.2 Welding consumables

Consumables intended for welding of fuel tanks shall be in accordance with recognized standards. Deposited weld metal tests and butt weld tests shall be required for all consumables. The results obtained from tensile and Charpy V-notch impact tests shall be in accordance with recognized standards. The chemical composition of the deposited weld metal shall be recorded for information.

16.3.3 Welding procedure tests for fuel tanks and process pressure vessels

16.3.3.1 Welding procedure tests for fuel tanks and process pressure vessels are required for all butt welds.

16.3.3.2 The test assemblies shall be representative of:

- .1 each base material;
- .2 each type of consumable and welding process; and
- .3 each welding position.

16.3.3.3 For butt welds in plates, the test assemblies shall be so prepared that the rolling direction is parallel to the direction of welding. The range of thickness qualified by each welding procedure test shall be in accordance with recognized standards. Radiographic or ultrasonic testing may be performed at the option of the fabricator.

16.3.3.4 The following welding procedure tests for fuel tanks and process pressure vessels shall be done in accordance with 16.2 with specimens made from each test assembly:

- .1 cross-weld tensile tests;
- .2 longitudinal all-weld testing where required by the recognized standards;
- .3 transverse bend tests, which may be face, root or side bends. However, longitudinal bend tests may be required in lieu of transverse bend tests in cases where the base material and weld metal have different strength levels;
- .4 one set of three Charpy V-notch impacts, generally at each of the following locations, as shown in figure 16.2:
  - .1 centreline of the welds;
  - .2 fusion line;
  - .3 1 mm from the fusion line;
  - .4 3 mm from the fusion line; and
  - .5 5 mm from the fusion line;
- .5 macrosection, microsection and hardness survey may also be required.

16.3.3.5 Each test shall satisfy the following:

- .1 tensile tests: cross-weld tensile strength is not to be less than the specified minimum tensile strength for the appropriate parent materials. For materials such as aluminium alloys, reference shall be made to 6.4.12.1.1.3 with regard to the regulations for weld metal strength of under-matched welds (where the weld metal has a lower tensile strength than the parent metal). In every case, the position of fracture shall be recorded for information;
- .2 bend tests: no fracture is acceptable after a 180° bend over a former of a diameter four times the thickness of the test pieces; and
- .3 Charpy V-notch impact tests: Charpy V-notch tests shall be conducted at the temperature prescribed for the base material being joined. The results of weld metal impact tests, minimum average energy (KV), shall be no less than 27 J. The weld metal regulations for sub-size specimens and single energy values shall be in accordance with 16.2.2. The results of fusion line and heat affected zone impact tests shall show a minimum average energy (KV) in accordance with the transverse or longitudinal regulations of the base material, whichever is applicable, and for sub-size specimens, the minimum average energy (KV) shall be in accordance with 16.2.2. If the material thickness does not permit machining either full-size or standard sub-size specimens, the testing procedure and acceptance standards shall be in accordance with recognized standards.

16.3.3.6 Procedure tests for fillet welding shall be in accordance with recognized standards. In such cases, consumables shall be so selected that exhibit satisfactory impact properties.

16.3.4 Welding procedure tests for piping

Welding procedure tests for piping shall be carried out and shall be similar to those detailed for fuel tanks in 16.3.3.

16.3.5 Production weld tests

16.3.5.1 For all fuel tanks and process pressure vessels except membrane tanks, production weld tests shall generally be performed for approximately each 50 m of butt-weld joints and shall be representative of each welding position. For secondary barriers, the same type production tests as required for primary tanks shall be performed, except that the number of tests may be reduced subject to agreement with the Administration. Tests, other than those specified in 16.3.5.2 to 16.3.5.5 may be required for fuel tanks or secondary barriers.

16.3.5.2 The production tests for types A and B independent tanks shall include bend tests and, where required for procedure tests, one set of three Charpy V-notch tests. The tests shall be made for each 50 m of weld. The Charpy V-notch tests shall be made with specimens having the notch alternately located in the centre of the weld and in the heat affected zone (most critical location based on procedure qualification results). For austenitic stainless steel, all notches shall be in the centre of the weld.

16.3.5.3 For type C independent tanks and process pressure vessels, transverse weld tensile tests are required in addition to the tests listed in 16.3.5.2. Tensile tests shall meet regulation 16.3.3.5.

16.3.5.4 The quality assurance/quality control (QA/QC) program shall ensure the continued conformity of the production welds as defined in the material manufacturers quality manual (QM).

16.3.5.5 The test regulations for membrane tanks are the same as the applicable test regulations listed in 16.3.3.

16.3.6 Non-destructive testing

16.3.6.1 All test procedures and acceptance standards shall be in accordance with recognized standards, unless the designer specifies a higher standard in order to meet design assumptions. Radiographic testing shall be used in principle to detect internal defects. However, an approved ultrasonic test procedure in lieu of radiographic testing may be conducted, but in addition supplementary radiographic testing at selected locations shall be carried out to verify the results. Radiographic and ultrasonic testing records shall be retained.

16.3.6.2 For type A independent tanks where the design temperature is below -20°C, and for type B independent tanks, regardless of temperature, all full penetration butt welds of the shell plating of fuel tanks shall be subjected to non-destructive testing suitable to detect internal defects over their full length. Ultrasonic testing in lieu of radiographic testing may be carried out under the same conditions as described in 16.3.6.1.

16.3.6.3 In each case the remaining tank structure, including the welding of stiffeners and other fittings and attachments, shall be examined by magnetic particle or dye penetrant methods as considered necessary.

16.3.6.4 For type C independent tanks, the extent of non-destructive testing shall be total or partial according to recognized standards, but the controls to be carried out shall not be less than the following:

.1 Total non-destructive testing referred to in 6.4.15.3.2.1.3 Radiographic testing:
  - .1 all butt welds over their full length.
    Non-destructive testing for surface crack detection:
  - .2 all welds over 10% of their length;
  - .3 reinforcement rings around holes, nozzles, etc. over their full length.
    As an alternative, ultrasonic testing, as described in 16.3.6.1, may be accepted as a partial substitute for the radiographic testing. In addition, the Administration may require total ultrasonic testing on welding of reinforcement rings around holes, nozzles, etc.

.2 Partial non-destructive testing referred to in 6.4.15.3.2.1.3: Radiographic testing:
  - .1 all butt welded crossing joints and at least 10% of the full length of butt welds at selected positions uniformly distributed.
    Non-destructive testing for surface crack detection:
  - .2 reinforcement rings around holes, nozzles, etc. over their full length.
    Ultrasonic testing:
  - .3 as may be required by the Administration in each instance.

16.3.6.5 The quality assurance/quality control (QA/QC) program shall ensure the continued conformity of the non-destructive testing of welds, as defined in the material manufacturer's quality manual (QM).

16.3.6.6 Inspection of piping shall be carried out in accordance with the regulations of Section 7.

16.3.6.7 The secondary barrier shall be non-destructive tested for internal defects as considered necessary. Where the outer shell of the hull is part of the secondary barrier, all sheer strake butts and the intersections of all butts and seams in the side shell shall be tested by radiographic testing.

16.4 OTHER REGULATIONS FOR CONSTRUCTION IN METALLIC MATERIALS

16.4.1 General

Inspection and non-destructive testing of welds shall be in accordance with regulations in 16.3.5 and 16.3.6. Where higher standards or tolerances are assumed in the design, they shall also be satisfied.

16.4.2 Independent tank

For type C tanks and type B tanks primarily constructed of bodies of revolution the tolerances relating to manufacture, such as out-of-roundness, local deviations from the true form, welded joints alignment and tapering of plates having different thicknesses, shall comply with recognized standards. The tolerances shall also be related to the buckling analysis referred to in 6.4.15.2.3.1 and 6.4.15.3.3.2.

16.4.3 Secondary barriers

During construction the regulations for testing and inspection of secondary barriers shall be approved or accepted by the Administration (see also 6.4.4.5 and 6.4.4.6).

16.4.4 Membrane tanks

The quality assurance/quality control (QA/QC) program shall ensure the continued conformity of the weld procedure qualification, design details, materials, construction, inspection and production testing of components. These standards and procedures shall be developed during the prototype testing programme.

16.5 TESTING

16.5.1 Testing and inspections during construction

16.5.1.1 All liquefied gas fuel tanks and process pressure vessels shall be subjected to hydrostatic or hydro-pneumatic pressure testing in accordance with 16.5.2 to 16.5.5, as applicable for the tank type.

16.5.1.2 All tanks shall be subject to a tightness test which may be performed in combination with the pressure test referred to in 16.5.1.1.

16.5.1.3 The gas tightness of the fuel containment system with reference to 6.3.3 shall be tested.

16.5.1.4 Regulations with respect to inspection of secondary barriers shall be decided by the Administration in each case, taking into account the accessibility of the barrier (see also 6.4.4).

16.5.1.5 The Administration may require that for ships fitted with novel type B independent tanks, or tanks designed according to 6.4.16 at least one prototype tank and its support shall be instrumented with strain gauges or other suitable equipment to confirm stress levels during the testing required in 16.5.1.1. Similar instrumentation may be required for type C independent tanks, depending on their configuration and on the arrangement of their supports and attachments.

16.5.1.6 The overall performance of the fuel containment system shall be verified for compliance with the design parameters during the first LNG bunkering, when steady thermal conditions of the liquefied gas fuel are reached, in accordance with the requirements of the Administration. Records of the performance of the components and equipment, essential to verify the design parameters, shall be maintained on board and be available to the Administration.

16.5.1.7 The fuel containment system shall be inspected for cold spots during or immediately following the first LNG bunkering, when steady thermal conditions are reached. Inspection of the integrity of thermal insulation surfaces that cannot be visually checked shall be carried out in accordance with the requirements of the Administration.

16.5.1.8 Heating arrangements, if fitted in accordance with 6.4.13.1.1.3 and 6.4.13.1.1.4, shall be tested for required heat output and heat distribution.

16.5.2 Type A independent tanks

All type A independent tanks shall be subjected to a hydrostatic or hydro-pneumatic pressure testing. This test shall be performed such that the stresses approximate, as far as practicable, the design stresses, and that the pressure at the top of the tank corresponds at least to the MARVS. When a hydropneumatic test is performed, the conditions shall simulate, as far as practicable, the design loading of the tank and of its support structure including dynamic components, while avoiding stress levels that could cause permanent deformation.

16.5.3 Type B independent tanks

Type B independent tanks shall be subjected to a hydrostatic or hydro-pneumatic pressure testing as follows:

.1 The test shall be performed as required in 16.5.2 for type A independent tanks.

.2 In addition, the maximum primary membrane stress or maximum bending stress in primary members under test conditions shall not exceed 90% of the yield strength of the material (as fabricated) at the test temperature. To ensure that this condition is satisfied, when calculations indicate that this stress exceeds 75% of the yield strength the test of the first of a series of identical tanks shall be monitored by the use of strain gauges or other suitable equipment.

16.5.4 Type C independent tanks and other pressure vessels

16.5.4.1 Each pressure vessel shall be subjected to a hydrostatic test at a pressure measured at the top of the tanks, of not less than 1.5 P_0. In no case during the pressure test shall the calculated primary membrane stress at any point exceed 90% of the yield strength of the material at the test temperature. To ensure that this condition is satisfied where calculations indicate that this stress will exceed 0.75 times the yield strength, the test of the first of a series of identical tanks shall be monitored by the use of strain gauges or other suitable equipment in pressure vessels other than simple cylindrical and spherical pressure vessels.

16.5.4.2 The temperature of the water used for the test shall be at least 30°C above the nil-ductility transition temperature of the material, as fabricated.

16.5.4.3 The pressure shall be held for 2 hours per 25 mm of thickness, but in no case less than 2 hours.

16.5.4.4 Where necessary for liquefied gas fuel pressure vessels, a hydro-pneumatic test may be carried out under the conditions prescribed in 16.5.4.1 to 16.5.4.3.

16.5.4.5 Special consideration may be given to the testing of tanks in which higher allowable stresses are used, depending on service temperature. However, regulation in 16.5.4.1 shall be fully complied with.

16.5.4.6 After completion and assembly, each pressure vessel and its related fittings shall be subjected to an adequate tightness test, which may be performed in combination with the pressure testing referred to in 16.5.4.1 or 16.5.4.4 as applicable.

16.5.4.7 Pneumatic testing of pressure vessels other than liquefied gas fuel tanks shall be considered on an individual case basis. Such testing shall only be permitted for those vessels designed or supported such that they cannot be safely filled with water, or for those vessels that cannot be dried and are to be used in a service where traces of the testing medium cannot be tolerated.

16.5.5 Membrane tanks

16.5.5.1 Design development testing

16.5.5.1.1 The design development testing required in 6.4.15.4.1.2 shall include a series of analytical and physical models of both the primary and secondary barriers, including corners and joints, tested to verify that they will withstand the expected combined strains due to static, dynamic and thermal loads at all filling levels. This will culminate in the construction of a prototype scaled model of the complete liquefied gas fuel containment system. Testing conditions considered in the analytical and physical model shall represent the most extreme service conditions the liquefied gas fuel containment system will be likely to encounter over its life. Proposed acceptance criteria for periodic testing of secondary barriers required in 6.4.4 may be based on the results of testing carried out on the prototype scaled model.

16.5.5.1.2 The fatigue performance of the membrane materials and representative welded or bonded joints in the membranes shall be determined by tests. The ultimate strength and fatigue performance of arrangements for securing the thermal insulation system to the hull structure shall be determined by analyses or tests.

16.5.5.2 Testing

.1 In ships fitted with membrane liquefied gas fuel containment systems, all tanks and other spaces that may normally contain liquid and are adjacent to the hull structure supporting the membrane, shall be hydrostatically tested.

.2 All hold structures supporting the membrane shall be tested for tightness before installation of the liquefied gas fuel containment system.

.3 Pipe tunnels and other compartments that do not normally contain liquid need not be hydrostatically tested.

16.6 WELDING, POST-WELD HEAT TREATMENT AND NON-DESTRUCTIVE TESTING

16.6.1 General

Welding shall be carried out in accordance with 16.3.

16.6.2 Post-weld heat treatment

Post-weld heat treatment shall be required for all butt welds of pipes made with carbon, carbon-manganese and low alloy steels. The Administration may waive the regulations for thermal stress relieving of pipes with wall thickness less than 10 mm in relation to the design temperature and pressure of the piping system concerned.

16.6.3 Non-destructive testing

In addition to normal controls before and during the welding, and to the visual inspection of the finished welds, as necessary for proving that the welding has been carried out correctly and according to the regulations in this paragraph, the following tests shall be required:

.1 100% radiographic or ultrasonic inspection of butt-welded joints for piping systems with;

  .1 design temperatures colder than minus 10°C; or

  .2 design pressure greater than 1.0 MPa; or

  .3 gas supply pipes in ESD protected machinery spaces; or

  .4 inside diameters of more than 75 mm; or

  .5 wall thicknesses greater than 10 mm.

.2 When such butt welded joints of piping sections are made by automatic welding procedures approved by the Administration, then a progressive reduction in the extent of radiographic or ultrasonic inspection can be agreed, but in no case to less than 10% of each joint. If defects are revealed the extent of examination shall be increased to 100% and shall include inspection of previously accepted welds. This approval can only be granted if well- documented quality assurance procedures and records are available to assess the ability of the manufacturer to produce satisfactory welds consistently.

.3 The radiographic or ultrasonic inspection regulation may be reduced to 10% for butt-welded joints in the outer pipe of double-walled fuel piping.

.4 For other butt-welded joints of pipes not covered by 16.6.3.1 and 16.6.3.3, spot radiographic or ultrasonic inspection or other non-destructive tests shall be carried out depending upon service, position and materials. In general, at least 10% of butt-welded joints of pipes shall be subjected to radiographic or ultrasonic inspection.

C16.6.3.5 *For secondary enclosures located inside the vacuum space of vacuum insulated tanks, the requirements in .1 applies. The extent of examination may be reduced based on special consideration.*

C16.6.3 *The radiographs shall be assessed according to ISO 10675 and shall at least meet the criteria for level 1. Ultrasonic testing shall be assessed according to ISO 11666 and shall at least meet the criteria for level 2.*

16.7 TESTING REGULATIONS

16.7.1 Type testing of piping components

Valves

Each type of piping component intended to be used at a working temperature below minus 55°C shall be subject to the following type tests:

.1 Each size and type of valve shall be subjected to seat tightness testing over the full range of operating pressures and temperatures, at intervals, up to the rated design pressure of the valve. Allowable leakage rates shall be to the requirements of the Administration During the testing satisfactory operation of the valve shall be verified.

.2 The flow or capacity shall be certified to a recognized standard for each size and type of valve.

.3 Pressurized components shall be pressure tested to at least 1.5 times the design pressure.

.4 For emergency shutdown valves, with materials having melting temperatures lower than 925°C, the type testing shall include a fire test to a standard at least equivalent to those acceptable to the Organization. [32]

C16.7.1.1 *See also IACS UR G 3.6.1.1.*

C16.7.1.2 *All valves shall be subject to production testing as given in IACS UR G 3.6.1.2.*

16.7.2 Expansion bellows

The following type tests shall be performed on each type of expansion bellows intended for use on fuel piping outside the fuel tank as found acceptable in 7.3.6.4.3.1.3 and where required by the Administration, on those installed within the fuel tanks:

.1 Elements of the bellows, not pre-compressed, but axially restrained shall be pressure tested at not less than five times the design pressure without bursting. The duration of the test shall not be less than five minutes.

.2 A pressure test shall be performed on a type expansion joint, complete with all the accessories such as flanges, stays and articulations, at the minimum design temperature and twice the design pressure at the extreme displacement conditions recommended by the manufacturer without permanent deformation.

.3 A cyclic test (thermal movements) shall be performed on a complete expansion joint, which shall withstand at least as many cycles under the conditions of pressure, temperature, axial movement, rotational movement and transverse movement as it will encounter in actual service. Testing at ambient temperature is permitted when this testing is at least as severe as testing at the service temperature.

.4 A cyclic fatigue test (ship deformation, ship accelerations and pipe vibrations) shall be performed on a complete expansion joint, without internal pressure, by simulating the bellows movement corresponding to a compensated pipe length, for at least 2,000,000 cycles at a frequency not higher than 5 Hz. This test is only required when, due to the piping arrangement, ship deformation loads are actually experienced.

C16.7.2 *See also IACS UR G 3.6.2.*

16.7.3 System testing regulations

16.7.3.1 The regulations for testing in this section apply to fuel piping inside and outside the fuel tanks. However, relaxation from these regulations for piping inside fuel tanks and open ended piping may be accepted by the Administration.

16.7.3.2 After assembly, all fuel piping shall be subjected to a strength test with a suitable fluid. The test pressure shall be at least 1.5 times the design pressure for liquid lines and 1.5 times the maximum system working pressure for vapour lines. When piping systems or parts of systems are completely manufactured and equipped with all fittings, the test may be conducted prior to installation on board the ship. Joints welded on board shall be tested to at least 1.5 times the design pressure.

C16.7.3.2 *Strength test shall be performed on piping before insulation and coating and in the presence of the Register surveyor. Where water cannot be used or the piping cannot be dried prior to putting the system into service, pneumatic testing or alternative testing means may be accepted by the Register.*

16.7.3.3 After assembly on board, the fuel piping system shall be subjected to a leak test using air, or other suitable medium to a pressure depending on the leak detection method applied.

[32] Refer to the recommendations by the International Organization for Standardization, in particular publications:
ISO 19921:2005, Ships and marine technology – Fire resistance of metallic pipe components with resilient and elastomeric seals – Test methods
ISO 19922:2005, Ships and marine technology – Fire resistance of metallic pipe components with resilient and elastomeric seals – Requirements imposed on the test bench

16.7.3.4 In double wall fuel piping systems the outer pipe or duct shall also be pressure tested to show that it can withstand the expected maximum pressure at pipe rupture.

C16.7.3.4 *Secondary enclosures for high-pressure fuel piping shall be pressure tested to the expected maximum pressure at pipe rupture, but minimum 10 bar. Secondary enclosures for low pressure fuel piping shall be tightness tested.*

Secondary enclosures located inside the vacuum space of vacuum insulated tanks shall be pressure tested to 1.5 times the design pressure. Pneumatic testing may be accepted based on a safety assessment of the test procedure.

16.7.3.5 All piping systems, including valves, fittings and associated equipment for handling fuel or vapours, shall be function tested under normal operating conditions not later than at the first bunkering operation, in accordance with the requirements of the Administration.

16.7.3.6 Emergency shutdown valves in liquefied gas piping systems shall close fully and smoothly within 30 s of actuation. Information about the closure time of the valves and their operating characteristics shall be available on board, and the closing time shall be verifiable and repeatable.

C16.7.3.6 *The closing characteristics of shutdown valves in liquefied gas fuel piping systems operated by the safety system shall be tested to demonstrate compliance with 16.7.3.6. The shutdown valves with actuators shall be function tested when the valve is subjected to full working pressure. The testing may be carried out on board after installation.*

16.7.3.7 The closing time of the valve referred to in 8.5.8 and 15.4.2.2 (i.e. time from shutdown signal initiation to complete valve closure) shall not be greater than:

$$\frac{360\,U}{BR}\ (seconds)$$

where:

U = ullage volume at operating signal level (m^3);

BR = maximum bunkering rate agreed between ship and shore facility (m^3/h); or

5 seconds, whichever is the least.

The bunkering rate shall be adjusted to limit surge pressure on valve closure to an acceptable level, taking into account the bunkering hose or arm, the ship and the shore piping systems, where relevant.

C16.7.4 *Pumps: Pumps shall be tested in accordance with IACS UR G 3.6.3.1 and G 3.6.3.2.*

C16.7.5 *Onboard testing: Control, monitoring and safety systems and the functionality of the cause and effect diagram shall be tested on board.*

APPENDIX 1
INTERIM GUIDELINES FOR THE SAFETY OF SHIPS USING METHYL/ETHYL ALCOHOL AS FUEL (MSC.1/Circ.1621)

1 Introduction

1.1 The purpose of these Interim Guidelines is to provide an international standard for ships using methyl/ethyl alcohol as fuel.

1.2 The basic philosophy of these Interim Guidelines is to provide provisions for the arrangement, installation, control and monitoring of machinery, equipment and systems using methyl/ethyl alcohol as fuel to minimize the risk to the ship, its crew and the environment, having regard to the nature of the fuels involved.

1.3 Throughout the development of these Interim Guidelines it was recognized that the provisions therein must be based on sound naval architectural and engineering principles and the best understanding available of current operational experience, field data and research and development. These Interim Guidelines address all areas that need special consideration for the use of methyl/ethyl alcohol as fuel.

1.4 These Interim Guidelines follow the goal-based approach (MSC.1/Circ.1394/Rev.2) by specifying goals and functional requirements for each section forming the basis for the design, construction and operation of ships using methyl/ethyl alcohol as fuel.

1.5 The current version of these Interim Guidelines includes provisions to meet the functional requirements for methyl/ethyl alcohol as fuel.

2 General

2.1 Application

Unless expressly provided otherwise, these Interim Guidelines apply to ships to which part G of SOLAS chapter II-1 applies.

2.2 Definitions

For the purpose of these Interim Guidelines, the terms used have the meanings defined in the following paragraphs. Terms not defined have the same meaning as in SOLAS chapter II-2 and the IGF Code.

2.2.1 *Bunkering* means the transfer of fuel from land-based or floating facilities into ships' permanent tanks or connection of portable tanks to the fuel supply system.

2.2.2 *Fuel* means methyl/ethyl alcohol fuels, containing allowable additives or impurities, suitable for the safe operation on board ships, complying with an international standard.

2.2.3 *Fuel tank* is any integral, independent or portable tank used for storage of fuel. 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 tank is situated. If tank connections are located in the fuel storage hold space, a fuel storage hold space should also be considered as tank connection space. Integral fuel tanks do not have a fuel storage hold space;
- .2 *Cofferdam* is a structural space surrounding a fuel tank which provides an added layer of gas and liquid tightness protection against external fire, and toxic and flammable vapours between the fuel tank and other areas of the ship; 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.

2.2.4 *Fuel preparation space* means any space containing equipment for fuel preparation purposes, such as fuel pumps, fuel valve train, heat exchangers and filters.

2.2.5 *Gas freeing* is the process carried out to achieve a safe tank atmosphere. It includes two distinct operations:

- .1 purging the hazardous tank atmosphere with an inert gas or other suitable medium (e.g. water) to dilute the hazardous vapour to a level where air can be safely introduced; and
- .2 replacing the diluted inert atmosphere with air.

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

2.2.7 *Integral tank* means a fuel-containment envelope tank which forms part of the ship's hull and which may be stressed in the same manner and by the same loads which stress the contiguous hull structure and which is normally essential to the structural completeness of the ship's hull.

2.2.8 *Portable tank* means an independent tank being able to be:

.1 easily connected and disconnected from ship systems; and
.2 easily removed from ship and installed on board ship.

2.2.9 *Single failure* is where loss of intended function occurs through one fault or action.

2.2.10 *Single fuel engine* means an engine capable of operating on a fuel defined as in 2.2.2 only.

2.3 Alternative design

2.3.1 These Interim Guidelines contain functional requirements for all appliances and arrangements related to the usage of methyl/ethyl alcohol fuels.

2.3.2 Appliances and arrangements of methyl/ethyl alcohol fuel systems may deviate from those set out in these Interim Guidelines, provided such appliances and arrangements meet the intent of the goal and functional requirements concerned and provide an equivalent level of safety to the relevant sections.

2.3.3 The equivalence of the alternative design should be demonstrated as specified in SOLAS regulation II-1/55 and approved by the Administration. However, the Administration should 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 these Interim Guidelines.

3 Goal and functional requirements

3.1 Goal

The goal of these Interim Guidelines 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 methyl/ethyl alcohol as fuel.

3.2 Functional requirements

3.2.1 The safety, reliability and dependability of the systems should 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 should be limited to a minimum through arrangement and system design, such as ventilation, detection and safety actions. In the event of fuel leakage or failure of the risk reducing measures, necessary safety actions should be initiated.

3.2.3 The design philosophy should ensure that risk-reducing measures and safety actions for the fuel installation do not lead to an unacceptable loss of power.

3.2.4 Hazardous areas should 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 should be minimized to that required for operational purposes and should be suitably and appropriately certified.

3.2.6 Unintended accumulation of explosive, flammable or toxic vapour and liquid concentrations should be prevented.

3.2.7 System components should be protected against external damage.

3.2.8 Sources of ignition in hazardous areas should be minimized to reduce the probability of fire and explosions.

3.2.9 Safe and suitable fuel supply, storage and bunkering arrangements should be provided, capable of receiving and containing the fuel in the required state without leakage.

3.2.10 Piping systems, containment and overpressure relief arrangements that are of suitable design, material, construction and installation for their intended application should be provided.

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

3.2.12 Suitable control, alarm, monitoring and shutdown systems should be provided to ensure safe and reliable operation.

3.2.13 Fixed fuel vapour and/or leakage detection suitable for all spaces and areas concerned should be arranged.

3.2.14 Fire detection, protection and extinction measures appropriate to the hazards concerned should be provided.

3.2.15 Commissioning, trials and maintenance of fuel systems and fuel utilization machinery should satisfy the goal in terms of safety, availability and reliability.

3.2.16 The technical documentation should 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.

3.2.17 A single failure in a technical system or component should not lead to an unsafe or unreliable situation.

4 General provisions

4.1 Goal

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

4.2 Risk assessment

4.2.1 A risk assessment should be conducted to ensure that risks arising from the use of methyl/ethyl alcohol fuels affecting persons on board, the environment, the structural strength, or the integrity of the ship are addressed. Consideration should be given to the hazards associated with physical layout, operation and maintenance, following any reasonably foreseeable failure.

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

4.3 Limitation of explosion consequences

An explosion in any space containing any potential sources of release [1] and potential ignition sources should 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;

[1] *Double wall fuel pipes are not considered as potential sources of release.*

.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 fire-fighting 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; or
.8 prevent persons' access to life-saving appliances (LSA) or impede escape routes.

5 Ship design and arrangement

5.1 Goal

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

5.2 Functional requirements

This section is related to functional requirements 3.2.1, 3.2.2, 3.2.3, 3.2.4, 3.2.5, 3.2.6, 3.2.7, 3.2.12, 3.2.14 and 3.2.16. In particular, the following applies:

.1 the fuel tank(s) should be located in such a way that the probability of the tank(s) being 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 release sources should be located and arranged such that released fuel, either as vapour or liquid, is led to safe locations;
.3 the access or other openings to spaces containing potential sources of fuel release should be arranged such that flammable, asphyxiating or toxic vapours or liquids cannot escape to spaces that are not designed for the presence of such substances;
.4 fuel piping should be protected against mechanical damage;
.5 the propulsion and fuel supply system should be designed such that safety actions after any fuel leakage do not lead to an unacceptable loss of power; and
.6 the probability of a fire or explosion in a machinery space as a result of a fuel release should be minimized in the design, with special attention to the risk of leakage from pumps, valves and connections.

5.3 General provisions

5.3.1 Tanks containing fuel should not be located within accommodation spaces or machinery spaces of category A.

5.3.2 Integral fuel tanks should be surrounded by protective cofferdams, except on those surfaces bound by shell plating below the lowest possible waterline, other fuel tanks containing methyl/ethyl alcohol, or fuel preparation space.

5.3.3 The fuel containment system should be abaft of the collision bulkhead and forward of the aft peak bulkhead.

5.3.4 Fuel tanks located on open decks should be protected against mechanical damage.

5.3.5 Fuel tanks on open decks should be surrounded by coamings and spills should be collected in a dedicated holding tank.

5.3.6 Special consideration should be given to chemical tankers using methyl/ethyl alcohol cargoes as fuel.

5.4 Independent fuel tanks

5.4.1 Independent tanks may be accepted on open decks or in a fuel storage hold space.

5.4.2 Independent tanks should be fitted with:
.1 mechanical protection of the tanks depending on location and cargo operations;
.2 if located on an open deck, drip tray arrangements for leak containment and water spray systems for emergency cooling; and
.3 if located in a fuel storage hold space, the space should meet the provisions of sections 11 and 13.

5.4.3 Independent fuel tanks should be secured to the ship's structure. The arrangement for supporting and fixing the tanks should be designed for the maximum expected static, dynamic inclinations and accidental loads as well as the maximum expected values of acceleration, taking into account the ship characteristics and the position of the tanks.

5.5 Portable tanks

5.5.1 Portable fuel tanks should be located in dedicated areas fitted with:
.1 mechanical protection of the tanks depending on location and cargo operations;
.2 if located on an open deck, drip tray arrangements for leak containment and water spray systems for emergency cooling; and
.3 if located in a fuel storage hold space, the space should meet the provisions of sections 11 and 13.

5.5.2 Portable fuel tanks should be secured to the deck while connected to the ship systems. The arrangement for supporting and fixing the tanks should be designed for the maximum expected static and dynamic inclinations, as well as the maximum expected values of acceleration, taking into account the ship characteristics and the position of the tanks.

5.5.3 Consideration should be given to the ship's strength and the effect of the portable fuel tanks on the ship's stability.

5.5.4 Connections to the ship's fuel piping systems should be made by means of approved flexible hoses suitable for methyl/ethyl alcohol or other suitable means designed to provide sufficient flexibility.

5.5.5 Arrangements should be provided to limit the quantity of fuel spilled in case of inadvertent disconnection or rupture of the non-permanent connections.

5.5.6 The pressure relief system of portable tanks should be connected to a fixed venting system.

5.5.7 Control and monitoring systems for portable fuel tanks should be integrated in the ship's control and monitoring system. A safety system for portable fuel tanks should be integrated in the ship's safety system (e.g. shutdown systems for tank valves, leak/vapour detection systems).

5.5.8 Safe access to tank connections for the purpose of inspection and maintenance should be ensured.

5.5.9 When connected to the ship's fuel piping system:
.1 each portable tank should be capable of being isolated at any time;
.2 isolation of one tank should not impair the availability of the remaining portable tanks; and
.3 the tank should not exceed its filling limits.

5.6 Provisions for machinery space

5.6.1 A single failure within the fuel system should not lead to a release of fuel into the machinery space.

5.6.2 All fuel piping within machinery space boundaries should be enclosed in gas and liquid tight enclosures in accordance with 9.4.

5.7 Provisions for location and protection of fuel piping

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

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

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

5.7.4 Fuel piping should comply with the following:

.1 Fuel piping that passes through enclosed spaces in the ship should be enclosed in a pipe or duct that is gas and liquid tight towards the surrounding spaces with the fuel contained in the inner pipe. Such double walled piping is not required in cofferdams surrounding fuel tanks, fuel preparation spaces or spaces containing independent fuel tanks as the boundaries for these spaces will serve as a second barrier.

.2 All fuel pipes should be self-draining to suitable fuel or collecting tanks in normal condition of trim and list of the ship. Alternative arrangements for draining the piping may be accepted by the Administration.

5.8 Provisions for fuel preparation spaces design

Fuel preparation spaces should be located outside machinery spaces of category A.

5.9 Provisions for bilge systems

5.9.1 Bilge systems installed in areas where methyl/ethyl alcohol can be present should be segregated from the bilge system of spaces where methyl alcohol or ethyl alcohol cannot be present.

5.9.2 One or more holding tanks for collecting drainage and any possible leakage of methyl/ethyl alcohol from fuel pumps, valves or from double walled inner pipes located in enclosed spaces should be provided. Means should be provided for safely transferring contaminated liquids to onshore reception facilities.

5.9.3 The bilge system serving the fuel preparation space should be operable from outside the fuel preparation space.

5.10 Provisions for drip trays

5.10.1 Drip trays should be fitted where leakage and spill may occur, in particular, in way of single wall pipe connections.

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

5.10.3 Each drip tray should be provided with means to safely drain spills or transfer spills to a dedicated holding tank. Means for preventing backflow from the tank should be provided.

5.10.4 Drip trays for leakage of less than 10 litres may be provided with means for manual emptying.

5.10.5 The holding tank should be equipped with a level indicator and alarm, and should be inerted at all times during normal operation.

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

5.11.1 Direct access should 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 the provisions of section 5.12 should be provided.

5.11.2 Fuel preparation spaces should have independent access direct from open deck. Where a separate access from open deck is not practicable, an airlock complying with section 5.12 should be provided.

5.11.3 Fuel tanks and surrounding cofferdams should have suitable access from the open deck, where practicable, for gas freeing, cleaning, maintenance and inspection.

5.11.4 Without direct access to open deck, an entry space to fuel tanks or surrounding cofferdams should be provided and comply with the following:

.1 be fitted with an independent mechanical extraction ventilation system, providing a minimum of six air changes per hour; a low oxygen alarm and a gas detection alarm should be fitted;

.2 have sufficient open area around the fuel tank hatch for efficient evacuation and rescue operation;

.3 not be an accommodation space, service space, control station or machinery space of category A; and

.4 a cargo space may be accepted as an entry space, depending upon the type of cargo, if the area is cleared of cargo and no cargo operation is undertaken during entry to the space.

5.11.5 The area around independent fuel tanks should be sufficient to carry out evacuation and rescue operations.

5.11.6 For safe access, horizontal hatches or openings to or within fuel tanks or surrounding cofferdams should have a minimum clear opening of 600 mm x 600 mm that also facilitates the hoisting of an injured person from the bottom of the tank/cofferdam. For access through vertical openings providing main passage through the length and breadth within fuel tanks and cofferdams, the minimum clear opening should not be less than 600 mm x 800 mm at a height of not more than 600 mm from bottom plating unless gratings or footholds are provided. Smaller openings may be accepted provided evacuation of an injured person from the bottom of the tank/cofferdam can be demonstrated.

5.12 Provisions for airlocks

5.12.1 An airlock is a space enclosed by gastight bulkheads with two 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 should not be less than 300 mm in height. The doors should be self-closing without any hold-back arrangements.

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

5.12.3 Airlocks should have a simple geometrical form. They should provide for free and easy passage and should have a deck area not less than 1.5 m2. Airlocks should not be used for other purposes, for instance as storerooms.

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

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

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

5.12.7 Electrical equipment which is not of the certified safe type for propulsion, power generation, manoeuvring, anchoring and mooring equipment as well as the emergency fire pumps should not be located in spaces to be protected by airlocks.

6 Fuel containment system

6.1 Goal

The goal of this section is to provide for a fuel containment system where the risk to the ship, its crew and to the environment is minimized to a level that is at least equivalent to a conventional oil-fuelled ship.

6.2 Functional requirements

6.2.1 This section refers to functional requirements 3.2.1, 3.2.2, 3.2.5 and 3.2.8 to 3.2.16 of these Interim Guidelines.

6.2.2 The fuel tanks should be designed such that a leakage from the fuel tank or its connections does not endanger the ship, persons on board or the environment. Potential dangers to be avoided include:

.1 flammable fuels spreading to locations with ignition sources;

.2 toxicity potential and risk of oxygen deficiency or other negative impacts on crew health due to fuels and inert gases;

.3 restriction of access to muster stations, escape routes or LSAs; and

.4 reduction in availability of LSAs.

6.2.3 The fuel containment system and the fuel supply system should be designed such that safety actions after any leakage, irrespective of in liquid or vapour phase, do not lead to an unacceptable loss of power.

6.2.4 If portable tanks are used for fuel storage, the design of the fuel containment system should be equivalent to permanent installed tanks as described in this section.

6.3 Provisions for fuel tanks venting and gas freeing system

6.3.1 The fuel tanks should be fitted with a controlled tank venting system.

6.3.2 A fixed piping system should be arranged to enable each fuel tank to be safely gas freed, and to be safely filled with fuel from a gas-free condition.

6.3.3 The formation of gas pockets during the gas freeing operation should be avoided by considering the arrangement of internal tank structure and location of gas freeing inlets and outlets.

6.3.4 Pressure and vacuum relief valves should be fitted to each fuel tank to limit the pressure or vacuum in the fuel tank. The tank venting system may consist of individual vents from each fuel tank or the vents from each individual fuel tank may be connected to a common header. Design and arrangement should prevent flame propagation into the fuel containment system. If pressure relief valves (PRVs) of the high velocity type are fitted to the end of the vent pipes, they should be certified for endurance burning in accordance with MSC/Circ.677. If PRVs are fitted in the vent line, the vent outlet should be fitted with a flame arrestor certified for endurance burning in accordance with MSC/Circ.677.

6.3.5 Shut-off valves should not be arranged either upstream or downstream of the PRVs. Bypass valves may be provided. For temporary tank segregation purposes (maintenance) shut-off valves in common vent lines may be accepted if a secondary independent over/underpressure protection is provided to all tanks as per 6.3.7.

6.3.6 The fuel tank-controlled venting system should be designed with redundancy for the relief of full flow overpressure and/or vacuum. Pressure sensors fitted in each fuel tank, and connected to an alarm system, may be accepted in lieu of the secondary redundancy requirement for pressure relief. The opening pressure of the PRVs should not be lower than 0.007 MPa below atmospheric pressure.

6.3.7 PRVs should vent to a safe location on open deck and should be of a type which allows the functioning of the valve to be easily checked.

6.3.8 The fuel tank vent system should be sized to permit bunkering at a design loading rate without over-pressurizing the fuel tank.

6.3.9 The fuel tank vent system should be connected to the highest point of each tank and vent lines should be self-draining under all normal operating conditions.

6.4 Inerting and atmospheric control within the fuel storage system

6.4.1 All fuel tanks should be inerted at all times during normal operation.

6.4.2 Cofferdams should be arranged either for purging or filling with water through a non-permanent connection. Emptying the cofferdams should be done by a separate drainage system, e.g. bilge ejector.

6.4.3 The system should be designed to eliminate the possibility of a flammable mixture atmosphere existing in the fuel tank during any part of the atmosphere change operation, gas freeing or inerting by utilizing an inerting medium.

6.4.4 To prevent the return of flammable liquid and vapour to the inert gas system, the inert gas supply line should be fitted with two shutoff valves in series with a venting valve in between (double block and bleed valves). In addition, a closable non-return valve should be installed between the double block and bleed arrangement and the fuel system. These valves should be located inside hazardous spaces.

6.4.5 Where the connections to the inert gas piping systems are non-permanent, two non-return valves may substitute the valves required in 6.4.4.

6.4.6 Blanking arrangements should be fitted in the inert gas supply line to individual tanks. The position of the blanking arrangements should be immediately obvious to personnel entering the tank. Blanking should be via removable spool piece.

6.4.7 Fuel tank vent outlets should be situated normally not less than 3 m above the deck or gangway if located within 4 m from such gangways. The vent outlets are also to be arranged at a distance of at least 10 m from the nearest air intake or opening to accommodation and service spaces and ignition sources. The vapour discharge should be directed upwards in the form of unimpeded jets.

6.4.8 Vapour outlets from fuel tanks should be provided with devices tested and type approved to prevent the passage of flame into the tank. Due attention should be paid in the design and position of the PRVs with respect to blocking and due to ice during adverse weather conditions. Provision for inspection and cleaning should be arranged.

6.4.9 The arrangements for gas freeing and ventilation of fuel tanks should be such as to minimize the hazards due to the dispersal of flammable vapours to the atmosphere and to flammable gas mixture in the tanks. The ventilation system for fuel tanks should be exclusively for ventilating and gas freeing purposes. Connection between fuel tank and fuel preparation space ventilation will not be accepted.

6.4.10 Gas freeing operations should be carried out such that vapour is initially discharged in one of the following ways:
- .1 through outlets at least 3 m above the deck level with a vertical efflux velocity of at least 30 m/s maintained during the gas freeing operation;
- .2 through outlets at least 3 m above the deck level with a vertical efflux velocity of at least 20 m/s which are protected by suitable devices to prevent the passage of flame; or
- .3 through outlets underwater.

6.4.11 In designing a gas freeing system in conformity with 6.3.2 due consideration should be given to the following:
- .1 materials of construction of system;
- .2 time to gas free;
- .3 flow characteristics of fans to be used;
- .4 the pressure losses created by ducting, piping, fuel tank inlets and outlets;
- .5 the pressure achievable in the fan driving medium (e.g. water or compressed air); and
- .6 the densities of the fuel vapour/air mixture.

6.5 Inert gas availability on board

6.5.1 Inert gas should be available permanently on board in order to achieve at least one trip from port to port considering maximum consumption of fuel expected and maximum length of trip expected, and to keep tanks inerted during 2 weeks in harbour with minimum port consumption.

6.5.2 A production plant and/or adequate storage capacities might be used to achieve the availability target defined in 6.5.1.

6.5.3 Fluid used for inerting should not modify the characteristics of the fuel.

6.5.4 The production plant, if fitted, should be capable of producing inert gas with oxygen content at no time greater than 5% by volume. A continuous-reading oxygen content meter should be fitted to the inert gas supply from the equipment and should be fitted with an alarm set at a maximum of 5% oxygen content by volume. The system should be designed to ensure that if the oxygen content exceeds 5% by volume, the inert gas should be automatically vented to atmosphere.

6.5.5 The system should be able to maintain an atmosphere with an oxygen content not exceeding 8% by volume in any part of any fuel tank.

6.5.6 An inert gas system should have pressure controls and monitoring arrangements appropriate to the fuel containment system.

6.5.7 Where a nitrogen generator or nitrogen storage facilities are installed in a separate compartment outside of the engine-room, the separate compartment should be fitted with an independent mechanical extraction ventilation system, providing a minimum of six air changes per hour. If the oxygen content is below 19% in the separate compartment, an alarm should be given. A minimum of two oxygen sensors should be provided in each space. Visual and audible alarms should be placed at each entrance to the inert gas room.

6.5.8 Nitrogen pipes should only be led through well ventilated spaces. Nitrogen pipes in enclosed spaces should:

.1 have only a minimum of flange connections as needed for fitting of valves and be fully welded; and

.2 be as short as possible.

6.5.9 Notwithstanding the provisions of section 6.5, inert gas utilized for gas freeing of tanks may be provided externally to the ship.

7 Material and general pipe design

7.1 Goal

The goal of this section is to ensure the safe handling of fuel, under all operating conditions, to minimize the risk to the ship, personnel and to the environment, having regard to the nature of the products involved.

7.2 Functional requirements

This section relates to functional requirements 3.2.1, 3.2.6, 3.2.8, 3.2.9 and 3.2.10 of these Interim Guidelines. In particular, all materials used should be suitable for the fuel under the maximum working pressure and temperature.

7.3 Provisions for general pipe design

7.3.1 The design pressure for any section of the fuel piping system is the maximum gauge pressure to which the system may be subjected in service, taking into account the highest set pressure on any relief valve on the system.

7.3.2 The wall thickness of pipes made of steel should not be less than:

$t = (t_0 + b + c) / (1 - a/100)$ mm

where:

t_0 = theoretical thickness, mm $t_0 = PD / (2Ke + P)$ mm

P = system design pressure, but not less than the design pressure given in 7.3.1, MPa

D = outside pipe diameter

K = allowable stress N/mm^2 (see 7.3.3)

e = efficiency factor equal to 1.0 for seamless pipes and for longitudinally or spirally welded pipes, delivered by approved manufacturers of welded pipes, which are considered equivalent to seamless pipes when non-destructive testing on welds is carried out in accordance with recognized standards. In other cases, an efficiency factor less than 1.0, in accordance with recognized standards, may be required depending upon the manufacturing process

b = allowance for bending (mm). The value for b should be chosen so that the calculated stress in the bend, due to internal pressure only, does not exceed the allowable stress. Where such justification is not given, b should not be less than: $b = Dt_0 / 2.5r$ where: r = mean radius of the bend (mm)

c = corrosion allowance (mm). If corrosion or erosion is expected, the wall thickness of piping should be increased over that required by the other design provisions

a = negative manufacturing tolerance for thickness (%)

7.3.3 For pipes made of steel the allowable stress K to be considered in the formula for t_0 in 7.3.2 is the lower of the following values:

R_m / A or R_e / B where:

R_m = specified minimum tensile strength at ambient temperature (N/mm^2)

R_e = specified minimum yield stress at ambient temperature (N/mm^2). If stress-strain curve does not show a defined yield stress, the 0.2% proof stress applies

The values of A and B should be at least A = 2.7 and B = 1.8

7.3.4 Where necessary for mechanical strength to prevent damage, collapse, excessive sag or buckling of pipes due to superimposed loads, the wall thickness should be increased over that required by 7.3.2 or, if this is impracticable or would cause excessive local stresses, these loads should be reduced, protected against or eliminated by other design methods. Such superimposed loads may be due to supports, ship deflections, liquid pressure surge during transfer operations, the weight of suspended valves, reaction to loading arm connections or otherwise.

7.3.5 For pipes made of materials other than steel, the allowable stress should be considered by the Administration.

7.3.6 High pressure fuel piping systems[2] should have sufficient constructive and fatigue strength. This should be confirmed by carrying out stress analysis and taking into account:

- .1 stresses due to the weight of the piping system;
- .2 acceleration loads when significant; and
- .3 internal pressure and loads induced by hog and sag of the ship.

[2] *Whether a fuel system should be considered as a high-pressure system for the purpose of these Guidelines depends on the design and arrangement of the specific system. Accordingly, the stress analysis should be waived or done to the satisfaction of the Administration.*

7.3.7 Fuel pipes and all the other piping needed for safe and reliable operation and maintenance should be colour marked in accordance with a standard at least equivalent to those acceptable to the Administration.

7.3.8 All fuel piping and independent fuel tanks should be electrically bonded to the ship's hull. Electrical conductivity should be maintained across all joints and fittings. Electrical resistance between piping and the hull should be maximum 10^6 Ohm.

7.3.9 Piping other than fuel supply piping and cabling may be arranged in the double wall piping or duct provided that it does not create a source of ignition or compromise the integrity of the double pipe or duct. The double wall piping or duct should only contain piping or cabling necessary for operational purposes.

7.3.10 Filling lines to fuel tanks should be arranged to minimize the possibility for static electricity, e.g. by reducing the free fall into the fuel tank to a minimum.

7.3.11 The arrangement and installation of fuel piping should provide the necessary flexibility to maintain the integrity of the piping system in the actual service situations, taking potential for fatigue into account. Expansion bellows should not be used.

7.3.12 Piping fabrication and joining details

7.3.12.1 The inner piping, where a protective duct is required, is to be full penetration butt-welded and fully radiographed. Flange connections in this piping are to only be permitted within the tank connection space and fuel preparation space or similar;

- .1 during the use of the fuel piping, all doors, ports and other openings on the corresponding superstructure or deckhouse side should normally be kept closed; and
- .2 the annular space in the double walled fuel piping should be segregated at the engine-room bulkhead; this implies that there should be no common ducting between the engine-room and other spaces.

7.3.12.2 Piping for fuel should be joined by welding except:

- .1 for approved connections to shut-off valve and expansion joints, if fitted; and
- .2 for other exceptional cases specifically approved by the Administration.

7.3.12.3 The following direct connections of pipe length without flanges may be considered:

- .1 butt-welded joints with complete penetrations at the root;
- .2 slip-on welded joints with sleeves and related welding having dimensions in accordance with recognized standards should only be used in pipes having an external diameter of 50 mm or less; the possibility for corrosion is to be considered; and
- .3 screwed connections, in accordance with recognized standards, should only be used for piping with an external diameter of 25 mm or less.

7.3.12.4 Welding, post-weld heat treatment, radiographic testing, dye penetrating testing, pressure testing, leakage testing and non-destructive testing should be performed in accordance with recognized standards. Butt welding should be subject to 100% non-destructive testing, while sleeve welds should be subject to at least 10% liquid penetrant testing (PT) or magnetic particle testing (MT).

7.3.12.5 Where flanges are used, they should be of the welded-neck or slip-on type. Socket welds are not to be used in nominal sizes above 50 mm.

7.3.12.6 Expansion of piping should normally be allowed for by the provision of expansion loops or bends in the fuel piping system. Use of expansion joints used in high pressure[3] fuel systems should be approved by the Administration. Slip joints should not be used.

[3] *Whether a fuel system should be considered as a high-pressure system for the purpose of these Guidelines depends on the design and arrangement*

7.3.12.7 Other connections: Piping connections should be joined in accordance with 7.3.12.2, but for other exceptional cases the Administration may consider alternative arrangements.

7.4 Provisions for materials

Due consideration should be taken with respect to the corrosive nature of fuel when selecting materials of the specific system.

8 Bunkering

8.1 Goal

The goal of this section is to provide for suitable systems on board the ship to ensure that bunkering can be conducted without causing danger to persons, the environment or the ship.

8.2 Functional requirements

8.2.1 This section relates to functional requirements 3.2.1, 3.2.2, 3.2.3, 3.2.4, 3.2.5, 3.2.6, 3.2.7, 3.2.8, 3.2.9, 3.2.10, 3.2.11, 3.2.13, 3.2.14, 3.2.15 and 3.2.16 of these Interim Guidelines. In particular, the following applies:

8.2.1.1 The piping system for transfer of fuel to the fuel tank should be designed such that any leakage from the piping system cannot cause danger to the persons on board, the environment or the ship.

8.3 Provisions for bunkering station

8.3.1 General provisions

8.3.1.1 The bunkering station should be located on open deck so that sufficient natural ventilation is provided. Closed or semi-enclosed bunkering stations should be subject to special consideration with respect to provisions for mechanical ventilation. The Administration may require special risk assessment.

8.3.1.2 Entrances, air inlets and openings to accommodation, service and machinery spaces and control stations should not face the bunkering station.

8.3.1.3 Closed or semi-enclosed bunkering stations should be surrounded by gas and liquid-tight boundaries against enclosed spaces.

8.3.1.4 Bunkering lines should not be led directly through accommodation, control stations or service spaces. Bunkering lines passing through non-hazardous areas in enclosed spaces should be double walled or located in gastight ducts.

8.3.1.5 Arrangements should be made for safe management of fuel spills. Coamings and/or drip trays should be provided below the bunkering connections together with a means of safely collecting and storing spills. This could be a drain to a dedicated holding tank equipped with a level indicator and alarm. Where coamings or drip trays are subject to rainwater, provision should be made to drain rainwater overboard.

8.3.1.6 Showers and eye wash stations for emergency usage are to be located in close proximity to areas where the possibility for accidental contact with fuel exists. The emergency showers and eye wash stations are to be operable under all ambient conditions.

8.3.2 Ships' bunker hoses

8.3.2.1 Bunker hoses carried on board are to be suitable for methyl/ethyl alcohol. Each type of bunker hose, complete with end-fittings, should be prototype-tested at a normal ambient temperature, with 200 pressure cycles from zero to at least twice the specified maximum working pressure. After this cycle pressure test has been carried out, the prototype test should demonstrate a bursting pressure of at least 5 times its specified maximum working pressure at the upper and lower extreme service temperature. Hoses used for prototype testing should not be used for bunker service.

8.3.2.2 Before being placed in service, each new length of bunker hose produced should be hydrostatically tested at ambient temperature to a pressure not less than 1.5 times its specified maximum working pressure, but not more than two fifths of its bursting pressure. The hose should be stencilled, or otherwise marked, with the date of testing, its specified maximum working pressure and, if used in services other than ambient temperature services, its maximum and minimum service temperature, as applicable. The specified maximum working pressure should not be less than 1 MPa gauge.

8.3.2.3 Means should be provided for draining any fuel from the bunkering hoses upon completion of operation.

8.3.2.4 Where fuel hoses are carried on board, arrangements should be made for safe storage of the hoses. Hoses should be stored on the open deck or in a storage room with an independent mechanical extraction ventilation system, providing a minimum of six air changes per hour.

8.4 Provisions for manifold

The bunkering manifold should be designed to withstand the external loads during bunkering. The connections at the bunkering station should be of dry-disconnect type equipped with additional safety dry break-away coupling/self-sealing quick release. The couplings should be of a standard type.

8.5 Provisions for bunkering system

8.5.1 Means should be provided for draining any fuel from the bunkering lines upon completion of operation.

8.5.2 Bunkering lines should be arranged for inerting and gas freeing. When not engaged in bunkering, the bunkering lines should be free of gas, unless the consequences of not gas freeing is evaluated and approved.

8.5.3 A ship-shore link (SSL) or an equivalent means for automatic and manual ESD communication to the bunkering source should be fitted.

8.5.4 In the bunkering line, as close to the connection point as possible, there should be a manually operated stop valve and a remotely operated shutdown valve arranged in series. Alternatively, a combined manually operated and remote shutdown valve may be provided. It should be possible to operate this remotely operated valve from the bunkering control station.

8.5.5 Where bunkering lines are arranged with a cross-over, suitable isolation arrangements should be provided to ensure that fuel cannot be transferred inadvertently to the ship side not in use for bunkering.

9 Fuel supply to consumers

9.1 Goal

The goal of this section is to ensure safe and reliable distribution of fuel to the consumers.

9.2 Functional requirements

This section is related to functional requirements 3.2.1, 3.2.2, 3.2.3, 3.2.4, 3.2.5, 3.2.6, 3.2.8, 3.2.9, 3.2.10, 3.2.11 and 3.2.13 to 3.2.17 of these Interim Guidelines.

9.3 General provisions for fuel supply system

9.3.1 The fuel piping system should be separate from all other piping systems.

9.3.2 The fuel supply system should be arranged such that the consequences of any release of fuel will be minimized, while providing safe access for operation and inspection. The causes and consequences of release of fuel should be subject to special consideration within the risk assessment in 4.2.

9.3.3 The piping system for fuel transfer to the consumers should be designed in a way that a failure of one barrier cannot lead to a leak from the piping system into the surrounding area causing danger to the persons on board, the environment or the ship.

9.3.4 Fuel lines should be installed and protected so as to minimize the risk of injury to persons on board in case of leakage.

9.4 Provisions for fuel distribution

9.4.1 The outer pipe or duct should be gas and liquid tight.

9.4.2 The annular space between inner and outer pipe should have mechanical ventilation of underpressure type with a capacity of minimum 30 air changes per hour and be ventilated to open air. Appropriate means for detecting leakage into the annular space should be provided. The double wall enclosure should be connected to a suitable draining tank allowing the collection and the detection of any possible leakage.

9.4.3 Inerting of the annular space might be accepted as an alternative to ventilation. Appropriate means of detecting leakage into the annular space should be provided. Suitable alarms should be provided to indicate a loss of inert gas pressure between the pipes.

9.4.4 The outer pipe in the double walled fuel pipes should be dimensioned for a design pressure not less than the maximum working pressure of the fuel pipes. As an alternative the calculated maximum built-up pressure in the duct in the case of an inner pipe rupture may be used for dimensioning of the duct.

9.5 Redundancy of fuel supply

Propulsion and power generation arrangements, together with fuel supply systems, should be arranged so that a failure in fuel supply does not lead to an unacceptable loss of power.

9.6 Safety functions of the fuel supply system

9.6.1 All fuel piping should be arranged for gas freeing and inerting.

9.6.2 Fuel tank inlet and outlet valves should be as close to the tank as possible. Valves required to be operated under normal operation, such as when fuel is supplied to consumers or during bunkering, should be remotely operated if not easily accessible.

9.6.3 The main fuel supply line to each consumer or set of consumers should be equipped with an automatically operated master fuel valve. The master fuel valve(s) should be situated in the part of the piping that is outside the machinery space containing methyl/ethyl alcohol-fuelled consumer(s). The master fuel valve(s) should automatically shut off the fuel supply in accordance with section 15.2.1.2 and table 1 in section 15.

9.6.4 Means of manual emergency shutdown of fuel supply to the consumers or set of consumers should be provided on the primary and secondary escape routes from the consumer compartment, at a location outside consumer space, outside the fuel preparation space and at the bridge. The activation device should be arranged as a physical button, duly marked and protected against inadvertent operation and operable under emergency lighting.

9.6.5 The fuel supply line to each consumer should be provided with a remotely operated shut-off valve.

9.6.6 There should be one manually operated shutdown valve in the fuel line to each consumer to ensure safe isolation during maintenance.

9.6.7 Valves should be of the fail-safe type.

9.6.8 When pipes penetrate the fuel tank below the top of the tank a remotely operated shut-off valve should be fitted to the fuel tank bulkhead. When the fuel tank is adjacent to a fuel preparation space, the valve may be fitted on the tank bulkhead on the fuel preparation space side.

9.7 Provisions for fuel preparation spaces and pumps

9.7.1 Any fuel preparation space should not be located within a machinery space of category A, should be gas and liquid tight to surrounding enclosed spaces and vented to open air.

9.7.2 Hydraulically powered pumps that are submerged in fuel tanks should be arranged with double barriers preventing the hydraulic system serving the pumps from being directly exposed to methyl/ethyl alcohol. The double barrier should be arranged for detection and drainage of eventual methyl/ethyl alcohol leakage.

9.7.3 All pumps in the fuel system should be protected against running dry (i.e. protected against operation in the absence of fuel or service fluid). All pumps which are capable of developing a pressure exceeding the design pressure of the system should be provided with relief valves. Each relief valve should be in closed circuit, i.e. arranged to discharge back to the piping upstream of the suction side of the pump and to effectively limit the pump discharge pressure to the design pressure of the system.

10 Power generation including propulsion and other energy converters

10.1 Goal

To provide safe and reliable delivery of mechanical, electrical or thermal energy.

10.2 Functional requirements

10.2.1 This section is related to functional requirements 3.2.1, 3.2.11, 3.2.13, 3.2.14, 3.2.15, 3.2.16 and 3.2.17 of these Interim Guidelines. In particular, the following applies:

.1 the exhaust system should be designed to prevent any accumulation of unburnt fuel; and
.2 each fuel consumer should have a separate exhaust system.

10.2.2 One single failure in the fuel system should not lead to an unacceptable loss of power.

10.3 General

10.3.1 All engine components and engine-related systems should be designed in such a way that fire and explosion risks are minimized.

10.3.2 Engine components containing methyl/ethyl alcohol fuel should be effectively sealed to prevent leakage of fuel into the machinery space.

10.3.3 For engines where the space below the piston is in direct communication with the crankcase, a detailed evaluation regarding the hazard potential of fuel gas accumulation in the crankcase should be carried out and reflected in the safety concept of the engine.

10.3.4 A means should be provided to monitor and detect poor combustion or misfiring. In the event that it is detected, continued operation may be allowed, provided that the fuel supply to the concerned cylinder is shut off and provided that the operation of the engine with one cylinder cut-off is acceptable with respect to torsional vibrations.

10.4 Provision for dual-fuel engines

10.4.1 In case of shut-off of the methyl/ethyl alcohol supply, the engines should be capable of continuous operation by oil fuel only without interruption.

10.4.2 An automatic system should be fitted to change over from methyl/ethyl alcohol fuel operation to oil fuel operation with minimum fluctuation of the engine power. Acceptable reliability should be demonstrated through testing. In the case of unstable operation on engines when methyl/ethyl alcohol firing, the engine should automatically change to oil fuel mode. There should also be the possibility for manual changeover.

10.4.3 In case of an emergency stop or a normal stop, the methyl/ethyl alcohol fuel should be automatically shut off not later than the pilot oil fuel. It should not be possible to shut off the pilot oil fuel without first or simultaneously closing the fuel supply to each cylinder or to the complete engine.

10.5 Provision for single fuel engines

In case of a normal stop or an emergency shutdown, the methyl/ethyl alcohol fuel supply should be shut off not later than the ignition source. It should not be possible to shut off the ignition source without first or simultaneously closing the fuel supply to each cylinder or to the complete engine.

11 Fire safety

11.1 Goal

The goal of this section is to provide fire protection, detection and fighting for all systems related to storing, handling, transfer and use of methyl/ethyl alcohol as fuel.

11.2 Functional requirements

This section is related to functional requirements 3.2.1, 3.2.2, 3.2.4, 3.2.5, 3.2.12, 3.2.14 and 3.2.16 of these Interim Guidelines.

11.3 General provisions

The provisions in this section are additional to those given in SOLAS chapter II-2.

11.4 Provision for fire protection

11.4.1 For the purposes of fire protection, fuel preparation spaces should be regarded as machinery space of category A. Should the space have boundaries towards other machinery spaces of category A, accommodation, control station or cargo areas, these boundaries should not be less than A-60.

11.4.2 Any boundary of accommodation up to navigation bridge windows, service spaces, control stations, machinery spaces and escape routes, facing fuel tanks on open deck should have A-60 fire integrity.

11.4.3 For fire integrity, the fuel tank boundaries should be separated from the machinery spaces of category A and other rooms with high fire risks by a cofferdam of at least 600 mm, with insulation of not less than A-60 class.

11.4.4 The bunkering station should be separated by A-60 class divisions towards machinery spaces of category A, accommodation, control stations and high fire risk spaces, except for spaces such as tanks, voids, auxiliary machinery spaces of little or no fire risk, sanitary and similar spaces where the insulation standard may be reduced to class A-0.

11.5 Provision for fire main

When the fuel storage tank is located on the open deck, isolating valves should be fitted in the fire main in order to isolate damaged sections of the fire main. Isolation of a section of fire main should not deprive the fire line ahead of the isolated section from the supply of water.

11.6 Provision for fire fighting

11.6.1 Where fuel tanks were located on open deck, there should be a fixed fire-fighting system of alcohol-resistant foam type, as set out in chapter 17 of the IBC Code and, where appropriate, chapter 14 of the FSS Code.

11.6.2 The alcohol-resistant foam type fire-fighting system should cover the area below the fuel tank where a spill of fuel could be expected to spread.

11.6.3 The bunker station should have a fixed fire-extinguishing system of alcohol resistant foam type and a portable dry chemical powder extinguisher or an equivalent extinguisher, located near the entrance of the bunkering station.

11.6.4 Where fuel tanks are located on open deck, there should be a fixed water spray system for diluting eventual spills, cooling and fire prevention. The system should cover exposed parts of the fuel tank.

11.6.5 A fixed fire detection and fire alarm system complying with Fire Safety System Code should be provided for all compartments containing the methyl/ethyl alcohol fuel system.

11.6.6 Suitable detectors should be selected based on the fire characteristics of the fuel. Smoke detectors should be used in combination with detectors which can more effectively detect methyl/ethyl alcohol fires.

11.6.7 Means to ease detection and recognition of methyl/ethyl alcohol fires in machinery spaces should be provided for fire patrols and for fire-fighting purposes, such as portable heat-detection devices.

11.7 Provision for fire extinguishing of engine-room and fuel preparation space

11.7.1 Machinery space and fuel preparation space where methyl/ethyl alcohol-fuelled engines or fuel pumps are arranged should be protected by an approved fixed fire-extinguishing system in accordance with SOLAS regulation II-2/10 and the FSS Code. In addition, the fire-extinguishing medium used should be suitable for the extinguishing of methyl/ethyl alcohol fires.

11.7.2 An approved alcohol-resistant foam system covering the tank top and bilge area under the floor plates should be arranged for machinery space category A and fuel preparation space containing methyl/ethyl alcohol.

12 Explosion prevention and area classification

12.1 Goal

The goal of this section is to provide for the prevention of explosions and for the limitation of effects of a fire and explosion.

12.2 Functional requirements

This section is related to functional requirements 3.2.1, 3.2.2, 3.2.3, 3.2.4, 3.2.5, 3.2.6, 3.2.8 and 3.2.11 to 3.2.17 of these Interim Guidelines. The probability of explosions should be reduced to a minimum by:

.1 reducing the number of sources of ignition;
.2 reducing the probability of formation of ignitable mixtures; and
.3 using certified safe type electrical equipment suitable for the hazardous zone where the use of electrical equipment in hazardous areas is unavoidable.

12.3 General provisions

12.3.1 Hazardous areas on open deck and other spaces not addressed in this section should be analysed and classified based on a recognized standard.[4] The electrical equipment fitted within hazardous areas should be according to the same standard.

[4] *Refer to IEC standard 60092-502:1999, part 4.4: Tankers carrying flammable liquefied gases, as applicable*

12.3.2 All hazardous areas should be inaccessible to passengers and unauthorized crew at all times.

12.4 Area classification

12.4.1 Area classification is a method of analysing and classifying the areas where explosive gas atmospheres may occur. The object of the classification is to allow the selection of electrical apparatus able to be operated safely in these areas.

12.4.2 In order to facilitate the selection of appropriate electrical apparatus and the design of suitable electrical installations, hazardous areas are divided into zones 0, 1 and 2, according to 12.5. In cases where the prescriptive provisions in 12.5 are deemed to be inappropriate, area classification according to IEC 60079-10-1:2015 should be applied with special consideration by the Administration.

12.4.3 Ventilation ducts should have the same area classification as the ventilated space.

12.5 Hazardous area zones

12.5.1 Hazardous area zone 0

This zone includes, but is not limited to, the interiors of methyl/ethyl fuel tanks, any pipework for pressure-relief or other venting systems for fuel tanks, pipes and equipment containing methyl/ethyl fuel.

12.5.2 Hazardous area zone 1

This zone includes, but is not limited to:

.1 cofferdams and other protective spaces surrounding the fuel tanks;
.2 fuel preparation spaces;
.3 areas on open deck, or semi-enclosed spaces on deck, within 3 m of any methyl/ethyl fuel tank outlet, gas or vapour outlet, bunker manifold valve, other methyl/ethyl fuel valve, methyl/ethyl fuel pipe flange, methyl/ethyl fuel preparation space ventilation outlets;
.4 areas on open deck or semi-enclosed spaces on deck in the vicinity of the fuel tank P/V outlets, within a vertical cylinder of unlimited height and 6 m radius centred upon the centre of the outlet and within a hemisphere of 6 m radius below the outlet;
.5 areas on open deck or semi-enclosed spaces on deck, within 1.5 m of fuel preparation space entrances, fuel preparation space ventilation inlets and other openings into zone 1 spaces;
.6 areas on the open deck within spillage coamings surrounding methyl/ethyl fuel bunker manifold valves and 3 m beyond these, up to a height of 2.4 m above the deck;
.7 enclosed or semi-enclosed spaces in which pipes containing methyl/ethyl fuel are located, e.g. ducts around methyl/ethyl fuel pipes, semi-enclosed bunkering stations; and
.8 a space protected by an airlock is considered as a non-hazardous area during normal operation, but will require equipment to operate following loss of differential pressure between the protected space and the hazardous area to be certified as suitable for zone 1.

12.5.3 Hazardous area zone 2

This zone includes, but is not limited to:

.1 areas 4 m beyond the cylinder and 4 m beyond the sphere defined in 12.5.2.1.4;
.2 areas within 1.5 m surrounding other open or semi-enclosed spaces of zone 1 defined in 12.5.2.1; and
.3 airlocks.

13 Ventilation

13.1 Goal

The goal of this section is to provide for the ventilation required for safe working conditions for personnel and the safe operation of machinery and equipment where methyl/ethyl alcohol is used as fuel.

13.2 Functional requirements

This section is related to functional requirements 3.2.1, 3.2.2, 3.2.4, 3.2.6 and 3.2.11 to 3.2.17 of these Interim Guidelines.

13.3 Provisions – General

13.3.1 Ventilation inlets and outlets for spaces required to be fitted with mechanical ventilation should be located such that according to the International Convention on Load Lines they will not be required to have closing appliances.

13.3.2 Any ducting used for the ventilation of hazardous spaces should be separate from that used for the ventilation of non-hazardous spaces. The ventilation should function at all temperatures and environmental conditions the ship will be operating in.

13.3.3 Electric motors for ventilation fans should not be located in ventilation ducts for hazardous spaces unless the motors are certified for the same hazard zone as the space served.

13.3.4 Design of ventilation fans serving spaces where vapours from fuels may be present should fulfil the following:

.1 ventilation fans should not produce a source of vapour ignition in either the ventilated space or the ventilation system associated with the space; ventilation fans and fan ducts, in way of fans only, should be of non-sparking construction defined as:
  .1 impellers or housings of non-metallic material, due regard being paid to the elimination of static electricity;
  .2 impellers and housings of non-ferrous metals;
  .3 impellers and housings of austenitic stainless steel;

.4 impellers of aluminium alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non-ferrous materials is fitted in way of the impeller, due regard being paid to static electricity and corrosion between ring and housing; or
.5 any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 mm tip design clearance;

.2 in no case should the radial air gap between the impeller and the casing be less than 0.1 of the diameter of the impeller shaft in way of the bearing but not less than 2 mm; the gap need not be more than 13 mm; and

.3 any combination of an aluminium or magnesium alloy fixed or rotating component and a ferrous fixed or rotating component, regardless of tip clearance, is considered a sparking hazard and should not be used in these places.

13.3.5 Ventilation systems required to avoid any vapour accumulation should consist of independent fans, each of sufficient capacity, unless otherwise specified in these Interim Guidelines. The ventilation system should be of a mechanical exhaust type, with extraction inlets located such as to avoid accumulation of vapour from leaked methyl/ethyl alcohol in the space.

13.3.6 Air inlets for hazardous enclosed spaces should be taken from areas that, in the absence of the considered inlet, would be non-hazardous. Air inlets for non-hazardous enclosed spaces should be taken from non-hazardous areas at least 1.5 m away from the boundaries of any hazardous area. Where the inlet duct passes through a more hazardous space, the duct should be gastight and have over-pressure relative to this space.

13.3.7 Air outlets from non-hazardous spaces should be located outside hazardous areas.

13.3.8 Air outlets from hazardous enclosed spaces should be located in an open area that, in the absence of the considered outlet, would be of the same or lesser hazard than the ventilated space.

13.3.9 The required capacity of the ventilation plant is normally based on the total volume of the room. An increase in required ventilation capacity may be necessary for rooms having a complicated form.

13.3.10 Non-hazardous spaces with entry openings to a hazardous area should be arranged with an airlock and be maintained at overpressure relative to the external hazardous area. The overpressure ventilation should be arranged according to the following:

.1 during initial start-up or after loss of overpressure ventilation, before energizing any electrical installations not certified safe for the space in the absence of pressurization, it should be required to:
.1 proceed with purging (at least five air changes) or confirm by measurements that the space is non-hazardous; and
.2 pressurize the space;

.2 operation of the overpressure ventilation should be monitored and in the event of failure of the overpressure ventilation:
.1 an audible and visual alarm should be given at a manned location; and
.2 if overpressure cannot be immediately restored, automatic or programmed, disconnection of electrical installations according to a recognized standard[5] should be required.

[5] *Refer to IEC 60092-502:1999 Electrical Installations in Ships – Tankers – Special Features, table 5*

13.3.11 Non-hazardous spaces with entry openings to a hazardous enclosed space should be arranged with an airlock and the hazardous space should be maintained at underpressure relative to the non-hazardous space. Operation of the extraction ventilation in the hazardous space should be monitored and in the event of failure of the extraction ventilation:

.1 an audible and visual alarm should be given at a manned location; and
.2 if underpressure cannot be immediately restored, automatic or programmed, disconnection of electrical installations according to recognized standards in the non-hazardous space should be required.

13.3.12 Double bottoms, cofferdams, duct keels, pipe tunnels, hold spaces and other spaces where methyl/ethyl fuel may accumulate should be capable of being ventilated to ensure a safe environment when entry into the spaces is necessary.

13.4 Provisions for fuel preparation spaces

13.4.1 Fuel preparation spaces should be provided with an effective mechanical forced ventilation system of extraction type. During normal operation the ventilation should be at least 30 air changes per hour.

13.4.2 The number and power of the ventilation fans should be such that the capacity is not reduced by more than 50% if a fan with a separate circuit from the main switchboard or emergency switchboard or a group of fans with common circuit from the main switchboard or emergency switchboard is inoperable.

13.4.3 Ventilation systems for fuel preparation spaces and other fuel handling spaces should be in operation when pumps or other fuel treatment equipment are working.

13.5 Provisions for bunkering station

Bunkering stations that are not located on open deck should be suitably ventilated to ensure that any vapour being released during bunkering operations will be removed outside. If the natural ventilation is not sufficient, the bunkering stations should be subject to special consideration with respect to provisions for mechanical ventilation. The Administration may require special risk assessment.

13.6 Provisions for ducts and double wall pipes

13.6.1 Ducts and double wall pipes containing fuel piping fitted with a mechanical ventilation system of the extraction type should be provided with a ventilation capacity of at least 30 air changes per hour.

13.6.2 The ventilation system for double wall piping and ducts should be independent of all other ventilation systems.

13.6.3 The ventilation inlet for the double wall piping or duct should always be located in a non-hazardous area, in open air, away from ignition sources. The inlet opening should be fitted with a suitable wire mesh guard and protected from ingress of water.

14 Electrical installations

14.1 Goal

The goal of this section is to provide for electrical installations that minimize the risk of ignition in the presence of a flammable atmosphere.

14.2 Functional requirements:

This section is related to functional requirements 3.2.1, 3.2.2, 3.2.3, 3.2.5, 3.2.8, 3.2.11, 3.2.13, 3.2.15, 3.2.16 and 3.2.17 of these Interim Guidelines.

14.3 Provisions – General

14.3.1 Electrical installations should comply with a recognized standard[6] at least equivalent to those acceptable to the Organization.

[6] *Refer to IEC 60092:2018 series standards, as applicable.*

14.3.2 Electrical equipment or wiring should not be installed in hazardous areas unless essential for operational purposes or safety enhancement.

14.3.3 Where electrical equipment is installed in hazardous areas as provided in 14.3.2, it should be selected, installed and maintained in accordance with IEC standards or other standards at least equivalent to those acceptable to the Organization.

14.3.4 The lighting system in hazardous areas should be divided between at least two branch circuits. All switches and protective devices should interrupt all poles or phases and should be located in a non-hazardous area.

14.3.5 The onboard installation of the electrical equipment units should be such as to ensure the safe bonding to the hull of the units themselves.

15 Control, monitoring and safety systems

15.1 Goal

The goal of this section is to provide for the arrangement of control, monitoring and safety systems that support an efficient and safe operation of the fuel installations as covered in the other sections of these Interim Guidelines.

15.2 Functional requirements

This section is related to functional requirements in 3.2.1, 3.2.2, 3.2.3, 3.2.9, 3.2.10, 3.2.11, 3.2.13, 3.2.14 and 3.2.17 of these Interim Guidelines. In particular, the following applies:

.1 the control, monitoring and safety systems of the methyl/ethyl alcohol installations should be arranged such that there is not an unacceptable loss of power in the event of a single failure;

.2 a fuel safety system should be arranged to close down the fuel supply system automatically, upon failure in systems as described in table 1 and upon other fault conditions which may develop too fast for manual intervention;

.3 the safety functions should be arranged in a dedicated fuel safety system that is independent of the fuel control system in order to avoid possible common cause failures; this includes power supplies and input and output signal;

.4 the safety systems including the field instrumentation should be arranged to avoid spurious shutdown, e.g. as a result of a faulty vapour detector or a wire break in a sensor loop; and

.5 where two fuel supply systems are required to meet the provisions, each system should be fitted with its own set of independent fuel control and safety systems.

15.3 General provisions

15.3.1 Suitable instrumentation devices should be fitted to allow a local and a remote reading of essential parameters to ensure safe management of the whole fuel equipment including bunkering.

15.3.2 Liquid leakage detection should be installed in the protective cofferdams surrounding the fuel tanks, in all ducts around fuel pipes, in fuel preparation spaces, and in other enclosed spaces containing single walled fuel piping or other fuel equipment.

15.3.3 The annular space in a double walled piping system should be monitored for leakages and the monitoring system should be connected to an alarm system. Any leakage detected should lead to shutdown of the affected fuel supply line in accordance with table 15.1.

15.3.4 At least one bilge well with a level indicator should be provided for each enclosed space, where an independent storage tank without a protective cofferdam is located. A high-level bilge alarm should be provided. The leakage detection system should trigger an alarm and the safety functions in accordance with table 15.1.

15.3.5 For tanks not permanently installed in the vessel, a monitoring system equivalent to that provided for permanent installed tanks should be provided.

15.4 Provisions for bunkering and fuel tank monitoring

15.4.1 Level indicators for fuel tanks

Each fuel tank should be fitted with closed level gauging devices, arranged to ensure a level reading is always obtainable and unless any necessary maintenance can be carried out while the fuel tank is in service, two devices should be installed.

15.4.2 Overflow control

15.4.2.1 Each fuel tank should be fitted with a visual and audible high-level alarm. This should be able to be function tested from the outside of the tank and can be common with the level gauging system (configured as an alarm on the gauging transmitter),but should be independent of the high-high-level alarm.

15.4.2.2 An additional sensor (high-high-level) operating independently of the high liquid level alarm should automatically actuate a shut-off valve to avoid excessive liquid pressure in the bunkering line and prevent the tank from becoming liquid full.

15.4.2.3 The high and high-high-level alarm for the fuel tanks should be visual and audible at the location at which gas freeing by water filling of the fuel tanks is controlled, given that water filling is the preferred method for gas freeing.

15.5 Provisions for bunkering control

15.5.1 Bunkering control should be from a safe remote location. At this safe remote location:

.1 tank level should be capable of being monitored;

.2 the remote-control valves required by 8.5.3 should be capable of being operated from this location; closing of the bunkering shutdown valve should be possible from the control location for bunkering and from another safe location; and

.3 overfill alarms and automatic shutdown should also be indicated at this location.

15.5.2 If the ventilation in the ducting enclosure or annular spaces of the double walled bunkering lines stops, an audible and visual alarm should be activated at the bunkering control location.

15.5.3 If fuel leakage is detected in ducting enclosure or the annular spaces of the double walled bunkering lines, an audible and visual alarm and emergency shutdown of the bunkering valve should automatically be activated.

15.6 Provisions for engine monitoring

In addition to the instrumentation provided in accordance with SOLAS chapter II-1, part C, indicators should be fitted on the navigation bridge, the engine control room and the manoeuvring platform for:

.1 operation of methyl/ethyl alcohol fuel engines; and

.2 operation and mode of operation of the engine in the case of dual fuel engines.

15.7 Provisions for gas detection

15.7.1 Permanently installed gas detectors should be fitted in:

.1 all ventilated annular spaces of the double walled fuel pipes;

.2 machinery spaces containing fuel equipment or consumers;

.3 fuel preparation spaces;

.4 other enclosed spaces containing fuel piping or other fuel equipment without ducting;

.5 other enclosed or semi-enclosed spaces where fuel vapours may accumulate;

.6 cofferdams and fuel storage hold spaces surrounding fuel tanks;

.7 airlocks; and

.8 ventilation inlets to accommodation and machinery spaces, if required, based on the risk assessment required in 4.2.

15.7.2 The number and placement of detectors in each space should be considered taking into account the size, layout and ventilation of the space. Gas dispersal analysis or a physical smoke test should be used to find the best arrangement.

15.7.3 Fuel vapour detection equipment should be designed, installed and tested in accordance with a recognized standard.[7]

[7] *Refer to IEC 60079-29-1:2016 – Explosive atmospheres – Gas detectors – Performance requirements of detectors for flammable gases.*

15.7.4 An audible and visible alarm should be activated at a fuel vapour concentration of 20% of the lower explosion limit (LEL). The safety system should be activated at 40% of LEL at two detectors. Special consideration should be given to toxicity in the design process of the detection system.

15.7.5 For ventilated ducts and annular spaces around fuel pipes in the machinery spaces containing methyl/ethyl alcohol-fuelled engines, the alarm limit should be set to 20% of LEL. The safety system should be activated at 40% of LEL at two detectors.

15.7.6 Audible and visible alarms from the fuel vapour detection equipment should be located on the navigation bridge, in the continuously manned central control station, safety centre and at the control location for bunkering as well as locally.

15.7.7 Fuel vapour detection required by this section should be continuous without delay.

15.8 Provisions for fire detection

Fire detection in machinery space containing methyl/ethyl alcohol engines and fuel storage hold spaces should give audible and visual alarms on the navigation bridge and in a continuously manned central control station or safety centre as well as locally.

15.9 Provisions for ventilation

Any loss of the required ventilating capacity should give an audible and visual alarm on the navigation bridge, and in a continuously manned central control station or safety centre as well as locally.

15.10 Provisions on safety functions of fuel supply systems

15.10.1 If the fuel supply is shut off due to activation of an automatic valve, the fuel supply should not be opened until the reason for the disconnection is ascertained and the necessary precautions taken. A readily visible notice giving instruction to this effect should be placed at the operating station for the shut-off valves in the fuel supply lines.

15.10.2 If a fuel leak leading to a fuel supply shutdown occurs, the fuel supply should not be operated until the leak has been found and dealt with. Instructions to this effect should be placed in a prominent position in the machinery space.

15.10.3 A caution placard or signboard should be permanently fitted in the machinery space containing methyl/ethyl-fuelled engines stating that heavy lifting, implying danger of damage to the fuel pipes, should not be done when the engine(s) is running on methyl/ethyl.

15.10.4 Pumps and fuel supply should be arranged for manual remote emergency stop from the following locations as applicable:

.1 navigation bridge;
.2 cargo control room;
.3 onboard safety centre;
.4 engine control room;
.5 fire control station; and
.6 adjacent to the exit of fuel preparation spaces.

Table 15.1
Monitoring of methyl/ethyl alcohol supply system to engines

Parameter	**Alarm**	**Automatic shutdown of tank valve** (valve(s) referred to in 9.6.2)	**Automatic shutdown of master fuel valve** (valve(s) referred to in 9.6.3)	**Automatic shutdown of bunkering valve**	**Comments**
High-level fuel tank	X			X	See 15.4.2.1
High-high-level fuel tank	X			X	See 15.4.2.2 and 15.5.1
Loss of ventilation in the annular space in the bunkering line	X			X	See 15.5.2
Gas detection in the annular space in the bunkering line	X			X	See 15.5.3
Loss of ventilation in ventilated areas	X				See 15.9
Manual shutdown				X	See 15.5.1
Liquid methyl/ethyl alcohol detection in the annular space of the double walled bunkering line	X			X	See 15.5.3
Vapour detection in ducts around fuel pipes	X				See 15.7.1.1
Vapour detection in cofferdams surrounding fuel tanks. One detector giving 20% of LEL	X				See 15.7.5
Vapour detection in airlocks	X				See 15.7.1.7
Vapour detection in cofferdams surrounding fuel tanks. Two detectors giving 40% of LEL, 1)	X	X		X	See 15.7.1.6
Vapour detection in ducts around double walled pipes, 20% of LEL	X				See 15.7.7
Vapour detection in ducts around double walled pipes, 40% of LEL, 1)	X	X	X		See 15.7.7. Two gas detectors to give min. 40% of LEL before shutdown
Liquid leak detection in annular space of double walled pipes	X	X	X		See 15.3.3
Liquid leak detection in engine-room	X	X			See 15.3.2
Liquid leak detection in fuel preparation space	X	X			See 15.3.2
Liquid leakage detection in protective cofferdams surrounding fuel tanks	X				See 15.3.2

16 Training, drills and emergency exercises

16.1 The goal of this section is to ensure that seafarers on board ships to which these Interim Guidelines apply are adequately qualified, trained and experienced.

16.2 Methyl/ethyl alcohol fuel-related drills and exercises should be incorporated into the schedule for periodical drills.

16.3 Such drills and exercises related to methyl/ethyl alcohol fuels could include for example:

.1 tabletop exercise;
.2 review of fuelling procedures based on the fuel handling manual required by 17.2.3;
.3 responses to potential contingencies;
.4 tests of equipment intended for contingency response; and
.5 reviews that assigned seafarers are trained to perform assigned duties during fuelling, operation and contingency response.

16.4 The response and safety system for hazards and accident control should be reviewed and tested.

16.5 The company should ensure that seafarers on board ships using methyl/ethyl alcohol fuels should have completed training to attain the abilities that are appropriate to the capacity to be filled, and duties and responsibilities to be taken up.

16.6 The master, officers, ratings and other personnel on ships using methyl/ethyl alcohol fuels should be trained and qualified in accordance with regulation V/3 of the STCW Convention and section A-V/3 of the STCW Code, taking into account the specific hazards of the methyl/ethyl alcohol used as fuel.

17 Operation

17.1 Goal

The goal of this section is to ensure that operational procedures for the loading, storage, operation, maintenance and inspection of systems for methyl/ethyl alcohol fuels minimize the risk to personnel, the ship and the environment, and are consistent with practices for a conventional oil-fuelled ship whilst taking into account the nature of these fuels.

17.2 Functional requirements

This section relates to the functional provisions 3.2.1 to 3.2.3, 3.2.9, 3.2.11, 3.2.14, 3.2.15 and 3.2.16 of these Interim Guidelines. In particular, the following applies:

.1 a copy of these Interim Guidelines, or national regulations incorporating the provisions of the same, should be on board every ship covered by these Interim Guidelines;
.2 maintenance procedures and information for all methanol/ethanol related installations should be available on board;
.3 the ship should be provided with operational procedures including a suitably detailed fuel handling manual, such that trained qualified personnel can safely operate the fuel bunkering, storage and transfer systems; and
.4 the ship should be provided with suitable emergency procedures.

17.3 Provisions for maintenance

17.3.1 Maintenance and repair procedures should include considerations with respect to the fuel containment system and adjacent spaces. Special consideration should be given to the toxicity of fuel.

17.3.2 The procedures and information should include maintenance of electrical equipment that is installed in explosion hazardous spaces and areas. The inspection and maintenance of electrical installations in explosion hazardous spaces should be performed in accordance with recognized standards.

17.4 Provisions for bunkering operations

17.4.1 Responsibilities

17.4.1.1 Before any bunkering operation commences, the master of the receiving ship or their representative and the representative of the bunkering source (persons in charge (PIC)) should:

.1 agree in writing the transfer procedure including the maximum transfer rate at all stages and volume to be transferred;
.2 agree in writing action to be taken in an emergency; and
.3 complete and sign the bunker safety checklist.

17.4.1.2 Upon completion of bunkering operations, the ship PIC should receive and sign documentation containing a description of the product and the quantity delivered.

17.4.2 Overview of control, automation and safety systems

17.4.2.1 The fuel handling manual required by 17.2.3 should include but not be limited to:

.1 overall operation of the ship from dry dock to dry dock, including procedures for bunker loading and, where appropriate, discharging, sampling, inerting and gas freeing;
.2 operation of inert gas systems;
.3 fire-fighting and emergency procedures: operation and maintenance of fire-fighting systems and use of extinguishing agents;
.4 specific fuel properties and special equipment needed for the safe handling of the particular fuel;
.5 fixed and portable gas detection operation and maintenance of equipment;
.6 emergency shutdown systems, where fitted; and
.7 a description of the procedural actions to take in an emergency situation, such as leakage, fire or poisoning.

17.4.2.2 A fuel system schematic/piping and instrumentation diagram (P&ID) should be reproduced and permanently displayed in the ship's bunker control station and at the bunker station.

17.4.3 Pre-bunkering verification

17.4.3.1 Prior to conducting bunkering operations, pre-bunkering verification including, but not limited to, the following should be carried out and documented in the bunker safety checklist:

.1 all communications methods, including ship shore link (SSL), if fitted;
.2 operation of fixed fire detection equipment;
.3 operation of portable gas detection equipment;
.4 readiness of fixed and portable fire-fighting systems and appliances;
.5 operation of remote-controlled valves; and
.6 inspection of hoses and couplings.

17.4.3.2 Documentation of successful verification should be indicated by the mutually agreed and executed bunkering safety checklist signed by both PICs.

17.4.4 Ship bunkering source communications

17.4.4.1 Communications should be maintained between the ship PIC and the bunkering source PIC at all times during the bunkering operation. In the event that communications cannot be maintained, bunkering should stop and not resume until communications are restored.

17.4.4.2 Communication devices used in bunkering should comply with recognized standards for such devices acceptable to the Administration.

17.4.4.3 PICs should have direct and immediate communication with all personnel involved in the bunkering operation.

17.4.4.4 The SSL or equivalent means to a bunkering source provided for automatic ESD communications should be compatible with the receiving ship and the delivering facility ESD system.[8]

[8] *Refer to ISO 28460:2010, Petroleum and natural gas industries – installation and equipment for liquefied natural gas – Ship-to-shore interface and port operations*

17.4.5 Electrical bonding

Consideration should be given to the electrical insulation between ship and shore.