Classification of Compressed Natural Gas Carriers

April 2007

Rule Note
NR 517 DR R00 E
ARTICLE 1

1.1. - BUREAU VERITAS is a Society the purpose of whose Marine Division (the "Society") is the classification ("Classification") of any ship or vessel or structure of any type or part of it or system therein collectively referred to as a "Unit" whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovercrafts, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment; subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

The Society:
- prepares and publishes Rules for classification, Guidance Notes and other documents ("Rules");
- issues Certificates, Attestations and Reports following its interventions ("Certificates");
- publishes Registers.

1.2. - The Society also participates in the application of National and International Regulations or Standards, including by delegation from different Governments. Those activities are hereafter collectively referred to as "Classification".

1.3. - The Society can also provide services related to Classification and Certification such as ship and company safety management certification; ship and port security certification; training activities; all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board.

1.4. - The interventions mentioned in 1.1., 1.2. and 1.3. are referred to as "Services". The party and/or its representative requesting the services is hereinafter referred to as the "Client".

The Services are prepared and carried out on the assumption that the Clients are aware of the International Maritime and/or Offshore Industry (the "Industry") practices.

1.5. - The Society is neither and may not be considered as an Underwriter, Broker in ship's sale or chartering, Expert in Unit's valuation, Consulting Engineer, Controller, Naval Architect, Manufacturer, Shipbuilder, Repair yard, Charterer or Shipowner who are not relied of any of their expressed or implied obligations by the interventions of the Society.

ARTICLE 2

2.1. - Classification is the appraiserment given by the Society for its Client, at a certain date, following surveys by its Surveyors along the lines specified in Articles 3 and 4 hereafter on the level of compliance of a Unit to its Rules or part of them. This appraiserment is represented by a class entered on the Certificates and periodically transcribed in the Society’s Register.

2.2. - Certification is carried out by the Society along the same lines as set out in Articles 3 and 4 hereafter and with reference to the applicable National and International Regulations or Standards.

2.3. - It is incumbent upon the Client to maintain the condition of the Unit after surveys, to present the Unit for surveys and to inform the Society without delay of circumstances which may affect the given appraiserment or cause to modify its scope.

2.4. - The Client is to give to the Society all access and information necessary for the performance of the requested Services.

ARTICLE 3

3.1. - The Rules, procedures and instructions of the Society take into account at the date of their preparation the state of currently available and proven technical knowledge of the Industry. They are not a code of construction neither a guide for maintenance or a safety handbook.

Committees consisting of personalities from the Industry contribute to the development of those documents.

3.2. - The Society only is qualified to apply its Rules and to interpret them. Any reference to them has no effect unless it involves the Society’s intervention.

3.3. - The Services of the Society are carried out by professional Surveyors according to the Code of Ethics of the Members of the International Association of Classification Societies (IACS).

3.4. - The operations of the Society in providing its Services are exclusively conducted by way of random inspections and do not in any circumstances involve monitoring or exhaustive verification.

ARTICLE 4

4.1. - The Society, acting by reference to its Rules:
- reviews the construction arrangements of the Units as shown on the documents presented by the Client;
- conducts surveys at the place of their construction;
- classes Units and enters their class in its Register;
- surveys periodically the Units in service to note that the requirements for the maintenance of class are met.

The Client is to inform the Society without delay of circumstances which may cause the date or the extent of the surveys to be changed.

ARTICLE 5

5.1. - The Society acts as a provider of services. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty.

5.2. - The certificates issued by the Society pursuant to 5.1. here above are a statement on the level of compliance of the Unit to its Rules or to the documents of reference for the Services provided for.

In particular, the Society does not engage in any work relating to the design, building, production or repair checks, neither in the operation of the Units or in their trade, neither in any advisory services, and cannot be held liable on those accounts. Its certificates cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or its value for sale, insurance or chartering.

5.3. - The Society does not declare the acceptance or commissioning of a Unit, nor of its construction in conformity with its design, that being the exclusive responsibility of its owner or builder, respectively.

5.4. - The Services of the Society cannot create any obligation bearing on the Society or constitute any warranty of proper operation, beyond any representation set forth in the Rules, of any Unit, equipment or machinery, computer software of any sort or other comparable concepts that has been subject to any survey by the Society.

ARTICLE 6

6.1. - The Society accepts no responsibility for the use of information related to its Services which was not provided for the purpose by the Society or with its assistance.

6.2. - If the Services of the Society cause to the Client a damage which is proved to be the direct and reasonably foreseeable consequence of an error or omission of the Society, its liability towards the Client is limited to ten times the amount of fee paid for the Service having caused the damage, provided however that this limit shall be subject to a minimum of eight thousand (8,000) Euro, and to a maximum which is the greater of eight hundred thousand (800,000) Euro and one and a half times the above mentioned fee.

The Society bears no liability for indirect or consequential loss such as e.g. loss of revenue, loss of profit, loss of production, loss relative to other contracts and indemnities for termination of other agreements.

6.3. - All claims are to be presented to the Society in writing within three months of the date when the Services were supplied or (if later) the date when the events which are relied on were first known to the Client, and any claim which is not so presented shall be deemed waived and absolutely barred.

ARTICLE 7

7.1. - Requests for Services are to be in writing.

7.2. - Either the Client or the Society can terminate as of right the requested Services after giving the other party thirty days’ written notice, for convenience, and without prejudice to the provisions in Article 8 hereunder.

7.3. - The class granted to the concerned Units and the previously issued certificates remain valid until the date of effect of the notice issued according to 7.2. hereabove subject to compliance with 2.3. hereabove and Article 8 hereunder.

ARTICLE 8

8.1. - The Services of the Society, whether completed or not, involve the payment of fee upon receipt of the invoice and the reimbursement of the expenses incurred.

8.2. - Overdue amounts are increased as of right by interest in accordance with the applicable legislation.

8.3. - The class of a Unit may be suspended in the event of non-payment of fee after a first unfutile notification to pay.

ARTICLE 9

9.1. - The documents and data provided to or prepared by the Society for its Services, and the information available to the Society, are treated as confidential. However:
- Clients have access to the data they have provided to the Society and, during the period of classification of the Unit for them, to the classification file consisting of survey reports and certificates which have been prepared at any time by the Society for the classification of the Unit;
- copies of the documents made available for the classification of the Unit and of available survey reports can be handed over to another Classification Society Member of the International Association of Classification Societies (IACS) in case of the Unit’s transfer of class;
- the data relative to the evolution of the Register, to the class suspension and to the survey status of the Units are passed on to IACS according to the association working rules;
- the certificates, documents and information relative to the Units classified with the Society may be reviewed during IACS audits and are disclosed upon order of the concerned governmental or inter-governmental authorities or of a Court having jurisdiction.

The documents and data are subject to a file management plan.

ARTICLE 10

10.1. - Any delay or shortcoming in the performance of its Services by the Society arising from an event not reasonably foreseeable by or beyond the control of the Society shall be deemed not to be a breach of contract.

ARTICLE 11

11.1. - In case of diverging opinions during surveys between the Client and the Society’s surveyor, the Society may designate another of its surveyors at the request of the Client.

11.2. - Disagreements of a technical nature between the Client and the Society can be submitted by the Society to the advice of its Marine Advisory Committee.

ARTICLE 12

12.1. - Disputes over the Services carried out by delegation of Governments are assessed within the framework of the applicable agreements with the States, international Conventions and national rules.

12.2. - Disputes arising out of the payment of the Society’s invoices by the Client are submitted to the Court of Nanterre, France.

12.3. - Other disputes over the present General Conditions or over the Services of the Society are exclusively submitted to arbitration, by three arbitrators, in London according to the Arbitration Act 1996 or any statutory modification or re-enactment thereof. The contract between the Society and the Client shall be governed by English law.

ARTICLE 13

13.1. - These General Conditions constitute the sole contractual obligations binding together the Society and the Client, to the exclusion of all other representation, statements, terms, conditions whether express or implied. They may be varied in writing by mutual agreement.

13.2. - The invalidity of one or more stipulations of the present General Conditions does not affect the validity of the remaining provisions.

13.3. - The definitions herein take precedence over any definitions serving the same purpose which may appear in other documents issued by the Society.

GE N E R AL CON DITIO NS

M A RIN E DI VISION

B V Mod. Ad. ME 545 | 16 February 2004
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Foreword

This document has been prepared to propose a set of requirements for ships carrying compressed natural gas (CNG).

It is based on the latest editions of Bureau Veritas Rules for the Classification of Steel Ships and on the IMO IGC code (including 1994, 1996 and 2000 amendments and draft amendments BLG9/17 2005) respectively.

As soon as the technical features of any CNG projects are sufficiently developed, it will be required to conduct a risk analysis focusing on the innovative components of each design, such as the containment system, and also on the process during cargo operations, in order to validate the main design options with respect to the present safety standard achieved through the application of the IMO IGC code.

In a first instance, it is observed that there is no dedicated existing set of rules and regulations covering the carriage in bulk of compressed natural gas. (For memory, SOLAS regulation II-2/19 deals with the carriage of dangerous goods in portable tanks or containers.)

However, the IMO “international code for the construction and equipment of ships carrying liquefied gases in bulk” (IGC code) mentions in §1.1.6:

“Where it is proposed to carry products which may be considered to come within the scope of the Code but are not at present designated in chapter 19, the Administrations and the port Administrations involved in such a carriage should establish preliminary suitable conditions of carriage based on the principles of the Code and notify the Organisations of such conditions.”

Therefore, the IMO IGC code is considered relevant to a project of ships carrying CNG, despite the fact that gas will not be transported in a liquid state.

The main reasons of this statement are:

- Methane is a substance mentioned in chapter 19 of the IGC code;
- The present note deals with CNG carried in bulk in fixed containers;
- Most of the hazards related to the carriage and to the handling of CNG are of a similar nature as those involved in the carriage of LNG;
- The IGC code is a consistent set of regulations, generally recognised by the flag administrations.

It is assumed in this Rule Note that any containers proposed are able to meet the criteria of independent type B or C cargo tanks as defined by the IMO IGC code.
In order to facilitate the use of this Rule Note and to have a self-standing document the applicable text of IGC Code has been incorporated and printed in Roman characters. Modifications and additional requirements are printed in italics.

The word “Administration” has been replaced by “Society”.

In this Rule Note, Ship Rules means the Bureau Veritas Rules for the Classification of Steel Ships.
1. General

1.1 Scope

1.1.1 Applicability

1.1.1.1 IGC Code requirements and the Society’s Rules

a) Ships which are intended for the carriage of compressed natural gases are to comply with the requirements of the latest version of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, as amended. In this Rule Note reference to this Code and its amendments is made by the wording “IGC Code”.

b) In general, this Rule Note applies to cargo containment and handling systems and to the interfaces between these systems and the remainder of the ship, which is to comply with the applicable requirements for hull and machinery given in Parts B, C and D of Ships Rules.

1.1.1.2 IGC Code requirements not within the scope of classification

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

- Chapter 1, Section 1.4 - Equivalents
- Chapter 1, Section 1.5 - Surveys and certification
- Chapter 11, Section 11.6 – Fireman’s outfits
- Chapter 14 – Personnel Protection
- Chapter 18 - Operating requirements.

Spare parts requirements are given for information within the scope of classification

1.1.1.3 Particularly hazardous products

For the carriage in bulk of products presenting more severe hazards than those covered by this Rule Note, the Society reserves the right to establish requirements and/or conditions additional to those contained in this Rule Note.
1.2 Safety Goal and Formal Safety Assessment

A quantified Formal Safety Assessment complying with IMO Guidelines MSC/Circ. 1023 is to be submitted in order to document that the safety level is equivalent or better than comparable ships covered by IGC Code.

It is the responsibility of the designer and/or the owner to define the applicable Risk Acceptance Criteria.

1.3 Additional requirements

1.3.1 Emergency towing arrangement

Emergency towing arrangements are to be fitted on compressed gas tankers of 20,000 dwt and above in accordance with Ship Rules, Pt B, Ch 10, Sec 4, [4].

1.3.2 Steering gear

Additional requirements for steering gear of compressed gas carriers of 10,000 dwt and above are given in Ship Rules, Pt D, Ch 7, Sec 4, [7].

1.4 Documentation to be submitted

Tab 2 lists the plans, information, analysis, etc. which are to be submitted in addition to the information required in Ship Rules for the parts of the ship not affected by the cargo, as applicable.

Table 2: Documents to be submitted

<table>
<thead>
<tr>
<th>No</th>
<th>A/I</th>
<th>Documents</th>
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<td>6</td>
<td>A</td>
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</tr>
<tr>
<td>7</td>
<td>A</td>
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<tr>
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<td>No</td>
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<td>No</td>
<td>A/I</td>
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**Note 1:** A = to be submitted for approval in four copies  
I = to be submitted for information in duplicate
1.5 Cargo equipment trials

1.5.1 Scope

1.5.1.1 Trials in working conditions

All the equipment to which this Rule Note is applicable is to be tested in actual working conditions.

1.5.1.2 Trials to be carried out when the ship is loaded

Those trials which may only be carried out when the ship is loaded are to be held at the first loading of the ship.

1.5.2 Extent of the tests

1.5.2.1 Cargo equipment testing procedure

The cargo equipment testing procedure is to be submitted to the Society for review.

1.5.2.2 Ships with mechanical refrigeration units

Ships fitted with a mechanical refrigeration unit are to be subjected to an initial testing procedure in order to check the suitability of the plant in respect of the applicable requirements. The recording of the data of the refrigeration system, such as working duration and ambient conditions, may be carried out during the first loaded voyage.

1.5.2.3 Use of cargo as fuel

The arrangements for using cargo as fuel are to be subjected to a special testing procedure.

1.6 Hazards

Hazards of natural gases considered in this Rule Note include fire, low temperature and pressure. Toxicity is not normally considered as it is assumed that the toxic components which may be present in the natural gas have been removed from the gas before introduction in tanks.

1.7 Definitions

Except where expressly provided otherwise, the following definitions apply to this Rule Note. Additional definitions are given in chapter 4.
1.7.1. **Accommodation spaces** are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobbies rooms, barber shops, pantries containing no cooking appliances and similar spaces. Public spaces are those portions of the accommodation which are used for halls, dining rooms, lounges and similar permanently enclosed spaces.

1.7.2. `A’ class divisions means divisions as defined in SOLAS regulation II-2/3.2.

1.7.3.1. **Administration** means the Government of the State whose flag the ship is entitled to fly.

1.7.3.2. **Port Administration** means the appropriate authority of the country in the port of which the ship is loading or unloading.

1.7.3.3. N/A

1.7.4. **Boiling point** is the temperature at which a product exhibits a vapour pressure equal to the atmospheric pressure.

1.7.5. **Breadth (B)** means the maximum breadth of the ship, measured amidships to the moulded line of the frame in a ship with a metal shell and to the outer surface of the hull in a ship with a shell of any other material. The breadth (B) is to be measured in metres.

1.7.6. **Cargo area** is that part of the ship which contains the cargo containment system and cargo pump and compressor rooms and includes deck areas over the full length and breadth of the part of the ship over the above-mentioned spaces. Where fitted, the cofferdams, ballast or void spaces at the after end of the aftermost hold space or at the forward end of the forwardmost hold space are excluded from the cargo area.

1.7.7. **Cargo containment system** is the arrangement for containment of cargo including, where fitted, associated insulation and any intervening spaces, and adjacent structure if necessary for the support of these elements.

1.7.8. **Cargo control room** is a space used in the control of cargo handling operations and complying with the requirements of 3.4.

1.7.9. **Cargoes** are products carried in bulk by ships subject to this Rule Note.

1.7.10. **Cargo service spaces** are spaces within the cargo area used for workshops, lockers and store-rooms of more than 2 m² in area, used for cargo handling equipment.

1.7.11. **Cargo tank** is the Gas-tight shell or shells connected together in assemblies designed to be the primary container of the cargo and includes all such containers whether or not associated with insulation or secondary barriers or both up to the first stop valve.

1.7.12. **Cofferdam** is the isolating space between two adjacent steel bulkheads or decks. This space may be a void space or a ballast space.
1.7.13. **Control stations** are those spaces in which ships’ radio or main navigating equipment or the emergency source of power is located or where the fire-recording or fire-control equipment is centralized. This does not include special fire-control equipment which can be most practically located in the cargo area.

1.7.14. **Flammable products** are the various types of natural gases.

1.7.15. **Flammability limits** are the conditions defining the state of fuel-oxidant mixture at which application of an adequately strong external ignition source is only just capable of producing flammability in a given test apparatus.

1.7.16. **CNG carrier** is a cargo ship constructed or adapted and used for the carriage in bulk of compressed natural gas.

1.7.17. **Gas-dangerous space or zone** is:

.1. a space in the cargo area which is not arranged or equipped in an approved manner to ensure that its atmosphere is at all times maintained in a gas-safe condition;

.2. an enclosed space outside the cargo area through which any piping containing condensate or gaseous products passes, or within which such piping terminates, unless approved arrangements are installed to prevent any escape of product vapour into the atmosphere of that space;

.3. a cargo containment system and cargo piping;

.4. a hold space where cargo is carried

.5. a space separated from a hold space described in 4 by a single gastight steel boundary;

.6. a cargo handling equipment room;

.7. a zone on the open deck, or semi-enclosed space on the open deck, within 3 m of any cargo tank outlet, gas or vapour outlet, cargo pipe flange or cargo valve or of entrances and ventilation openings to cargo handling equipment rooms;

.8. the open deck over the cargo area and 3 m forward and aft of the cargo area on the open deck up to a height of 2.4 m above the weather deck;

.9. a zone within 2.4 m of the outer surface of a cargo containment system where such surface is exposed to the weather;

.10. an enclosed or semi-enclosed space in which pipes containing products are located. A space which contains gas detection equipment complying with 13.6.5 and a space utilizing cargo gas as fuel and complying with chapter 16 are not considered gas-dangerous spaces in this context;

.11. a compartment for cargo hoses; or
1.2. an enclosed or semi-enclosed space having a direct opening into any gas-
dangerous space or zone.

1.7.18. **Gas-safe space** is a space other than a gas-dangerous space.

1.7.19. **Hold space** is the space enclosed by the ship’s structure in which a cargo
containment system is situated.

1.7.20. **Independent** means that a piping or venting system, for example, is in no way
connected to another system and there are no provisions available for the potential
connection to other systems.

1.7.21. **Insulation space** is the space occupied wholly or in part by insulation.

1.7.22. N/A

1.7.23. **Length (L)** means 96% of the total length on a waterline at 85% of the least moulded
depth measured from the top of the keel, or the length from the foreside of the stem to the
axis of the rudder stock on that waterline, if that be greater. In ships designed with a rake of
keel, the waterline on which this length is measured are to be parallel to the designed
waterline. The length (L) are to be measured in metres.

1.7.24. **Machinery spaces of category A** are those spaces and trunks to such spaces which
contain:

.1. internal combustion machinery used for main propulsion; or

.2. internal combustion machinery used for purposes other than main propulsion where
such machinery has in the aggregate a total power output of not less than 375 kW; or

.3. any oil-fired boiler or oil fuel unit.

1.7.25. **Machinery spaces** are all machinery spaces of category A and all other spaces
containing propelling machinery, boilers, oil fuel units, steam and internal combustion
engines, generators and major electrical machinery, oil filling stations, refrigerating,
stabilizing, ventilation and air-conditioning machinery, and similar spaces; and trunks to such
spaces.

1.7.26. **MARVS** is the maximum allowable relief valve setting of a cargo tank.

1.7.27. **Oil fuel unit** is the equipment used for the preparation of oil fuel for delivery to an oil-
-fired boiler, or equipment used for the preparation for delivery of heated oil to an internal
combustion engine, and includes any oil pressure pumps, filters and heaters dealing with oil
at a pressure of more than 1.8 bar gauge.

1.7.28. **Organization** is the International Maritime Organization (IMO).

1.7.29. **Permeability** of a space means the ratio of the volume within that space which is
assumed to be occupied by water to the total volume of that space.
1.7.30. Recognized standards are applicable international or national standards acceptable to the Society.

1.7.31. Relative density is the ratio of the mass of a volume of a product to the mass of an equal volume of fresh water.

1.7.32. Separate means that a cargo piping system or cargo vent system, for example, is not connected to another cargo piping or cargo vent system. This separation may be achieved by the use of design or operational methods. Operational methods are not to be used within a cargo tank and are to consist of one of the following types:

1. removing spool pieces or valves and blanking the pipe ends;
2. arrangement of two spectacle flanges in series with provisions for detecting leakage into the pipe between the two spectacle flanges.

1.7.33. Service spaces are those used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, store-rooms, workshops other than those forming part of the machinery spaces and similar spaces and trunks to such spaces.

1.7.34. SOLAS means the International Convention for the Safety of Life at Sea, 1974, as amended.

1.7.35.

1.7.36. Tank cover is the protective structure intended to protect the cargo containment system against damage where it protrudes through the weather deck or to ensure the continuity and integrity of the deck structure.

1.7.37.

1.7.38. Toxic products are natural gases containing toxic components.

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

1.7.40. Void space is an enclosed space in the cargo area external to a cargo containment system, other than a hold space, ballast space, fuel oil tank, cargo handling equipment room, or any space in normal use by personnel.
1.8 Equivalents

1.8.1. Where this Rule Note requires that a particular fitting, material, appliance, apparatus, item of equipment or type thereof are to be fitted or carried in a ship, or that any particular provision are to be made, or any procedure or arrangement are to be complied with, the Society may allow any other fitting, material, appliance, apparatus, item of equipment or type thereof to be fitted or carried, or any other provision, procedure or arrangement to be made in that ship, if it is satisfied by trial thereof or otherwise that such fitting, material, appliance, apparatus, item of equipment or type thereof or that any particular provision, procedure or arrangement is at least as effective as that required by this Rule Note. However, the Society may not allow operational methods or procedures to be made an alternative to a particular fitting, material, appliance, apparatus, item of equipment, or type thereof which is prescribed by this Rule Note.

1.9 Classification and Surveys

Classification and surveys are detailed in Ship Rules Pt A.
2. Ship Survival Capability and Location of Cargo Tanks

2.1 General

2.1.1. Ships subject to this Rule Note are to survive the normal effects of flooding following assumed hull damage caused by some external force. In addition, to safeguard the ship and the environment, the cargo tanks are to be protected from penetration in the case of minor damage to the ship resulting, for example, from contact with a jetty or tug, and given a measure of protection from damage in the case of collision or stranding, by locating them at specified minimum distances inboard from the ship’s shell plating. Both the damage to be assumed and the proximity of the tanks to the ship’s shell are to be dependent upon the degree of hazard presented by the product to be carried.

2.1.2. Ships subject to this Rule Note are to be designed either:

1. To the type 2G ship standard which is a gas carrier intended to transport products which require significant preventive measures to preclude the escape of such cargo; or

2. To the type 2PG ship standard which is a gas carrier of 150 m in length or less intended to transport products which require significant preventive measures to preclude the escape of such cargo and where the products are carried in independents type C tanks designed to a temperature of -55 or above.

*Damage stability will be assessed when the notation SDS is assigned*

2.2 Freeboard and intact stability

2.2.1. Ships subject to this Rule Note may be assigned the minimum freeboard permitted by the International Convention on Load Lines in force. However, the draught associated with the assignment is not to be greater than the maximum draught otherwise permitted by this Rule Note.

2.2.2. The stability of the ship for the loading conditions in Ship Rules, Pt B, Ch 3, App 2, [1.2.8] is to be in compliance with the requirements of Ship Rules, Pt B, Ch 3, Sec 2.

2.2.3. When calculating the effect of free surfaces of consumable liquids for loading conditions it are to be assumed that, for each type of liquid, at least one transverse pair or a single centre tank has a free surface and the tank or combination of tanks to be taken into account are to be those where the effect of free surfaces is the greatest. The free surface effect is to be calculated in accordance with Ship Rules, Pt B, Ch 3, Sec 2, [4].
2.2.4. Solid ballast are not normally be used in double bottom spaces in the cargo area. Where, however, because of stability considerations, the fitting of solid ballast in such spaces becomes unavoidable, then its disposition is to be governed by the need to ensure that the impact loads resulting from bottom damage are not directly transmitted to the cargo tank structure.

2.2.5. *The Master of the ship is to be supplied with a Loading Manual as specified in Ship Rules, Pt B, Ch 11, Sec 2, [3] and a Trim and Stability booklet as specified in Ship Rules, Pt B, Ch 3, App 2.*

2.3 Shipside discharges below the freeboard deck

2.3.1. The provision and control of valves fitted to discharges led through the shell from spaces below the freeboard deck or from within the superstructures and deckhouses on the freeboard deck fitted with weathertight doors are to comply with the requirements of the relevant regulation of the International Convention on Load Lines in force, except that the choice of valves are to be limited to:

1. one automatic non-return valve with a positive means of closing from above the freeboard deck; or

2. where the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds 0.01L, two automatic non-return valves without positive means of closing, provided that the inboard valve is always accessible for examination under service conditions.

2.3.2. For the purpose of this chapter “summer load waterline” and “freeboard deck”, have the meanings defined in the International Convention on Load Lines in force.

2.3.3. The automatic non-return valves referred to in 2.3.1.1 and 2.3.1.2 are to be fully effective in preventing admission of water into the ship, taking into account the sinkage, trim and heel in survival requirements in 2.9 and are to comply with recognized standards.

2.4 Conditions of loading

2.4.1. Damage survival capability are to be investigated on the basis of loading information submitted to the Society for all anticipated conditions of loading and variations in draught and trim. The survival requirements need not be applied to the ship when in the ballast condition provided that any cargo retained on board is solely used for cooling, circulation or fuelling purposes.

*Loading conditions other than those in the Loading Manual and the Trim and Stability booklet are to be previously submitted to the Society. Alternatively, such cases may be examined by the Master or a delegated officer when a loading instrument approved in accordance with the requirements of Ship Rules, Pt B, Ch 11, Sec 2, [4] is installed on board.*
2.5 Damage assumptions

2.5.1. The assumed maximum extent of damage is to be:

.1 Side damage:

.1.1 Longitudinal extent: \(1/3L^{2/3}\) or 14.5 m, whichever is less

.1.2 Transverse extent:
measured inboard from the ship’s side at right angles to the centreline at the level of the summer load line

.1.3 Vertical extent: from the moulded line of the bottom shell plating at centreline upwards without limit

.2 Bottom damage:

For 0.3\(L\) from the forward perpendicular of the ship

Any other part of the ship

.2.1 Longitudinal extent: \(1/3L^{2/3}\) or 14.5 m, whichever is less \(1/3L^{2/3}\) or 5 m, whichever is less

.2.2 Transverse extent: \(B/6\) or 10 m, whichever is less \(B/6\) or 5 m, whichever is less

.2.3 Vertical extent: \(B/15\) or 2 m, whichever is less measured from the moulded line of the bottom shell plating at centreline (see 2.6.3). \(B/15\) or 2 m, whichever is less measured from the moulded line of the bottom shell plating at centreline (see 2.6.3).

2.5.2. Other damage:

.1. If any damage of a lesser extent than the maximum damage specified in 2.5.1 would result in a more severe condition, such damage are to be assumed.

.2. Local side damage anywhere in the cargo area extending inboard 760 mm measured normal to the hull shell are to be considered and transverse bulkheads are to be assumed damaged when also required by the applicable subparagraphs of 2.8.1.
2.6 Location of cargo tanks

2.6.1. Cargo tanks are to be located at a distance inboard from the moulded line of the bottom shell plating at centreline not less than the vertical extent of damage specified in 2.5.1.2.3 and nowhere less than 760 mm from the shell plating.

2.6.2. For the purpose of tank location, the vertical extent of bottom damage are to be measured to the bottom of the cargo tanks. The transverse extent of side damage is to be measured to the side of the cargo tanks (see figure 2.1).

2.6.3. Suction wells installed in cargo tanks may protrude into the vertical extent of bottom damage specified in 2.5.1.2.3 provided that such wells are as small as practicable and the protrusion below the inner bottom plating does not exceed 25% of the depth of the double bottom or 350 mm, whichever is less. Where there is no double bottom, the protrusion below the upper limit of bottom damage is not to exceed 350 mm. Suction wells installed in accordance with this paragraph may be ignored in determining the compartments affected by damage.

2.6.4 A Quantified Collision and Grounding Risk Assessment should be performed to verify that the above mentioned damage assumptions are still valid.
2.7 Flooding assumptions

2.7.1. The requirements of 2.9 are to be confirmed by calculations which take into consideration the design characteristics of the ship; the arrangements, configuration and contents of the damaged compartments; the distribution, relative densities and the free surface effects of liquids; and the draught and trim for all conditions of loading.

2.7.2. The permeabilities of spaces assumed to be damaged are to be as follows:

<table>
<thead>
<tr>
<th>Spaces</th>
<th>Permeabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appropriated to stores</td>
<td>0.60</td>
</tr>
<tr>
<td>Occupied by accommodation</td>
<td>0.95</td>
</tr>
<tr>
<td>Occupied by machinery</td>
<td>0.85</td>
</tr>
<tr>
<td>Voids</td>
<td>0.95</td>
</tr>
<tr>
<td>Intended for consumable liquids</td>
<td>0 to 0.95</td>
</tr>
<tr>
<td>Intended for other liquids</td>
<td>0 to 0.95</td>
</tr>
</tbody>
</table>

2.7.3. Wherever damage penetrates a tank containing liquids, it are to be assumed that the contents are completely lost from that compartment and replaced by salt water up to the level of the final plane of equilibrium.

2.7.4. Where the damage between transverse watertight bulkheads is envisaged as specified in 2.8.1.4, .5, and .6, transverse bulkheads are to be spaced at least at a distance equal to the longitudinal extent of damage specified in 2.5.1.1.1 in order to be considered effective. Where transverse bulkheads are spaced at a lesser distance, one or more of these bulkheads within such extent of damage are to be assumed as non-existent for the purpose of determining flooded compartments. Further, any portion of a transverse bulkhead bounding side compartments or double bottom compartments are to be assumed damaged if the watertight bulkhead boundaries are within the extent of vertical or horizontal penetration required by 2.5. Also, any transverse bulkhead are to be assumed damaged if it contains a step or recess of more than 3 m in length located within the extent of penetration of assumed damage. The step formed by the after peak bulkhead and after peak tank top is not to be regarded as a step for the purpose of this paragraph.

2.7.5. The ship is to be so designed as to keep unsymmetrical flooding to the minimum consistent with efficient arrangements.
2.7.6. Equalization arrangements requiring mechanical aids such as valves or cross-levelling pipes, if fitted, are not to be considered for the purpose of reducing an angle of heel or attaining the minimum range of residual stability to meet the requirements of 2.9.1 and sufficient residual stability are to be maintained during all stages where equalization is used. Spaces which are linked by ducts of large cross-sectional area may be considered to be common.

2.7.7. If pipes, ducts, trunks or tunnels are situated within the assumed extent of damage penetration, as defined in 2.5, arrangements are to be such that progressive flooding cannot thereby extend to compartments other than those assumed to be flooded for each case of damage.

*Tunnels, ducts, pipes, doors, bulkheads and decks which might form watertight boundaries of intact spaces in the case of assumed conventional damage are to have minimum strength adequate to withstand the pressure height corresponding to the deepest equilibrium waterline in damaged conditions.*

2.7.8. The buoyancy of any superstructure directly above the side damage are to be disregarded. The unflooded parts of superstructures beyond the extent of damage, however, may be taken into consideration provided that:

.1. they are separated from the damaged space by watertight divisions and the requirements of 2.9.1.1 in respect of these intact spaces are complied with; and

.2. openings in such divisions are capable of being closed by remotely operated sliding watertight doors and unprotected openings are not immersed within the minimum range of residual stability required in 2.9.2.1; however, the immersion of any other openings capable of being closed weathertight may be permitted.

### 2.8 Standard of damage

2.8.1. Ships are to be capable of surviving the damage indicated in 2.5 with the flooding assumptions in 2.7 to the extent determined by the ship’s type according to the following standards:

.2. A type 2G ship of more than 150 m in length is to be assumed to sustain damage anywhere in its length;

.3. A type 2G ship of 150 m in length or less are to be assumed to sustain damage anywhere in its length except involving either of the bulkheads bounding a machinery space located aft;

2.8.2. In the case of small type 2G ships which do not comply in all respects with the appropriate requirements of 2.8.1.3, .4, and .6, special dispensations may only be considered by the Society provided that alternative measures can be taken which maintain the same degree of safety.
The longitudinal extent of damage to the superstructure (see also 2.7.8) in the case of side damage to a machinery space aft, as per 2.8.1, is to be the same as the longitudinal extent of the side damage to the machinery space (see Fig 2.2).

*Figure 2.2: Longitudinal extension of superstructures damage*

2.9 Survival requirements

Ships subject to this Rule Note are to be capable of surviving the assumed damage specified in IGC Code 2.5.1 and 2.5.2 to the standard provided in IGC Code 2.8.1 and for the loading conditions in Ship Rules, Pt B, Ch 3, App 2, [1.2.8] in a condition of stable equilibrium and such as to satisfy the criteria in 2.9 and are to satisfy the following criteria.

2.9.1. In any stage of flooding:

.1. the waterline, taking into account sinkage, heel and trim, are to be below the lower edge of any opening through which progressive flooding or downfloodding may take place. Such openings are to include air pipes and openings which are closed by means of weathertight doors or hatch covers and may exclude those openings closed by means of watertight manhole covers and watertight flush scuttles, small watertight cargo tank hatch covers which maintain the high integrity of the deck, remotely operated watertight sliding doors, and side scuttles of the non-opening type;

.2. the maximum angle of heel due to unsymmetrical flooding is not to exceed 30°; and

.3. the residual stability during intermediate stages of flooding are to be to the satisfaction of the Society. However, it never be significantly less than that required by 2.9.2.1.

2.9.2. At final equilibrium after flooding:
1. The righting lever curve is to have a minimum range of 20° beyond the position of equilibrium in association with a maximum residual righting lever of at least 0.1 m within the 20° range; the area under the curve within this range is not to be less than 0.0175 m.rad. Unprotected openings are not to be immersed within this range unless the space concerned is assumed to be flooded. Within this range, the immersion of any of the openings listed in 2.9.1.1 and other openings capable of being closed weathertight may be permitted; and

2. The emergency source of power are to be capable of operating.

2.9.3. Intermediate stages of flooding

The criteria applied to the residual stability during intermediate stages of flooding are to be those relevant to the final stage of flooding as specified in 2.9.2. However, small deviations from these criteria may be accepted by the Society on a case-by-case basis.

2.9.4. Definition of range of positive stability

The 20° range may be measured from any angle commencing between the position of equilibrium and the angle of 25° (or 30° if no deck immersion occurs) (see Fig 2.3).

Figure 2.3: Range of positive stability

![Figure 2.3: Range of positive stability](image)
3. Ship Arrangements

3.1 Segregation of the cargo area

3.1.1. Hold spaces are to be segregated from machinery and boiler spaces, accommodation spaces, service spaces and control stations, chain lockers, drinking and domestic water tanks and from stores. Hold spaces are to be located forward of machinery spaces of category A, other than those deemed necessary by the Society for the safety or navigation of the ship.

*Bow thrusters are allowed to be fitted forward of the hold spaces.*

3.1.2. Segregation of hold spaces from spaces referred to in 3.1.1 or spaces either below or outboard of the hold spaces may be effected by cofferdams, fuel oil tanks or a single gastight bulkhead of all-welded construction forming an A-60 class division. A gastight A-0 class division is satisfactory if there is no source of ignition or fire hazard in the adjoining spaces.

*Hold spaces may be separated from each other by single bulkheads. Where cofferdams are used instead of single bulkheads, they may be used as ballast tanks subject to special approval by the Society*

3.1.3 N/A

3.1.4. N/A

3.1.5. Any piping system which may contain cargo or cargo vapour:

1. is to be segregated from other piping systems, except where inter-connections are required for cargo-related operations such as purging, gas-freeing or inerting. In such cases, precautions are to be taken to ensure that cargo or cargo vapour cannot enter such other piping systems through the inter-connections.

2. Except as provided for a fuel gas system, is not to pass through any accommodation space, service space or control station or through a machinery space other than a cargo pump room or cargo compressor space.

3. Except for bow or stern loading and unloading arrangements in accordance with Subsection/8 and except as provided for fuel gas systems is to be located in the cargo area above the open deck.

4. Except for athwartship shore connection piping not subject to internal pressure at sea is to be located inboard of the transverse tank location requirements of 2.6.1
3.1.6. Any emergency cargo blow down piping system is to comply with 3.1.5 as appropriate and may be led aft externally to accommodation spaces, service spaces or control stations or machinery spaces, but is not to pass through them.

The location of the cold vent or flare outlet is to be subject to a gas dispersion, a flare radiation and a noise analysis as appropriate.

3.1.7. Arrangements are to be made for sealing the weather decks in way of openings for cargo containment systems.

3.2 Accommodation, service and machinery spaces and control stations

3.2.1. No accommodation space, service space or control station is to be located within the cargo area. The bulkhead of accommodation spaces, service spaces or control stations which face the cargo area are to be so located as to avoid the entry of gas from the hold space to such spaces through a single failure of a deck or bulkhead.

Some acceptable arrangements of accommodation spaces, with respect to cargo tanks, are shown in Fig 3.1

3.2.2. In order to guard against the danger of hazardous vapours, due consideration are to be given to the location of air intakes and openings into accommodation, service and machinery spaces and control stations in relation to cargo piping, cargo vent systems and machinery space exhausts from gas burning arrangements.

Compliance with the relevant requirements of this Rule Note, in particular with 3.2.4, 3.8, 8.2.10 and 12.1.6, as applicable, also ensures compliance with the requirements in 3.2.2, relevant to precautions against hazardous vapours.

3.2.3. Access through doors, gastight or otherwise, is not to be permitted from a gas-safe space to a gas-dangerous space, except for access to service spaces forward of the cargo area through air-locks as permitted by 3.6.1 when accommodation spaces are aft.

3.2.4. Entrances, air inlets and openings to accommodation spaces, service spaces, machinery spaces and control stations are not to face the cargo area. They are to be located on the end bulkhead not facing the cargo area or on the outboard side of the superstructure or deck house or on both at a distance of at least 4% of the length (L) of the ship but not less than 3 m from the end of the superstructure or deck house facing the cargo area. This distance, however, need not exceed 5 m. Windows and sidescuttles facing the cargo area and on the sides of the superstructure of deck house within the distance mentioned above are to be of the fixed (non-opening) type. Wheelhouse windows may be non-fixed and wheelhouse doors may be located within the above limits so long as they are so designed that a rapid and efficient gas and vapour tightening of the wheelhouse can be ensured.

3.2.5. Sidescuttles in the shell below the uppermost continuous deck and in the first tier of the superstructure or deck house are to be of the fixed (non-opening) type.
3.2.6. All air intakes and openings into the accommodation spaces, service spaces and control stations are to be fitted with closing devices.

The closing devices are to give a reasonable degree of gas-tightness. Ordinary steel fire-flaps without gaskets/seals are normally not considered satisfactory.

Bolted plates of A60 class for removal of machinery may be accepted on bulkheads facing cargo areas, provided signboards are fitted to warn that these plates may only be opened when the ship is in gas-free condition.

Figure 3.1 Acceptability of common corners between hold space and other spaces

3.3 Cargo handling systems rooms

3.3.1.1. Cargo handling systems rooms are to be situated above the weather deck and located within the cargo area unless specially approved by the Society. Cargo handling equipment rooms are to be treated as cargo pump rooms for the purpose of fire protection according to SOLAS regulation II-2/9.2.4.

3.3.1.2. When cargo handling equipment rooms are permitted to be fitted above or below the weather deck at the after end of the aftermost hold space or at the forward end of the forwardmost hold space, the limits of the cargo area as defined in 1.3.6 are to be extended to include the cargo handling equipment rooms for the full breadth and depth of the ship and deck areas above those spaces.

3.3.1.3. Where the limits of the cargo area are extended by 3.3.1.2, the bulkhead which separates the cargo handling equipment rooms from accommodation and service spaces, control stations and machinery spaces of category A are to be so located as to avoid the entry of gas to these spaces through a single failure of a deck or bulkhead.

3.3.1.4. When cargo handling equipment rooms are permitted to be fitted at the after end of the aftermost hold space, the bulkhead which separates the cargo pump handling equipment rooms from accommodation and service spaces, control stations and machinery spaces of category A is to be so located as to avoid the entry of gas to these spaces through a single failure of a deck or bulkhead. The same condition is also to be satisfied when cargo handling equipment rooms fitted within the cargo area have a bulkhead in common with accommodation and service spaces, control stations and machinery spaces of category A.
3.3.2. Where *handling equipment* are driven by shafting passing through a bulkhead or deck, gastight seals with efficient lubrication or other means of ensuring the permanence of the gas seal are to be fitted in way of the bulkhead or deck.

3.3.3. Arrangements of cargo handling equipment rooms are to be such as to ensure safe unrestricted access for personnel wearing protective clothing and breathing apparatus, and in the event of injury to allow unconscious personnel to be removed. All valves necessary for cargo handling are to be readily accessible to personnel wearing protective clothing. Suitable arrangements are to be made to deal with drainage of cargo handling rooms.

3.3.4. *Cargo handling equipment rooms may not contain electrical equipment, except as provided for in Chapter 10, or other ignition sources such as internal combustion engines or steam engines with operating temperature which could cause ignition or explosion of mixtures of gases, if any, with air.*

### 3.4 Cargo control rooms

3.4.1. Any cargo control room are to be above the weather deck and may be located in the cargo area. The cargo control room may be located within the accommodation spaces, service spaces or control stations provided the following conditions are complied with:

- the cargo control room is a gas-safe space; and

- if the entrance complies with 3.2.4, the control room may have access to the spaces described above;

- if the entrance does not comply with 3.2.4, the control room is to have no access to the spaces described above and the boundaries to such spaces are to be insulated to A-60 class integrity.

3.4.2. If the cargo control room is designed to be a gas-safe space, instrumentation is to, as far as possible, be by indirect reading systems and is to in any case be designed to prevent any escape of gas into the atmosphere of that space. Location of the gas detector within the cargo control room will not violate the gas-safe space if installed in accordance with 13.6.5.

3.4.3. If the cargo control room is a gas-dangerous space, sources of ignition are to be excluded. Consideration is to be paid to the safety characteristics of any electrical installations.

### 3.5 Access to spaces in the cargo area

3.5.1. Visual inspection is to be possible of at least one side of the inner hull structure without the removal of any fixed structure or fitting. If such a visual inspection, whether combined with those inspections required in 3.5.2, 4.7.7 or 4.10.16 or not, is only possible at the outer face of the inner hull, the inner hull is not to be a fuel-oil tank boundary wall.
3.5.2. Inspection of one side of any insulation in hold spaces is to be possible. If the integrity of the insulation system can be verified by inspection of the outside of the hold space boundary when tanks are at service temperature, inspection of one side of the insulation in the hold space need not be required.

3.5.3. Arrangements for hold spaces, void spaces and other spaces that could be considered gas-dangerous and cargo tanks are to be such as to allow entry and inspection of any such space by personnel wearing protective clothing and breathing apparatus and in the event of injury to allow unconscious personnel to be removed from the space and are to comply with the following:

.1. Access is to be provided:

   .1.1. *in general and if possible* to cargo tanks direct from the open deck;

   .1.2. through horizontal openings, hatches or manholes, the dimensions of which are to be sufficient to allow a person wearing a breathing apparatus to ascend or descend any ladder without obstruction and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of the space; the minimum clear opening are to be not less than 600 mm x 600 mm; and

   .1.3. through vertical openings, or manholes providing passage through the length and breadth of the space, the minimum clear opening of which are to be not less than 600 mm by 800 mm at a height of not more than 600 mm from the bottom plating unless gratings or other footholds are provided.

.2. The dimensions referred to in 3.5.3.1.2 and .1.3 may be decreased if the ability to traverse such openings or to remove an injured person can be proved to the satisfaction of the Society.

.3. The requirements of 3.5.3.1.2 and .1.3 do not apply to spaces described in 1.3.17.5. Such spaces are to be provided only with direct or indirect access from the open weather deck, not including an enclosed gas-safe space.

.4. *when access is not possible due to the design then alternative means of inspection are to be provided and submitted for special consideration by the Society*

3.5.4. Access from the open weather deck to gas-safe spaces are to be located in a gas-safe zone at least 2.4 m above the weather deck unless the access is by means of an air-lock in accordance with 3.6.

3.5.5. *Designated passageways below and above cargo tanks are to have at least the cross-sections as specified in 3.5.3.1.*

3.5.6. *For the purpose of the requirements in 3.5.1 and 3.5.2, the following applies:*
Where the Surveyor needs to pass between the flat or curved surface to be inspected and structural elements such as deck beams, stiffeners, frames, girders etc., the distance between that surface and the free edge of the structural elements is to be at least 380 mm. The distance between the surface to be inspected and the surface to which the above structural elements are fitted, e.g. deck, bulkhead or shell, is to be at least 450 mm in the case of a curved tank surface (e.g. type C-tank) or 600 mm in case of a flat tank surface (e.g. type B-tank) (see Fig 3.2).

**Figure 3.2 : Minimum passage over cargo tanks**

Where the Surveyor does not need to pass between the surface to be inspected and any part of the structure, for visibility reasons the distance between the free edge of that structural element and the surface to be inspected is to be at least 50 mm or half the breadth of the structure’s face plate, whichever is the greater (see Fig 3.3).

**Figure 3.3: Minimum distance of structures from cargo tank to allow visual inspection**

If for inspection of a curved surface the Surveyor needs to pass between that surface and another flat or curved surface, to which no structural elements are fitted, the distance between both surfaces is to be at least 380 mm (see Fig 3.4). Where the Surveyor does not need to pass between a curved surface and another surface, a smaller distance than 380 mm may be accepted taking into account the shape of the curved surface.

If for inspection of an approximately flat surface the Surveyor needs to pass between two approximately flat and approximately parallel surfaces, to which no structural elements are fitted, the distance between those surfaces is to be at least 600 mm (see Fig 3.5).

The minimum distances between a cargo tank sump and adjacent double bottom structure in way of a suction well may not be less than that defined in Fig 3.6. If there is no suction well, the distance between the cargo tank sump and the inner bottom may not be less than 50 mm.
The distance between a cargo tank dome and deck structures may not be less than 150 mm (see Fig 3.7).

Where necessary for inspection, fixed or portable staging is to be installed. This staging may not impair the distances specified in 3.5.3.

Where fixed or portable ventilation ducting is to be fitted in compliance with 12.2, such ducting may not impair the distances specified in 3.5.3.

Figure 3.4: Minimum passage between curved surfaces
Figure 3.5: Minimum passage between flat surfaces

Figure 3.6: Minimum distance of cargo tank sump and inner bottom

Figure 3.7: Minimum distance between cargo dome and deck structures
For the purpose of the requirements in 3.5.3, the following applies:

The term "minimum clear opening of not less than 600 x 600 mm" means that such openings may have corner radii up to a maximum of 100 mm (see Fig 3.8).

*Figure 3.8: Minimum horizontal hatch size*

The term "minimum clear opening of not less than 600 x 800 mm" also includes an opening of the size specified in Fig 3.9:

*Figure 3.9: Minimum size of manholes*

Circular access openings in type C cargo tanks are to have diameters of not less than 600 mm.
Where fitted, cofferdams are to have sufficient size for easy access to all their parts. The width of the cofferdams may not be less than 600 mm.

Pipe tunnels are to have enough space to permit inspection of pipes. The pipes in pipe tunnels are to be installed as high as possible from the ship’s bottom.

Access to pipe tunnels through manholes in the engine space is not permitted.

3.6 Air-locks

3.6.1. An airlock is to be only permitted between a gas-dangerous zone on the open weather deck and a gas-safe space and is to consist of two steel doors substantially gastight spaced at least 1.5 m but not more than 2.5 m apart.

Air-locks are to be such as to provide easy passage and are to cover a deck area of not less than 1.5 m². Air-locks are to be kept unobstructed and may not be employed for other uses, such as storage.

3.6.2. The doors are to be self-closing and without any holding back arrangements.

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

The alarm systems are to be of the intrinsically safe type. However, signalling lamps may be of a safe type authorised for the dangerous spaces in which they are installed.

3.6.4. In ships carrying flammable products, electrical equipment which is not of the certified safe type in spaces protected by airlocks are to be de-energized upon loss of overpressure in the space (see also 10.2.5.4). Electrical equipment which is not of the certified safe type for manœuvring, anchoring and mooring equipment as well as the emergency fire pumps are not to be located in spaces to be protected by airlocks.

The following means are considered acceptable alternatives to differential pressure sensing devices in spaces having a ventilation rate not less than 30 air changes per hour:

- Monitoring of current or power in the electrical supply to the ventilation motors; or
- Air flow sensors in the ventilation ducts.

In spaces where the ventilation rate is less than 30 air changes per hour and where one of the above alternatives is fitted, in addition to the alarms required in 3.6.3, arrangements are to be made to de-energise electrical equipment which is not of the certified safe type if more than one air-lock door is moved from the closed position.

3.6.5. The airlock spaces are to be mechanically ventilated from a gas-safe space and maintained at an overpressure to the gas-dangerous zone on the open weather deck.

The spaces protected by air-locks are to be ventilated for the time necessary to give at least 10 air changes prior to energising the non-safe type electrical installations.
3.6.6. The airlock spaces are to be monitored for cargo vapour.

3.6.7. Subject to the requirements of the International Convention on Load Lines in force, the door sill is not to be less than 300 mm in height.

3.7 Bilge, ballast and fuel oil arrangements

3.7.1.1. Hold spaces are to be provided with suitable drainage arrangements not connected with the machinery space. Means of detecting any leakage are to be provided.

3.7.2.1. N/A

3.7.2.2. N/A

3.7.3. N/A

3.7.4. Ballast spaces, including wet duct keels used as ballast piping, fuel-oil tanks and gas-safe spaces may be connected to pumps in the machinery spaces. Dry duct keels with ballast piping passing through, may be connected to pumps in the machinery spaces, provided the connections are led directly to the pumps and the discharge from the pumps lead directly overboard with no valves or manifolds in either line which could connect the line from the duct keel to lines serving gas-safe spaces. Pump vents are not to be open to machinery spaces.

3.7.5. Dry spaces within the cargo area are to be fitted with a bilge or drain arrangement not connected to the machinery space. Spaces not accessible at all times are to be fitted with sounding arrangements. Spaces without a permanent ventilation system are to be fitted with a pressure/vacuum relief system or with air pipes.

Bilge arrangements for holds containing cargo tanks are to be operable from the weather deck.

The diameter of the bilge main may be smaller than the diameter specified in Ship Rules, Pt C, Ch 1, Sec 10, [6.8.1], provided that this diameter is not less than twice the value given in Ship Rules, Pt C, Ch 1, Sec 10, [6.8.3]. This reduction of diameter, however, is not applicable to the determination of the capacity of fire pumps according to Ship Rules, Pt C, Ch 1, Sec 10, [6.7.4].

With reference to the means to ascertain leakages in holds, the following requirements apply:

- The above-mentioned means is to be suitable to ascertain the presence of water in holds containing type C independent tanks

- The above-mentioned means is to be suitable to ascertain the presence of condensate cargo in the spaces adjacent to cargo tanks which are not type C independent tanks.
Where the aforesaid spaces may be affected by water leakages from the adjacent ship structures, the means is also to be suitable to ascertain the presence of water.

Where the above-mentioned means is constituted by electrical level switches, the relevant circuits are to be of the intrinsically safe type and signals are to be transduced to the wheelhouse and to the cargo control station, if fitted.

### 3.8 Bow or stern loading and unloading arrangements

3.8.1. Subject to the requirements of this section, cargo piping may be arranged to permit bow or stern loading and unloading.

3.8.1.1. N/A.

3.8.2. Portable arrangements are not to be permitted.

3.8.3. In addition to the requirements of chapter 5 the following provisions apply to cargo piping and related piping equipment:

- 1. Cargo piping and related piping equipment outside the cargo area is to have only welded connections. The piping outside the cargo area is to run on the open deck and are to be at least 760 mm inboard except for athwartships shore connection piping. Such piping are to be clearly identified and fitted with a shutoff valve at its connection to the cargo piping system within the cargo area. At this location, it is also to be capable of being separated by means of a removable spool piece and blank flanges when not in use.

- 2. The piping is to be full penetration but welded, and fully radiographed regardless of pipe diameter and design temperature. Flange connections in the piping are only permitted within the cargo area and at the shore connection.

- 3. Arrangements are to be made to allow such piping to be purged and gas-freed after use. When not in use, the spool pieces are to be removed and the pipe ends be blank-flanged. The vent pipes connected with the purge are to be located in the cargo area.

3.8.4. Entrances, air inlets and openings to accommodation spaces, service spaces, machinery spaces and control stations are not to face the cargo shore connection location of bow or stern loading and unloading arrangements. They are to be located on the outboard side of the superstructure or deckhouse at a distance of at least 4% of the length of the ship but not less than 3 m from the end of the superstructure or deck house facing the cargo shore connection location of the bow or stern loading and unloading arrangements. This distance, however, need not exceed 5 m. Sidescuttles facing the shore connection location and on the sides of the superstructure or deckhouse within the distance mentioned above are to be of the fixed (non-opening) type. In addition, during the use of the bow or stern loading and unloading arrangements, all doors, ports and other openings on the corresponding superstructure or deckhouse side are to be kept closed. Where, in the case of small ships, compliance with 3.2.4 and this paragraph is not possible, the Society may approve relaxations from the above requirements.
3.8.5. Deck openings and air inlets to spaces within distances of 10 m from the cargo shore connection location are to be kept closed during the use of bow or stern loading or unloading arrangements.

3.8.6. Electrical equipment within a zone of 3 m from the cargo shore connection location are to be in accordance with chapter 10.

3.8.7. Fire-fighting arrangements for the bow or stern loading and unloading areas are to be in accordance with 11.3.1.3 and 11.4.7.

*Devices to stop cargo handling equipment and to close cargo valves are to be fitted in a position from which it is possible to keep under control the loading/unloading manifolds.*

3.8.8. Means of communication between the cargo control station and the shore connection location are to be provided and if necessary certified safe.

3.8.9. *In case of turret mooring the requirements of the STL notation are to be fulfilled.*
4. Cargo Containment

4.1 General

4.1.1 N/A

4.1.2. In addition to the definitions in 1.3, the definitions given in this chapter apply throughout this Rule Note.

Independent cargo containment systems of the following types are considered in this Rule Note:

- Full metal pressure vessels
- Composite reinforced pressure vessels
- Full composite pressure vessels.

Their design and construction are to comply with relevant Recognised Codes and Standards within theirs limits of validity (i.e. High Pressure Vessel Code for a tank like design or Piping Code for a piping like design such as BV PV code, ASME BPV Codes, Code Case 2390 “Composite Reinforced Pressure Vessels (CRPV)”, BS 5500, CODAP, ANSI B31.3, etc.). As an alternative, the requirements of 4.4, 4.5, 4.9, 4.10, 4.11 and 4.13 can be used.

The applicability of Codes and Standards to sea going containment system is to be demonstrated Subject to special consideration by the Society these Codes and Standards may be amended to take into account specificities of the proposed design.

The “leak before failure” principle is to be used for the design of cargo tanks

In general accesses are to be provided to allow for external and internal inspection of cargo tanks. Reference is made to the designer/manufacturer specifications.

If internal or external inspection is not possible then alternative means of inspection are to be provided and submitted for special consideration by the Society

4.2 Definitions

4.2.1 N/A

4.2.2 N/A
4.2.3 N/A

4.2.4 Cargo tanks

4.2.4.1. Independent tanks are self-supporting; they do not form part of the ship’s hull and are not essential to the hull strength.

There are two types of cargo tanks:

- Type 1. cargo tanks - cargo tanks consisting of long length small diameter (less than 200 mm) coiled pressurized piping supported independently up to first stop valve.

- Type 2. cargo tanks – cargo tanks consisting of assembly of multiple individual vertical or horizontal cylindrical pressure vessels connected by a common manifold and supported individually inside the cargo hold up to first stop valve. Type two tanks can be metallic, composites and hybrids (combination of metallic and non-metallic materials).

There are two categories of Cargo tanks referred to in 4.2.4.3 and 4.2.4.4.

4.2.4.2. N/A

4.2.4.3. Type B independent tanks are tanks which are designed using model tests, refined analytical tools and analysis methods to determine stress levels, fatigue life and crack propagation characteristics.

4.2.4.4. Type C independent tanks (also referred to as pressure vessels) are tanks meeting pressure vessel criteria

However, the Society may allocate a tank complying with the criterion of this subparagraph to type B, dependent on the configuration of the tank and the arrangement of its supports and attachments.

4.2.5 N/A

4.2.6 Design vapour pressure

4.2.6.1. The design vapour pressure \( P_0 \) is the maximum gauge pressure at the top of the tank which has been used in the design of the tank.

4.2.6.2. For cargo tanks where there is no temperature control and where the pressure of the cargo is dictated only by the ambient temperature, \( P_0 \) is not to be less than the gauge pressure of the cargo at a temperature of 45°C. However, lesser values of this temperature may be accepted by the Society for ships operating in restricted areas or on voyages of restricted duration and account may be taken in such cases of any insulation of the tanks. Conversely, higher values of this temperature may be required for ships permanently operating in areas of high ambient temperature.

4.2.6.3. In all cases, including 4.2.6.2, \( P_0 \) is not to be less than \text{MARVS}.

4.2.6.4. N/A
4.2.7 Design temperature

The design temperature for selection of materials is the minimum temperature at which cargo may be loaded or transported in the cargo tanks. Provisions to the satisfaction of the Society are to be made to ensure that the tank or cargo temperature cannot be lowered below the design temperature.

Possibilities to have lower temperatures due to blow down, leak or jet impingement are to be considered.

4.3 Design loads

4.3.1 General

4.3.1.1. Tanks together with their supports and other fixtures are to be designed taking into account proper combinations of the following loads:

- internal pressure
- external pressure
- dynamic loads due to the motions of the ship
- thermal loads
- loads corresponding to ship deflection
- tank and cargo weight with the corresponding reactions in way of supports
- insulation weight
- Loads in way piping connections and other attachments.
- Cargo transfer liquid head
- Cyclic loads
- Accidental loads
- Residual loads due to fabrication

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

4.3.1.2. Account is to be taken of the loads corresponding to the pressure test referred to in 4.10.

4.3.1.3.. N/A
4.3.1.4. The tanks are to be designed for the most unfavourable static heel angle within the range 0° to 30° without exceeding allowable stresses given in 4.5.1.

4.3.2 Internal pressure

4.3.2.1. The internal pressure $P_{eq}$ in bar gauge resulting from the design vapour pressure $P_0$ and the liquid pressure $P_{gd}$ defined in 4.3.2.2 are to be calculated as follows:

$$P_{eq} = P_0 + P_{gd} \text{ (bar)}$$

Equivalent calculation procedures may be applied.

4.3.2.2. The internal liquid pressures are those created by the cargo transfer liquid where applicable

$P_{gd(\text{max})}$ is sum of static fluid pressure head and loads resulting from the acceleration of center of gravity of the cargo due to the ship motions, if fluid is used for transfer of cargo from the cargo tank cylinder and dense phase fluid or condensate is being stored in the cargo tank.

4.3.3 External pressure

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

4.3.4 Dynamic loads due to ship motions

4.3.4.1. The determination of dynamic loads is to take account of the long-term distribution of ship motions, including the effects of surge, sway, heave, roll, pitch and yaw on irregular seas which the ship will experience during its operating life (normally taken to correspond to $10^8$ wave encounters). Account may be taken of reduction in dynamic loads due to necessary speed reduction and variation of heading when this consideration has also formed part of the hull strength assessment.

4.3.4.2. For design against plastic deformation and buckling the dynamic loads are to be taken as the most probable largest loads the ship will encounter during its operating life (normally taken to correspond to a probability level of $10^{-8}$). Formulae for acceleration components are given in 4.12.

4.3.4.3. When design against fatigue is to be considered, the dynamic spectrums are to be determined by long-term distribution calculation based on the operating life of the ship (normally taken to correspond to $10^8$ wave encounters). If simplified dynamic loading spectra are used for the estimation of the fatigue life, those are to be specially considered by the Society.

4.3.4.4. For practical application of crack propagation estimates, simplified load distribution over a period of 15 days may be used. Such distributions may be obtained as indicated in figure 4.3.
4.3.4.5. Ships for restricted service may be given special consideration.

4.3.4.6. The accelerations acting on tanks are estimated at their centre of gravity and include the following components:

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

4.3.5. N/A

4.3.6 Thermal loads

4.3.6.1. Transient thermal loads during cooling down periods are to be considered for tanks intended for cargo temperatures below -55°C.

4.3.6.2. Stationary thermal loads are to be considered for tanks where design supporting arrangements and operating temperature may give rise to significant thermal stresses.

4.3.7 Loads on supports

- The loads on supports are covered by 4.6.

4.4 Structural analyses

4.4.1. N/A

4.4.2 N/A

4.4.3 N/A

4.4.4. N/A

4.4.5 Type B independent tanks

- For tanks of this type the following applies:

  1. The effects of all dynamic and static loads are to be used to determine the suitability of the structure with respect to:

     - plastic deformation
     - buckling
• fatigue failure
• crack propagation.

Statistical wave load analysis in accordance with 4.3.4, finite element analysis or similar methods and fracture mechanics analysis or an equivalent approach, are to be carried out.

.2. A three-dimensional analysis is to be carried out to evaluate the stress levels contributed by the ship’s hull. The model for this analysis is to include the cargo tank with its supporting and keying system as well as a reasonable part of the hull.

.3. A complete analysis of the particular ship accelerations and motions in irregular waves and of the response of the ship and its cargo tanks to these forces and motions are to be performed unless these data are available from similar ships.

.4. A buckling analysis is to consider the maximum construction tolerances.

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

.6. The cumulative effect of the fatigue load is to comply with:

\[ \frac{n}{N_i} + 10^{3/N_i} < C_w \]

Where:

- \( n \) = number of stress cycles at each stress level during the life of the ship
- \( N_i \) = number of cycles to fracture for the respective stress level according to the Wöhler (S-N) curve
- \( N_j \) = number of cycles to fracture for the fatigue loads due to loading and unloading

\( C_w \) are to be less than or equal to 0.1. When model tests are required to establish S-N curve, the characteristic S-N curve for use in design is defined as the “mean-minus-three standard deviations” curve obtained from a log\(_{10}\)S-log\(_{10}\)N experimental data. With a Gaussian assumption for the residuals in log\(_{10}\)N with respect to the mean curve through the data, this corresponds to a curve with 99.865% survival probability. The uncertainty in this curve when its derivation is based on a limited number of test data shall be accounted for. It is required that the characteristic curve be estimated with at least 95% confidence. When a total of \( n \) observations of the number of cycles to failure \( N \) are available from \( n \) fatigue tests carried out at the same representative stress range \( S \), then the characteristic value of log\(_{10}\)N at this stress level shall be taken as:

\[ \log_{10} N_c = \overline{\log_{10} N} - c \cdot \sigma \log N \]

Where: \( \overline{\log_{10} N} \) is the mean value of the \( n \) observed values of log\(_{10}\)N and,

\( c \cdot \sigma \log N \) is the standard deviation of the \( n \) observed values of log\(_{10}\)N and \( c \) is a factor whose value depends on \( n \) and is shown in following table.
Additional fatigue analysis using fracture mechanics crack propagation calculations are required for cargo tank cylinders regardless if S-N curve is obtained by model tests or adopted from pressure vessel codes.

7. Plating and ordinary stiffeners

The net scantlings of plating and ordinary stiffeners of type B independent tanks are to be not less than those obtained from the applicable formulae in Ship Rules, Pt B, Ch 7, where the internal pressure is to be calculated according to [2.2].

The scantlings of plating and ordinary stiffeners of type B independent tanks are to be not less than those obtained from the applicable formulae in Ship Rules, Pt B, Ch 7.

8. Primary supporting members

8.1 Analysis criteria

The analysis of the primary supporting members of the tank subjected to lateral pressure based on a three dimensional model is to be carried out according to the following requirements:

- the structural modelling is to comply with the requirements from Ship Rules, Pt B, Ch 7, App 1, [1] to Ship Rules, Pt B, Ch 7, App 1, [3]
- the stress calculation is to comply with the requirements in Ship Rules, Pt B, Ch 7, App 1, [5]
- The longitudinal extension of the structural model is to comply with Ship Rules, Pt B, Ch 7, App 1, [3.2]. In any case, the structural model is to include the hull and the tank with its supporting and keying system
- Wave hull girder loads and wave pressures are to be obtained from a complete analysis of the ship motion and accelerations in irregular waves, to be submitted to the Society for approval, unless these data are available from similar ships. These loads are to be obtained as the most probable the ship may experience during its operating life, for a probability level of $10^{-8}$.
- The inertial loads to be applied on the model are to be obtained from the formulae in 4.3.2.
.8.2 Yielding check of primary supporting members of type B independent tanks primarily constructed of bodies of revolution

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

\[ s_E \leq s_{ALL} \]

where:

- \( s_E \): Equivalent stress, in N/mm\(^2\), to be obtained from the formulae in Ship Rules, Pt B, Ch 7, App 1, [5.1], as a result of direct calculations to be carried out in accordance with above analysis criteria

- \( s_{ALL} \): Allowable stress, in N/mm\(^2\), to be obtained from table 4.2.

.8.3 Yielding check of primary supporting members of type B independent tanks primarily constructed of plane surfaces

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

\[ \sigma_E \leq \sigma_{ALL} \]

where:

- \( \sigma_E \): Equivalent stress, in N/mm\(^2\), to be obtained from the formulae in Ship Rules, Pt B, Ch 7, App 1, [5.1], as a result of direct calculations to be carried out in accordance with above analysis criteria

- \( \sigma_{ALL} \): Allowable stress, in N/mm\(^2\), to be obtained from table 4.2.
Table 4.2: Allowable stress for primary supporting members primarily constructed of plane surfaces

<table>
<thead>
<tr>
<th>Material</th>
<th>Allowable stress, in N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-Mn steel and Ni-steels</td>
<td>The lesser of:</td>
</tr>
<tr>
<td></td>
<td>• 0.75 $R_{ehH}$</td>
</tr>
<tr>
<td></td>
<td>• 0.5 $R_m$</td>
</tr>
<tr>
<td>Austenitic steels</td>
<td>The lesser of:</td>
</tr>
<tr>
<td></td>
<td>• 0.80 $R_{ehH}$</td>
</tr>
<tr>
<td></td>
<td>• 0.4 $R_m$</td>
</tr>
<tr>
<td>Aluminium alloy</td>
<td>The lesser of:</td>
</tr>
<tr>
<td></td>
<td>• 0.75 $R_{ehH}$</td>
</tr>
<tr>
<td></td>
<td>• 0.35 $R_m$</td>
</tr>
</tbody>
</table>

Note 1:

- $R_{ehH}$: Minimum yield stress, in N/mm², of the material, as defined in Ship Rules, Pt B, Ch 4, Sec 1, [2.1]
- $R_m$: Ultimate minimum tensile strength, in N/mm², of the material, as defined in Ship Rules, Pt B, Ch 4, Sec 1, [2.1]

.8.4 Buckling check of local buckling of plate panels of primary supporting members

A local buckling check is to be carried out according to Ship Rules, Pt B, Ch 7, Sec 1, [5] for plate panels which constitute primary supporting members.

In performing this check, the stresses in the plate panels are to be obtained from direct calculations to be carried out in accordance with above analysis criteria.

.9. Fatigue analysis

.9.1 General

The fatigue analysis is to be performed for areas where high fatigue loads induced stresses or large stress concentrations are expected, for welded joints and parent material. Such areas are to be defined by the Designer and agreed by the Society on a case-by-case basis.

Fatigue analysis is to be performed, considering all fatigue loads and their appropriate combinations for the life of the cargo tanks. Fatigue analysis is to be based on S-N curves used in conjunction with Miner’s rule to sum cumulative damage due to the various stresses expected to arise in service. 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. Model testing of cargo tank cylinders or cargo tank cylinder detail may be required to establish S-N curve.
.9.2 Material properties

The material properties affecting fatigue of the items checked are to be documented. Where this documentation is not available, the Society may request to obtain these properties from experiments performed in accordance with recognised standards.

.9.3 Wave loads

In upright ship and in inclined ship conditions the wave loads to be considered for the fatigue analysis of the tank include:

- Maximum and minimum wave hull girder loads and wave pressures, to be obtained from a complete analysis of the ship motion and accelerations in irregular waves, to be submitted to the Society for approval, unless these data are available from similar ships. These loads are to be obtained as the most probable the ship may experience during its operating life, for a probability level of $10^{-8}$.

- Maximum and minimum inertial pressures, to be obtained from the formulae in 4.3.2 as a function of the arbitrary direction $\beta$.

.9.4 Simplified stress distribution for fatigue analysis

The simplified long-term distribution of wave loads may be represented by means of 8 stress ranges, each characterised by an alternating stress $\pm \sigma_i$ and a number of cycles $n_i$ (see Fig 4.1). The corresponding values of $\sigma_i$ and $n_i$ are to be obtained from the following formulae:

$$\sigma_i = \sigma_0 \left(1,0625 - \frac{i}{8}\right)$$

$$n_i = 0.9 \cdot 10^4$$

Where:

- $\sigma_i$ Stress ($i = 1, 2, \ldots, 8$), in N/mm$^2$ (see Fig 4.1)
- $\sigma_0$ Most probable maximum stress over the life of the ship, in N/mm$^2$, for a probability level of $10^{-8}$
- $n_i$ Number of cycles for each stress $\sigma_i$ considered ($i = 1, 2, \ldots, 8$).
.9.5 Conventional cumulative damage

For each structural detail for which the fatigue analysis is to be carried out, the conventional cumulative damage is to be calculated according to the following procedure:

The long-term value of hot spot stress range $\Delta \sigma_{S,0}$ is to be obtained from the following formula:

$$\Delta \sigma_{S,0} = \left| \sigma_{S,\text{MAX}} - \sigma_{S,\text{MIN}} \right|$$

Where:

$\sigma_{S,\text{MAX}}, \sigma_{S,\text{MIN}}$ : Maximum and minimum hot spot stress to be obtained from a structural analysis carried out in accordance with Ship Rules, Pt B, Ch 7, App 1, where the wave loads are those defined in [7.3].

The long-term value of the notch stress range $\Delta \sigma_{N,0}$ is obtained from the formulae in Ship Rules, Pt B, Ch 7, Sec 4, [4.3] as a function of the hot spot stress range $\Delta \sigma_{S,0}$.

The long-term distribution of notch stress ranges $\Delta \sigma_{N,i}$ is to be calculated. Each stress range $\Delta \sigma_{N,i}$ of the distribution, corresponding to $n_i$ stress cycles, is obtained from the formulae in [9.4], where $\sigma_0$ is taken equal to $\Delta \sigma_{N,0}$.

For each notch stress range $\Delta \sigma_{N,i}$, the number of stress cycles $N_i$ which cause the fatigue failure is to be obtained by means of S-N curves corresponding to the as-rolled condition (see Fig 4.2). The criteria adopted for obtaining the S-N curves are to be documented. Where this documentation is not available, the Society may require the curves to be obtained from experiments performed in accordance with recognised standards.
The conventional cumulative damage for the notch stress ranges $\Delta \sigma_{N,i}$ is to be obtained from the formula in 4.4.5.6.

The conventional cumulative damage, to be calculated according to [9.5], is to be not greater than $C_{W}$.

**Figure 4.2**: Fatigue check based on conventional cumulative damage method

Distribution of notch stress ranges

S-N curve corresponding to the as-rolled condition

.10. Crack propagation analysis

.10.1 General

The crack propagation analysis is to be carried out for highly stressed areas. The latter are to be defined by the Designer and agreed by the Society on a case-by-case basis. Propagation rates in the parent material, weld metal and heat-affected zone are to be considered.

The following checks are to be carried out:

- crack propagation from an initial defect, in order to check that the defect will not grow and cause a brittle fracture before the defect is detected; this check is to be carried out according to [10.4]

- crack propagation from an initial through thickness defect, in order to check that the defect, resulting in a leakage, will not grow and cause a brittle fracture less than 15 days after its detection; this check is to be carried out according to [10.5].
10.2 Material properties

The material fracture mechanical properties used for the crack propagation analysis, i.e. the properties relating the crack propagation rate to the stress intensity range at the crack tip, are to be documented for the various thicknesses of parent material and weld metal alike. Where this documentation is not available, the Society may request to obtain these properties from experiments performed in accordance with recognised standards.

10.3 Simplified stress distribution for crack propagation analysis

The simplified wave load distribution indicated in 4.3.4.4 may be represented over a period of 15 days by means of 5 stress ranges, each characterised by an alternating stress $\pm \sigma_i$ and number of cycles, $n_i$ (see Fig 4.7). The corresponding values of $\sigma_i$ and $n_i$ are to be obtained from the following formulae:

$$\sigma_i = \sigma_0 \left(1.1 - \frac{i}{5.3}\right)$$

$$n_i = 0.913 \cdot 10^i$$

Where:

$\sigma_i$ : Stress ($i = 1.06; 2.12; 3.18; 4.24; 5.30$), in N/mm² (see Fig 4.7)

$\sigma_0$ : Defined in [7.4]

$n_i$ : Number of cycles for each stress $\sigma_i$ considered ($i = 1.06; 2.12; 3.18; 4.24; 5.30$).

Figure 4.3: Simplified stress distribution for crack propagation analysis
10.4 Crack propagation analysis from an initial defect

It is to be checked that an initial crack will not grow, under wave loading based on the stress distribution in [9.4], beyond the allowable crack size. The initial size and shape of the crack is to be considered by the Society on a case-by-case basis, taking into account the structural detail and the inspection method. The allowable crack size is to be considered by the Society on a case-by-case basis; in any event, it is to be taken less than that which may lead to a loss of effectiveness of the structural element considered.

10.5 Crack propagation analysis from an initial through thickness defect

It is to be checked that an initial through thickness crack will not grow, under dynamic loading based on the stress distribution in [10.3], beyond the allowable crack size. The initial size of the through thickness crack is to be taken not less than that through which the minimum flow size that can be detected by the monitoring system (e.g. gas detectors) may pass. The allowable crack size is to be considered by the Society on a case-by-case basis; in any event, it is to be taken far less than the critical crack length, defined in [10.6].

10.6 Critical crack length

The critical crack length is the crack length from which a brittle fracture may initiate and it is to be considered by the Society on a case-by-case basis. In any event, it is to be evaluated for the most probable maximum stress experienced by the structural element in the ship life, which is equal to the stress in the considered detail obtained from the structural analysis to be performed in accordance with the following:

- the structural modelling is to comply with the requirements from Ship Rules, Pt B, Ch 7, App 1, [1] to Ship Rules, Pt B, Ch 7, App 1, [3]
- the stress calculation is to comply with the requirements in Ship Rules, Pt B, Ch 7, App 1, [5]
- The longitudinal extension of the structural model is to comply with Ship Rules, Pt B, Ch 7, App 1, [3.2]. In any case, the structural model is to include the hull and the tank with its supporting and keying system
- Wave hull girder loads and wave pressures are to be obtained from a complete analysis of the ship motion and accelerations in irregular waves, to be submitted to the Society for approval, unless these data are available from similar ships. These loads are to be obtained as the most probable the ship may experience during its operating life, for a probability level of $10^{-8}$.
- The inertial loads are to be obtained from the formulae in 4.3.2.

4.4.6 Type C independent tanks

The requirements of 4.4.5 are applicable.

The type C independent cargo tanks are to comply with the requirements of Ship Rules, Pt C, Ch 1, Sec 3 related to class 1 pressure vessels.
4.4.6.1. Scantlings based on internal pressure are to be calculated as follows:

.1. The thickness and form of pressure-containing parts of pressure vessels under internal pressure, including flanges are to be determined according to a standard acceptable to the Society. These calculations in all cases are to be based on generally accepted pressure vessel design theory. Openings in pressure-containing parts of pressure vessels are to be reinforced in accordance with a standard acceptable to the Society.

.2. The design condensate pressures defined in 4.3.2 are to be taken into account in the above calculations.

.3. The welded joint efficiency factor to be used in the calculation according to 4.4.6.1.1 is to be 0.95 when the inspection and the non-destructive testing referred to in 4.10.9 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 special materials, the above-mentioned factors are to be reduced depending on the specified mechanical properties of the welded joint.

4.4.6.2. Buckling criteria are to be as follows:

.1. The thickness and form of pressure vessels subject to external pressure and other loads causing compressive stresses are to be to a standard acceptable to the Society. These calculations in all cases are to be based on generally accepted pressure vessel buckling theory and are to 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.

.2. The design external pressure $P_e$ used for verifying the buckling of the pressure vessels is not to be less than that given by:

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

Where:

$P_1 =$ setting value of vacuum relief valves. For vessels not fitted with vacuum relief valves $P_1$ are to be specially considered, but is not in general to be taken as less than 0.25 bar.

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

$P_3 =$ compressive actions in the shell due to the weight and contraction of 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, accelerations and hull deflection. In addition the local effect of external or internal pressure or both are to 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 $P_4 = 0$. 
4.4.6.3. Stress analysis in respect of static and dynamic loads is to be performed as follows:

.1. Pressure vessel scantlings are to be determined in accordance with 4.4.6.1 and .2.

.2. Calculations of the loads and stresses in way of the supports and the shell attachment of the support are to be made. Loads referred to in 4.3 are to be used, as applicable. Stresses in way of the supports are to be to a standard acceptable to the Society. In special cases a fatigue analysis may be required by the Society.

.3. If required by the Society, secondary stresses and thermal stresses are to be specially considered.

4.4.6.4. For pressure vessels, the thickness calculated according to 4.4.6.1 or the thickness required by 4.4.6.2 plus the corrosion allowance, if any, are to be considered as a minimum without any negative tolerance.

4.4.6.5. N/A

4.4.6.6. Stiffening rings in way of tank supports

4.4.6.6.1 Structural model

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

4.4.6.6.2 Width of attached plating

On each side of the web, the width of the attached plating to be considered for the yielding and buckling checks of the stiffening rings, as in [4.4.6.6.5] and [4.4.6.6.6], respectively, is to be obtained, in mm, from the following formulae:

\[ b = 0.78 \sqrt{rt} \text{ for cylindrical shell,} \]

\[ b = 20 t_b \text{ for longitudinal bulkheads (in the case of lobe tanks)} \]

Where:

\[ r \] : Mean radius, in mm, of the cylindrical shell

\[ t \] : Shell thickness, in mm

\[ t_b \] : Bulkhead thickness, in mm.

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

The boundary conditions of the stiffening ring are to be modelled as follows:

- circumferential forces applied on each side of the ring, whose resultant is equal to the shear force in the tank and calculated through the bi-dimensional shear flow theory
- reaction forces in way of tank supports, to be obtained according to 4.6.11.

4.4.6.6.4 Lateral pressure

The lateral pressure to be considered for the check of the stiffening rings is to be obtained from 4.3.2.

4.4.6.6.5 Yielding check

The equivalent stress in stiffening rings in way of supports is to comply with the following formula: \( \sigma_E \leq \sigma_{ALL} \)

Where:

\[
\sigma_E : \text{Equivalent stress in stiffening rings calculated for the load cases defined in 4.6.2 and 4.6.3, in N/mm}^2, \text{ and to be obtained from the following formula:} \]
\[
\sigma_E = \sqrt{(\sigma_N + \sigma_B) + 3\tau^2}
\]

\( \sigma_N \) : Normal stress, in N/mm\(^2\), in the circumferential direction of the stiffening ring

\( \sigma_B \) : Bending stress, in N/mm\(^2\), in the circumferential direction of the stiffening ring

\( \tau \) : Shear stress, in N/mm\(^2\), in the stiffening ring

\( \sigma_{ALL} \) : Allowable stress, in N/mm\(^2\), to be taken equal to the lesser of the following values:

- 0,57 \( R_m \)
- 0,85 \( R_{eH} \)

\( R_m \) : Defined in Ship Rules, Pt B, Ch 4, Sec 1, [2.1]

\( R_{eH} \) : Defined in Ship Rules, Pt B, Ch 4, Sec 1, [2.1].

4.4.6.6.6 Buckling check

The buckling strength of the stiffening rings is to be checked in compliance with the applicable formulae in Ship Rules, Pt B, Ch 7, Sec 2.
4.4.7 N/A

4.5 Allowable stresses and corrosion allowances

4.5.1 Allowable stresses

4.5.1.1. N/A

4.5.1.2. N/A

4.5.1.3. N/A

4.5.1.4. For type B independent tanks, primarily constructed of bodies of revolution, the allowable stresses are not to exceed:

\[ \sigma_m \leq f \]

\[ \sigma_L \leq 1.5f \]

\[ \sigma_b \leq 1.5F \]

\[ \sigma_L + \sigma_b \leq 1.5F \]

\[ \sigma_m + \sigma_b \leq 1.5F \]

Where

\( \sigma_m \) = equivalent primary general membrane stress

\( \sigma_L \) = equivalent primary local membrane stress

\( \sigma_b \) = equivalent primary bending stress

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

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

With \( R_m \) and \( R_e \) as defined in 4.5.1.7. With regard to the stresses \( \sigma_m \), \( \sigma_L \) and \( \sigma_b \) see also the definition of stress categories in 4.13. The values A, B, C and D are to have at least the following minimum values:

<table>
<thead>
<tr>
<th></th>
<th>Nickel steels and carbon–manganese steels</th>
<th>Austenitic Steels</th>
<th>Aluminium Alloys</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3</td>
<td>3.5</td>
<td>4</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td>C</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>1.5</td>
<td>1.5</td>
<td>1.5</td>
</tr>
</tbody>
</table>
4.5.1.5. For type B independent tanks, primarily constructed of plane surfaces, the Society may require compliance with additional or other stress criteria.

4.5.1.6. For type C independent tanks the maximum allowable membrane stress to be used in calculation according to 4.4.6.1.1 are to be the lower of:

\[ R_m/A \text{ or } R_e/B \]

Where:

\( R_m \) and \( R_e \) are as defined in 4.5.1.7.

4.5.1.7. For the purpose of 4.5.1.3, 4.5.1.4 and 4.5.1.6 the following apply:

.1. \( R_e = \) 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.

\( R_m = \) specified minimum tensile strength at room temperature (N/mm²).

For welded connections in aluminium alloys the respective values of \( R_e \) or \( R_m \) in annealed conditions are to be used.

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

4.5.1.8. The equivalent stress \( \sigma_C \) (von Mises, Huber) are to be determined by:

\[ \sigma_C = \left( \sigma_x^2 + \sigma_y^2 - \sigma_x \sigma_y + 3 \tau_{xy}^2 \right)^{1/2} \]

Where:

\( \sigma_x \) = total normal stress in x-direction

\( \sigma_y \) = total normal stress in y-direction

\( \tau_{xy} \) = total shear stress in x-y plane.

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

\[ \sigma_x = \sigma_{x,st} \text{ or } \sigma_{x,dyn} \]

\[ \sigma_y = \sigma_{y,st} \text{ or } \sigma_{y,dyn} \]

\[ \tau_{xy} = \tau_{xy,st} \text{ or } \tau_{xy,dyn} \]

Where:

\( \sigma_{x,st}, \sigma_{y,st} \) and \( \tau_{xy,st} = \) static stresses
\( \sigma_{x\text{dyn}}, \sigma_{y\text{dyn}} \) and \( \tau_{xy\text{dyn}} \) = dynamic stresses

all determined separately from acceleration components and hull strain components due to deflection and torsion.

4.5.1.10. N/A

4.5.1.11. Allowable stresses for materials other than those covered by chapter 6 are to be subject to approval by the Society in each case.

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

4.5.2 Corrosion allowances

4.5.2.1. No corrosion allowance is to be generally required in addition to the thickness resulting from the structural analysis. However, where there is no environmental control around the cargo tank, such as inerting, or where the cargo is of a corrosive nature, the Society may require a suitable corrosion allowance.

4.5.2.2. For pressure vessels no corrosion allowance is generally required if the contents of the pressure vessel are non-corrosive and the external surface is protected by inert atmosphere or by an appropriate insulation with an approved vapour barrier. Paint or other thin coatings are not to be credited as protection. Where special alloys are used with acceptable corrosion resistance, no corrosion allowance is to be required. If the above conditions are not satisfied, the scantlings calculated according to 4.4.6 are to be increased as appropriate.

4.6 Supports

4.6.1. Cargo tanks are to be supported by the hull in a manner which will prevent bodily movement of the tank under static and dynamic loads while allowing contraction and expansion of the tank under temperature variations and hull deflections without undue stressing of the tank and of the hull.

4.6.2. The tanks with supports are also to be designed for a static angle of heel of 30° without exceeding allowable stresses given in 4.5.1.

4.6.3. The supports are to be calculated for the most probable largest resulting acceleration, taking into account rotational as well as translational effects. This acceleration in a given direction may be determined as shown in figure 4.1. The half axes of the “acceleration ellipse” are to be determined according to 4.3.4.2.

4.6.4. Suitable supports are to be provided to withstand a collision force acting on the tank corresponding to one half the weight of the tank and cargo in the forward direction and one quarter the weight of the tank and cargo in the aft direction without deformation likely to endanger the tank structure.
4.6.5. The loads mentioned in 4.6.2 and 4.6.4 need not be combined with each other or with wave-induced loads.

4.6.6. Provision are to be made to key the tanks against the rotational effects referred to in 4.6.3.

4.6.7. Antiflotation arrangements are to be provided. The antiflotation arrangements are to be suitable to withstand an upward force caused by an empty tank in a hold space flooded to the summer load draught of the ship, without plastic deformation likely to endanger the hull structure.

*Adequate clearance between the tanks and the hull structures is to be provided in all operating conditions.*

4.6.8. The reaction forces in way of tank supports are to be transmitted as directly as possible to the hull primary supporting members, minimising stress concentrations. Where the reaction forces are not in the plane of primary members, web plates and brackets are to be provided in order to transmit these loads by means of shear stresses.

4.6.9. Special attention is to be paid to continuity of structure between circular tank supports and the primary supporting members of the ship.

4.6.10. In primary supporting members of tank supports and hull structures in way of tank supports which constitute hull supports, openings are to be avoided and local strengthening may be necessary.

4.6.11. The reaction forces in way of tank supports are to be obtained from the structural analysis of the tank or stiffening rings in way of tank supports, considering the loads specified in:

- [4.4.5], for the structural analysis of type B independent tanks
- [4.4.6], for the structural analysis of type C independent tanks.

*The final distribution of the reaction forces at the supports is not to show any tensile forces*

4.6.12 Rolling keys

Rolling keys are to be checked under transverse and vertical accelerations, defined in Ship Rules, Pt B, Ch 5, Sec 3, [3.4.1] for the inclined ship conditions, and applied on the maximum weight of the full tank.

*It is to be checked that the combined stress in rolling keys is in compliance with the following formula:* 

\[ \sigma_{ALL} > \sigma_C \]

*where:*

- \( \sigma_{ALL} \): Allowable stress, N/mm², to be taken equal to the minimum of 0.75 \( R_{eh} \) and 0.5 \( R_m \)
\( R_{eH} \): Yield stress, in N/mm\(^2\), of the steel used, at 20 °C

\( R_{m} \): Minimum ultimate tensile strength, in N/mm\(^2\), at 20 °C.

4.6.13. Pitching keys

Pitching keys are to be checked under longitudinal accelerations, to be taken not less than 0.3, and vertical accelerations defined in Ship Rules, Pt B, Ch 5, Sec 3, [3.4.1] for the upright conditions, and applied on the maximum weight of the full tank.

It is to be checked that the combined stress in pitching keys is in compliance with the following formula:

\[ \sigma_{\text{ALL}} > \sigma_{\text{C}} \]

Where:

\( \sigma_{\text{ALL}} \): Allowable stress, N/mm\(^2\), defined in [4.6.12].

4.6.14. The net scantlings of plating, ordinary stiffeners and primary supporting members of tank supports and hull structures in way are to be not less than those obtained by applying the criteria in Ship Rules, Pt B, Ch 7.

The hull girder loads and the lateral pressure to be considered in the formulae above are to be obtained from the formulae in Ship Rules, Pt B, Ch 5.

The values of reaction forces in way of tank supports to be considered for the scantlings of these structural elements are to be obtained multiplying by 0.625 the part of the reaction forces due to the inertial pressure obtained from the structural analysis of the tank (see [4.6.11]).

4.7 Secondary barrier

N/A

4.8 Insulation

4.8.1. Where a product is carried at a temperature below -10 °C suitable insulation are to be provided to ensure that the temperature of the hull structure does not fall below the minimum allowable design temperature given in chapter 6 for the grade of steel concerned, as detailed in 4.9, when the cargo tanks are at their design temperature and the ambient temperatures are 5 °C for air and 0 °C for seawater. These conditions may generally be used for world-wide service. However, higher values of the ambient temperatures may be accepted by the Society for ships operated in restricted areas. Conversely, lesser values of the ambient temperatures may be fixed by the Society for ships trading occasionally or regularly to areas in latitudes where such lower temperatures are expected during the winter months. 4.8.2. N/A
4.8.3. Calculations required by 4.8.1 and 4.8.2 are to be made assuming still air and still water, and except as permitted by 4.8.4, no credit are to be given for means of heating. In the case referred to in 4.8.2, the cooling effect of the leaking cargo is to be considered in the heat transmission studies. For structural members connecting inner and outer hulls, the mean temperature may be taken for determining the steel grade.

4.8.4. In all cases referred to in 4.8.1 and 4.8.2 and for ambient temperature conditions of 5°C for air and 0°C for seawater, approved means of heating transverse hull structural material may be used to ensure that the temperatures of this material do not fall below the minimum allowable values. If lower ambient temperatures are specified, approved means of heating may also be used for longitudinal hull structural material, provided this material remains suitable for the temperature conditions of 5°C for air and 0°C for seawater without heating. Such means of heating are to comply with the following requirements:

.1. sufficient heat are to be available to maintain the hull structure above the minimum allowable temperature in the conditions referred to in 4.8.1 and 4.8.2;

.2. the heating system are to be so arranged that, in the event of a failure in any part of the system, stand-by heating could be maintained equal to not less than 100% of the theoretical heat load;

.3. the heating system are to be considered as an essential auxiliary; and

.4. the design and construction of the heating system are to be to the satisfaction of the Society.

Where a hull heating system complying with 4.8.4 is installed, this system is to be contained solely within the cargo area or the drain returns from the hull heating coils in the wing tanks, cofferdams and double bottom are to be led to a degassing tank. The degassing tank is to be located in the cargo area and the vent outlets are to be located in a safe position and fitted with a flame screen.

4.8.5. In determining the insulation thickness, due regard are to be paid to the amount of acceptable pressure rise in tanks in association with the cooling plant on board, main propulsion machinery using cargo as fuel or other temperature control system.

4.9 Materials

4.9.1. The shell and deck plating of the ship and all stiffeners attached thereto are to be in accordance with Ships Rules, Pt B, Ch 4, Sec 1, unless the calculated temperature of the material in the design condition is below -5°C due to the effect of the low temperature cargo, in which case the material are to be in accordance with table 6.5 assuming the ambient sea and air temperature of 0°C and 5°C respectively.

4.9.2. N/A

4.9.3. Materials used in the construction of cargo tanks are to be in accordance with Table 6.1, 6.2 or 6.3. or equivalent recognized standards acceptable to the Society.
4.9.4. Materials other than those referred to in 4.9.1 and 4.9.3 used in the construction of the ship which are subject to reduced temperature due to the cargo are to be in accordance with table 6.5 for temperatures as determined by 4.8. This includes inner bottom plating, longitudinal bulkhead plating, transverse bulkhead plating, floors, webs, stringers and all attached stiffening members.

4.9.5. The insulation materials are to be suitable for loads which may be imposed on them by the adjacent structure.

4.9.6. Where applicable, due to location or environmental conditions, insulation materials are to have suitable properties of resistance to fire and flame spread and are to be adequately protected against penetration of water vapour and mechanical damage.

4.9.7.1. Materials used for thermal insulation are to be tested for the following properties as applicable, to ensure that they are adequate for the intended service:

.1. compatibility with the cargo
.2. N/A
.3. absorption of the cargo
.4. shrinkage
.5. ageing
.6. closed cell content
.7. density
.8. mechanical properties
.9. thermal expansion
.10. abrasion
.11. cohesion
.12. thermal conductivity
.13. resistance to vibrations
.14. resistance to fire and flame spread.

4.9.7.2.

4.9.8. The procedure for fabrication, storage, handling, erection, quality control and control against harmful exposure to sunlight of insulation materials are to be to the satisfaction of the Society.
4.9.9. Where powder or granulated insulation is used, the arrangements are to be such as to prevent compacting of the material due to vibrations. The design is to incorporate means to ensure that the material remains sufficiently buoyant to maintain the required thermal conductivity and also prevent any undue increase of pressure on the cargo containment system.

4.9.10 Insulation material characteristics:

- The materials for insulation are to be approved by the Society.
- The approval of bonding materials, sealing materials, lining constituting a vapour barrier or mechanical protection is to be considered by the Society on a case-by-case basis. In any event, these materials are to be chemically compatible with the insulation material.
- Before applying the insulation, the surfaces of the tank structures or of the hull are to be carefully cleaned.
- Where applicable, the insulation system is to be suitable to be visually examined at least on one side.
- 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.

4.10 Construction and testing

4.10.1.1. All welded joints of the shells of independent tanks are to be of the butt weld, full penetration type. For dome-to-shell connections, the Society may approve tee welds of the full penetration type. Except for small penetrations on domes, nozzle welds are also generally to be designed with full penetration.

4.10.1.2. Welding joint details for type C independent tanks are to be as follows:

.1. All longitudinal and circumferential joints of pressure vessels are to be of butt welded, full penetration, double vee or single vee type. Full penetration butt welds are to be obtained by double welding, by the use of backing rings or by inert gas back-up (Gas Tungsten Arc welding) properly qualified process. If used, backing rings are to be removed, unless specifically approved by the Society for very small process pressure vessels. Other edge preparations may be allowed by the Society depending on the results of the tests carried out at the approval of the welding procedure.

.2. The bevel preparation of the joints between the pressure vessel body and domes and between domes and relevant fittings are to be designed according to a standard for pressure vessels acceptable to the Society. All welds connecting nozzles, domes or other penetrations of the vessel and all welds connecting flanges to the vessel or nozzles are to be full penetration welds extending through the entire thickness of the vessel wall or nozzle wall, unless specially approved by the Society for small nozzle diameters.
4.10.2. Workmanship is to be to the satisfaction of the Society. Inspection and non-destructive testing of welds for tanks other than type C independent tanks are to be in accordance with the requirements of 6.3.7.

4.10.3. N/A

4.10.4. N/A

4.10.5.1. N/A

4.10.5.2. A quality control specification including maximum permissible size of constructional defects, tests and inspections during the fabrication, installation and also sampling tests at each of these stages are to be to the satisfaction of the Society.

4.10.6. N/A

4.10.7. N/A

4.10.8.1. N/A

4.10.8.2. N/A

4.10.8.3. N/A

4.10.8.4. N/A

4.10.9. For type C independent tanks, inspection and non-destructive testing are to be as follows:

.1. Manufacture and workmanship - The tolerances relating to manufacture and workmanship such as out-of-roundness, local deviations from the true form, welded joints alignment and tapering of plates having different thicknesses, are to comply with standards acceptable to the Society. The tolerances are also to be related to the buckling analysis referred to in 4.4.6.2.

.2. Non-destructive testing - As far as completion and extension of non-destructive testing of welded joints are concerned, the extent of non-destructive testing are to be total or partial according to standards acceptable to the Society, but the controls to be carried out are not to be less than the following:

.2.1. Total non-destructive testing referred to in 4.4.6.1.3:

Radiography or Ultrasonic testing:

butt welds 100% and

Surface crack detection:

all welds 100%;

reinforcement rings around holes, nozzles, etc. 100%.
In addition, the Society may require total ultrasonic testing on welding of reinforcement rings around holes, nozzles, etc.

3 The following provisions apply to independent tanks:

- Tracing, cutting and shaping are to be carried out so as to prevent, at the surface of the pieces, the production of defects detrimental to their use. In particular, marking the plates by punching and starting welding arcs outside the welding zone are to be avoided.

- Before welding, the edges to be welded are to be carefully examined, with possible use of non-destructive examination, in particular when chamfers are carried out.

- In all cases, the working units are to be efficiently protected against bad weather.

- The execution of provisional welds, where any, is to be subjected to the same requirements as the constructional welds. After elimination of the fillets, the area is to be carefully ground and inspected (the inspection is to include, if necessary, a penetrant fluid test).

- All welding consumables are subject to agreement. Welders are also to be agreed.

4.10.10. Each independent tank is to be subjected to a hydrostatic or hydropneumatic test as follows:

.1. N/A

.2. For type B independent tanks, the tests are to be performed so that the stresses approximate, as far as practicable, to 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 should simulate, as far as practicable, the actual loading of the tank and of its supports. In addition, the maximum primary membrane stress or maximum bending stress in primary members under test conditions are not to 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 prototype tests are to be monitored by the use of strain gauges or other suitable equipment.

.3. Type C independent tanks are to be tested as follows:
.3.1. Each pressure vessel, when completely manufactured, are to be subjected to a hydrostatic test in accordance with Recognized Standards, but in no case during the pressure test the calculated primary membrane stress at any point is to exceed 90% of the yield stress of the material. The definition of Po is given in 4.2.6. To ensure that this condition is satisfied where calculations indicate that this stress will exceed 0.75 times the yield strength, the prototype test are to be monitored by the use of strain gauges or other suitable equipment in pressure vessels other than simple cylindrical and spherical pressure vessels.

When the autofrettage technique is used during the manufacturing process the 90% limit requirement on yield stress is not applicable.

.3.2. The temperature of the water used for the test are to be at least 30 °C above the nil ductility transition temperature of the material as fabricated.

.3.3. The pressure are to be held for 2 h per 25 mm of thickness but in no case less than 2 h.

.3.4. Where necessary for cargo pressure vessels, and with the specific approval of the Society, a hydropneumatic test may be carried out under the conditions prescribed in 4.10.10.3.1, .2 and .3.

.3.5. Special consideration may be given by the Society to the testing of tanks in which higher allowable stresses are used, depending on service temperature. However, the requirements of 4.10.10.3.1 are to be fully complied with.

.3.6. After completion and assembly, each pressure vessel and its related fittings are to be subjected to an adequate tightness test.

.3.7. Pneumatic testing of pressure vessels other than cargo tanks is only to be considered on an individual case basis by the Society. Such testing are to be permitted only for those vessels which are so designed or supported that they cannot be safely filled with water, or for those vessels which cannot be dried and are to be used in a service where traces of the testing medium cannot be tolerated.

The conditions in which testing is performed are to simulate as far as possible the actual loading on the tank and its supports.

When testing takes place after installation of the cargo tank, provision is to be made prior to the launching of the ship in order to avoid excessive stresses in the ship structures

4.10.11. All tanks are to be subjected to a tightness test which may be performed in combination with the pressure test referred to in 4.10.10 or separately.

4.10.12. N/A.

4.10.13. In ships fitted with type B independent tanks, at least one tank and its support are to be instrumented to confirm stress levels unless the design and arrangement for the size of ship involved are supported by full-scale experience. Similar instrumentation may be required by the Society for type C independent tanks dependent on their configuration and on the arrangement of their supports and attachments.
4.10.14. The overall performance of the cargo containment system is to be verified for compliance with the design parameters during the initial cool-down, loading and discharging of the cargo. Records of the performance of the components and equipment essential to verify the design parameters are to be maintained and be available to the Society.

4.10.15. Heating arrangements, if fitted in accordance with 4.8.4, are to be tested for required heat output and heat distribution.

4.10.16. The hull is to be inspected for cold spots following the first loaded voyage.

4.10.17. N/A

4.10.18. For type C independent tanks, the required marking of the pressure vessel are to be achieved by a method which does not cause unacceptable local stress raisers.

4.10.19. Final tests

*The tests on the completed system are to be performed in the presence of a Surveyor and are to demonstrate that the cargo containment arrangements are capable of being inerted, cooled, loaded and unloaded in a satisfactory way and that all the safety devices operate correctly.*

Tests are to be performed at the minimum service temperature or at a temperature very close to it.

*The refrigeration and inert gas production systems, if any, and the installation, if any, for use of gas as fuel for boilers and internal combustion engines are also to be tested to the satisfaction of the Surveyor.*

*All operating data and temperatures read during the first voyage of the loaded ship are to be sent to the Society.*

*All data and temperatures read during subsequent voyages are to be kept at the disposal of the Society for a suitable period of time.*

### 4.11 Stress relieving for Cargo tanks

4.11.1. For type *B and C* independent tanks of carbon and carbon-manganese steel, post-weld heat treatment are to be performed after welding if the design temperature is below -10°C. Post-weld heat treatment in all other cases and for materials other than those mentioned above are to be to the satisfaction of the Society. The soaking temperature and holding time are to be to the satisfaction of the Society.

*For tanks, manufactured using the autofrettage technique the post weld heat treatment is not requested.*
4.11.2. In the case of large cargo pressure vessels of carbon or carbon-manganese steel for which it is difficult to perform the heat treatment or for which the post weld heat treatment will degrade the steel properties, mechanical stress relieving by pressurizing may be carried out as an alternative to the heat treatment and subject to the following conditions:

.1. Complicated welded pressure vessel parts such as sumps or domes with nozzles, with adjacent shell plates are to be heat treated before they are welded to larger parts of the pressure vessel.

.2. The mechanical stress relieving process is to be preferably carried out during the hydrostatic pressure test required by paragraph 4.10.10.3, by applying a higher pressure than the test pressure required by 4.10.10.3.1. The pressurizing medium is to be water.

.3. For the water temperature, paragraph 4.10.10.3.2 applies.

.4. Stress relieving are to be performed while the tank is supported by its regular saddles or supporting structure or, when stress relieving cannot be carried out on board, in a manner which will give the same stresses and stress distribution as when supported by its regular saddles or supporting structure.

.5. The maximum stress relieving pressure is to be held for 2 h per 25 mm of thickness but in no case less than 2 h.

.6. The upper limits placed on the calculated stress levels during stress relieving are to be the following:

- equivalent general primary membrane stress: $0.9R_e$

- equivalent stress composed of primary bending stress plus membrane stress: $1.35R_e$

where $R_e$ is the specific lower minimum yield stress or 0.2% proof stress at test temperature of the steel used for the tank.

.7. Strain measurements will normally be required to prove these limits for at least the first tank of a series of identical tanks built consecutively. The locations of strain gauges are to be included in the mechanical stress relieving procedure to be submitted in accordance with 4.11.2.14.

.8. The test procedure is to demonstrate that a linear relationship between pressure and strain is achieved at the end of the stress relieving process when the pressure is raised again up to the design pressure.

.9. High stress areas in way of geometrical discontinuities such as nozzles and other openings are to be checked for cracks by dye penetrant or magnetic particle inspection after mechanical stress relieving. Particular attention in this respect is to be given to plates exceeding 30 mm in thickness.
10. Steels which have a ratio yield stress to ultimate tensile strength greater than 0.8 are generally not to be mechanically stress relieved. If, however, the yield stress is raised by a method giving high ductility of the steel, slightly higher rates may be accepted upon consideration in each case.

11. Mechanical stress relieving cannot be substituted for heat treatment of cold formed parts of tanks if the degree of cold forming exceeds the limit above which heat treatment is required.

12. N/A.

13. N/A.

14. The procedure for mechanical stress relieving is to be submitted beforehand to the Society for approval

4.12 Formulae for acceleration components

The components of acceleration due to ship's motions corresponding to a probability level of 10^-8 in the North Atlantic are obtained from Ships Rules, Pt B, Ch 5, Sec 3 by multiplying those values by 1.6

4.13 Stress categories

. For the purpose of stress evaluation referred to in 4.5.1.4, stress categories are defined in this section.


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

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

4.13.4. Shear stress is the component of the stress acting in the plane of reference.

4.13.5. Primary stress is a stress produced by the imposed loading and 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 which considerably exceed the yield strength will result in failure or at least in gross deformations.

4.13.6. Primary general membrane stress is a primary membrane stress which is so distributed in the structure that no redistribution of load occurs as a result of yielding.
4.13.7. 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

\( f \) = allowable primary general membrane stress.

4.13.8. 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 which cause the stress to occur.
5. Process Pressure Vessels and Condensate, Vapour and Pressure Piping Systems

5.1 General

5.1.1 N/A

5.1.2. The requirements for type C independent tanks in chapter 4 may also apply to process pressure vessels if required by the Society. If so required the term “pressure vessels” as used in chapter 4 covers both type C independent tanks and process pressure vessels.

Process pressure vessels handling cargo are to be considered as class 1 pressure vessels, in accordance with Ship Rules, Pt C, Ch 1, Sec 3, [1.4.1].

5.2 Cargo and process piping

5.2.1 General

5.2.1.1. The requirements of sections 5.2, 5.3, 5.4 and 5.5 apply to product and process piping including vapour piping and vent lines of safety valves or similar piping. Instrument piping not containing cargo is exempt from these requirements.

5.2.1.2. Provision are to be made by the use of offsets, loops, bends, mechanical expansion joints such as bellows, slip joints and ball joints or similar suitable means to protect the piping, piping system components and cargo tanks from excessive stresses due to thermal movement and from movements of the tank and hull structure. Where mechanical expansion joints are used in piping they are to be held to a minimum and, where located outside cargo tanks, are to be of the bellows type.

Expansion joints are to be protected from extensions and compressions greater than the limits fixed for them and the connected piping is to be suitably supported and anchored. Bellow expansion joints are to be protected from mechanical damage.

5.2.1.3. Low-temperature piping is to 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.

High temperature pipes are to be thermally isolated from the adjacent structures. In particular, the temperature of pipelines is not to exceed 220 °C in gas-dangerous zones.
5.2.1.4. Where tanks or piping are separated from the ship’s structure by thermal isolation, provision is to be made for electrically bonding both the piping and the tanks. All gasketed pipe joints and hose connections are to be electrically bonded. *(See 10.3)*

5.2.1.5. Suitable means are to be provided to relieve the pressure from cargo loading and discharging crossover headers and cargo hoses to the cargo tanks or other suitable location, prior to disconnecting the cargo hoses.

5.2.1.6. N/A.

5.2.1.7. N/A.

*Cargo and process piping have to comply with the applicable requirements of Ship Rules, Pt C, Ch 1, Sec 10 for class I pressure piping, unless otherwise specified in the present Chapter.*

5.2.2 Scantlings based on internal pressure

5.2.2.1. Subject to the conditions stated in 5.2.4, the wall thickness of pipes is not to be less than:

\[
t = \frac{t_o + b + c}{1 - \frac{a}{100}} \text{ (mm)}
\]

Where:

to = theoretical thickness

to = PD/(20Ke + P) (mm)

With:

P = design pressure (bar) referred to in 5.2.3

D = outside diameter (mm)

K = allowable stress (N/mm²) referred to in 5.2.4

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 of less than 1.0, in accordance with recognized standards, may be required depending on the manufacturing process.

b = allowance for bending (mm). The value of b are to 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 is to be:
\[ b = \frac{D_{10}}{2.5r} \quad \text{(mm)} \]

With:

\( r \) = mean radius of the bend (mm)

\( c \) = corrosion allowance (mm). If corrosion or erosion is expected, the wall thickness of the piping is to be increased over that required by other design requirements. This allowance is to be consistent with the expected life of the piping.

\( a \) = negative manufacturing tolerance for thickness (%)

5.2.3 Design pressure

5.2.3.1. The design pressure \( P \) in the formula for to in 5.2.2.1 is the maximum gauge pressure to which the system may be subjected in service:

For each piping section, the maximum pressure value among those applicable in paragraph 5.2.2.1 is to be considered.

5.2.3.2. The greater of the following design conditions are to be used for piping, piping system and components as appropriate:

\( \text{.1. N/A} \)

\( \text{.2. for systems or components which may be separated from their relief valves the resulting final pressure at 45^\circ C \text{ or higher or lower if agreed upon by the Society (see 4.2.6.2), or} } \)

\( \text{.3. the MARVS of the cargo tanks and cargo processing systems; or} \)

\( \text{.4. the pressure setting of the associated pump or compressor discharge relief valve; or} \)

\( \text{.5. the maximum total discharge or loading head of the cargo piping system; or} \)

\( \text{.6. the relief valve setting on a pipeline systems.} \)

5.2.3.3. The design pressure is not to be less than 10 bar gauge except for open-ended lines where it are to be not less than 5 bar gauge.

5.2.4 Permissible stresses

5.2.4.1. For pipes, the permissible stress to be considered in the formula for \( t \) in 5.2.2.1 is the lower of the following values:

\( R_{\text{us}}/A \) or \( R_{\text{us}}/B \)
Where:

\[ R_m = \text{specified minimum tensile strength at room temperature (N/mm}^2\text{)} \]

\[ R_y = \text{specified minimum yield stress at room temperature (N/mm}^2\text{)}. \text{If the stress-strain curve does not show a defined yield stress, the 0.2}\%\text{ proof stress applies.} \]

The values of A and B have values of at least A = 2.7 and B = 1.8.

5.2.4.2. The minimum wall thickness are to be in accordance with Recognized Standards.

5.2.4.3. Where necessary for mechanical strength to prevent damage, collapse, excessive sag or buckling of pipes due to superimposed loads from supports, ship deflection or other causes, the wall thickness are to be increased over that required by 5.2.2, or, if this is impracticable or would cause excessive local stresses, these loads are to be reduced, protected against or eliminated by other design methods.

5.2.4.4. Flanges, valves and other fittings are to comply with recognized standards, taking into account the design pressure defined in 5.2.2. For bellows expansion joints used in vapour service, a lower minimum design pressure may be accepted.

5.2.4.5. For flanges not complying with a standard, the dimensions of flanges and related bolts are to be to the satisfaction of the Society.

For flanges not complying with a standard, the dimensions and type of gaskets are to be to the satisfaction of the Society.

5.2.5 Stress analysis

When the design temperature is -110°C or lower, 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 for each branch of the piping system are to be submitted to the Society. For temperatures of above -110°C, a stress analysis may be required by the Society in relation to such matters as the design or stiffness of the piping system and the choice of materials. In any case, consideration is to be given to thermal stresses, even though calculations are not submitted. The analysis may be carried out according to a code of practice acceptable to the Society.

When such an analysis is required, it is to be carried out in accordance with the requirements listed below. Subject to this condition, calculations in accordance with recognised standards are admitted by the Society.

The calculations are to be made for every possible case of operation, but only those leading to the most unfavourable results are required to be submitted.
The calculations are to be carried out taking into account the following loads:

Piping not subject to green seas:

- pressure
- weight of the piping and of the internal fluid
- contraction

Piping subject to green seas that is liable to be in operation at sea and in port:

- pressure
- weight of the piping and of the internal fluid
- green seas
- contraction
- ship motion accelerations

Piping subject to green seas that is in operation only in port; the more severe of the following two combinations of loads:

- pressure
- weight of the pipe and of the internal fluid
- contraction and ;
- weight of the piping
- green seas
- Expansion, assuming that the thermal stresses are fully relaxed.

When green seas are considered, their effects are to be studied, unless otherwise justified, in the following three directions:

- axis of the ship
- vertical
- horizontal, perpendicular to the axis of the ship. The load on the pipes is the load $R^*$ defined in [5.2.2.1].
The stress intensity is to be determined as specified in the formulae in Ship Rules, Pt C, Ch 1, Sec 10, [2.3.2] for pipes intended for high temperatures:

for primary stresses resulting from:
- pressure
- weight
- green seas

for primary stresses and secondary stresses resulting from contraction.

For the first case, the stress intensity is to be limited to the lower of:

\[ 0.8 R_e \text{ and } 0.4 R_m \]

For the second case, the stress intensity is to be limited to the lower of:

\[ 1.6 R_e \text{ and } 0.8 R_m \].

For piping fitted with expansion devices, their characteristics are to be submitted to the Society. Where these characteristics are such that the forces and moments at the ends of the devices are negligible for the contraction they must absorb, the calculation of the loads due to contraction in the corresponding piping is not required. It is, however, to be checked that the stress intensity corresponding to the primary stresses does not exceed the limits given above.

The flexibility coefficient of elbows is to be determined from the formulae given in Ship Rules, Pt C, Ch 1, Sec 10, [2.3.2] for pipes intended for high temperatures.

Particular attention is to be paid to the calculation of local stresses in the assemblies subjected to axial forces and bending moments. The Society reserves the right to request additional justifications or local strengthening where considered necessary.

5.2.6 Materials

5.2.6.1. The choice and testing of materials used in piping systems is to comply with the requirements of chapter 6 taking into account the minimum design temperature. However, some relaxation may be permitted in the quality of material of open-ended vent piping, provided the temperature of the cargo at the pressure relief valve setting is -55 °C or greater and provided no condensate discharge to the vent piping can occur. Similar relaxations may be permitted under the same temperature conditions to open-ended piping inside cargo tanks, excluding discharge piping and all piping inside membrane and semi-membrane tanks.

5.2.6.2. Materials having a melting point below 925 °C are not to be used for piping outside the cargo tanks except for short lengths of pipes attached to the cargo tanks, in which case fire-resisting insulation are to be provided.
5.3 Type tests on piping components

5.3.1. Each type of piping component is to be subject to type tests.

5.3.2.1. Each size and type of valve intended to be used at a working temperature below -55°C are to be subjected to a tightness test to the minimum design temperature or lower, and to a pressure not lower than the design pressure of the valve. During the test the satisfactory operation of the valve are to be ascertained.

5.3.2.2. The following type tests are to be performed on each type of expansion bellows intended for use on cargo piping outside the cargo tank and, where required, on those expansion bellows installed within the cargo tanks:

.1. A type element of the bellows, not precompressed, is to be pressure tested at not less than five times the design pressure without bursting. The duration of the test is not to be less than five min.

.2. A pressure test are to be performed on a type expansion joint complete with all the accessories such as flanges, stays and articulations, at twice the design pressure at the extreme displacement conditions recommended by the manufacturer without permanent deformation. Depending on the materials used, the Society may require the test to be at the minimum design temperature.

.3. A cyclic test (thermal movements) are to be performed on a complete expansion joint, which is to successfully 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) are to 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 cycles/s. This test is only required when, due to the piping arrangement, ship deformation loads are actually experienced.

.5. The Society may waive performance of the tests referred to in this paragraph provided that complete documentation is supplied to establish the suitability of the expansion joints to withstand the expected working conditions. When the maximum internal pressure exceeds 1.0 bar gauge this documentation is to include sufficient test data to justify the design method used, with particular reference to correlation between calculation and test results.

The piping components mentioned in the present Article are subject to a type approval by the Society
5.4 Piping fabrication and joining details

5.4.1. The requirements of this section apply to piping inside and outside the cargo tanks. Relaxations from these requirements may be accepted, in accordance with recognized standards, for piping inside cargo tanks and open-ended piping.

Within cargo holds piping connections are to be fully welded.

5.4.2. The following direct connection of pipe lengths, without flanges, may be considered:

.1. Butt welded joints with complete penetration at the root may be used in all applications. For design temperatures below -10°C, butt welds are to 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 bars and design temperatures of -10°C or lower, backing rings are to be removed.

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

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

5.4.3.1. Flanges in flange connections are to be of the welded neck, slip-on or socket welded type.

5.4.3.2. Flanges are to comply with recognized standards as to their type, manufacture and test. In particular, for all piping except open ended, the following restrictions apply:

.1. For design temperatures lower than -55°C, only welded neck flanges are to be used.

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

5.4.4. Piping connections, other than those mentioned in 5.4.2 and .3 may be accepted by the Society in each case.

5.4.5. N/A

5.4.6. Welding, post-weld heat treatment and non-destructive testing

.1. Welding is to be carried out in accordance with 6.3.

.2. Post-weld heat treatment is to be required for all butt welds of pipes made with carbon, carbon-manganese and low alloy steels. The Society may waive the requirement for thermal stress relieving of pipes having wall thickness less than 10 mm in relation to the design temperature and pressure of the piping system concerned.
.3. 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 requirements of this paragraph, the following tests are to be required:

.3.1. 100% radiographic inspection of butt welded joints for piping systems with design temperatures lower than -10°C and with inside diameters of more than 75 mm or wall thicknesses greater than 10 mm. When such butt welded joints of piping sections are made by automatic welding procedures in the pipe fabrication shop, upon special approval by the Society, the extent of radiographic inspection may be progressively reduced but in no case to less than 10% of each joint. If defects are revealed the extent of examination are to be increased to 100% and are to include inspection of previously accepted welds. This special approval can only be granted if well-documented quality assurance procedures and records are available to enable the Society to assess the ability of the manufacturer to produce satisfactory welds consistently.

.3.2. For other butt welded joints of pipes not covered by 5.4.6.3.1, spot radiographic tests or other non-destructive tests are to be carried out at the discretion of the Society depending upon service, position and materials. In general, at least 10% of butt welded joints of pipes are to be radiographed.

5.5 Testing of piping

5.5.1. The requirements of this section apply to piping inside and outside the cargo tanks. However, the Society may accept relaxations from these requirements for piping inside cargo tanks and open-ended piping.

5.5.2. After assembly, all cargo and process piping are to be subjected to a hydrostatic test to at least 1.5 times the design pressure. When piping systems or parts of systems are completely manufactured and equipped with all fittings, the hydrostatic test may be conducted prior to installation aboard ship. Joints welded on board are to be hydrostatically tested to at least 1.5 times the design pressure. Where water cannot be tolerated and the piping cannot be dried prior to putting the system into service, proposals for alternative testing fluids or testing means are to be submitted to the Society for approval.

5.5.3. After assembly on board, each cargo and process piping system are to be subjected to a leak test using air, halides, or other suitable medium to a pressure depending on the leak detection method applied.

5.5.4. All piping systems including valves, fittings and associated equipment for handling cargo or vapours are to be tested under normal operating conditions not later than at the first loading operation.
5.6 Cargo system valving requirements

5.6.1. Every cargo piping system and cargo tanks are to be provided with the following valves, as applicable:

.1. N/A.

.2. All connections, except safety relief valves and condensate level gauging devices \textit{if any}, are to be equipped with a manually operated stop valve and a remotely controlled emergency shutdown valve. These valves are to be located as close to the tank as practicable. Where the pipe size does not exceed 50 mm in diameter, excess flow valves may be used in lieu of the emergency shutdown valve. A single valve may be substituted for the two separate valves provided the valve complies with the requirements of 5.6.4, is capable of local manual operation and provides full closure of the line.

.3. Cargo handling equipment is to be arranged to shutdown automatically if the emergency shutdown valves required by 5.6.1.1 and .2 are closed by the emergency shutdown system required by 5.6.4.

5.6.2. Cargo tank connections for gauging or measuring devices need not be equipped with excess flow or emergency shutdown valves provided that the devices are so constructed that the outward flow of tank contents cannot exceed that passed by a 1.5 mm diameter circular hole.

5.6.3. One remotely operated emergency shutdown valve is to be provided at each cargo hose connection in use. Connections not used in transfer operations may be blinded with blank flanges in lieu of valves.

5.6.4. The control system for all required emergency shutdown valves are to be so arranged that all such valves may be operated by single controls situated in at least two remote locations on the ship. One of these locations is to be the control position required by 13.1.3 or cargo control room. The control system is also to be provided with fusible elements designed to melt at temperatures between 98°C and 104°C which will cause the emergency shutdown valves to close in the event of fire. Locations for such fusible elements are to include the tank domes and loading stations. Emergency shutdown valves are to be of the fail-closed (closed on loss of power) type and be capable of local manual closing operation. Emergency shutdown valves in condensate piping are to fully close under all service conditions within 30 s of actuation. Information about the closing time of the valves and their operating characteristics are to be available on board and the closing time is to be verifiable and reproducible. Such valves are to close smoothly.

\textit{The cargo stations in way of which the fusible elements are to be fitted are to be intended as the loading and unloading manifolds.}

5.6.5. The closure time of 30 s for the emergency shutdown valves referred to in 5.6.4 are to be measured from the time of manual or automatic initiation to final closure. This is called the total shutdown time and is made up of a signal response time and a valve closure time. The valve closure time is to be such as to avoid surge pressure in pipelines. Such valves are to close in such a manner as to cut off the flows smoothly.
5.6.6. Excess flow valves are to close automatically at the rated closing flow of gas as specified by the manufacturer. The piping including fittings, valves, and appurtenances protected by an excess flow valve, is to have a greater capacity than the rated closing flow of the excess flow valve. Excess flow valves may be designed with a bypass not exceeding an area of 1.0 mm diameter circular opening to allow equalization of pressure, after an operating shutdown.

5.7 Ship’s cargo hoses

5.7.1. Hoses used for cargo transfer are to be compatible with the cargo and suitable for the cargo temperature. Hoses are to be designed, manufactured and tested in accordance with Recognized Standards acceptable to the Society.

5.7.2. Hoses subject to tank pressure, or the discharge pressure of cargo handling equipment, are to be designed for a bursting pressure not less than 2.5 times the maximum pressure the hose will be subjected to during cargo transfer.

5.7.3. Each new type of cargo hose, complete with end-fittings, are to 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 is to demonstrate a bursting pressure of at least 3 times its specified maximum working pressure at the extreme service temperature. Hoses used for prototype testing is not to be used for cargo service. Thereafter, before being placed in service, each new length of cargo hose produced are to be hydrostatically tested at ambient temperature to a pressure not less than 1.5 times its specified maximum working pressure. The hose are to be stencilled or otherwise marked with the date of testing, its specified maximum working pressure and, if used in services other than the ambient temperature services, its maximum and minimum service temperature, as applicable.

5.8 Cargo transfer methods

The cargo transfer method is subject to the review by the Society

5.9 Vapour return connections

N/A.
6. Materials of Construction

6.1 General

6.1.1. N/A

6.1.2. This chapter gives the requirements for plates, sections, pipes, forgings, castings and weldments used in the construction of cargo tanks, cargo process pressure vessels, cargo and process piping and contiguous hull structures associated with the transportation of the products. The requirements for materials are given in table 6.1, 6.2, 6.3, 6.4 and 6.5. The requirements for weldments are given in 6.3.

6.1.3. The manufacture, testing, inspection and documentation are to be in accordance with the Society’s Rules on Materials and Welding and the specific requirements given in this Rule Note

6.1.4.1. Acceptance tests are to include Charpy V-notch toughness tests unless otherwise specified by the Society. The testing procedure is to be in accordance with the Society’s Rules on Materials and Welding. The testing and requirements for specimens smaller than 5.0 mm size are to be in accordance with Recognized Standards acceptable to the Society.
Notch location:
1. Centre of weld
2. On fusion line
3. In HAZ, 1 mm from fusion line
4. In HAZ, 3 mm from fusion line
5. In HAZ, 5 mm from fusion line

HAZ = heat affected zone

The largest size of Charpy specimens possible for the material thickness is to be machined with the centre of 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 is to be approximately one (1) mm or greater. In addition, for double-V butt welds, specimens are to be machined closer to the surface of the second welded side.

6.1.4.2. At the discretion of the Society other types of toughness tests, such as a drop weight test, may be used. This may be in addition to or in lieu of the Charpy V-notch test.
6.1.5. Tensile strength, yield stress and elongation are to be to the satisfaction of the Society. For carbon-manganese steel and other materials with definitive yield points, consideration is to be given to the limitation of the yield to tensile ratio.

6.1.6. The bend test may be omitted as a material acceptance test, but is required for weld tests.

6.1.7. Materials with alternative chemical composition or mechanical properties may be accepted by the Society.

6.1.8. In cases where a post-weld heat treatment is applied, the test requirements may be modified at the discretion of the Society.

6.1.9. Where reference is made in this chapter to A, B, D, E, AH, DH and EH hull structural steels, these steel grades are hull structural steels according to the Society’s Rules on Materials and Welding.

6.1.10. When required CTOD tests are to comply with the Society’s Rules on Materials and Welding

**6.2 Material requirements**

The requirements for materials of construction are shown in the table 6.1, 6.2, 6.3, 6.4 and 6.5 as follows
Table 6.1

<table>
<thead>
<tr>
<th>Chemical Composition and Heat Treatment</th>
<th>Fully killed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon-Manganese Steel</td>
<td></td>
</tr>
<tr>
<td>Fine grain steel where thickness exceeds 20 mm</td>
<td></td>
</tr>
<tr>
<td>Small additions of alloying elements by agreement with the Society</td>
<td></td>
</tr>
<tr>
<td>Composition limits to be approved by the Society</td>
<td></td>
</tr>
<tr>
<td>Normalized, or quenched and tempered²</td>
<td></td>
</tr>
</tbody>
</table>

**Tensile and Toughness (Impact) Test Requirements**

<table>
<thead>
<tr>
<th>Plates</th>
<th>Each “piece” to be tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sections and Forgings</td>
<td>Batch test</td>
</tr>
<tr>
<td>Tensile Properties</td>
<td>Specified minimum yield stress not to exceed 410 N/mm²</td>
</tr>
</tbody>
</table>

**Charpy V-Notch Test**

<table>
<thead>
<tr>
<th>Plates</th>
<th>Transverse test pieces. Minimum average energy value (E) 27 J</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sections and Forgings</td>
<td>Longitudinal test pieces. Minimum average energy value (E) 41 J</td>
</tr>
</tbody>
</table>

**Test Temperature:**

<table>
<thead>
<tr>
<th>Thickness t (mm)</th>
<th>Test temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>t ≤ 20</td>
<td>0</td>
</tr>
<tr>
<td>20 &lt; t ≤ 40</td>
<td>-20</td>
</tr>
</tbody>
</table>

**Notes**

1. For seamless pipes and fittings normal practice applies. The uses of longitudinally and spirally welded pipes are to be specially approved by the Society.

2. A controlled rolling procedure may be used as an alternative to normalizing or quenching and tempering, subject to special approval by the Society.

3. Materials with specified minimum yield stress exceeding 410 N/mm² may be specially approved by the Society. For these materials, particular attention is to be given to the hardness of the weld and heat affected zone.
### Table 6.2

**PLATES, SECTIONS AND FORGINGS\(^1\) FOR CARGO TANKS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES -0°C AND DOWN TO -55°C**

<table>
<thead>
<tr>
<th>Maximum thickness 25 mm(^2)</th>
</tr>
</thead>
</table>

**CHEMICAL COMPOSITION AND HEAT TREATMENT**

<table>
<thead>
<tr>
<th>Carbon-manganese steel</th>
<th>Fully killed</th>
<th>Aluminium treated fine grain steel</th>
</tr>
</thead>
</table>

*Chemical composition (ladle analysis)*

<table>
<thead>
<tr>
<th>C</th>
<th>Mn</th>
<th>Si</th>
<th>S</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.16%</td>
<td>0.70</td>
<td>0.10</td>
<td>0.035%</td>
<td>0.035%</td>
</tr>
<tr>
<td>max.(^3)</td>
<td>1.60%</td>
<td>0.50% max.</td>
<td>max.</td>
<td></td>
</tr>
</tbody>
</table>

Optional additions: Alloys and grain refining elements may be generally in accordance with the following:

<table>
<thead>
<tr>
<th>Ni</th>
<th>Cr</th>
<th>Mo</th>
<th>Cu</th>
<th>Nb</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.80% max.</td>
<td>0.25% max.</td>
<td>0.08% max.</td>
<td>0.35% max.</td>
<td>0.05% max.</td>
<td>0.10% max.</td>
</tr>
</tbody>
</table>

Normalized or quenched and tempered\(^4\)

**TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS**

<table>
<thead>
<tr>
<th>PLATES</th>
<th>Each &quot;piece&quot; to be tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>SECTIONS</td>
<td>Batch test</td>
</tr>
<tr>
<td>CHARPY V-NOTCH TEST</td>
<td>Test temperatures 5°C below the design temperature or -20°C whichever is lower</td>
</tr>
<tr>
<td>PLATES</td>
<td>Transverse test pieces. Minimum average energy value (E) 27J</td>
</tr>
<tr>
<td>SECTIONS AND FORGINGS(^1)</td>
<td>Longitudinal test pieces. Minimum average energy value (E) 41J</td>
</tr>
</tbody>
</table>
NOTES table 6.2

1 The Charpy V-notch and chemistry requirements for forgings may be specially considered by the Society.

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

<table>
<thead>
<tr>
<th>Material thickness (mm)</th>
<th>Test temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 &lt; t ≤ 30</td>
<td>10° below design temperature or -20° whichever is lower</td>
</tr>
<tr>
<td>30 &lt; t ≤ 35</td>
<td>15° below design temperature or -20° whichever is lower</td>
</tr>
<tr>
<td>35 &lt; t ≤ 40</td>
<td>20° below design temperature</td>
</tr>
</tbody>
</table>

The impact energy values are to 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 are to be specially considered. 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 are to be the same as that required for the adjacent tank-shell thickness.

3 By special agreement with the Society, the carbon content may be increased to 0.18% maximum provided the design temperature is not lower than -40°C.

4 A controlled rolling procedure may be used as an alternative to normalizing or quenching and tempering, subject to special approval by the Society.

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 6.3 may be necessary.
Table 6.3

PLATES, SECTIONS AND FORGINGS¹ FOR CARGO TANKS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES BELOW -55°C

Maximum thickness 25 mm³

<table>
<thead>
<tr>
<th>Minimum design temp. (°C)</th>
<th>Chemical composition⁴ and heat treatment</th>
<th>Impact test temp. (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-60</td>
<td>1.5% nickel steel - normalized</td>
<td>-65</td>
</tr>
<tr>
<td>-65</td>
<td>2.25% nickel steel - normalized or normalized and tempered⁵</td>
<td>-70</td>
</tr>
<tr>
<td>-90</td>
<td>3.5% nickel steel - normalized or normalized and tempered⁵</td>
<td>-95</td>
</tr>
</tbody>
</table>

TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS

PLATES Each "piece" to be tested
SECTIONS AND FORGINGS Batch test

CHARPY V-NOTCH TEST

PLATES Transverse test pieces. Minimum average energy value (E) 27J
SECTIONS AND FORGINGS Longitudinal test pieces. Minimum average energy value (E) 41J

NOTES table 6.3

1 The impact test required for forgings used in critical applications are to be subject to special consideration by the Society.
2 N/A
3 For materials 1.5% Ni, 2.25% Ni, 3.5% Ni i, with thickness greater than 25 mm, the impact tests are to be conducted as follows:

<table>
<thead>
<tr>
<th>Material thickness (mm)</th>
<th>Test temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 &lt; t ≤ 30</td>
<td>10 ° below design temperature</td>
</tr>
<tr>
<td>35 &lt; t ≤ 40</td>
<td>20 ° below design temperature</td>
</tr>
</tbody>
</table>

In no case shall the test temperature be above that indicated in the table. The energy values are to be in accordance with the table for the application type of test specimen. For material thickness of more than 40 mm, the Charpy V-notch values are to be specially considered.

4 The chemical composition limits are to be approved by the Society.
5 A lower minimum design temperature for quenched and tempered steels may be specially agreed with the Society.
6 A
7 The impact test may be omitted subject to agreement with the Society.
### Table 6.4

<table>
<thead>
<tr>
<th>Maximum thickness 25 mm</th>
<th>Chemical composition and heat treatment</th>
<th>Impact test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Test temp. (°C)</td>
</tr>
<tr>
<td>-55</td>
<td>Carbon-manganese steel. Fully killed fine grain. Normalized or as agreed</td>
<td>4</td>
</tr>
<tr>
<td>-65</td>
<td>2.25% nickel steel. Normalized or normalized and tempered</td>
<td>-70</td>
</tr>
<tr>
<td>-90</td>
<td>3.5% nickel steel - normalized or normalized and tempered</td>
<td>-95</td>
</tr>
</tbody>
</table>

#### TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS

Each batch to be tested

Impact test – Longitudinal test pieces

#### NOTES table 6.4

1 The use of longitudinally or spirally welded pipes is to be specially approved by the Society.
2 The requirements for forgings and castings may be subject to special consideration by the Society.
3 N/A
4 The test temperature is to be 5 °C below the design temperature or -20 °C whichever is lower.
5 The composition limits are to be approved by the Society.
6 A lower design temperature may be specially agreed with the Society for quenched and tempered materials.
7 This chemical composition is not suitable for castings.
8 Impact tests may be omitted subject to agreement with the Society.

A In general, impact tests are not required for forgings, rolled products and seamless pipes in stainless austenitic steel of grades 304, 304L, 316, 316L, 321 and 347.

B Impact tests are required for:

- castings in steel grades 304, 304L, 321 and 347 when the service temperature is below -60 °C
- castings in steel grades 316 and 316L (which contain molybdenum) at any temperature. A reduction of the tests may be granted for design temperatures above -60 °C after examination of each case by the Society.
Table 6.5

<table>
<thead>
<tr>
<th>Minimum design temperature of hull structure (°C)</th>
<th>Maximum thickness (mm) for steel grades in accordance with 6.1.9</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>0 and above¹</td>
<td></td>
</tr>
<tr>
<td>-5 and above²</td>
<td></td>
</tr>
<tr>
<td>-5 and below 0</td>
<td>15</td>
</tr>
<tr>
<td>-10 and below -5</td>
<td>X</td>
</tr>
<tr>
<td>-20 and below -10</td>
<td>X</td>
</tr>
<tr>
<td>-30 and below -20</td>
<td>X</td>
</tr>
<tr>
<td>Below -30</td>
<td></td>
</tr>
</tbody>
</table>

Normal practice

In accordance with table 6.2 except that the thickness limitation given in table 6.2 and in ² of that table does not apply.

NOTES

¹“X” means steel grade not to be used.
²For the purpose of 4.9.1.

6.3 Welding and non-destructive testing

6.3.1 General

The requirements of this section are those generally employed for carbon, carbon-manganese, nickel alloy and stainless steels, and may form the basis for acceptance testing of other material. At the discretion of the Society, impact testing of stainless steel and aluminium alloy weldments may be omitted and other tests may be specially required for any material.

6.3.2 Welding consumables

Welding consumables intended for welding of cargo tanks are to be of a type approved by the Society in accordance with the Society’s Rules on Materials and Welding, unless otherwise agreed with the Society.

*This paragraph also covers process pressure vessels*

6.3.3 Welding procedure tests for cargo tanks and process pressure vessels
6.3.3.1. Welding procedure tests for cargo tanks and process pressure vessels are required for all butt welds and the test assemblies are to be representative of:

- each base material
- each type of consumable and welding process
- each welding position.

For butt welds in plates, the test assemblies are to be so prepared that the rolling direction is parallel to the direction of welding. The range of thickness qualified by each welding procedure test is to be in accordance with Recognized Standards. Radiographic or ultrasonic testing may be performed at the option of the fabricator or the Society. Procedure tests for consumables intended for fillet welding are to be in accordance with Recognized Standards. In such cases consumables are to be selected which exhibit satisfactory impact properties.

6.3.3.2. The following welding procedure tests for cargo tanks and process pressure vessels are to be made from each test assembly:

.1. Cross-weld tensile tests.

.2. Transverse bend tests which may be face, root or side bends at the discretion of the Society. However, longitudinal bend tests may be required in lieu of transverse bend tests in cases where the base material and weld metal have different strength levels.

.3. One set of three Charpy V-notch impacts, generally at each of the following locations, as shown in figure 6.1:

- the F.L. Centreline of the welds
- Fusion line (F.L.)
- 1 mm from the F.L.
- 3 mm from the F.L.
- 5 mm from

.4. Macrosection, microsection and hardness survey may also be required by the Society.

6.3.4 Test requirements

6.3.4.1. Tensile tests: Generally, tensile strength is not to be less than the specified minimum tensile strength for the appropriate parent materials. The Society may also require that the transverse weld tensile strength is not to be less than the specified minimum tensile strength for the weld metal, where the weld metal has a lower tensile strength than that of the parent metal. In every case, the position of fracture is to be reported for information.
6.3.4.2. Bend tests: No fracture is acceptable after a 180° bend over a former of a diameter four times the thickness of the test pieces, unless otherwise specially required by or agreed with the Society.

As an alternative to the bend test indicated in paragraph 6.3.2, a test over a mandrel having a diameter equal to 3 times the thickness with a bend angle up to 120° may be required.

6.3.4.3. Charpy V-notch impact tests: Charpy tests are to be conducted at the temperature prescribed for the base material being joined. The results of weld metal impact tests, minimum average energy (E), are to be no less than 27 J for the full size specimen.. The results of fusion line and heat affected zone impact tests shall show a minimum average energy (E) in accordance with the transverse or longitudinal requirements of the base material. The testing procedure is to be in accordance with the Society’s Rules on Materials and Welding. If the material thickness does not permit machining either full-size or standard subsizes specimens, the testing procedure and acceptance standards are to be in accordance with Recognized Standards acceptable to the Society.

6.3.5 Welding procedure tests for piping

Welding procedure tests for piping are to be carried out and are to be similar to those detailed for cargo tanks in 6.3.3. Unless otherwise specially agreed with the Society, the test requirements are to be in accordance with 6.3.4.

6.3.6 Production weld tests

6.3.6.1. For all cargo tanks and process pressure vessels except integral and membrane tanks, production weld tests are generally to be performed for butt weld joints at the discretion of the Society and are to be representative of each welding position.

6.3.6.2. The production tests for types B independent tanks are to include the following tests:

.1. Bend tests, and where required for procedure tests one set of three Charpy V-notch tests are to be made for each 50 m of weld. The Charpy V-notch tests are to be made with specimens having the notch alternately located in the centre of the weld and in the heat affected zone (most critical location based on procedure qualification results). For austenitic stainless steel, all notches are to be in the centre of the weld.

.2. The test requirements are the same as the applicable test requirements listed in 6.3.4 except that impact tests that do not meet the prescribed energy requirements may still be accepted, upon special consideration by the Society, by passing a drop weight test. In such cases, two drop weight specimens are to be tested for each set of Charpy specimens that failed and both must show “no break” performance at the temperature at which the Charpy tests were conducted.

6.3.6.3. In addition to those tests listed in 6.3.6.2.1 for type C independent tanks and process pressure vessels, transverse weld tensile tests are required. The test requirements are listed in 6.3.4 except that impact tests that do not meet the prescribed energy requirements may still be accepted upon special consideration by the Society, by passing a drop weight test. In such cases, two drop weight specimens are to be tested for each set of Charpy specimens that failed, and both must show “no break” performance at the temperature at which the Charpy tests were conducted.

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6.3.6.4.

6.3.7 Non-destructive testing

6.3.7.1. For type B independent tanks regardless of temperature, all full penetration butt welds of the shell plating of cargo tanks are to be subjected to 100% radiographic inspection.

6.3.7.1.1. N/A.

6.3.7.1.2. In each case the remaining tank structure including the welding of stiffeners and other fittings and attachments are to be examined by magnetic particle or dye penetrant methods as considered necessary by the Society.

6.3.7.1.3. All test procedures and acceptance standards are to be in accordance with Recognized Standards. The Society may accept an approved ultrasonic test procedure in lieu of radiographic inspection, but may in addition require supplementary inspection by radiography at selected locations. Further, the Society may require ultrasonic testing in addition to normal radiographic inspection.

6.3.7.2. Inspection of type C independent tanks and process pressure vessels are to be carried out in accordance with 4.10.9.

6.3.7.3. N/A.

6.3.7.4. N/A.

6.3.7.5. Inspection of piping is to be carried out in accordance with the requirements of chapter 5.

6.3.7.6. N/A.
7. Cargo Pressure/Temperature Control

7.1 General

7.1.1. Unless the entire cargo system is designed to withstand the full pressure gauge of the cargo under conditions of the upper ambient design temperatures, maintenance of the cargo tank pressure below the MARVS are to be provided by one or more of the following means, except as otherwise provided in this section:

.1. a system which regulates the pressure in the cargo tanks by the use of mechanical refrigeration;

.2. N/A;

.3. N/A;

.4. other systems acceptable to the Society;

.5. N/A.

7.1.2. The systems required by 7.1.1 are to be constructed, fitted and tested to the satisfaction of the Society. Materials used in their construction are to be suitable for use with the cargoes to be carried. For normal service, the upper ambient design temperatures are to be:

    sea 32°C
    air 45°C.

For service in especially hot or cold zones these design temperatures are to be increased or reduced, as appropriate, by the Society.

7.1.3. N/A.
7.2 Refrigeration systems

7.2.1. A refrigeration system is to consist of one or more units capable of maintaining the required cargo pressure/temperature under conditions of the upper ambient design temperatures. Unless an alternative means of controlling the cargo pressure/temperature is provided to the satisfaction of the Society, a stand-by unit (or units) affording spare capacity at least equal to the largest required single unit are to be provided. A stand-by unit is to consist of a compressor with its driving motor, control system and any necessary fittings to permit operation independently of the normal service units. A stand-by heat exchanger is to be provided unless the normal heat exchanger for the unit has an excess capacity of at least 25% of the largest required capacity. Separate piping systems are not required.

7.2.2.1. N/A.

7.2.2.2. N/A

7.2.3. Where cooling water is required in refrigeration systems, an adequate supply are to be provided by a pump or pumps used exclusively for this purpose. This pump or these pumps are to have at least two sea suction lines, where practicable leading from sea-chests, one port and one starboard. A spare pump of adequate capacity are to be provided, which may be a pump used for other services so long as its use for cooling would not interfere with any other essential service.

7.2.4. N/A.

7.2.5. All primary and secondary refrigerants must be compatible with each other and with the cargo with which they come into contact. The heat exchange may take place either remotely from the cargo tank or by cooling coils fitted inside or outside the cargo tank.

In general, in addition to the requirements of 7.2, refrigerating plants are to comply with the provisions of Ship Rules, Pt C, Ch 1, Sec 13 and Pt F, Ch 8, as applicable.
8. Cargo Tank Vent Systems

8.1 General

All cargo tanks are to be provided with a pressure relief system appropriate to the design of the cargo containment system and the cargo being carried. Hold spaces and cargo piping which may be subject to pressures beyond their design capabilities are also to be provided with a suitable pressure relief system. The pressure relief system are to be connected to a vent piping system so designed as to minimize the possibility of cargo vapour accumulating on the decks, or entering accommodation spaces, service spaces, control stations and machinery spaces, or other spaces where it may create a dangerous condition. Pressure control systems specified by chapter 7 are to be independent of the pressure relief valves.

8.2 Pressure relief systems

8.2.1. Each cargo tank with a volume exceeding 20 m3 are to be fitted with at least two pressure relief valves of approximately equal capacity, suitably designed and constructed for the prescribed service. For cargo tanks with a volume not exceeding 20 m3, a single relief valve may be fitted.

8.2.2. N/A.

8.2.3. In general, the setting of the pressure relief valves is not to be higher than the vapour pressure which has been used in the design of the tank. However, where two or more pressure relief valves are fitted, valves comprising not more than 50% of the total relieving capacity may be set at a pressure up to 5% above MARVS.

8.2.4. Pressure relief valves are to be connected to the highest part of the cargo tank above deck level. Pressure relief valves on cargo tanks with a design temperature below 0°C are to be arranged to prevent their becoming inoperative due to ice formation when they are closed. Due consideration are to be given to the construction and arrangement of pressure relief valves on cargo tanks subject to low ambient temperatures. Valves are to be constructed of materials with a melting point above 925°C. Consideration of lower melting point materials for internal parts and seals are to be given if their use provides significant improvement to the general operation of the valve.

8.2.5. Pressure relief valves are to be prototype tested to ensure that the valves have the capacity required. Each valve are to be tested to ensure that it opens at the prescribed pressure setting with an allowance not exceeding ± 10% for 0 to 1.5 bar, ± 6% for 1.5 to 3.0 bar, ± 3% for 3.0 bar and above. Pressure relief valves are to be set and sealed by a competent authority acceptable to the Society and a record of this action, including the values of set pressure, are to be retained aboard the ship.
8.2.6. N/A.

8.2.7. N/A

8.2.8. Stop valves or other means of blanking off pipes between tanks and pressure relief valves to facilitate maintenance are not to be fitted unless all the following arrangements are provided:

.1. suitable arrangements to prevent more than one pressure relief valve being out of service at the same time;

.2. a device which automatically and in a clearly visible way indicates which one of the pressure relief valves is out of service; and

.3. pressure relief valve capacities such that if one valve is out of service the remaining valves have the combined relieving capacity required by 8.5. However, this capacity may be provided by the combined capacity of all valves, if a suitably maintained spare valve is carried on board.

8.2.9. Each pressure relief valve installed on a cargo tank are to be connected to a venting system which are to be so constructed that the discharge of gas will be unimpeded and directed vertically upwards at the exit and so arranged as to minimize the possibility of water or snow entering the vent system. The height of vent exits is not to be less than B/3 or 6 m, whichever is the greater, above the weather deck and 6 m above the working area, the fore and aft gangway, deck storage tanks and cargo lines.

The height of vent exits is also to be measured above storage tanks and cargo lines, where applicable

8.2.10. Cargo tank pressure relief valve vent exits are to be arranged at a distance at least equal to B or 25 m, whichever is less, from the nearest air intake or opening to accommodation spaces, service spaces and control stations, or other gas-safe spaces. For ships less than 90 m in length, smaller distances may be permitted by the Society. All other vent exits connected to the cargo containment system are to be arranged at a distance of at least 10 m from the nearest air intake or opening to accommodation spaces, service spaces and control stations, or other gas-safe spaces.

Additional requirements on vent location:

a. The distances of the vent exits are to be measured horizontally.

b. The vent exits are to be arranged at a distance of at least 5 m from exhaust ducts and at least 10 m from intake ducts serving cargo handling system rooms.

c. The distances are also intended to refer to outlets of ventilation ducts of safe spaces.

8.2.11. All other cargo vent exits not dealt with in other chapters are to be arranged in accordance with 8.2.9 and 8.2.10.

8.2.12. N/A.
8.2.13. In the vent piping system, means for draining condensate from places where it may accumulate are to be provided. The pressure relief valves and piping are to be so arranged that condensate can under no circumstances accumulate in or near the pressure relief valves.

8.2.14. Suitable protection screens are to be fitted on vent outlets to prevent the ingress of foreign objects.

8.2.15. All vent piping is to be so designed and arranged that it will not be damaged by temperature variations to which it may be exposed, or by the ship's motions.

8.2.16. The back pressure in the vent lines from the pressure relief valves are to be taken into account in determining the flow capacity required by 8.5. The pressure drop in the vent line from the tank to the pressure relief valve inlet is not to exceed 3% of the valve set pressure. For unbalanced pressure relief valves the back pressure in the discharge line is not to exceed 10% of the gauge pressure at the relief valve inlet with the vent lines under fire exposure as referred to in 8.5.2.

8.2.17 N/A

8.2.18. N/A.

8.2.19. It is to be possible to relieve the pressure of a tank or group of containers in a safe manner.

8.3 Additional pressure relieving system for liquid level control

N/A

8.4 Vacuum protection systems

A vacuum protection system of hold spaces is to be provided as per 8.5 below.

8.5 Size of valves

Cargo Tanks Pressure relief valves are to have a combined relieving capacity for each cargo tank to discharge the greater of the following with not more than a 20% * rise in cargo tank pressure above the MARVS:

1. The maximum capacity of the cargo tank inerting system if the maximum attainable working pressure of the cargo tank inerting system exceeds the MARVS of the cargo tanks; or
2. Gas expansion generated under fire exposure calculated according to a Recognized Standard (i.e. API 521); or

3. The maximum pressure generated by the cargo transfer means if the maximum attainable working pressure of the cargo tank transfer system exceeds the MARVS of the cargo tanks

* This value is dependant on the allowed safety factors and is subject to the agreement of the Society.

Hold Spaces pressure/vacuum relief valves are to be set at a positive pressure not exceeding 0.021 N/mm² and at a negative pressure not exceeding 0.007 N/mm². (Higher setting values not exceeding 0.07 N/mm² may be accepted in positive pressure if the scantlings of the holds are appropriate) and are to have a relieving capacity to discharge the greater of the following:

For overpressure the greater of:

1. The maximum capacity of the cargo hold inerting system if the maximum attainable working pressure of the cargo hold inerting system exceeds the allowable pressure limit of the cargo hold structure; or

2. The maximum possible leak rate of the cargo containment system in the hold

For vacuum the greater of:

1. The bilge system capacity; or

2. The suction rate of the hold purging system where applicable

If the risk of explosive gas release in the hold is identified relief panels, designed according to a Recognised Standard (i.e. NFPA 68), are to be provided to prevent the hold structure to reach its survival loads.
9. Environmental Control

9.1 Environmental control within cargo tanks and cargo piping systems

9.1.1. A piping system is to be provided to enable each cargo tank to be safely gas-freed, and to be safely purged with cargo gas from a gas-free condition. The system is to be arranged to minimize the possibility of pockets of gas or air remaining after gas-freeing or purging.

9.1.2. A sufficient number of gas sampling points are to be provided for each cargo tank in order to adequately monitor the progress of purging and gas-freeing. Gas sampling connections are to be valved and capped above the main deck.

9.1.3. The system is to be arranged to minimize the possibility of a flammable mixture existing in the cargo tank during any part of the gas-freeing operation by utilizing an inerting medium as an intermediate step. In addition, the system is to enable the cargo tank to be purged with an inerting medium prior to filling with cargo gas, without permitting a flammable mixture to exist at any time within the cargo tank.

9.1.4. Piping systems which may contain cargo are to be capable of being gas-freed and purged as provided in 9.1.1 and 9.1.3.

9.1.5. Inert gas utilized in these procedures may be provided from the shore or from the ship.

9.2 Environmental control within the hold spaces (cargo containment systems other than type C independent tanks)

9.2.1. N/A

9.2.2.1. Hold spaces associated with cargo containment systems are to be inerted with suitable dry inert gas and kept inerted with make-up gas provided by a shipboard inert gas generation system or by shipboard storage which are to be sufficient for normal consumption for at least 30 days.

9.2.2.2. N/A.

9.2.3. N/A.

9.2.4. N/A
9.3 Environmental control of spaces surrounding type C independent tanks

Ditto 9.2.

9.4 Inerting

9.4.1. Inerting refers to the process of providing a non-combustible environment by the addition of compatible gases, which may be carried in storage vessels or produced on board the ship or supplied from the shore. The inert gases are to be compatible chemically and operationally, at all temperatures likely to occur within the spaces to be inerted, with the materials of construction of the spaces and the cargo. The dew points of the gases are to be taken into consideration.

9.4.2. Where inert gas is also stored for fire-fighting purposes, it is to be carried in separate containers and is not to be used for cargo services.

9.4.3. Where inert gas is stored at temperatures below 0 °C, either as a liquid or as a vapour, the storage and supply system are to be so designed that the temperature of the ship’s structure is not reduced below the limiting values imposed on it.

9.4.4. Arrangements suitable for the cargo carried are to be provided to prevent the backflow of cargo vapour into the inert gas system.

9.4.5. The arrangements are to be such that each space being inerted can be isolated and the necessary controls and relief valves etc. are to be provided for controlling pressure in these spaces (Refer to 8.5).

9.5 Inert gas production on board

9.5.1. The equipment are to be capable of producing inert gas with an oxygen content at no time greater than 5% by volume. A continuous-reading oxygen content meter are to be fitted to the inert gas supply from the equipment and are to be fitted with an alarm set at a maximum of 5% oxygen content by volume. Additionally, where inert gas is made by an on-board process of fractional distillation of air which involves the storage of the cryogenic liquefied nitrogen for subsequent release, the liquefied gas entering the storage vessel are to be monitored for traces of oxygen to avoid possible initial high oxygen enrichment of the gas when released for inerting purposes and is to be free of CO and CO₂, or corrosive products.

9.5.2. An inert gas system is to have pressure controls and monitoring arrangements appropriate to the cargo containment system. A means acceptable to the Society, located in the cargo area, of preventing the backflow of cargo gas are to be provided.
9.5.3. Spaces containing inert gas generating plants are to have no direct access to accommodation spaces, service spaces or control stations, but may be located in machinery spaces. If such plants are located in machinery spaces or other spaces outside the cargo area, two non-return valves, or equivalent devices are to be fitted in the inert gas main in the cargo area as required in 9.5.2. Inert gas piping is not to pass through accommodation spaces, service spaces or control stations. When not in use, the inert gas system is to be made separate from the cargo system in the cargo area except for connections to the hold spaces.

9.5.4. Flame burning equipment for generating inert gas is not to be located within the cargo area. Special consideration may be given to the location of inert gas generating equipment using the catalytic combustion process.

9.5.5. Exemptions:

Inert gas generating systems are to be considered as essential services and are to comply with the applicable Sections of the Rules, as far as applicable.

Where, in addition to inert gas produced on board, it is possible to introduce dry air into the above-mentioned spaces, or to introduce inert gas from a supply existing on board, it is not necessary that standby or spare components for the inert gas system are kept on board.

9.5.6. Engineering specifications

The requirements of Ch 8, Sec 9, [2] are to be complied with, as far as applicable
10. Electrical Installations

10.1 General

10.1.1. The provisions of this chapter are to be applied in conjunction with part D of chapter 11-1 of the 1983 SOLAS amendments.

10.1.2. Electrical installations are to be such as to minimize the risk of fire and explosion from flammable products. Electrical installations complying with this chapter need not be considered as a source of ignition for the purposes of chapter 3.

10.1.3. N/A

10.1.4. Electrical equipment or wiring is not to be installed in gas-dangerous spaces or zones unless essential for operational purposes, when the exceptions listed in 10.2 are permitted.

10.1.5. Where electrical equipment is installed in gas-dangerous spaces or zones it is to be to the satisfaction of the Society and approved by the relevant authorities recognized by the Society for operation in the flammable atmosphere concerned

10.1.6. The requirements in this Section apply, in addition to those contained in Ship Rules, Pt C, Ch 2, to gas carriers.

10.1.8. Acceptable systems of supply

The following systems of generation and distribution of electrical energy are acceptable:

a. direct current:
   • two-wire insulated

b. alternating current:
   • single-phase, two-wire insulated
   • three-phase, three-wire insulated.
   • In insulated distribution systems, no current carrying part is to be earthed, other than:
     • through an insulation level monitoring device
     • through components used for the suppression of interference in radio circuits.
10.1.9. Earthed system with hull return

Earthed systems with hull return are not permitted, with the following exceptions to the satisfaction of the Society:

a. Impressed current cathodic protective systems

b. Limited and locally earthed systems, such as starting and ignition systems of internal combustion engines, provided that any possible resulting current does not flow directly through any hazardous area

c. Insulation level monitoring devices, provided that the circulation current of the device does not exceed 30 mA under the most unfavourable conditions.

10.1.10. Earthed systems without hull return

Earthed systems without hull return are not permitted, with the following exceptions:

a. earthed intrinsically safe circuits and the following other systems to the satisfaction of the Society

b. power supplies, control circuits and instrumentation circuits in non-hazardous areas where technical or safety reasons preclude the use of a system with no connection to earth, provided the current in the hull is limited to not more than 5 A in both normal and fault conditions; or

c. limited and locally earthed systems, such as power distribution systems in galleys and laundries to be fed through isolating transformers with the secondary windings earthed, provided that any possible resulting hull current does not flow directly through any hazardous area; or

d. alternating current power networks of 1,000 V root mean square (line to line) and over, provided that any possible resulting current does not flow directly through any hazardous area; to this end, if the distribution system is extended to areas remote from the machinery space, isolating transformers or other adequate means are to be provided.

10.1.11. Monitoring of circuits in hazardous areas

The devices intended to continuously monitor the insulation level of all distribution systems are also to monitor all circuits, other than intrinsically safe circuits, connected to apparatus in hazardous areas or passing through such areas. An audible and visual alarm is to be given, at a manned position, in the event of an abnormally low level of insulation.

10.1.12. Precautions against inlet of gases or vapours

Suitable arrangements are to be provided, to the satisfaction of the Society, so as to prevent the possibility of gases or vapours passing from a gas-dangerous space to another space through runs of cables or their conduits.
10.2 Types of equipment

The electrical equipment specified in Tab 10.1 may be installed in the gas-dangerous spaces and zones indicated therein.

Certified safe type equipment may be fitted in gas-dangerous spaces and zones in accordance with the following provisions:

10.2.5.5. Temperature class and explosion group

temperature class and explosion group will be II A T2

Table 10.1: Electrical equipment permitted in gas-dangerous spaces and zones

<table>
<thead>
<tr>
<th>Hazardous area</th>
<th>Spaces</th>
<th>Electrical equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 0</td>
<td>1</td>
<td>Cargo containment systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>certified intrinsically safe apparatus Ex(ia);</td>
</tr>
<tr>
<td></td>
<td></td>
<td>simple electrical apparatus and components (e.g. thermocouples, photocells, strain gauges, switching devices), included in intrinsically safe circuits of category &quot;ia&quot; not capable of storing or generating electrical power or energy in excess of limits stated in the relevant rules, and acceptable to the appropriate authority;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>equipment specifically designed and certified by the appropriate authority for use in Zone 0;</td>
</tr>
<tr>
<td>Hazardous area</td>
<td>Spaces</td>
<td>Electrical equipment</td>
</tr>
<tr>
<td>---------------</td>
<td>----------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Zone 1</td>
<td>2 Hold spaces</td>
<td>any type considered for Zone 0; certified intrinsically safe apparatus Ex(ib); simple electrical apparatus and components (e.g. thermocouples, photocells, strain gauges, switching devices), included in intrinsically safe circuits of category &quot;ib&quot; not capable of storing or generating electrical power or energy in excess of limits stated in the relevant rules, and acceptable to the appropriate authority; based on electrical cables passing through the spaces; Lighting fittings are to have pressurised enclosures Ex(p) or to be of the flameproof type Ex(d). The lighting system is to be divided between at least two branch circuits. All switches and protective devices are to interrupt all poles or phases and are to be located in a gas-safe space; hull fittings containing the terminals or shell plating penetrations for anodes or electrodes of an impressed current cathodic protection system, or transducers such as those for depth sounding or log systems, provided that such fittings are of gas-tight construction or housed within a gas-tight enclosure, and are not located adjacent to a cargo tank bulkhead. The design of such fittings or their enclosures and the means by which cables enter, and any testing to establish their gas-tightness, are to be to the satisfaction of the Society.</td>
</tr>
<tr>
<td>Hazardous area</td>
<td>Spaces</td>
<td>Electrical equipment</td>
</tr>
<tr>
<td>----------------</td>
<td>--------</td>
<td>----------------------</td>
</tr>
</tbody>
</table>
| Zone 1         | 3 Cargo handling equipment rooms | any type considered for Zone 0;  
certified intrinsically safe apparatus Ex(ib);  
simple electrical apparatus and components (e.g. thermocouples,  
photocells, strain gauges, switching devices), included in intrinsically safe  
circuits of category "ib" not capable of storing or generating electrical power or  
energy in excess of limits stated in the relevant rules, and acceptable to the  
appropriate authority;  
lighting fittings are to have pressurised enclosures Ex(p) or to be of the  
flameproof type Ex(d). The lighting system is to be divided between at least two  
branch circuits. All switches and protective devices are to interrupt all poles or phases  
and are to be located in a gas-safe space;  
electric motors for driving cargo handling equipment are to be separated from these  
spaces by a gas-tight bulkhead or deck. Flexible couplings or other means of maintaining  
alignment are to be fitted to the shafts between the driven equipment and its motors, and in  
addition, suitable glands are to be provided where the shafts pass through the bulkhead or deck.  
Such electric motors and associated equipment are to be located in a compartment complying with Chapter 12; |
<table>
<thead>
<tr>
<th>Hazardous area</th>
<th>Spaces</th>
<th>Electrical equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1</td>
<td>4</td>
<td>Zones on open deck or non-enclosed spaces on the open deck, within 3 m of any cargo tank outlet, gas or vapour outlet, cargo pipe flange, cargo valve or entrances and ventilation openings to cargo handling equipment rooms</td>
</tr>
<tr>
<td></td>
<td></td>
<td>any type considered for Zone 0; certified intrinsically safe apparatus Ex(ib); simple electrical apparatus and components (e.g. thermocouples, photocells, strain gauges, switching devices), included in intrinsically safe circuits of category &quot;ib&quot; not capable of storing or generating electrical power or energy in excess of limits stated in the relevant rules, and acceptable to the appropriate authority; certified flameproof Ex(d); certified pressurised Ex(p); certified increased safety Ex(e); certified encapsulated Ex(m); certified sand filled Ex(q); certified specially Ex(s); Based on 10.2.5.1.2 electrical cables passing through the spaces.</td>
</tr>
<tr>
<td>Hazardous area</td>
<td>Spaces</td>
<td>Electrical equipment</td>
</tr>
<tr>
<td>---------------</td>
<td>---------------------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td><strong>N°</strong></td>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>Zone 1</td>
<td>5</td>
<td>Zones on the open deck over the cargo area and 3 m forward and aft of the cargo area on the open deck and up to a height of 2,4 m above the deck</td>
</tr>
<tr>
<td>Zone 1</td>
<td>6</td>
<td>Zones within 2,4 m of the outer surface of a cargo containment system where such surface is exposed to the weather</td>
</tr>
<tr>
<td>Zone 1</td>
<td>7</td>
<td>Areas on open deck, or semi-enclosed spaces on open deck, within 3 m of any cargo tank pressure relief valve vent exits</td>
</tr>
<tr>
<td>Zone 1</td>
<td>8</td>
<td>Compartments for cargo hoses</td>
</tr>
<tr>
<td></td>
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<tr>
<td>Hazardous area</td>
<td>Spaces</td>
<td>Electrical equipment</td>
</tr>
<tr>
<td>----------------</td>
<td>--------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Zone 1</td>
<td>9 Enclosed or semi-enclosed spaces in which pipes containing cargoes are located</td>
<td>As allowed for spaces under item 8.</td>
</tr>
<tr>
<td>Zone 2</td>
<td>10 Areas of 1.5 m surrounding the Zone 1 spaces defined in item 9</td>
<td>any type considered for Zone 1; electrical equipment of a type which ensures the absence of sparks, arcs and &quot;hot spots&quot; during its normal operation; electrical equipment tested specially for Zone 2 (e.g. type &quot;n&quot; protection); electrical equipment encapsulated and acceptable to the Society.</td>
</tr>
<tr>
<td>Zone 2</td>
<td>11 Spaces 22 m or (B - 3) m, whichever is the lesser, beyond the Zone 1 spaces defined in item 9</td>
<td>As allowed for spaces under item 10.</td>
</tr>
</tbody>
</table>

### 10.3 Bonding

#### 10.3.1. Acceptable resistance

To avoid the hazard of an incentive discharge due to the build-up of static electricity resulting from the flow of the liquid/gases/vapours, the resistance between any point on the surface of the cargo tanks, piping systems and equipment, and the hull of the ship is not to be greater than $10^6 \, \Omega$.

#### 10.3.2. Bonding straps

Bonding straps are required for cargo and slop tanks, piping systems and equipment which are not permanently connected to the hull of the ship, for example:

- a. Independent cargo tanks
- b. Cargo tank piping systems which are electrically separated from the hull of the ship
- c. Pipe connections arranged for the removal of the spool pieces.
Where bonding straps are required, they are to be:

a. Clearly visible so that any shortcoming can be clearly detected

b. Designed and sited so that they are protected against mechanical damage and are not affected by high resistivity contamination, e.g. corrosive products or paint

c. Easy to install and replace
11. Fire Protection and Fire Extinction

11.1 Fire safety requirements

11.1.1. The requirements for tankers in SOLAS chapter II-2 are to apply to ships covered by this Rule Note, irrespective of tonnage including ships of less than 500 tons gross tonnage, except that:

.1. regulation 4.5.1.6 and 4.5.10 do not apply;

.2. regulation 10.2 as applicable to cargo ships and regulation 10.4 and 10.5 are to apply as they would apply to tankers of 2,000 tons gross tonnage and over;

.3. regulation 10.5.6 is to apply to ships of 2,000 tons gross tonnage and over;

.4. the following regulations of SOLAS chapter II-2 related to tankers do not apply and are replaced by chapters and sections of this Rule Note as detailed below:

<table>
<thead>
<tr>
<th>Regulation</th>
<th>Replaced by</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.10</td>
<td>11.6</td>
</tr>
<tr>
<td>4.5.1.1 and 4.5.1.2</td>
<td>chapter 3</td>
</tr>
<tr>
<td>4.5.5 and 10.8</td>
<td>11.3 and 11.4</td>
</tr>
<tr>
<td>10.9</td>
<td>11.5</td>
</tr>
</tbody>
</table>

.5. regulation 13.3.4 and 13.4.3 are to apply to ships of 500 gross tonnage and over

11.1.2. All sources of ignition are to be excluded from spaces where flammable vapour may be present except as otherwise provided in chapters 10 and 16.

11.1.3. The provisions of this section apply in conjunction with chapter 3.

11.1.4. For the purposes of fire fighting, any open deck areas above cofferdams, ballast or void spaces at the after end of the aftermost hold space or at the forward end of the forwardmost hold space are to be included in the cargo area.
11.2 Fire water main equipment

11.2.1. All ships, irrespective of size, carrying products which are subject to this Rule Note are to comply with the requirements of SOLAS regulations II-2/10.2, 10.4 and 10.5, except that the required fire pump capacity and fire main and water service pipe diameter is not to be limited by the provisions of regulations II-2/10.2.2.4.1 and 10.2.1.3 when the fire pump and fire main are used as part of the water spray system as permitted by 11.3.3. In addition, the requirements of regulation II-2/10.2.1.6 are to be met at a pressure of at least 5.0 bar gauge.

11.2.2. The arrangements are to be such that at least two jets of water can reach any part of the deck in the cargo area and those portions of the cargo containment system and tank covers above the deck. The necessary number of fire hydrants is to be located to satisfy the above arrangements and to comply with the requirements of SOLAS regulations II-2/10.2.1.5.1 and 10.2.3.3, with hose lengths as specified in 10.2.3.1.1.

11.2.3. Stop valves are to be fitted in any crossover provided and in the fire main or mains at the poop front and at intervals of not more than 40 m between hydrants on the deck in the cargo area for the purpose of isolating damaged sections of the main.

11.2.4. All water nozzles provided for fire-fighting use are to be of an approved dual-purpose type capable of producing either a spray or a jet. All pipes, valves, nozzles and other fittings in the fire-fighting systems are to be resistant to the effects of fire and to corrosion by water.

11.2.5. Where the ship’s engine-room is unattended, arrangements are to be made to start and connect to the fire main at least one fire pump by remote control from the navigating bridge or other control station outside the cargo area.

11.3 Water spray system

11.3.1. A water spray system for cooling, fire prevention and crew protection are to be installed to cover:

1. any exposed parts of cargo tanks;

2. exposed on-deck storage vessels for flammable or toxic products;

3. cargo condensate and vapour discharge and loading manifolds and the area of their control valves and any other areas where essential control valves are situated and which are to be at least equal to the area of the drip trays provided; and

4. boundaries of superstructures and deckhouses normally manned, cargo handling equipment rooms, store-rooms containing high fire risk items and cargo control rooms, all facing the cargo area. Boundaries of unmanned forecastle structures not containing high fire risk items or equipment do not require water spray protection.
5. Boundaries of spaces containing internal combustion engines and/or fuel treatment units, of store-rooms for flammable liquids having a flashpoint equal to or less than 60 °C and of paint lockers.

11.3.2. The system are to be capable of covering all areas mentioned in 11.3.1 with a uniformly distributed water spray of at least 10l/m² per minute for horizontal projected surfaces and 4l/m² per minute for vertical surfaces. For structures having no clearly defined horizontal or vertical surfaces, the capacity of the water spray system are to be the greater of the following:

.1. projected horizontal surface multiplied by 10l/m² per minute; or
.2. actual surface multiplied by 4l/m² per minute.

On vertical surfaces, spacing of nozzles protecting lower areas may take account of anticipated rundown from higher areas. Stop valves are to be fitted at intervals in the spray main for the purpose of isolating damaged sections. Alternatively, the system may be divided into two or more sections which may be operated independently provided the necessary controls are located together, aft of the cargo area. A section protecting any area included in 11.3.1.1 and .2 is to cover the whole of the athwartship tank grouping which includes that area.

In general the vertical distance between the water spray nozzle rows protecting vertical surfaces should not exceed 3.7 m.

11.3.3. The capacity of the water spray pumps are to be sufficient to deliver the required amount of water to all areas simultaneously or where the system is divided into sections, the arrangements and capacity are to be such as to supply water simultaneously to any one section and to the surfaces specified in 11.3.1.3 and .4. Alternatively, the main fire pumps may be used for this service provided that their total capacity is increased by the amount needed for the spray system. In either case, a connection, through a stop valve, are to be made between the fire main and water spray main outside the cargo area.

11.3.4. Subject to the approval of the Society, water pumps normally used for other services may be arranged to supply the water spray main.

11.3.5. All pipes, valves, nozzles and other fittings in the water spray systems are to be resistant to corrosion by seawater, for which purpose galvanized pipe, for example, may be used, and to the effect of fire.

11.3.6. Remote starting of pumps supplying the water spray system and remote operation of any normally closed valves in the system are to be arranged in suitable locations outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the areas protected.

11.3.7. A stop valve is to be fitted on the water-spray main as close as possible to the poop front so that the accommodation spaces are always protected in the case of a spray-main failure.
11.4 Dry chemical powder fire-extinguishing systems

11.4.1. Ships are to be fitted with fixed dry chemical powder type extinguishing systems for the purpose of fighting fire on the deck in the cargo area and bow or stern cargo handling areas if applicable. The system and the dry chemical powder are to be adequate for this purpose and satisfactory to the Society.

11.4.2. The system are to be capable of delivering powder from at least two hand hose lines or combination monitor/hand hose lines to any part of the above-deck exposed cargo area including above-deck product piping. The system are to be activated by an inert gas such as nitrogen, used exclusively for this purpose and stored in pressure vessels adjacent to the powder containers.

*Any exposed point of the cargo area, including cargo piping, is to be capable of being reached by powder delivered from at least two hoses or from a fixed monitor and one hose, which are not to be supplied by the same powder unit.*

11.4.3. The system for use in the cargo area is to consist of at least two independent self-contained dry chemical powder units with associated controls, pressurizing medium fixed piping, monitors or hand hose lines. For ships with a cargo capacity of less than 1,000 m$^3$ only one such unit need be fitted, subject to approval by the Society. A monitor are to be provided and so arranged as to protect the cargo loading and discharge manifold areas and be capable of actuation and discharge locally and remotely. The monitor is not required to be remotely aimed if it can deliver the necessary powder to all required areas of coverage from a single position. All hand hose lines and monitors are to be capable of actuation at the hose storage reel or monitor. At least one hand hose line or monitor are to be situated at the after end of the cargo area.

*Two powder units, even if mutually connected through a common main, may be considered independent on condition that non-return valves or other arrangements suitable to prevent powder from passing from one unit to the other are fitted.*

*The powder units which constitute the system are to contain, in general, the same powder quantity and, when they are not grouped together in a single position, they are to be uniformly located over the area to be protected.*

*Where powder units are grouped together in a single position or, in the case of ships having a cargo capacity less than 1000 m$^3$, a single powder unit is installed, the said units are to be located aft of the cargo area.*

11.4.4. A fire-extinguishing unit having two or more monitors, hand hose lines, or combinations thereof, is to have independent pipes with a manifold at the powder container, unless a suitable alternative means is provided to ensure proper performance as approved by the Society. Where two or more pipes are attached to a unit the arrangement are to be such that any or all of the monitors and hand hose lines are to be capable of simultaneous or sequential operation at their rated capacities.
11.4.5. The capacity of a monitor are to be not less than 10kg/s. Hand hose lines are to be non-kinkable and be fitted with a nozzle capable of on/off operation and discharge at a rate not less than 3.5 kg/s. The maximum discharge rate is to be such as to allow operation by one man. The length of a hand hose line is not to exceed 33 m. Where fixed piping is provided between the powder container and a hand hose line or monitor, the length of piping is not to exceed that length which is capable of maintaining the powder in a fluidized state during sustained or intermittent use, and which can be purged of powder when the system is shut down. Hand hose lines and nozzles are to be of weather-resistant construction or stored in weather-resistant housing or covers and be readily accessible.

11.4.6. A sufficient quantity of dry chemical powder are to be stored in each container to provide a minimum 45 seconds discharge time for all monitors and hand hose lines attached to each powder unit. Coverage from fixed monitors is to be in accordance with the following requirements:

<table>
<thead>
<tr>
<th>Capacity of fixed monitors (kg/s) each</th>
<th>10</th>
<th>25</th>
<th>45</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum distance of coverage(m)</td>
<td>10</td>
<td>30</td>
<td>40</td>
</tr>
</tbody>
</table>

Hand hose lines are to be considered to have a maximum effective distance of coverage equal to the length of hose. Special consideration is to be given where areas to be protected are substantially higher than the monitor or hand hose reel locations.

11.4.7. Ships fitted with bow or stern loading and discharge arrangements are to be provided with an additional dry chemical powder unit complete with at least one monitor and one hand hose line complying with the requirements of 11.4.1, 11.4.2, 11.4.3, 11.4.4, 11.4.5 and 11.4.6. This additional unit are to be located to protect the bow or stern loading and discharge arrangements. The area of the cargo line forward or aft of the cargo area is to be protected by hand hose lines.

11.5 Cargo handling equipment rooms

11.5.1. The cargo handling equipment rooms of any ship are to be provided with a carbon dioxide system as specified in SOLAS regulation II-2/10.9.1.1. *Or equivalent*. A notice is to be exhibited at the controls stating that the system is only to be used for fire-extinguishing and not for inerting purposes, due to the electrostatic ignition hazard. The alarms referred to in SOLAS regulation II-2/10.9.1.1.1 are to be safe for use in a flammable cargo vapour-air mixture. For the purpose of this requirement, an extinguishing system is to be provided which would be suitable for machinery spaces. However, the amount of carbon dioxide gas carried are to be sufficient to provide a quantity of free gas equal to 45% of the gross volume of the cargo compressor and pump-rooms in all cases.

*Audible alarms fitted to warn of the release of fire extinguishing medium into pump rooms, are to be of the pneumatic type or electric type:*

a. *In cases where the periodic testing of pneumatically operated alarms is required, CO₂ operated alarms should not be used owing to the possibility of the generation of static electricity in the CO₂ cloud. Air operated alarms may be used provided the air supply is clean and dry.*
b. When electrically operated alarms are used, the arrangements are to be such that the electric actuating mechanism is located outside the pump room except where the alarms are certified intrinsically safe.

At least two portable extinguishers of a recognised type are to be fitted in the room.

11.5.2. Others fire extinguishing system can be considered
12. Mechanical Ventilation in the Cargo Area

The requirements of this chapter are to be substituted for SOLAS regulation II-2/4.5.2.6 and 4.5.4

12.1 Spaces required to be entered during normal cargo handling operations

12.1.1. Electric motor rooms, cargo compressor rooms, other enclosed spaces which contain cargo handling equipment and similar spaces in which cargo handling operations are performed are to be fitted with mechanical ventilation systems capable of being controlled from outside such spaces. Provision are to be made to ventilate such spaces prior to entering the compartment and operating the equipment and a warning notice requiring the use of such ventilation are to be placed outside the compartment.

12.1.2. Mechanical ventilation inlets and outlets are to be arranged to ensure sufficient air movement through the space to avoid the accumulation of flammable or toxic vapours and to ensure a safe working environment, but in no case the ventilation system is to have a capacity of less than 30 changes of air per hour based upon the total volume of the space. As an exception, gas-safe cargo control rooms may have eight changes of air per hour.

12.1.3. Ventilation systems are to be fixed and, if of the negative pressure type, permit extraction from either the upper or the lower parts of the spaces, or from both the upper and the lower parts, depending on the density of the vapours of the products carried.

12.1.4. In rooms housing electric motors driving cargo compressors or cargo handling equipment, spaces except machinery spaces containing inert gas generators, cargo control rooms if considered as gas-safe spaces and other gas-safe spaces within the cargo area, the ventilation are to be of the positive pressure type.

12.1.5. In cargo compressor and cargo handling equipment rooms and in cargo control rooms if considered gas-dangerous, the ventilation are to be of the negative pressure type.

12.1.6. Ventilation exhaust ducts from gas-dangerous spaces are to discharge upwards in locations at least 10 m in the horizontal direction from ventilation intakes and openings to accommodation spaces, service spaces and control stations and other gas-safe spaces.

Ventilation ducts are to be arranged at a suitable height from the weather deck. This height is not to be less than 2.4 m for intake ducts.

Ventilation ducts are to be fitted with metallic fire dampers provided with "open" and "closed" signs. These dampers are to be arranged in the open, in a readily accessible position.
Gas-dangerous spaces for the purpose of 1.1.1.a) are those mentioned in paragraph 12.1.5. For other spaces which are gas-dangerous only due to their position, some relaxation may be granted.

12.1.7. Ventilation intakes are to be so arranged as to minimize the possibility of recycling hazardous vapours from any ventilation discharge opening.

Exhaust ducts from gas-dangerous spaces are to be arranged at a distance in the horizontal direction of at least 10 m from ventilation outlets of gas-safe spaces. Shorter distances may be accepted for ventilation outlets from safe spaces protected by air-locks.

Intakes of gas-dangerous spaces are to be arranged at a distance in the horizontal direction of at least 3 m from ventilation intakes and outlets and openings of accommodation spaces, control stations and other gas-safe spaces.

Exhaust and intake ducts for the same gas-dangerous space, or for the same space rendered safe by an air-lock, are to be arranged at a distance from each other in the horizontal direction of not less than 3 m.

12.1.8. Ventilation ducts from gas-dangerous spaces are not to be led through accommodation, service and machinery spaces or control stations, except as allowed in chapter 16.

12.1.9. Electric motors driving fans are to be placed outside the ventilation ducts if the carriage of flammable products is intended. Ventilation fans are not to 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, for gas-dangerous spaces are to be of non-sparking construction.

12.1.10. Spare parts are to be carried for each type of fan on board referred to in this chapter.

12.1.11. Protection screens of not more than 13 mm square mesh are to be fitted in outside openings of ventilation ducts.

12.1.12. Additional requirements for non-sparking fans

12.1.12.1. Non-sparking fans

A fan is considered as non-sparking if in either normal or abnormal conditions it is unlikely to produce sparks.

The air gap between the impeller and the casing is to be not less than 0.1 of the shaft diameter in way of the impeller bearing and not less than 2 mm. It need not be more than 13 mm.

Protection screens of not more than 13 mm$^2$ mesh are to be fitted in the inlet and outlet of ventilation ducts to prevent the entrance of objects into the fan housing.
12.1.12.2. Materials for non-sparking fans

The impeller and the housing in way of the impeller are to be made of alloys which are recognised as being spark proof by appropriate tests.

Electrostatic charges both in the rotating body and the casing are to be prevented by the use of antistatic materials. Furthermore, the installation on board of the ventilation units is to be such as to ensure their safe bonding to the hull.

Tests may not be required for fans having the following combinations:

- Impellers and/or housings of non-metallic material, due regard being paid to the elimination of static electricity
- Impellers and housings of non-ferrous materials
- 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
- Any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 mm design tip clearance.

The following impellers and housings are considered as sparking and are not permitted:

- Impellers of an aluminium alloy or magnesium alloy and a ferrous housing, regardless of tip clearance
- Housing made of an aluminium alloy or a magnesium alloy and a ferrous impeller, regardless of tip clearance
- Any combination of ferrous impeller and housing with less than 13 mm design tip clearance.

12.1.12.3. Type test for non-sparking fans

Type tests on the finished product are to be carried out in accordance with the requirements of the Society or an equivalent national or international standard.

12.1.12.4. Motor shafting

The shafting penetration of motors driving fans through bulkheads and decks of dangerous spaces or through ventilation ducts is to be fitted with a gas-tight sealing device, of the oil-seal type or equivalent, deemed suitable by the Society.
12.2 Spaces not normally entered

Hold spaces, void spaces, cofferdams, spaces containing cargo piping and other spaces where cargo vapours may accumulate, are to be capable of being ventilated to ensure a safe environment when entry into the spaces is necessary. Where a permanent ventilation system is not provided for such spaces, approved means of portable mechanical ventilation are to be provided. Where necessary owing to the arrangement of spaces, such as hold spaces, essential ducting for such ventilation is to be permanently installed. Fans or blowers are to be clear of personnel access openings, and are to comply with 12.1.9.
13. Instrumentation (Gauging, Gas Detection)

13.1 General

13.1.1. Each cargo tank is to be provided with means for indicating level if applicable, pressure and temperature of the cargo. Pressure gauges and temperature indicating devices are to be installed in the condensate if applicable and vapour piping systems, in cargo refrigerating installations and in the inert gas systems as detailed in this chapter.

*The instrumentation is to be of a type approved by the Society.*

13.1.2. N/A.

13.1.3. If the loading and unloading of the ship is performed by means of remotely controlled valves and pumps, all controls and indicators associated with a given cargo tank are to be concentrated in one control position.

13.1.4. Instruments are to be tested to ensure reliability in the working conditions and recalibrated at regular intervals. Test procedures for instruments and the intervals between recalibration are to be approved by the Society.

13.1.5. Monitoring list

The following information and alarms are to be concentrated in the positions specified in this requirement.

a. The following is to be transduced to the "cargo control room" and the "control position" as defined in 3.4.1:

1. the indication signalling the presence of water and/or condensate cargo in holds
2. the cargo heater low temperature alarm required in 4.10.19
3. the alarm signalling the presence of condensate cargo in the vent main as per 5.2.1.7
4. the indication of the hull temperature and the hull structure low temperature alarm required in 13.5.
5. the indication of the cargo level and the cargo tank high level alarm required in 13.3.1
6. the indication of the vapour space pressure and the vapour space pressure gauges of each cargo tank and associated high and low pressure alarms required in 13.4.

7. the gas detection equipment alarm required in 13.6.4

8. the cargo compressor high temperature alarm required in 17.4.2.2

9. the alarm for automatic shutdown of the cargo compressor for high pressure or high temperature, as required in 17.18.4.4.

When the cargo system is not remote controlled and therefore the aforesaid "control positions" are not required, the above-mentioned controls, information and alarms are to be located in a suitable, easily accessible location. If this position is an enclosed space, it is to comply with the requirements of 3.3.4. This position should preferably be located in the wheelhouse.

b. Independently of the above, the following is to be transduced to the wheelhouse:

1. the alarm signalling the presence of water and/or condensate cargo in holds

2. the cargo heater low temperature alarm required in 4.2.7.2

3. the alarm signalling the presence of condensate cargo in the vent main as per 5.2.1.7

4. the indication of the pressure value in each cargo tank mentioned in 13.4.1; such indication is to give the setting pressure value of the relief valve and the minimum allowable pressure value in the cargo tank concerned

5. the high pressure and low pressure alarms, when required, for cargo tanks as per 13.4.1

6. the hull structure low temperature alarm required in 13.5.2

7. the gas detection equipment alarm required in 13.6.4

8. the cargo compressor high temperature alarm required in 17.4.2.2

9. the alarm for automatic shutdown of the cargo compressor for high pressure or high temperature, as required in 17.18.4.4.

10. Where the cargo control room is located within the accommodation spaces and is readily accessible, the alarms in 13.3.2 may be grouped in a single audible and visual alarm except for the indication and alarms in 1.3.2.b.4, 1.3.2.b.5 and 1.3.2.b.7, which are to be independent from each other.

11. The high or low pressure audible and visual alarms for cargo tanks as per 13.3.1 and 13.3.2 and the alarm signalling the presence of condensate in the vent main are to be located in such a position as to be clearly heard and identifiable by the personnel in charge of loading operation control.
13.2 Level indicators for cargo tanks (if applicable)

13.2.1. Each cargo tank are to be fitted with at least one condensate level gauging device, designed to operate at pressures not less than the MARVS of the cargo tank and at temperatures within the cargo operating temperature range. Where only one condensate level gauge is fitted it is to be so arranged that any necessary maintenance can be carried out while the cargo tank is in service.

In order to assess whether or not one level gauge is acceptable, the wording "any necessary maintenance" is to be interpreted to mean that any part of the level gauge can be overhauled while the cargo tank is in service.

Where level gauges containing cargo are arranged outside the tank they serve, means are to be provided to shut them off automatically in the event of failure.

13.2.2. Cargo tank condensate level gauges may be of the following types:

.1. indirect devices, which determine the amount of cargo by means such as weighing or pipe flow meters;

.2. closed devices, which do not penetrate the cargo tank, such as devices using radioisotopes or ultrasonic devices;

.3. closed devices, which penetrate the cargo tank, but which form part of a closed system and keep the cargo from being released, such as float type systems, electronic probes, magnetic probes and bubble tube indicators. If a closed gauging device is not mounted directly on the tank it are to be provided with a shutoff valve located as close as possible to the tank; and

.4. restricted devices, which penetrate the tank and when in use permit a small quantity of cargo vapour or condensate to escape to the atmosphere, such as fixed tube and slip tube gauges. When not in use, the devices are to be kept completely closed. The design and installation are to ensure that no dangerous escape of cargo can take place when opening the device. Such gauging devices are to be so designed that the maximum opening does not exceed 1.5 mm diameter or equivalent area unless the device is provided with an excess flow valve.

13.2.3. N/A.

13.2.4. N/A.

13.3 Overflow control

N/A
13.4 Pressure gauges

13.4.1. Each cargo tank is to be provided with a pressure gauge which is to incorporate an indicator in the control position required by 13.1.3. In addition, a high-pressure alarm and, if vacuum protection is required, a low-pressure alarm, are to be provided on the navigating bridge. Maximum and minimum allowable pressures are to be marked on the indicators. The alarms are to be activated before the set pressures are reached.

*The low pressure alarm is also to be located in the cargo control room.*

13.4.2. Each cargo pump manifold is to be provided with at least one pressure gauge.

13.4.3. Local-reading manifold pressure gauges are to be provided to indicate the pressure between stop valves and hose connections to the shore.

13.4.4. Hold spaces are to be provided with pressure gauges.

13.5 Temperature indicating devices

13.5.1. Each cargo tank are to be provided with at least two devices for indicating cargo temperatures. The temperature indicating devices are to be marked to show the lowest temperature for which the cargo tank has been approved by the Society.

13.5.2. N/A.

13.5.3. If cargo is to be carried at temperatures lower than -55°C, the cargo tank boundaries, if appropriate for the design of the cargo containment system, are to be fitted with temperature indicating devices as follows:

.1. A sufficient number of devices to establish that an unsatisfactory temperature gradient does not occur.

.2. On one tank a number of devices in excess of those required in 13.5.3.1 in order to verify that the initial cool down procedure is satisfactory. These devices may be either temporary or permanent. When a series of similar ships is built, the second and successive ships need not comply with the requirements of this subparagraph.

13.5.4. The number and position of temperature indicating devices are to be to the satisfaction of the Society.

*The temperatures are to be continuously recorded at regular intervals. Audible and visual alarms are to be automatically activated when the hull steel temperature approaches the lowest temperature for which the steel has been approved.*
13.6 Gas detection requirements

13.6.1. Gas detection equipment acceptable to the Society and suitable for the gases to be carried is to be provided.

13.6.2. In every installation, the positions of fixed sampling heads are to be determined with due regard to the density of the vapours of the products intended to be carried and the dilution resulting from compartment purging or ventilation.

*Sampling heads in cargo holds are not to be located in positions where bilge water may collect*

13.6.3. Pipe runs from sampling heads are not to be led through gas-safe spaces except as permitted by 13.6.5.

13.6.4. Audible and visual alarms from the gas detection equipment, if required by this section, are to be located on the navigating bridge, in the control position required by 13.1.3, and at the gas detector readout location.

13.6.5. Gas detection equipment may be located in the control position required by 13.1.3, on the navigating bridge or at other suitable locations. When such equipment is located in a gas-safe space the following conditions are to be met:

1. gas-sampling lines are to have shutoff valves or an equivalent arrangement to prevent cross-communication with gas-dangerous spaces; and

2. exhaust gas from the detector are to be discharged to the atmosphere in a safe location.

*Gas sampling lines are to be located outside accommodation spaces, unless they are fitted within gas-tight pipes.*

13.6.6. Gas detection equipment is to be so designed that it may readily be tested. Testing and calibration are to be carried out at regular intervals. Suitable equipment and span gas for this purpose are to be carried on board. Where practicable, permanent connections for such equipment are to be fitted.

13.6.7. A permanently installed system of gas detection and audible and visual alarms are to be provided for:

1. cargo handling equipment rooms;

2. cargo compressor rooms;

3. motor rooms for cargo handling machinery;

4. cargo control rooms unless designated as gas-safe;

5. other enclosed spaces in the cargo area where vapour may accumulate including hold spaces;
.6. ventilation hoods and gas ducts where required by chapter 16; and

.7. airlocks.

In addition to the list the gas detection system is also to serve spaces adjacent to cargo handling equipment rooms and compressor rooms.

13.6.8. The gas detection equipment are to be capable of sampling and analysing from each sampling head location sequentially at intervals not exceeding 30 minutes, except that in the case of gas detection for the ventilation hoods and gas ducts referred to in 13.6.7.6 sampling are to be continuous. Common sampling lines to the detection equipment are not to be fitted.

13.6.9. N/A.

13.6.10. For the spaces listed in 13.6.7, alarms are to be activated when the vapour concentration reaches 30% of the lower flammable limit.

13.6.11. N/A.

13.6.12. N/A.

13.6.13. Every ship is to be provided with at least two sets of portable gas detection equipment acceptable to the Society and suitable for the products to be carried.

13.6.14. A suitable instrument for the measurement of oxygen levels in inert atmospheres is to be provided.
14. Personnel Protection

Out of classification Scope.
15. Filling Limits for Cargo Tanks

15.1 General

The cargo tanks are to be filled so that at any time during the transport or unloading the pressure will not reach the MARVS at the reference temperature

15.1.1. N/A

15.1.2 N/A.

15.1.3. N/A.

15.1.4. For the purpose of this chapter only, “reference temperature” means:

1. the temperatures defined in 7.1.2 when no cargo vapour pressure/temperature control as referred to in chapter 7 is provided;

2. the temperature of the cargo upon termination of loading, during transport, or at unloading, whichever is the greatest, when a cargo vapour pressure/temperature control as referred to in chapter 7 is provided.

15.1.5. N/A.

15.2 Information to be provided to the master

Out of classification Scope
16. Use of Cargo as Fuel

16.1 General

16.1.1. Methane (CNG) may be utilized in machinery spaces of category A and in such spaces may be utilized only in boilers, inert gas generators, combustion engines and gas turbines provided the percentage of heavier components such as propane, butane, etc. is limited in order to prevent the risks of stratification or accumulation of heavy components in the low parts of the fuelled equipment or in machinery space.

16.1.2. These provisions do not preclude the use of gas fuel for auxiliary services in other locations, provided that such other services and locations are to be subject to special consideration by the Society.

16.2 Arrangement of machinery spaces of category A

16.2.1. Spaces in which gas fuel is utilized are to be fitted with a mechanical ventilation system and are to be arranged in such a way as to prevent the formation of dead spaces. Such ventilation is to be particularly effective in the vicinity of electrical equipment and machinery or of other equipment and machinery which may generate sparks. Such a ventilation system is to be separate from those intended for other spaces.

16.2.2. Gas detectors are to be fitted in these spaces, particularly in the zones where air circulation is reduced. The gas detection system is to comply with the requirements of chapter 13.

16.2.3. Electrical equipment located in the double wall pipe or duct specified in 16.3.1 are to be of the intrinsically safe type.

16.3 Gas fuel supply

16.3.1. Gas fuel piping is not to pass through accommodation spaces, service spaces, or control stations. Gas fuel piping may pass through or extend into other spaces provided they fulfil one of the following:

1. the gas fuel piping are to be a double wall piping system with the gas fuel contained in the inner pipe. The space between the concentric pipes is to be pressurized with inert gas at a pressure greater than the gas fuel pressure. Suitable alarms are to be provided to indicate a loss of inert gas pressure between the pipes; or
The gas fuel piping is to be installed within a ventilated pipe or duct. The air space between the gas fuel piping and inner wall of this pipe or duct are to be equipped with mechanical exhaust ventilation having a capacity of at least 30 air changes per hour. The ventilation system is to be arranged to maintain a pressure less than the atmospheric pressure. The fan motors are to be placed outside the ventilated pipe or duct. The ventilation outlets are to be placed in a position where no flammable gas-air mixture may be ignited. The ventilation is always to be in operation when there is gas fuel in the piping. Continuous gas detection is to be provided to indicate leaks and to shut down the gas fuel supply to the machinery space in accordance with 16.3.10. The master gas fuel valve required by 16.3.7 is to close automatically, if the required air flow is not established and maintained by the exhaust ventilation system.

**Piping**

**Piping runs**

The main gas line between the gas make-up station and the machinery space is to be as short as possible.

The gas piping is to be installed as high in the space as possible and at the greatest possible distance from the ship’s hull.

**Segregation of piping**

Gas piping is to be independent of other systems and may only be used for the conveyance of gas. It is to be ensured by its arrangement that it is protected against external damage.

**Earthing**

Gas piping is to be suitably earthed.

**Testing**

Piping, valves and fittings are to be hydrostatically tested, after assembly on board, to 1.5 times the working pressure but to not less than 7 bar. Subsequently, they are to be pneumatically tested to ascertain that all the joints are perfectly tight.

16.3.2. If a gas leak occurs, the gas fuel supply is not to be restored until the leak has been found and repaired. Instructions to this effect are to be placed in a prominent position in the machinery spaces.

16.3.3. The double wall piping system or the ventilated pipe or duct provided for the gas fuel piping is to terminate at the ventilation hood or casing required by 16.3.4.
16.3.4. A ventilation hood or casing are to be provided for the areas occupied by flanges, valves, etc., and for the gas fuel piping, at the gas fuel utilization units, such as boilers, diesel engines or gas turbines. If this ventilation hood or casing is not served by the exhaust ventilation fan serving the ventilated pipe or duct as specified in 16.3.1.2, then it are to be equipped with an exhaust ventilation system and continuous gas detection are to be provided to indicate leaks and to shut down the gas fuel supply to the machinery space in accordance with 16.3.10. The master gas fuel valve required by 16.3.7 is to close automatically if the required air flow is not established and maintained by the exhaust ventilation system. The ventilation hood or casing are to be installed or mounted to permit the ventilating air to sweep across the gas utilization unit and be exhausted at the top of the ventilation hood or casing.

16.3.5. The ventilation inlet and discharge for the required ventilation systems are to be respectively from and to a safe location.

16.3.6. Each gas utilization unit are to be provided with a set of three automatic valves. Two of these valves are to be in series in the gas fuel pipe to the consuming equipment. The third valve are to 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. These valves are to be arranged so that failure of the necessary forced draught, loss of flame on boiler burners, abnormal pressure in the gas fuel supply line, or failure of the valve control actuating medium will cause the two gas fuel valves which are in series to close automatically and the vent valve to open automatically. Alternatively, the function of one of the valves in series and the vent valve can be incorporated into one valve body so arranged that, when one of the above conditions occurs, flow to the gas utilization unit will be blocked and the vent opened. The three shut-off valves are to be arranged for manual reset.

Valves

Manual operation

The three valves are to be capable of being manually operated.

Automatic operation

It is to be possible to operate the valves indicated in paragraph 16.3.6.1 of the IGC Code locally and from each control platform. They are to close automatically under the following service conditions:

a. Whenever the gas pressure varies by more than 10 % or, in the case of supercharged engines, if the differential pressure between gas and charging air is no longer constant

b. In the event of one of the following fault situations:

1. Gas supply to boiler burners

   a. Insufficient air supply for complete combustion of the gas
b. Extinguishing of the pilot burner for an operating burner, unless the gas supply line to every individual burner is equipped with a quick-closing valve that automatically cuts off the gas

c. Low pressure of the gas

2. Gas supply to internal combustion engines

a. Failure of supply to pilot fuel injection pump

b. Drop of engine speed below the lowest service speed

c. Indication by the gas detector in the crankcase vent line that the gas concentration is approaching the lower explosion limit.

16.3.7. A master gas fuel valve that can be closed from within the machinery space are to be provided within the cargo area. The valve are to be arranged so as to close automatically if leakage of gas is detected, or loss of ventilation for the duct or casing or loss of pressurization of the double wall gas fuel piping occurs.

16.3.8. Gas fuel piping in machinery spaces is to comply with sections 5.2, 5.3, 5.4 and 5.5 as far as found applicable. The piping is to, as far as practicable, have welded joints. Those parts of the gas fuel piping, which are not enclosed in a ventilated pipe or duct according to 16.3.1 and are on the open deck outside the cargo area shall have full penetration butt welded joints and are to be fully radiographed.

16.3.9. Provision is to be made for inerting and gas-freeing that portion of the gas fuel piping system located in the machinery space.

16.3.10. Gas detection systems provided in accordance with the requirements of 16.3.1 and 16.3.4 is to comply with 13.6.2 and 13.6.4, 13.6.5, 13.6.6, 13.6.7 and 13.6.8 as applicable; they are to activate the alarm at 30% of the lower flammable limit and shut down the master gas fuel valve referred to in 16.3.7 before the gas concentration reaches 60% of the lower flammable limit.

16.4 Gas make-up plant and related storage tanks

16.4.1. All equipment (heaters, fuel gas handling equipment filters, etc.) for making up the gas for its use as fuel, and the related storage tanks are to be located in the cargo area in accordance with paragraph 3.1.5.4. If the equipment is in an enclosed space, the space are to be ventilated according to section 12.1 of this Rule Note and be equipped with a fixed fire-extinguishing system according to section 11.5 and with a gas detection system according to section 13.6, as applicable.

Location of equipment for making up gas

Means for purging of flammable gases before opening are to be provided in the equipment for making up gas.
**Equipment located on weather deck**

Where the equipment (heaters, fuel gas handling equipment filters) for making up the gas for its use as fuel and the storage tanks are located on the weather deck, they are to be suitably protected from atmospheric agents and the sea.

16.4.2. N/A

16.4.3. If the heating medium for the gas fuel evaporator or heater is returned to spaces outside the cargo area it is to first go through a degassing tank. The degassing tank is to be located in the cargo area. Provisions are to be made to detect and alarm the presence of gas in the tank. The vent outlet is to be in a safe position and fitted with a flame screen.

**Operation of the heaters is to be automatically regulated depending on the gas temperature at the heater outlet.**

Before it is returned to the machinery space, the heating medium (steam or hot water) is to go through a degassing tank located in the cargo area.

Provisions are to be made to detect and signal the presence of gas in the tank. The vent outlet is to be in a safe position and fitted with a flame screen.

16.4.4. Piping and pressure vessels in the gas fuel conditioning system are to comply with chapter 5.

**16.5 Special requirements for main boilers**

16.5.1. Each boiler is to have a separate uptake.

*Boilers are to be located as high as possible in boiler spaces and are to be of the membrane wall type or equivalent, so as to create a space with forced air circulation between the membrane wall and the boiler casing.*

16.5.2. A system suitable to ensure the forced draught in the boilers are to be provided. The particulars of such a system are to be to the satisfaction of the Society.

16.5.3. Combustion chambers of boilers are to be of suitable form such as not to present pockets where gas may accumulate.

*The Society may, at its discretion, require gas detectors to be fitted in those combustion chamber areas where gas could accumulate, as well as the provision of suitable air nozzles.*
16.5.4. The burner systems are to be of dual type, suitable to burn either oil fuel or gas fuel alone or oil and gas fuel simultaneously. Only oil fuel are to be used during manoeuvring and port operations unless automatic transfer from gas to oil burning is provided in which case the burning of a combination of oil and gas or gas alone may be permitted provided the system is demonstrated to the satisfaction of the Society. It is to be possible to change over easily and quickly from gas fuel operation to oil fuel operation. Gas nozzles are to be fitted in such a way that gas fuel is ignited by the flame of the oil fuel burner. A flame scanner are to be installed and arranged to assure that gas flow to the burner is cut off unless satisfactory ignition has been established and maintained. On the pipe of each gas burner a manually operated shut-off valve are to be fitted. An installation are to be provided for purging the gas supply piping to the burners by means of inert gas or steam after the extinguishing of these burners.

Safety devices

A mechanical device is to be installed to prevent the gas valve from opening until the air and the fuel oil controls are in the ignition position. A flame screen, which may be incorporated in the burner, is to be fitted on the pipe of each gas burner.

Shut-off

The gas supply is to be automatically stopped by the shut-off devices specified in paragraph 16.3.6.

16.5.5. Alarm devices are to be fitted in order to monitor a possible decrease in condensate fuel oil pressure or a possible failure of the related pumps.

16.5.6. Arrangements are to be made that, in case of flame failure of all operating burners for gas or oil or for a combination thereof, the combustion chambers of the boilers are automatically purged before relighting. Arrangements are also to be made to enable the boilers to be manually purged.

16.6 Special requirements for gas-fired internal combustion engines and gas-fired turbines

Special provisions for gas-fuelled internal combustion engines and for gas turbines will be considered by the Society in each case.

16.6.1. Gas fuel supply to engine

Flame arresters

Flame arresters are to be provided at the inlet to the gas supply manifold for the engine.

Manual shut-off

Arrangements are to be made so that the gas supply to the engine can be shut off manually from the starting platform or any other control position.
Prevention of fatigue failure

The arrangement and installation of the gas piping are to provide the necessary flexibility for the gas supply piping to accommodate the oscillating movements of the engines without risk of fatigue failure.

Protection of gas line connections

The connecting of gas line and protection pipes or ducts as per [4.2.1] to the gas fuel injection valves is to provide complete coverage by the protection pipe or ducts.

16.6.2. Gas fuel supply piping systems

Fuel piping in machinery spaces

Gas fuel piping may pass through or extend into machinery spaces or gas-safe spaces other than accommodation spaces, service spaces and control stations provided that they fulfil one of the following conditions:

a. The system complies with paragraph 16.3.1.1, and in addition, with 1) to 3) below:

1. The pressure in the space between concentric pipes is monitored continuously. Alarm is to be issued and the automatic valves specified in 16.3.6 (hereafter referred to as "interlocked gas valves") and the master gas fuel valves specified in 16.3.7 (hereafter referred to as "master gas valves") are to be closed before the pressure drops to below the inner pipe pressure (however, an interlocked gas valve connected to the vent outlet is to be opened).

2. The construction and strength of the outer pipes are to comply with the requirements of 5.2.

3. It is to be so arranged that the inside of the gas fuel supply piping system between the master gas valve and the engine is automatically purged with inert gas when the master gas valve is closed; or

b. The system complies with paragraph 16.3.1.2, and, in addition, with 1) to 4) below:

1. The materials, construction and strength of protection pipes or ducts and mechanical ventilation systems are to be sufficiently durable against bursting and rapid expansion of high pressure gas in the event of gas pipe burst.

2. The capacity of mechanical ventilating systems is to be determined considering the flow rate of gas fuel and construction and arrangement of protective pipes or ducts, as deemed appropriate by the Society.
3. The air intakes of mechanical ventilating systems are to be provided with non-return devices effective for gas fuel leaks. However, if a gas detector is fitted at the air intakes, this requirement may be dispensed with.

4. The number of flange joints of protective pipes or ducts is to be minimised; or

c. Alternative arrangements to those given in a) and b) will be specially considered by the Society based upon an equivalent level of safety.

High pressure pipes

High pressure gas piping systems are to be checked for sufficient constructive strength by carrying out stress analysis taking into account the stresses due to the weight of the piping system including acceleration load, when significant, internal pressure and loads induced by hog and sag of the ship.

Valves and expansion joints

All valves and expansion joints used in high pressure gas fuel supply lines are to be of an approved type.

Pipe joints

Joints on the entire length of the gas fuel supply lines are to be butt-welded joints with full penetration and to be fully radiographed, except where specially approved by the Society.

Non-welded pipe joints

Pipe joints other than welded joints at the locations specifically approved by the Society are to comply with the appropriate standards recognised by the Society, or with joints whose structural strength has been verified through test analysis as deemed appropriate by the Society.

Post-weld heat treatment

For all butt-welded joints of high pressure gas fuel supply lines, post-weld heat treatment is to be performed depending on the kind of material.

16.6.3. Shut-off of gas fuel supply

Fuel supply shut-off

In addition to the causes specified in 16.3.6, supply of gas fuel to engines is to be shut-off by the interlocked gas valves in the event of the following abnormalities:

a. abnormality specified in Ship Rules, Pt C, Ch 1, App 2

b. engine stops due to any cause.
Master gas valve shut-off

In addition to the causes specified in 16.3.7, the master gas valve is to be closed in the event of any of the following:

a. the oil mist detector or bearing temperature detector specified in Ship Rules, Pt C, Ch 1, App 2 detects abnormality

b. any kind of gas fuel leakage is detected

c. Abnormality specified in Ship Rules, Pt C, Ch 1, App 2.

Automatic operation

The master gas valve is to close automatically upon activation of the interlocked gas valves.

16.6.4. Emergency stop of dual fuel engines

Dual fuel engines are to be stopped before the gas concentration detected by the gas detectors specified in 16.2.2 of the IGC Code reaches 60% of the lower flammable limit.

16.6.5. Gas fuel make-up plant and related storage tanks

Equipment construction

The construction, control and safety system of pressure vessels and heat exchangers constituting a gas fuel make-up plant are to be arranged to the satisfaction of the Society.

Fatigue

The possibility of fatigue failure of the high pressure gas piping due to vibration is to be considered.

16.6.6. Requirements on dual fuel engines

Specific requirements on internal combustion engines supplied by gas are given in Ship Rules, Pt C, Ch 1, App 2.
17. Hull Scantlings

17.1 Hull scantlings

17.1.1 Structural Details

Special structural details

The specific requirements in Ship Rules, Pt B, Ch 12, Sec 2, [2.4] for ships with the service notation compressed gas carrier are to be complied with.

Connections of the inner hull plating with intermediate plating

The connections of the inner hull plating with intermediate plating are to be made according to:

sheets 4.5 to 4.7 in Ship Rules, Pt B, Ch 12, App 2 for position 1 in Fig 20.1

sheets 6.8 and 6.9 in Ship Rules, Pt B, Ch 12, App 2 for position 2 in Fig 20.1

for positions 3 and 4 in Fig 20.1, in a similar way to positions 1 and 2.

Where there is no prolonging bracket in way of knuckle joints in positions 1 and/or 2, the connection of transverse webs to the inner hull and longitudinal girder plating is to be made with partial penetration welds over a length not less than 400 mm.
Figure 20.1: Positions of connections

Connections of inner bottom with transverse cofferdam bulkheads

In addition to sheet 3.5 in Ship Rules, Pt B, Ch 12, App 2, the following requirements apply:

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

Vertical webs fitted within the cofferdam bulkhead are to be aligned with the double bottom girders.

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

Cut-outs and connections

Cut-outs for the passage of inner hull and cofferdam bulkhead ordinary stiffeners through the vertical webs are to be closed by collar plates welded to the inner hull plating.

Where deemed necessary, adequate reinforcements are to be fitted in the double hull and transverse cofferdams at connection of the cargo containment system to the hull structure. Details of the connection are to be submitted to the Society for approval.