Transportstyrelsens författningssamling

TRANSPORT STYRELSEN

TSFS 2021:89

SJÖFART

Transportstyrelsens föreskrifter och allmänna råd om fartyg som transporterar kondenserade gaser i bulk (IGC-koden)

Innehåll

Transportstyrelsens författningssamling

Transportstyrelsens föreskrifter och allmänna råd om fartyg som transporterar kondenserade gaser i bulk (IGC-koden);

TSFS 2021:89
Utkom från trycket
den 10 november 2021

SJÖFART

beslutade den 1 november 2021.

Transportstyrelsen föreskriver följande med stöd av 2 kap. 1 § samt 3 kap. 2 och 4 §§ fartygssäkerhetsförordningen (2003:438) samt beslutar följande allmänna råd.

Införlivande av IGC-koden

1 § Som Transportstyrelsens föreskrifter ska gälla den internationella koden för konstruktion och utrustning av fartyg som transporterar kondenserade gaser i bulk (the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC-koden)), som antogs av den internationella sjöfartsorganisationen (IMO) den 17 juni 1983 genom resolution MSC.5(48)[1], i lydelsen enligt resolution MSC.441(99)[2].

Den engelska, franska, spanska och arabiska texten av IGC-koden ska ha samma giltighet.[3] Kodens engelska text med ändringar antagna till och med resolution MSC.441(99) finns i bilaga 1 och 2.

Allmänna råd
Fartyg som transporterar kondenserad koldioxid i bulk bör tillämpa koden i enlighet med IMO-cirkulär MSC.1/Circ.1213[4].

Tillämpningsområde

2 § Gastankfartyg byggda under perioden 1 juli 1986 till och med 30 juni 2016 ska, vid transport av kondenserade gaser i bulk inom Sveriges sjöterritorium, uppfylla IGC-koden i lydelsen enligt resolution MSC.5(48) efter

[1] MSC.5(48), Adoption of the international code for the construction and equipment of ships carrying liquefied gases in bulk (IGC Code).
[2] MSC.441(99), Amendments to the international code for the construction and equipment of ships carrying liquefied gases in bulk (IGC Code).
[3] Texterna på franska, spanska och arabiska finns tillgängliga hos IMO.
[4] MSC.1/Circ.1213, Interpretation and application of the IGC Code for ships carrying liquefied carbon dioxide in bulk.

ändringar antagna genom resolutionerna MSC.17(58)[5], MSC.30(61)[6], MSC.32(63)[7], MSC.59(67)[8], MSC.103(73)[9], MSC.177(79)[10] och MSC.220 (82)[11]. Resolutionerna finns i bilaga 1. Svenska gastankfartyg ska uppfylla kraven också vid transport utanför sjöterritoriet.

Gastankfartyg enligt första stycket får i stället uppfylla kraven i 3 §.

3 § Gastankfartyg byggda den 1 juli 2016 eller senare ska, vid transport av kondenserade gaser i bulk inom Sveriges sjöterritorium, uppfylla IGC-koden i lydelsen enligt resolution MSC.370(93)[12] efter ändringar antagna genom resolutionerna MSC.93/22/Add.1/Corr.3[13], MSC.93/22/Add.1/Corr.5[14], MSC.411(97)[15] och MSC.441(99)[16]. Resolutionerna finns i bilaga 2. Svenska gastankfartyg ska uppfylla kraven också vid transport utanför sjöterritoriet.

4 § Gastankfartyg enligt 2 och 3 §§ som undergår reparation, ändringar, modifieringar och utrustas i samband därmed ska fortsätta att uppfylla åtminstone de krav som tidigare varit tillämpliga för fartyget.

5 § Om ett fartyg byggt under perioden 1 juli 1986 till och med 30 juni 2016 genomgår en väsentlig förändring, och utrustas i samband därmed, ska det uppfylla kraven för fartyg byggda den 1 juli 2016 eller senare i den utsträckning Transportstyrelsen anser det är rimligt och praktiskt möjligt.

6 § Fartyg, oavsett byggnadsdatum, som konverteras till gastankfartyg ska uppfylla de krav som gäller för ett gastankfartyg med byggnadsdatum det datum då konverteringen påbörjades.

[5] MSC.17(58), Adoption of amendments to the international code for the construction and equipment of ships carrying liquefied gases in bulk (IGC Code).

[6] MSC.30(61), Adoption of amendments to the international code for the construction and equipment of ships carrying liquefied gases in bulk (IGC Code).

[7] MSC.32(63), Adoption of amendments to the international code for the construction and equipment of ships carrying liquefied gases in bulk (IGC Code).

[8] MSC.59(67), Adoption of amendments to the international code for the construction and equipment of ships carrying liquefied gases in bulk (IGC Code).

[9] MSC.103(73), Adoption of amendments to the international code for the construc-tion and equipment of ships carrying liquefied gases in bulk (IGC Code).

[10] MSC.177(79), Adoption of amendments to the international code for the construc-tion and equipment of ships carrying liquefied gases in bulk (IGC Code).

[11] MSC.220(82), Adoption of amendments to the international code for the construc-tion and equipment of ships carrying liquefied gases in bulk (IGC Code).

[12] MSC.370(93), Amendments to the international code for the construction and equipment of ships carrying liquefied gases in bulk (IGC Code).

[13] MSC.93/22/Add.1/Corr.3, Amendments to the international code for the construc-tion and equipment of ships carrying liquefied gases in bulk (IGC Code).

[14] MSC. 93/22/Add.1/Corr.5, Amendments to the international code for the construc-tion and equipment of ships carrying liquefied gases in bulk (IGC Code).

[15] MSC.411(97) Amendments to the international code for the construction and equipment of ships carrying liquefied gases in bulk (IGC Code).

Ömsesidighetsklausul

7 § Varor som lagligen saluförs i en annan medlemsstat i Europeiska unionen eller i Turkiet, eller som har sitt ursprung i och som lagligen saluförs i en Eftastat som är part i EES-avtalet förutsätts vara förenliga med dessa regler. Tillämpningen av dessa regler omfattas av förordning (EU) 2019/515 av den 19 mars 2019 om ömsesidigt erkännande av varor som är lagligen saluförda i en annan medlemsstat.

Definitioner

8 § I dessa föreskrifter används följande termer och definitioner.

fartyg byggda	fartyg som är kölsträckt eller befinner sig på motsvarande byggnadsstadium
gastankfartyg	lastfartyg som är byggt eller anpassat för och som används för bulktransport av kondenserad gas eller andra produkter uppräknade i kapitel 19 i IGC-koden
motsvarande byggnadsstadium	byggnation som kan identifieras till ett visst fartyg har påbörjats och sammanfogning av fartyget har nått en omfattning av minst 50 ton eller 1 % av den uppskattade totalvikten av allt material som ingår i fartygets struktur, varvid den lägsta angivelsen ska gälla
väsentlig förändring	ändrade huvuddimensioner eller utökad kapacitet

Undantag

9 § Transportstyrelsen får, om det finns särskilda skäl, medge undantag från dessa föreskrifter om det inte strider mot internationella överenskommelser eller gemenskapsrättslig lagstiftning.

Ikraftträdande och övergångsbestämmelser

1. Denna författning träder i kraft den 1 januari 2022.
2. Sjöfartsverkets och Transportstyrelsens beslut som gäller då denna författning träder i kraft gäller även efter ikraftträdandet av denna författning. Sådana beslut som meddelats av Sjöfartsverket ska anses ha meddelats av Transportstyrelsen. Sjöfartsverkets och Transportstyrelsens beslut gäller till dess att Transportstyrelsen meddelar ett nytt beslut eller giltighetstiden för beslutet går ut.

På Transportstyrelsens vägnar

JONAS BJELFVENSTAM

Robin Cook
(Sjö- och luftfart)

Utgivare: Kristina Nilsson, Transportstyrelsen, Norrköping ISSN 2000-1975

ANNEX 12

RESOLUTION MSC.5(48)
adopted on 17 June 1983

ADOPTION OF THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK (IGC CODE)

THE MARITIME SAFETY COMMITTEE,

RECALLING resolution A.328(IX) by which the Assembly authorized the Maritime Safety Committee to amend the Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk as may be necessary,

NOTING resolution MSC.6(48) by which it adopts, inter alia, amendments to Chapter VII of the International Convention for the Safety of Life at Sea, 1974 (1974 SOLAS Convention), to make the provisions of the International Code for the Construction and Equipment of Ships carrying Liquefied Gases in Bulk (IGC Code) mandatory under that Convention,

HAVING CONSIDERED the text of the proposed IGC Code:

1 ADOPTS the IGC Code the text of which is given in the Annex to the present resolution;

2 NOTES that under Part C of Chapter VII of the 1974 SOLAS Convention as amended by resolution MSC.6(48), amendments to the IGC Code shall be adopted, brought into force and take effect in accordance with the provisions of Article VIII of that Convention;

3 REQUESTS the Secretary-General to circulate to all Governments concerned amendments to the IGC Code adopted as above which comprise the inclusion in Chapter 19 of new products, recommending that, pending the entry into force of those amendments, these new products should be carried by gas carriers in compliance with the provisions of the amendments;

4 FURTHER REQUESTS the Secretary-General to transmit a copy of the present resolution together with the text of the IGC Code to all Members of the Organization and to all Contracting Governments to the 1974 SOLAS Convention which are not members of the Organization.

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ANNEX

INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK

TABLE OF CONTENTS

5 Requirements for new products and their conditions of carriage will be circulated as recommendations, on an interim basis, when adopted by the Maritime Safety Committee of the Organization, prior to the entry into force of the appropriate amendments, under the terms of Article VIII of the International Convention for the Safety of Life at Sea, 1974.

6 The Code primarily deals with ship design and equipment. In order to ensure the safe transport of the products the total system must, however, be appraised. Other important facets of the safe transport of the products, such as training, operation, traffic control and handling in port, are being or will be examined further by the Organization.

7 The development of the Code has been greatly assisted by the work of the International Association of Classification Societies (IACS) and full account has been taken of the IACS Unified Requirements for Liquefied Gas Tankers in Chapters 4, 5 and 6.

8 The development of Chapter 10 has been greatly assisted by the relevant work of the International Electrotechnical Commission (IEC).

9 Chapter 18 of the Code dealing with operation of liquefied gas carriers highlights the regulations in other chapters that are operational in nature and mentins those other important safety features that are peculiar to gas carrier operation.

10 The layout of the Code is in line with the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code) adopted by the Maritime Safety Committee at its forty-eighth session.

CHAPTER 1 - GENERAL

1.1 Application

1.1.1 The Code applies to ships regardless of their size, including those of less than 500 gross tonnage engaged in carriage of liquefied gases having a vapour pressure exceeding 2.8 bar absolute at a temperature of 37.8°C, and certain other substances as shown in Chapter 19, when carried in bulk.

1.1.2 Unless expressly provided otherwise the Code applies to ships the keels of which were laid or which were at a stage at which:

.1 construction identifiable with the ship begins; and

.2 assembly of that ship has commenced comprising at least 50 tonnes or one per cent of the estimated mass of all structural material, whichever is less;

on or after [1 May 1986].

1.1.3 A ship, irrespective of the date of construction, which is converted to a gas carrier on or after [1 May 1986] should be treated as a gas carrier constructed on the date on which such conversion commences.

1.1.4 Flammable liquids having a flashpoint not exceeding 60°C (closed cup test) should not be carried in tanks located between the shell plating and the cargo tanks when the cargo tanks contain products covered by Chapter 19 except those requiring a Type 3G ship. Such flammable liquids may be so carried when the quantity of Chapter 19 products retained on board are solely used for cooling, circulation or fuelling purposes.

1.1.5 Except as provided in 1.1.8.1, when it is intended to carry products covered by this Code and products covered by the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk to be adopted by the Maritime Safety Committee under the authority of the Assembly of the Organization conferred by resolution A.490(XII), as may be amended by the Organization (IBC Code), the ship should comply with the requirements of both Codes appropriate to the products carried.

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 carriage should establish preliminary suitable conditions of carriage based on the principles of the Code and notify the Organization of such conditions.

1.1.7.1 The requirements of this Code should take precedence when a ship is designed and constructed for the carriage of the following products:

.1 those listed exclusively in Chapter 19 of this Code; and

.2 one or more of the products which are listed both in this Code and in the International Bulk Chemical Code. These products are marked with an asterisk (*) in column 'a' of Chapter 19.

1.1.7.2 When a ship is intended exclusively to carry one or more of the products noted in 1.1.8.1.2 the requirements of the International Bulk Chemical Code as amended should apply.

1.1.8 Compliance of the ship with the requirements of the International Gas Carrier Code should be shown in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk provided for in 1.5. Compliance with the amendments to the Code, as appropriate, should also be indicated in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk.

1.2 Hazards

Hazards of gases considered in this Code include fire, toxicity, corrosivity, reactivity, low temperature and pressure.

1.3 Definitions

Except where expressly provided otherwise, the following definitions apply to the Code. Additional definitions are given in Chapter 4.

1.3.1 "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.

1.3.2 "'A' class divisions" means divisions as defined in Regulation II-2/3.3 of the 1981 SOLAS Amendments.

1.3.3.1 "Administration" means the Government of the state whose flag the ship is entitled to fly.

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

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

1.3.5 "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) should be measured in metres.

1.3.6 "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 beam and length of the ship above the foregoing. Where fitted, the cofferdams, ballast or void spaces at the after end of the aftermost hold space or the forward end of the forwardmost hold space are excluded from the cargo area.

1.3.7 "Cargo containment system" is the arrangement for containment of cargo including, where fitted, a primary and secondary barrier, associated insulation and any intervening spaces, and adjacent structure if necessary for the support of these elements. If the secondary barrier is part of the hull structure it may be a boundary of the hold space.

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

1.3.9 "Cargoes" are products listed in Chapter 19 carried in bulk by ships subject to the Code.

1.3.10 "Cargo service spaces" are spaces within the cargo area used for workshops, lockers and store rooms of more than 2 m^2 in area, used for cargo handling equipment.

1.3.11 "Cargo tank" is the liquid-tight shell 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.

1.3.12 "Cofferdam" is the isolating space between two adjacent steel bulkheads or decks. This space may be a void space or a ballast space.

1.3.13 "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.

1.3.14 "Flammable products" are those identified by an "F" in column "f" in the table of Chapter 19.

1.3.15 "Flammability limits" are those 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.

1.3.16 "Gas carrier" is a cargo ship constructed or adapted and used for the carriage in bulk of any liquefied gas or other substance listed in the table of Chapter 19.

1.3.17 "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 liquid 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;

.4.1 a hold space where cargo is carried in a cargo containment system requiring a secondary barrier;

.4.2 a hold space where cargo is carried in a cargo containment system not requiring a secondary barrier;

.5 a space separated from a hold space described in .4.1 above by a single gas-tight steel boundary;

.6 a cargo pump room and cargo compressor 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 pump rooms and cargo compressor 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 boil-off gas as fuel and complying with Chapter 16 are not considered gas-dangerous spaces in this context;

.11 a compartment for cargo hoses; or

.12 an enclosed or semi-enclosed space having a direct opening into any gas-dangerous space or zone.

1.3.18 "Gas-safe space" is a space other than a gas-dangerous space.

1.3.19 "Hold space" is the space enclosed by the ship's structure in which a cargo containment system is situated.

1.3.20 "Insulation space" is the space, which may or may not be an interbarrier space, occupied wholly or in part by insulation.

1.3.21 "Interbarrier space" is the space between a primary and a secondary barrier, whether or not completely or partially occupied by insulation or other material.

1.3.22 "Length (L)" means 96 per cent of the total length on a waterline at 85 per cent 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 should be parallel to the designed waterline. The length (L) should be measured in metres.

1.3.23 "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.

1.3.24 "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.

1.3.25 "MARVS" is the maximum allowable relief valve setting of a cargo tank.

1.3.26 "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.

1.3.27 "Organization" is the International Maritime Organization (IMO).

1.4.2 When an Administration so allows any fitting, material, appliance, apparatus, item of equipment, or type thereof, or provision, procedure or arrangement to be substituted, it should communicate to the Organization the particulars thereof together with a report on the evidence submitted, so that the Organization may circulate the same to other Contracting Governments to the 1974 SOLAS Convention for the information of their officers.

1.5 Surveys and certification

1.5.1 Survey procedure

1.5.1.1 The survey of ships, so far as regards the enforcement of the provisions of the Regulations and the granting of exemptions therefrom, should be carried out by officers of the Administration. The Administration may, however, entrust the surveys either to surveyors nominated for the purpose or to organizations recognized by it.

1.5.1.2 The Administration nominating surveyors or recognizing organizations to conduct surveys should, as a minimum, empower any nominated surveyor or recognized organization to:

.1 require repairs to a ship; and

.2 carry out surveys if requested by the Port Administration* concerned.

The Administrations should notify the Organization of the specific responsibilities and conditions of the authority delegated to nominated surveyors or recognized organizations for circulation to the Contracting Governments.

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* Joint MSC/MEPC Working Group on Surveys and Certification at its 6th session agreed to use the phrase "Port State authority" for the purpose of the SOLAS Convention, the definition of which reads: ""Port State Authority" means the officers or persons authorized by a Contracting Government to enforce the requirements of the Convention".

1.5.1.3 When a nominated surveyor or recognized organization determines that the condition of the ship or its equipment does not correspond substantially with the particulars or the cetificate or is such that the ship is not fit to proceed to sea without danger to the ship, or persons on board, such surveyor or organization should immediately ensure that corrective action is taken and should in due course notify the Administration. If such corrective action is not taken the relevant certificate should be withdrawn and the Administration should be notified immediately; and, if the ship is in a port of another Contracting Government, the Port Administration concerned should also be notified immediately.

1.5.1.4 In every case, the Administration should guarantee the completeness and efficiency of the survey, and should undertake to ensure the necessary arrangements to satisfy this obligation.

1.5.2 Survey requirements

1.5.2.1 The structure, equipment, fittings, arrangements and material (other than items in respect of which a Cargo Ship Safety Construction Certificate, Cargo Ship Safety Equipment Certificate and Cargo Ship Radiotelegraphy Certificate or Radiotelephony Certificate are issued) of a gas carrier should be subjected to the following surveys:

.1 An initial survey before the ship is put in service or before the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk is issued for the first time, which should include a complete examination of its structure, equipment, fittings, arrangements and material in so far as the ship is covered by the Code. This survey should be such as to ensure that the structure, equipment, fittings, arrangements and material fully comply with the applicable provisions of the Code.

.2 A periodical survey at intervals specified by the Administration, but not exceeding five years which should be such as to ensure that the structure, equipment, fittings, arrangements and material comply with the applicable provisions of the Code.

.3 A minimum of one intermediate survey during the period of validity of the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk. In cases where only one such intermediate survey is carried out in any one certificate validity period, it should be held not before six months prior to, nor later than six months after, the half-way date of the certificate's period of validity. Intermediate surveys should be such as to ensure that the safety equipment, and other equipment, and associated pump and piping systems comply with the applicable provisions of the Code and are in good working order. Such surveys should be endorsed on the International Certificate of Firness for the Carriage of Liquefied Gases in Bulk.

.4 A mandatory annual survey within three months before or after the anniversary date of the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk which should include a general examination to ensure that the structure, equipment, fittings, arrangements and materials remain in all respects satisfactory for the service for which the ship is intended. Such a survey should be endorsed in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk.

.5 An additional survey, either general or partial according to the circumstances, should be made when required after an investigation prescribed in 1.5.3.3, or whenever any important repairs or renewals are made. Such a survey should ensure that the necessary repairs or renewals have been effectively made, that the material and workmanship of such repairs or renewals are satisfactory; and that the ship is fit to proceed to sea without danger to the ship or persons on board.

1.5.3 Maintenance of conditions after survey

1.5.3.1 The condition of the ship and its equipment should be maintained to conform with the provisions of the Code to ensure that the ship will remain fit to proceed to sea without danger to the ship or persons on board.

1.5.3.2 After any survey of the ship under 1.5.2 has been completed, no change should be made in the structure, equipment, fittings, arrangements and material covered by the survey, without the sanction of the Administration, except by direct replacement.

1.5.3.3 Whenever an accident occurs to a ship or a defect is discovered, either of which affects the safety of the ship or the efficiency or completeness of its life-saving appliances or other equipment, the master or owner of the ship should report at the earliest opportunity to the Administration, the nominated surveyor or recognized organization responsible for issuing the relevant certificate, who should cause investigations to be initiated to determine whether a survey, as required by 1.5.2.5 is necessary. If the ship is in a port of another Contracting Government, the master or owner should also report immediately to the Port Administration concerned and the nominated surveyor or recognized organization should ascertain that such a report has been made.

1.5.4 Issue of certificate

1.5.4.1 A certificate called an International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk, the model form of which is set out at Appendix, should be issued after an initial or periodical survey to a gas carrier which complies with the relevant requirements of the Code.

1.5.4.2 The certificate issued under the provisions of this section should be available on board for inspection at all times.

1.5.4.3 When a ship is designed and constructed under the provisions of 1.1.5, International Certificates of Fitness should be issued in accordance with the requirements of this section and with the requirements of section 1.5 of the International Bulk Chemical Code.

1.5.5 Issue or endorsement of certificate by another Government

1.5.5.1 A Contracting Government may, at the request of another Government cause a ship entitled to fly the flag of the other Government to be surveyed and, if satisfied that the requirements of the Code are complied with, issue or authorize the issue of the certificate to the ship, and, where appropriate, endorse or authorize the endorsement of the certificate on the ship in accordance with the Code. Any certificate so issued should contain a statement to the effect that it has been issued at the request of the Government of the State the flag of which the ship is entitled to fly.

1.5.6 Duration and validity of the certificate

1.5.6.1 An International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk should be issued for a period specified by the Administration which should not exceed five years from the date of the initial survey or the periodical survey.

1.5.6.2 No extension of the five year period of the certificate should be permitted.

1.5.6.3 The certificate should cease to be valid:

.1 if the surveys are not carried out within the period specified by 1.5.2;

.2 upon transfer of the ship to the flag of another Government. A new certificate should only be issued when the Government issuing the new certificate is fully satisfied that the ship is in compliance with the requirements of 1.5.3.1 and 1.5.3.2. Where a transfer occurs between Contracting Governments, the Government of the State whose flag the ship was formerly entitled to fly would, if requested within twelve months after the transfer has taken place, as soon as possible transmit to the Administration copies of the certificates carried by the ship before the transfer and, if available, copies of the relevant survey reports.

CHAPTER 2 - SHIP SURVIVAL CAPABILITY* AND LOCATION OF CARGO TANKS

2.1 General

2.1.1 Ships subject to the Code should 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 should 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 hull plating. Both the damage to be assumed and the proximity of the tanks to the ship's shell should be dependent upon the degree of hazard presented by the product to be carried.

2.1.2 Ships subject to the Code should be designed to one of the following standards:

.1 A Type 1G ship is a gas carrier intended to transport products indicated in Chapter 19 which require maximum preventive measures to preclude the escape of such cargo.

.2 A Type 2G ship is a gas carrier intended to transport products indicated in Chapter 19 which require significant preventive measures to preclude the escape of such cargo.

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* Reference is made to the Guidelines for Uniform Application of the Survival Requirements of the Bulk Chemical Code and the Gas Carrier Codes, set out in the Appendix.

.3 A Type 2PG ship is a gas carrier of 150 m in length or less intended to transport products indicated in Chapter 19 which require significant preventive measures to preclude escape of such cargo, and where the products are carried in independent type C tanks designed (see 4.2.4.4) for a MARVS of at least 7 bar and a cargo containment system design temperature of -55°C or above. Note that a ship of this description but over 150 m in length is to be considered a type 2G ship.

.4 A Type 3G ship is a gas carrier intended to carry products indicated in Chapter 19 which require moderate preventive measures to preclude the escape of such cargo.

Thus a Type 1G ship is a gas carrier intended for the transportation of products considered to present the greatest overall hazard and Types 2G/2PG and Type 3G for products of progressively lesser hazards. Accordingly, a Type 1G ship should survive the most severe standard of damage and its cargo tanks should be located at the maximum prescribed distance inboard from the shell plating.

2.1.3 The ship type required for individual products is indicated in column "c" in the table of Chapter 19.

2.1.4 If it is intended to carry more than one product listed in Chapter 19 the standard of damage should correspond to that product having the most stringent ship type requirement. The requirements for the location of individual cargo tanks, however, are those for ship types related to the respective products intended to be carried.

2.2 Freeboard and intact stability

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

2.2.2 The stability of the ship in all sea-going conditions and during loading and unloading cargo should be to a standard which is acceptable to the Administration.

2.2.3 When calculating the effect of free surfaces of consumable liquids for loading conditions it should 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 should be those where the effect of free surfaces is the greatest. The free surface effect in undamaged compartments should be calculated by a method acceptable to the Administration.

2.2.4 Solid ballast should 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 should be governed by the need to ensure that the impact loads resulting from a bottom damage are not directly transmitted to the cargo tank structure.

2.2.5 The master of the ship should be supplied with a Loading and Stability Information booklet. This booklet should contain details of typical service conditions, loading, unloading and ballasting operations, provisions for evaluating other conditions of loading and a summary of the ship's survival capabilities. In addition, the booklet should contain sufficient information to enable the master to load and operate the ship in a safe and seaworthy manner.

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 should comply with the requirements of the relevant regulation of the International Convention on Load Lines in force, except that the choice of valves should 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 section "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 should be of a type acceptable to the Administration and should 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.

2.4 Conditions of loading

Damage survival capability should be investigated on the basis of loading information submitted to the Administration 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.

* The cargo content of small independent purge tanks on deck need not be taken into account when assessing the ballast condition.

2.5 Damage assumptions

2.5.1 The assumed maximum extent of damage should 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 centre line at the level of the summer load line	B/5 or 11.5 m, whichever is less
.1.3	Vertical extent: from the moulded line of the bottom shell plating at centre line.	upwards without limit

.2 Bottom damage:

	For 0.3L 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, which- 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 centre line (see 2.6.3).	B/15 or 2 m, whichever is less measured from the moulded line of the bottom shell plating at centre line (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 should be assumed.

.2 Local side damage anywhere in the cargo area extending inboard 760 mm measured normal to the hull shell should be considered and transverse bulkheads should be assumed damaged when also required by the applicable sub-paragraphs of 2.8.1.

2.6 Location of cargo tanks

2.6.1 Cargo tanks should be located at the following distances inboard:

.1 Type 1G ships: from the side shell plating not less than the transverse extent of damage specified in 2.5.1.1.2 and from the moulded line of the bottom shell plating at centre line 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 Types 2G/2PG and 3G ships: from the moulded line of the bottom shell plating at centre line 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 should be measured to the inner bottom when membrane or semi membrane tanks are used, otherwise to the bottom of the cargo tanks. The transverse extent of side damage should be measured to the longitudinal bulkhead when membrane or semi-membrane tanks are used, otherwise to the side of the cargo tanks (see figure 2.1). For internal insulation tanks the extent of damage should be measured to the supporting tank plating.

2.6.3 Except for Type 1G ships, 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 per cent 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 should not exceed 350 mm. Suction wells installed in accordance with this paragraph may be ignored in determining the compartments affected by damage.

2.7 Flooding assumptions

2.7.1 The requirements of 2.9 should 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 should be as follows:

Spaces	Permeabilities
Appropriated to stores	0.60
Occupied by accommodation	0.95
Occupied by machinery	0.85
Voids	0.95
Intended for consumable liquids	0 to 0.95*
Intended for other liquids	0 to 0.95*

* The permeability of partially filled compartments should be consistent with the amount of liquid carried in the compartment.

2.7.3 Wherever damage penetrates a tank containing liquids, it should 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 should 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 should 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 should 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 should 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 should not be regarded as a step for the purpose of this paragraph.

2.7.5 The ship should 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, should not 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 should 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 should be such that progressive flooding cannot thereby extend to compartments other than those assumed to be flooded for each case of damage.

2.7.8 The buoyancy of any superstructure directly above the side damage should 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 2.9.1.2.1 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 2.9.1; however the immersion of any other openings capable of being closed weathertight may be permitted.

2.8 Standard of damage

2.8.1 Ships should 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:

.1 A Type 1G ship should be assumed to sustain damage anywhere in its length;

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

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

.4 A Type 2PG ship should be assumed to sustain damage anywhere in its length except involving transverse bulkheads spaced further apart than the longitudinal extent of damage as specified in 2.5.1.1.1;

.5 A Type 3G ship of 125 m in length or more should be assumed to sustain damage anywhere in its length except involving transverse bulkheads spaced further apart than the longitudinal extent of damage specified in 2.5.1.1.1;

.6 A Type 3G ship less than 125 m in length should be assumed to sustain damage anywhere in its length except involving transverse bulkheads spaced further apart than the longitudinal extent of damage specified in 2.5.1.1.1 and except damage involving the machinery space when located aft. However, the ability to survive the flooding of the machinery space should be considered by the Administration.

2.8.2 In the case of small Type 2G/2PG and Type 3G 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 Administration provided that alternative measures can be taken which maintain the same degree of safety. The nature of the alternative measures should be approved and clearly stated and be available to the Port Administration. Any such dispensation should be duly noted on the International Certificate of Fitness for the Carriage of Liquefied Gases referred to in 1.5.

2.9 <u>Survival requirements</u>

Ships subject to the Code should be capable of surviving the assumed damage specified in 2.5 to the standard provided in 2.8 in a condition of stable equilibrium and should satisfy the following criteria:

2.9.1 In any stage of flooding:

.1 the waterline, taking into account sinkage, heel, and trim, should be below the lower edge of any opening through which progressive flooding or downflooding may take place. Such openings should include air pipes and those 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 should not exceed 30 degrees; and

.3 the residual stability during intermediate stages of flooding should be to the satisfaction of the Administration. However, it should 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 should have a minimum range of 20 degrees beyond the position of equilibrium in association with a maximum residual righting lever of at least 0.1 m within the 20-degree range; the area under the curve within this range should not be less than 0.0175 metre radians. Unprotected openings should not 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 should be capable of operating.

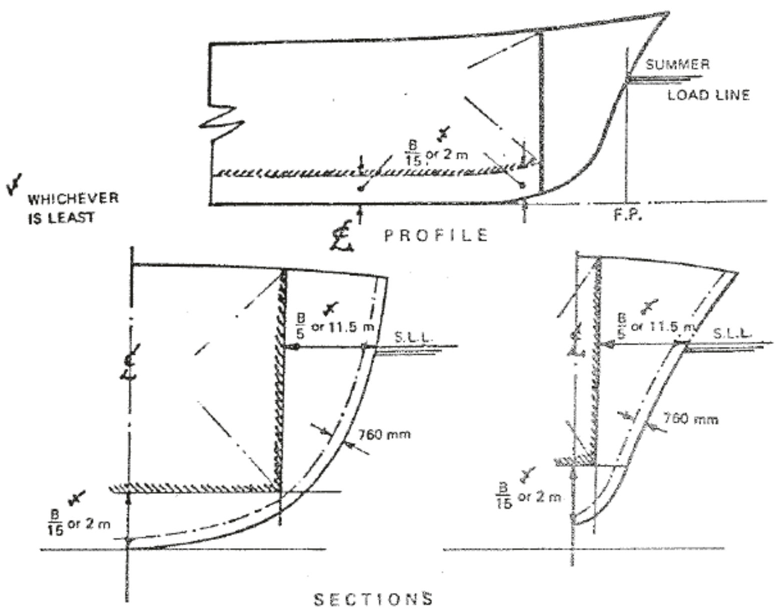

Figure 2.1 – Tank Location Requirements as set out in 2.6

CHAPTER 3 - SHIP ARRANGEMENTS

3.1 Segregation of the cargo area

3.1.1 Hold spaces should 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 should be located forward of machinery spaces of category A, other than those deemed necessary by the Administration for the safety or navigation of the ship.

3.1.2 Where cargo is carried in a cargo containment system not requiring a secondary barrier, 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 gas-tight A-0 class division is satisfactory if there is no source of ignition or fire hazard in the adjoining spaces.

3.1.3 Where cargo is carried in a cargo containment system requiring a secondary barrier, segregation of hold spaces from spaces referred to in 3.1.1 or spaces either below or outboard of the hold spaces which contain a source of ignition or fire hazard should be effected by cofferdams or fuel oil tanks. If there is no source of ignition or fire hazard in the adjoining space, segregation may be by a single A-0 class division which is gas-tight.

3.1.4 When cargo is carried in a cargo containment system requiring a secondary barrier:

.1 at temperatures below $-10^{\circ}C$, hold spaces should be segregated from the sea by a double bottom; and

.2 at temperatures below $-55^{\circ}C$, the ship should also have a longitudinal bulkhead forming side tanks.

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

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

.2 except as provided in Chapter 16, not 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 be connected into the cargo containment system directly from the open deck except that pipes installed in a vertical trunkway or equivalent arrangement may be used to traverse void spaces above a cargo containment system and except that pipes for drainage, venting or purging may traverse cofferdams;

.4 except for bow or stern loading and unloading arrangements in accordance with 3.8, and except in accordance with Chapter 16, be located in the cargo area above the open deck; and

.5 except for thwartship shore connexion piping not subject to internal pressure at sea or emergency cargo jettisoning arrangements, be located inboard of the transverse tank location requirements of 2.6.1.

.6 Emergency cargo jettisoning arrangements may be led aft externally to accommodation spaces, service spaces or control stations or machinery spaces, but should not pass through them. If an emergency cargo jettisoning arrangement is permanently installed a suitable means of isolation from the cargo piping should be provided within the cargo area.

3.1.6 Arrangements should 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 should be located within the cargo area. The bulkhead of accommodation spaces, service spaces or control stations which face the cargo area should be so located as to avoid gas from the hold space entering such spaces through a single failure of a deck or bulkhead on a ship having a containment system requiring a secondary barrier.

3.2.2 In order to guard against the danger of hazardous vapours, due consideration should 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.

3.2.3 Access through doors, gas-tight or otherwise, should not 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 and control stations should not face the cargo area. They should be located on the end bulkhead not facing the cargo area or on the outboard side of the house or on both at a distance of at least 4 per cent of the length of the ship but not less than 3 m from the end of the house facing the cargo area. This distance, however, need not exceed 5 m. Port lights facing the cargo area and on the sides of the houses within the distance mentioned above should be of the fixed (non-opening) type. Wheelhouse windows may be non-fixed and navigating bridge 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 navigating bridge can be ensured. For ships dedicated to the carriage of cargoes which have neither flammable nor toxic hazards, the Administration may approve relaxations from the above requirements.

3.2.5 Side scuttles in the shell below the uppermost continuous deck and in the first tier of the superstructure 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 should be fitted with closing devices. For toxic gases they are to be operated from inside the space.

3.3 Cargo pump rooms and cargo compressor rooms

3.3.1.1 Cargo pump rooms and cargo compressor rooms should be situated above the weather deck and located within the cargo area unless specially approved by the Administration. Cargo compressor rooms should be treated as cargo pump rooms for the purpose of fire protection according to Regulation II-2/58 of the 1981 SOLAS Amendments.

3.3.1.2 When cargo pump rooms and cargo compressor 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 foremost hold space, the limits of the cargo area as defined in 1.3.6 should be extended to include the cargo pump rooms and cargo compressor rooms for the full beam 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 this paragraph, the bulkhead which separates the cargo pump rooms and cargo compressor rooms from accommodation and service spaces, control stations and machinery spaces of category A should be located so as to avoid gas from entering these spaces through a single failure of a deck or bulkhead.

3.3.2 Where pumps and compressors are driven by shafting passing through a bulkhead or deck, gas-tight seals with efficient lubrication or other means of ensuring the permanence of the gas seal should be fitted in way of the bulkhead or deck.

3.3.3 Arrangements of cargo pump rooms and cargo compressor rooms should 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 should be readily accessible to personnel wearing protective clothing. Suitable arrangements should be made to deal with drainage of pump and compressor rooms.

3.4 <u>Cargo control rooms</u>

3.4.1 Any cargo control room should 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:

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

.2.1 if the entrance from the cargo area complies with 3.2.4, the control room may have access to the spaces described above;

.2.2 if the entrance from the cargo area does not comply with 3.2.4, the control room shall have no access to the spaces described above and the boundaries to such spaces shall be insulated to 'A-60' standard.

3.4.2 If the cargo control room is designed to be a gas-safe space, instrumentation should, as far as possible, be by indirect reading systems and should 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 for ships carrying flammable cargoes is a gas-dangerous space, sources of ignition should be excluded. Consideration should be paid to the safety characteristics of any electrical installations.

3.5 Access to spaces in the cargo area

3.5.1 Visual inspection should 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 should not be a fuel-oil tank boundary wall.

3.5.2 Inspection of one side of any insulation in hold spaces should 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 should 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 should comply with the following:

.1 Access should be provided:

.1.1 to cargo tanks direct from the open deck;

.1.2 through horizontal openings, hatches or manholes, the dimensions of which should 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 of which should be not less than 600 mm by 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 should 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 Administration.

.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 should be provided only with direct or indirect access from the open weather deck, not including an enclosed gas-safe space.

3.5.4 Access from the open weather deck to gas-safe spaces should 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.

3.6 Air locks

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

3.6.2 The doors should 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 air-lock should be provided to indicate if more than one door is moved from the closed position.

3.6.4 In ships carrying flammable products non-certified safe electrical equipment in spaces protected by air-locks should be de-energized upon loss of over-pressure in the space (see also 10.2.5.4). Non-certified safe electrical equipment for manoeuvring, anchoring and mooring equipment as well as the emergency fire pumps should not be located in spaces to be protected by air-locks.

3.6.5 The air-lock space should be mechanically ventilated from a gas-safe space and maintained at an over-pressure to the gas-dangerous zone on the open weather deck.

3.6.6 The air-lock space should be monitored for cargo vapour.

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

3.7 <u>Bilge, ballast and fuel oil arrangements</u>

3.7.1.1 Where cargo is carried in a cargo containment system not requiring a secondary barrier, hold spaces should be provided with suitable drainage arrangements not connected with the machinery space. Means of detecting such leakage should be provided.

3.7.1.2 Where there is a secondary barrier, suitable drainage arrangements for dealing with any leakage into the hold or insulation spaces through adjacent ship structure should be provided. The suction should not be led to pumps inside the machinery space. Means of detecting such leakage should be provided.

3.7.2 The inter-barrier space should be provided with a drainage system suitable for handling liquid cargo in the event of cargo tank leakage or rupture. Such arrangements should provide for the return of leakage to the cargo tanks.

3.7.3 In case of internal insulation tanks, means of detecting leakage and drainage arrangements are not required for inter-barrier spaces and spaces between the secondary barrier and the inner hull or independent tank structure which are completely filled by insulation material complying with 4.9.7.2.

3.7.4 Ballast spaces, fuel oil tanks and gas-safe spaces may be connected to pumps in the machinery spaces. Duct keels may be connected to pumps in the machinery spaces, provided the connexions are led directly to the pumps and the discharge from the pumps led directly over-board 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 should not be open to machinery spaces.

3.8 Bow or stern loading and unloading arrangements

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

3.8.1.1 Bow or stern loading and unloading lines which are led past accommodation spaces, service spaces or control stations should not be used for the transfer of products requiring a Type 1G ship. Bow or stern loading and unloading lines should not be used for the transfer of toxic products as specified in 1.3.35 unless specifically approved by the Administration.

3.8.2 Portable arrangements should not 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 should have only welded connexions. The piping outside the cargo area should run on the open deck and should be at least 760 mm in board except for thwartships shore connexion piping. Such piping should be clearly identified and fitted with a shut-off valve at its connexion to the cargo piping system within the cargo area. At this location, it should also 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 butt welded, and fully radiographed regardless of pipe diameter and design temperature. Flange connexions in the piping are only permitted within the cargo area and at the shore connexion.

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

3.8.4 Entrances, air inlets and openings to accommodation spaces, service spaces, machinery spaces and control stations should not face the cargo shore connexion location of bow or stern loading and unloading arrangements. They should be located on the outboard side of the superstructure or deckhouse at a distance of at least 4 per cent of the length of ship but not less than 3 m from the end of the house facing the cargo shore connexion location of the bow or stern loading and unloading arrangements. This distance, however, need not exceed 5 m. Port lights facing the shore connexion location and on the sides of the superstructure or deckhouse within the distance mentioned above should 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 should be kept closed. Where in case of small ships compliance with 3.2.4 and this paragraph is not possible, the Administration 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 connexion location should 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 connexion location should be in accordance with Chapter 10.

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

3.8.8 Means of communication between the cargo control station and the shore connexion location should be provided and if necessary certified safe.

CHAPTER 4 - CARGO CONTAINMENT

4.1 General

4.1.1 Administrations should take appropriate steps to ensure uniformity in the implementation and application of the provisions of this chapter*.

4.1.2 In addition to the definitions in 1.3, the definitions given in this Chapter apply throughout the Code.

4.2 Definitions

4.2.1 Integral tanks

4.2.1.1 Integral tanks form a structural part of the ship's hull and are influenced in the same manner and by the same loads which stress the adjacent hull structure.

4.2.1.2 The design vapour pressure P_o as defined in 4.2.6 should not normally exceed 0.25 bar. If, however, the hull scantlings are increased accordingly, P_o may be increased to a higher value but less than 0.7 bar.

4.2.1.3 Integral tanks may be used for products provided the boiling point of the cargo is not below $-10^{o}C$. A lower temperature may be accepted by the Administration subject to special consideration.

4.2.2 Membrane tanks

4.2.2.1 Membrane tanks are non-self-supporting tanks which consist of a thin layer (membrane) supported through insulation by the adjacent hull structure. The membrane is designed in such a way that thermal and other expansion or contraction is compensated for without undue stressing of the membrane.

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* Reference is made to the published Rules of members and associate members of the International Association of Classification Societies and in particular to IACS Unified Requirements Nos. G1 and G2.

4.2.2.2 The design vapour pressure P_o should not normally exceed 0.25 bar. If, however, the hull scantlings are increased accordingly and consideration is given, where appropriate, to the strength of the supporting insulation, P_o may be increased to a higher value but less than 0.7 bar.

4.2.2.3 The definition of membrane tanks does not exclude designs such as those in which non-metallic membranes are used or in which membranes are included or incorporated in insulation. Such designs require, however, special consideration by the Administration. In any case the thickness of the membranes should normally not exceed 10 mm.

4.2.3 Semi-membrane tanks

4.2.3.1 Semi-membrane tanks are non-self-supporting tanks in the loaded condition and consist of a layer, parts of which are supported through insulation by the adjacent hull structure, whereas the rounded parts of this layer connecting the above mentioned supported parts are designed also to accommodate the thermal and other expansion or contraction.

4.2.3.2 The design vapour pressure P_o should not normally exceed 0.25 bar. If, however, the hull scantlings are increased accordingly, and consideration is given, where appropriate, to the strength of the supporting insulation, P_o may be increased to a higher value but less than 0.7 bar.

4.2.4 Independent 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 three categories of independent tanks referred to in 4.2.4.2 - 4.2.4.4.

4.2.4.2 Type A independent tanks are tanks which are designed primarily using Recognized Standards* of classical ship-structural analysis procedures. Where such tanks are primarily constructed of plane surfaces

* Recognized Standards for the purpose of Chapters 4, 5 and 6 are standards laid down and maintained by a classification society recognized by the Administration.

(gravity tanks), the design vapour pressure P_o should be less than 0.7 bar.

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. Where such tanks are primarily constructed of plane surfaces (gravity tanks) the design vapour pressure P_o should be less than 0.7 bar.

4.2.4.4 Type C independent tanks (also referred to as pressure vessels) are tanks meeting pressure vessel criteria and having a design vapour pressure not less than:

$$P_o = 2 + AC(\rho_r)^{1.5} \quad \text{(bar)}$$

where:

$$A = 0.0185\left(\frac{\sigma_m}{\Delta\sigma_A}\right)^2$$

with

σ_m = design primary membrane stress

$\Delta\sigma_A$ = allowable dynamic membrane stress (double amplitude at probability level $Q = 10^{-8}$)
55 N/mm^2 for ferritic/martensitic steel
25 N/mm^2 for aluminium alloy (5083-0)

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

h; 0.75b; or 0.45ℓ

with

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

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

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

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

However, the Administration may allocate a tank complying with the criterion of this sub-paragraph to type A or type B, dependent on the configuration of the tank and the arrangement of its supports and attachments.

4.2.5 Internal insulation tanks

4.2.5.1 Internal insulation tanks are non-self-supporting and consist of thermal insulation materials which contribute to the cargo containment and are supported by the structure of the adjacent inner hull or of an independent tank. The inner surface of the insulation is exposed to the cargo.

4.2.5.2 The two categories of internal insulation tanks are:

.1 Type 1 tanks which are tanks in which the insulation or a combination of the insulation and one or more liners function only as the primary barrier. The inner hull or an independent tank structure should function as the secondary barrier when required.

.2 Type 2 tanks which are tanks in which the insulation or a combination of the insulation and one or more liners function as both the primary and the secondary barrier and where these barriers are clearly distinguishable.

The term "liner" means a thin, non-self-supporting, metallic, nonmetallic or composite material which forms part of an internal insulation tank in order to enhance its fracture resistance or other mechanical properties. A liner differs from a membrane in that it is not intended to function alone as a liquid barrier.

4.2.5.3 Internal insulation tanks should be of suitable materials enabling the cargo containment system to be designed using model tests and refined analytical methods as required in 4.4.7.

4.2.5.4 The design vapour pressure P_o should not normally exceed 0.25 bar. If, however, the cargo containment system is designed for a higher vapour pressure, P_o may be increased to such higher value, but not exceeding 0.7 bar if the internal insulation tanks are supported by the inner hull structure. However, a design vapour pressure of more than 0.7 bar may be accepted by the Administration provided the internal insulation tanks are supported by suitable independent tank structures.

4.2.6 Design vapour pressure

4.2.6.1 The design vapour pressure P_o 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_o should not be less than the gauge vapour pressure of the cargo at a temperature of 45°C. However, lesser values of this temperature may be accepted by the Administration 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_o should not be less than MARVS.

4.2.6.4 Subject to special consideration by the Administration and to the limitations given in 4.2.1 to 4.2.5 for the various tank types, a vapour pressure higher than P_o may be accepted in harbour conditions, where dynamic loads are reduced.

4.2.7 Design temperature

Design temperature for selection of materials is the minimum temperature at which cargo may be loaded or transported in the cargo tanks. Provision to the satisfaction of the Administration should be made to ensure that the tank or cargo temperature cannot be lowered below the design temperature.

4.3 Design loads

4.3.1 General

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

internal pressure
external pressure
dynamic loads due to the motion of the ship

thermal loads

sloshing loads

loads corresponding to ship deflection

tank and cargo weight with the corresponding reactions in way of supports

insulation weight

loads in way of towers and other attachments.

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

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

4.3.1.3 Account should be taken of an increase of vapour pressure in harbour conditions referred to in 4.2.6.4.

4.3.1.4 The tanks should be designed for the most unfavourable static heel angle within the range 0^{o} to 30^{o} without exceeding allowable stresses given in 4.5.1.

4.3.2 Internal pressure.

4.3.2.1 The internal pressure head h_{eq} in bar resulting from the design vapour pressure P_o and the liquid pressure h_{gd} defined in 4.3.2.2, but not including effects of liquid sloshing, should be calculated as follows:

$$h_{eq} = P_o + (h_{gd})_{max} \qquad \text{(bar)}$$

Equivalent calculation procedures may be applied.

4.3.2.2 The internal liquid pressures are those created by the resulting acceleration of the centre of gravity of the cargo due to the motions of the ship referred to in 4.3.4.1. The value of internal pressure head h_{gd} resulting from combined effects of gravity and dynamic accelerations should be calculated as follows:

$$h_{gd} = a_\beta Z_\beta \frac{\rho}{1.02 \times 10^4} \text{ (bar)}$$

where:

a_β = dimensionless acceleration (i.e. relative to the acceleration of gravity), resulting from gravitational and dynamic loads, in an arbitrary direction β (see figure 4.1).

Z_β = largest liquid height (m) above the point where the pressure is to be determined measured from the tank shell in the β direction (see figure 4.2). Small tank domes not considered to be part of the accepted total volume of the cargo tank need not be considered when determining Z_β.

ρ = maximum cargo density (kg/m^3) at the design temperature.

The direction which gives the maximum value $(h_{gd})_{max}$ of h_{gd} should be considered. Where acceleration in three directions needs to be considered, an ellipsoid should be used instead of the ellipse in figure 4.1. The above formula applies only to full tanks.

4.3.3 External pressure.

External design pressure loads should 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 should 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 should 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}). Guidance formulae for acceleration components are given in 4.12.

4.3.4.3 When design against fatigue is to be considered, the dynamic spectrum should 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 should be specially considered by the Administration.

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 Sloshing loads.

4.3.5.1 When partial filling is contemplated, the risk of significant loads due to sloshing induced by any of the ship motions referred to in 4.3.4.6 should be considered.

4.3.5.2 When risk of significant sloshing induced loads is found to be present, special tests and calculations should be required.

4.3.6 Thermal loads.

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

4.3.6.2 Stationary thermal loads should be considered for tanks where design supporting arrangement 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 Integral tanks.

The structural analysis of integral tanks should be in accordance with recognized standards. The tank boundary scantlings should meet at least the requirements for deep tanks taking into account the internal pressure as indicated in 4.3.2, but the resulting scantlings should not be less than normally required by such standards.

4.4.2 Membrane tanks.

4.4.2.1 For membrane tanks, the effects of all static and dynamic loads should be considered to determine the suitability of the membrane and of the associated insulation with respect to plastic deformation and fatigue.

4.4.2.2 Before approval is given, a model of both the primary and secondary barriers, including corners and joints, should normally be tested to verify that they will withstand the expected combined strains due to static, dynamic and thermal loads. Test conditions should represent the most extreme service conditions the cargo containment system will see in its life. Material tests should ensure that ageing is not liable to prevent the materials from carrying out their intended function.

4.4.2.3 For the purpose of the test referred to in 4.4.2.2, a complete analysis of the particular motions, accelerations and response of ships and cargo containment systems should be performed, unless these data are available from similar ships.

4.4.2.4 Special attention should be paid to the possible collapse of the membrane due to an over-pressure in the inter-barrier space, to a possible vacuum in the cargo tank, to the sloshing effects and to hull vibration effects.

4.4.2.5 A structural analysis of the hull should be to the satisfaction of the Administration, taking into account the internal pressure as indicated in 4.3.2. Special attention, however, should be paid to deflections of the hull and their compatibility with the membrane and associated insulation. Inner hull plating thickness should meet at least the requirements of Recognized Standards for deep tanks taking into account the internal pressure as indicated in 4.3.2. The allowable stress for the membrane, membrane supporting material and insulation should be determined in each particular case.

4.4.3 Semi-membrane tanks.

A structural analysis should be performed in accordance with the requirements for membrane tanks or independent tanks as appropriate, taking into account the internal pressure as indicated in 4.3.2.

4.4.4 Type A independent tanks.

4.4.4.1 A structural analysis should be performed to the satisfaction of the Administration taking into account the internal pressure as indicated in 4.3.2. The cargo tank plating thickness should meet at least the requirements of Recognized Standards for deep tanks taking into account the internal pressure as indicated in 4.3.2 and any corrosion allowance required by 4.5.2.

4.4.4.2 For parts such as structure in way of supports not otherwise covered by Recognized Standards, stresses should be determined by direct calculations, taking into account the loads referred to in 4.3 as far as applicable, and the ship deflection in way of supports.

4.4.5 Type B independent tanks.

For tanks of this type the following applies:

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

plastic deformation
buckling
fatigue failure
crack propagation.

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

.2 A three-dimensional analysis should be carried out to evaluate the stress levels contributed by the ship's hull. The model for this analysis should 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 should be performed unless these data are available from similar ships.

.4 A buckling analysis should consider the maximum construction tolerances.

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

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

$$\Sigma \frac{n_i}{N_i} + \frac{10^3}{N_j} \leq Cw$$

where:

n_i = 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 = should be less than or equal to 0.5, except that the Administration may give special consideration to the use of a value greater than 0.5 but not greater than 1.0, dependent on the test procedure and data used to establish the Wöhler (S-N) curve.

4.4.6 Type C independent tanks

4.4.6.1 Scantling based on internal pressure should be calculated as follows:

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

.2 The design liquid pressure defined in 4.3.2 should 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 should 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 process pressure vessels the Administration may accept partial non-destructive examinations, but not less than those of 4.10.9.2.2 depending on such factors as the material used, the design temperature, the nil ductility transition temperature of the material as fabricated, the type of joint and welding procedure, but in this case an efficiency factor of not more than 0.85 should be adopted. For special materials, the above-mentioned factors should be reduced depending on the specified mechanical properties of the welded joint.

4.4.6.2 Buckling criteria should be as follows:

.1 The thickness and form of pressure vessels subject to external pressure and other loads causing compressive stresses should be to a standard acceptable to the Administration. These calculations in all cases should be based on generally accepted pressure vessel buckling theory and should 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 should not be less than that given by:

$$P_e = P_1 + P_2 + P_3 + P_4 \qquad \text{(bar)}$$

where:

P_1 = setting value of vacuum relief valves. For vessels not fitted with vacuum relief valves P_1 should be specially considered, but should not in general 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, effect of product in the partially filled condition, accelerations and hull deflection. In addition the local effect of external or internal pressure or both should 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 should be performed as follows:

.1 Pressure vessel scantlings should 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 should be made. Loads referred to in 4.3 should be used, as applicable. Stresses in way of the supports should be to a standard acceptable to the Administration. In special cases a fatigue analysis may be required by the Administration.

.3 If required by the Administration, secondary stresses and thermal stresses should 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, should be considered as a minimum without any negative tolerance.

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

4.4.7 Internal insulation tanks.

4.4.7.1 The effects of all static and dynamic loads should be considered to determine the suitability of the tank with respect to:

fatigue failure
crack propagation from both free and supported surfaces
adhesive and cohesive strength
compressive, tensile and sheer strength.

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

4.4.7.2.1 Special attention should be given to crack resistance and to deflections of the inner hull or independent tank structure and their compatibility with the insulation materials. A three-dimensional structural analysis should be carried out to the satisfaction of the Administration. This analysis is to evaluate the stress levels and deformations contributed either by the inner hull or by the independent tank structure or both and should also take into account the internal pressure as indicated in 4.3.2. Where water ballast spaces are adjacent to the inner hull forming the supporting structure of the internal insulation tank, the analysis should take account of the dynamic loads caused by water ballast under the influence of ship motions.

4.4.7.2.2 The allowable stresses and associated deflections for the internal insulation tank and the inner hull structure or independent tank structure should be determined in each particular case.

4.4.7.2.3 Thicknesses of plating of the inner hull or of an independent tank should at least comply with the requirements of recognized standards, taking into account the internal pressure as indicated in 4.3.2. Tanks constructed of plane surfaces should at least comply with Recognized Standards for deep tanks.

4.4.7.3 A complete analysis of the response of ship, cargo and any ballast to accelerations and motions in irregular waves of the particular ship should be performed to the satisfaction of the Administration unless such analysis is available for a similar ship.

4.4.7.4.1 In order to confirm the design principles, prototype testing of composite models including structural elements should be carried out under combined effects of static, dynamic and thermal loads.

4.4.7.4.2 Test conditions should represent the most extreme service conditions the cargo containment system will be exposed to during the lifetime of the ship, including thermal cycles. For this purpose, 400 thermal cycles are considered to be a minimum, based upon 19 round voyages per year; where more than 19 round voyages per year are expected, a higher number of thermal cycles will be required. These 400 thermal cycles may be divided into 20 full cycles (cargo temperature to 45°C) and 380 partial cycles (Cargo temperature to that temperature expected to be reached in the ballast voyage).

4.4.7.4.3 Models should be representative of the actual construction including corners, joints, pump mounts, piping penetrations and other critical areas, and should take into account variations in any material properties, workmanship and quality control.

4.4.7.4.4 Combined tension and fatigue tests should be carried out to evaluate crack behaviour of the insulation material in the case where a through crack develops in the inner hull or independent tank structure. In these tests, where applicable the crack area should be subjected to the maximum hydrostatic pressure of the ballast water.

4.4.7.5 The effects of fatigue loading should be determined in accordance with 4.4.5.6 or by an equivalent method.

4.4.7.6 For internal insulation tanks, repair procedures should be developed during the prototype testing programme for both the insulation material and the inner hull or the independent tank structure.

4.5 Allowable stresses and corrosion allowances

4.5.1 Allowable stresses

4.5.1.1 For integral tanks, allowable stresses should normally be those given for hull structure in recognized standards.

4.5.1.2 For membrane tanks, reference is made to the requirements of 4.4.2.5.

4.5.1.3 For type A independent tanks primarily constructed of plane surfaces, the stresses for primary and secondary members (stiffeners, web frames, stringers, girders) when calculated by classical analysis procedures should not exceed the lower of $R_m/2.66$ or $R_e/1.33$ for carbon-manganese steels and aluminium alloys, where R_m and R_e are defined in 4.5.1.7. However, if detailed calculations are carried out for the primary members, the equivalent stress σ_C as defined in 4.5.1.8 may be increased over that indicated above to a stress acceptable to the Administration; calculations should take into account the effects of bending, shear, axial and torsional deformation as well as the hull/cargo tank interaction forces due to the deflection of the double bottom and cargo tank bottoms.

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

$$\sigma_m \leq f$$
$$\sigma_L \leq 1.5\ f$$
$$\sigma_b \leq 1.5\ F$$
$$\sigma_L + \sigma_b \leq 1.5\ F$$
$$\sigma_m + \sigma_b \leq 1.5\ F$$

where

σ_m = equivalent primary general membrane stress

σ_L = equivalent primary local membrane stress

σ_b = equivalent primary bending stress

f = the lesser of $\frac{R_m}{A}$ or $\frac{R_e}{B}$

F = the lesser of $\frac{R_m}{C}$ or $\frac{R_e}{D}$

with R_m and R_e as defined in 4.5.1.7. With regard to the stresses σ_m, σ_L and σ_b see also the definition of stress categories in 4.13. The values of A, B, C and D should be shown on the International Certificate of Fitness and should have at least the following minimum values:

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

4.5.1.5 For type B independent tanks, primarily constructed of plane surfaces, the Administration 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 should be the lower of:

$$\frac{R_m}{A} \text{ or } \frac{R_e}{B}$$

where:

R_m and R_e are as defined in 4.5.1.7.

The values of A and B should be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk provided for in 1.5, and should have at least the minimum values indicated in the table of 4.5.1.4.

4.5.1.7 For the purpose of 4.5.1.3, 4.5.1.4 and 4.5.1.5 the following apply:

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

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

For welded connexions in aluminium alloys the respecive values of R_e or R_m in annealed conditions should be used.

.2 The above properties should correspond to the minimum specified mechanical properties of the material, including the weld metal in the as fabricated condition. Subject to special consideration by the Administration, account may be taken of enhanced yield stress and tensile strength at low temperature. The temperature on which the material properties are based should be shown on the International Certificate of Fitness for the Carriage of Liquid Gases in Bulk provided for in 1.5.

4.5.1.8 The equivalent stress σ_C (von Mises, Huber) should be determined by:

$$\sigma_C = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x \sigma_y + 3\tau_{xy}^2}$$

where:

σ_x = total normal stress in x-direction

σ_y = total normal stress in y-direction

τ_{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 should be calculated according to:

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

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

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

where:

$\sigma_{x.st}$, $\sigma_{y.st}$ and $\tau_{xy.st}$ = static stresses

$\sigma_{x.dyn}$, $\sigma_{y.dny}$ and $\tau_{xy.dyn}$ = dynamic stresses

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

4.5.1.10 For internal insulation tanks, reference is made to the requirement of 4.4.7.2.

4.5.1.11 Allowable stresses for materials other than those covered by Chapter 6 should be subject to approval by the Administration 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 should generally be 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 Administration 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 should not be credited as protection. Where special alloys are used with acceptable corrosion resistance, no corrosion allowance should be required. If the above conditions are not satisfied, the scantlings calculated according to 4.4.6 should be increased as appropriate.

4.6 Supports

4.6.1 Cargo tanks should 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 should also be designed for a static angle of heel of 30° without exceeding allowable stresses given in 4.5.1.

4.6.3 The supports should 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" should be determined according to 4.3.4.2.

4.6.4 Suitable supports should 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 For independent tanks and, where appropriate, for membrane and semi-membrane tanks, provision should be made to key the tanks against the rotational effects referred to in 4.6.3.

4.6.7 Antiflotation arrangements should be provided for independent tanks. The antiflotation arrangements should 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.

4.7 <u>Secondary barrier</u>

4.7.1 Where the cargo temperature at atmospheric pressure is below $-10^{\circ}C$, a secondary barrier should be provided when required by 4.7.3 to act as a temporary containment for any envisaged leakage of liquid cargo through the primary barrier.

4.7.2 Where the cargo temperature at atmospheric pressure is not below $-55^{\circ}C$, the hull structure may act as a secondary barrier. In such a case:

.1 the hull material should be suitable for the cargo temperature at atmospheric pressure as required by 4.9.2; and

.2 the design should be such that this temperature will not result in unacceptable hull stresses.

4.7.3 Secondary barriers in relation to tank types should normally be provided in accordance with the following table. For tanks which differ from the basic tank types as defined in 4.2 the secondary barrier requirements should be decided by the Administration in each case.

Cargo temperature at atmospheric pressure	−10°C and above	Below −10°C down to −55°C	Below −55°C
Basic tank type	No secondary barrier required	Hull may act as secondary barrier	Separate secondary barrier where required
Integral		Tank type not normally allowed 1/	
Membrane		Complete secondary barrier	
Semi-membrane		Complete secondary barrier 2/	
Independent			
Type A		Complete secondary barrier	
Type B		Partial secondary barrier	
Type C		No secondary barrier required	
Internal insulation			
Type 1		Complete secondary barrier	
Type 2		Complete secondary barrier is incorporated	

1/ A complete secondary barrier should normally be required if cargoes with a temperature at atmospheric pressure below -10°C are permitted in accordance with 4.2.

2/ In the case of semi-membrane tanks which comply in all respects with the requirements applicable to type B independent tanks, except for the manner of support, the Administration may, after special consideration, accept a partial secondary barrier.

4.7.4 The secondary barrier should be so designed that:

.1 it is capable of containing any envisaged leakage of liquid cargo for a period of 15 days, unless different requirements apply for particular voyages, taking into account the load spectrum referred to in 4.3.4.4;

.2 it will prevent lowering of the temperature of the ship structure to an unsafe level in the case of leakage of the primary barrier as indicated in 4.8.2; and

.3 the mechanism of failure for the primary barrier does not also cause the failure of the secondary barrier and vice versa.

4.7.5 The secondary barrier should fulfil its functions at a static angle of heel of 30°.

4.7.6.1 Where a partial secondary barrier is required, its extent should be determined on the basis of cargo leakage corresponding to the extent of failure resulting from the load spectrum referred to in 4.3.4.4 after the initial detection of a primary leak. Due account may be taken of liquid evaporation, rate of leakage, pumping capacity and other relevant factors. In all cases, however, the inner bottom in way of cargo tanks should be protected against liquid cargo.

4.7.6.2 Clear of the partial secondary barrier, provision such as a spray shield should be made to deflect any liquid cargo down into the space between the primary and secondary barriers and to keep the temperature of the hull structure to a safe level.

4.7.7 The secondary barrier should be capable of being periodically checked for its effectiveness, by means of a pressure vacuum test, a visual inspection or another suitable method acceptable to the Administration. The method should be submitted to the Administration for approval.

4.8 Insulation

4.8.1 Where a product is carried at a temperature below $-10^{o}C$ suitable insulation should be provided to ensure that the temperature of the hull structure does not fall below the minimum allowable service 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 $5^{o}C$ for air and $0^{o}C$ for sea-water. These conditions may generally be used for world-wide service. However, higher values of the ambient temperatures may be accepted by the Administration for ships operated in restricted areas. Conversely, lesser values of the ambient temperatures may be fixed by the Administration for ships trading occasionally or regularly to areas in latitudes where such lower temperatures are expected during the winter months. The ambient temperatures used in the design should be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk as provided for in 1.5.

4.8.2 Where a complete or partial secondary barrier is required, calculations should be made with the assumptions in 4.8.1 to check that the temperature of the hull structure does not fall below the minimum allowable service temperature given in Chapter 6 for the grade of steel concerned, as detailed in 4.9. The complete or partial secondary barrier should be assumed to be at the cargo temperature at atmospheric pressure.

4.8.3 Calculations required by 4.8.1 and 4.8.2 should be made assuming still air and still water, and except as permitted by 4.8.4, no credit should be given for means of heating. In the case referred to in 4.8.2, the cooling effect of the rising boil-off vapour from the leaked cargo should be considered in the heat transmission studies. For 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 sea-water, 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 sea-water without heating. Such means of heating should comply with the following requirements:

.1 sufficient heat should 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 should 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 per cent of the theoretical heat load;

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

.4 the design and construction of the heating system should be to the satisfaction of the Administration.

4.8.5 In determining the insulation thickness, due regard should be paid to the amount of acceptable boil-off in association with the reliquefaction plant on board, main propulsion machinery or other temperature control system.

4.9 Materials

4.9.1 The shell and deck plating of the ship and all stiffeners attached thereto should be in accordance with Recognized Standards, unless the calculated temperature of the material in the design condition is below $-5^{\circ}C$ due to the effect of the low temperature cargo, in which case the material should be in accordance with table 6.5 assuming the ambient sea and air temperature of $0^{\circ}C$ and $5^{\circ}C$ respectively. In the design condition the complete or partial secondary barrier should be assumed to be at the cargo temperature at atmospheric pressure and for tanks without secondary barriers, the primary barrier should be assumed to be at the cargo temperature.

4.9.2 Hull material forming the secondary barrier should be in accordance with table 6.2. Metallic materials used in secondary barriers not forming part of the hull structure should be in accordance with table 6.2 or 6.3 as applicable. Insulation materials forming a secondary barrier should comply with the requirements of 4.9.7. Where the secondary barrier is formed by the deck or side shell plating, the material grade required by table 6.2 should be carried into the adjacent deck or side shell plating, where applicable, to a suitable extent.

4.9.3 Materials used in the construction of cargo tanks should be in accordance with tables 6.1, 6.2 or 6.3.

4.9.4 Materials other than those referred to in 4.9.1, 4.9.2 and 4.9.3 used in the construction of the ship which are subject to reduced temperature due to the cargo and which do not form part of the secondary barrier should 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 should 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 should have suitable properties of fire resistance and flame spread and should be adequately protected against penetration of water vapour and mechanical damage.

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

.1 compatibility with the cargo
.2 solubility in the cargo
.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 In addition to meeting the above requirements insulation materials which form part of the cargo containment as defined in 4.2.5 should be tested for the following properties after simulation of ageing and thermal cycling to ensure that they are adequate for the intended service:

.1 bonding (adhesive and cohesive strength)
.2 resistance to cargo pressure
.3 fatigue and crack propagation properties
.4 compatibility with cargo constituencies and any other agent expected to be in contact with the insulation in normal service
.5 where applicable the influence of presence of water and water pressure on the insulation properties should be taken into account
.6 gas de-absorbing.

4.9.7.3 The above properties, where applicable, should be tested for the range between the expected maximum temperature in service and $5^{\circ}C$ below the minimum design temperature, but not lower than $-196^{\circ}C$.

4.9.8 The procedure for fabrication, storage, handling, erection, quality control and control against harmful exposure to sunlight of insulation materials should be to the satisfaction of the Administration.

4.9.9 Where powder or granulated insulation is used, the arrangements should be such as to prevent compacting of the material due to vibrations. The design should 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 containment system.

4.10 Construction and testing

4.10.1.1 All welded joints of the shells of independent tanks should be of the butt weld, full penetration type. For dome to shell connexions, the Administration 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 should be as follows:

.1 All longitudinal and circumferential joints of pressure vessels should be of butt welded, full penetration, double vee or single vee type. Full penetration butt welds should be obtained by double welding or by the use of backing rings. If used, backing rings should be removed, unless specifically approved by the Administration for very small process pressure vessels. Other edge preparations may be allowed by the Administration 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 should be designed according to a standard for pressure vessels acceptable to the Administration. All welds connecting nozzles, domes or other penetrations of the vessel and all welds connecting flanges to the vessel or nozzles should be full penetration welds extending through the entire thickness of the vessel wall or nozzle wall, unless specially approved by the Administration for small nozzle diameters.

4.10.2 Workmanship should be to the satisfaction of the Administration. Inspection and non-destructive testing of welds for tanks other than type C independent tanks should be in accordance with the requirements of 6.3.7.

4.10.3 For membrane tanks, quality assurance measures, weld procedure qualification, design details, materials, construction, inspection and production testing of components, should be to standards developed during the prototype testing programme.

4.10.4 For semi-membrane tanks the relevant requirements in this section for independent tanks or for membrane tanks should be applied as appropriate.

4.10.5.1 For internal insulation tanks, in order to ensure uniform quality of the material, quality control procedures including environmental control, application procedure qualification, corners, penetrations and other design details, materials specification, installation and production testing of components should be to standards developed during the prototype test programme.

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 should be to the satisfaction of the Administration.

4.10.6 Integral tanks should be hydrostatically or hydropneumatically tested to the satisfaction of the Administration. The test in general should be so performed 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.

4.10.7 In ships fitted with membrane or semi-membrane tanks, cofferdams and all spaces which may normally contain liquid and are adjacent to the hull structure supporting the membrane should be hydrostatically or hydropneumatically tested in accordance with Recognized Standards. In addition, any other hold structure supporting the membrane should be tested for tightness. Pipe tunnels and other compartments which do not normally contain liquid need not be hydrostatically tested.

4.10.8.1 In ships fitted with internal insulation tanks where the inner hull is the supporting structure, all inner hull structure should be hydrostatically or hydropheumatically tested in accordance with Recognized Standards, taking into account the MARVS.

4.10.8.2 In ships fitted with internal insulation tanks where independent tanks are the supporting structure, the independent tanks should be tested in accordance with 4.10.10.1.

4.10.8.3 For internal insulation tanks where the inner hull structure or an independent tank structure acts as a secondary barrier, a tightness test of these structures should be carried out using techniques to the satisfaction of the Administration.

4.10.8.4 These tests should be performed before the application of the materials which will form the internal insulation tank.

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

.1 Manufacture and workmanship - The tolerances relating to manufacture and workmanship such as local out-of-roundness deviations from the true form, welded joints alignment and tapering of plates having different thicknesses, should comply with standards acceptable to the Administration. The tolerances should also 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 should be total or partial according to standards acceptable to the Administration, but the controls to be carried out should not be less than the following:

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

Radiography:

butt welds 100 per cent and

Surface crack detection:

all welds 10 per cent;

reinforcement rings around holes, nozzles, etc. 100 per cent.

As an alternative, ultrasonic testing may be accepted as a partial substitute for the radiographic testing, if specially allowed by the Administration. In addition, the Administration may require total ultrasonic testing on welding or reinforcement rings around holes, nozzles, etc.

.2.2 Partial non-destructive testing referred to in 4.4.6.1.3:

Radiography:

butt welds: all welded crossing joints and at least 10 per cent of the full length at selected positions uniformly distributed and

Surface crack detection:

reinforcement rings around holes, nozzles, etc. 100 per cent

Ultrasonic testing:

as may be required by the Administration in each instance.

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

.1 For type A independent tanks, this test should 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.

.2 For type B independent tanks, the test should be performed as required in 4.10.10.1 for type A independent tanks. In addition, the maximum primary membrane stress or maximum bending stress in primary members under test conditions should not exceed 90 per cent 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 per cent of the yield strength the prototype test should be monitored by the use of strain gauges or other suitable equipment.

.3 Type C independent tanks should be tested as follows:

.3.1 Each pressure vessel, when completely manufactured, should be subjected to a hydrostatic test at a pressure measured at the top of the tanks, of not less than 1.5 P_o, but in no case during the pressure test should the calculated primary membrane stress at any point exceed 90 per cent of the yield stress of the material. The definition of P_o 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 should be monitored by the use of strain gauges or other suitable equipment in pressure vessels other than simple cylindrical and spherical pressure vessels.

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

.3.3 The pressure should be held for two hours per 25 mm of thickness but in no case less than two hours.

.3.4 Where necessary for cargo pressure vessels, and with the specific approval of the Administration, a hydropneumatic test may be carried out under the conditions prescribed in 4.10.10.1, .2 and .3.

.3.5 Special consideration may be given by the Administration to the testing of tanks in which higher allowable stresses are used, depending on service temperature. However, the requirements of 4.10.10.1 should be fully complied with.

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

.3.7 Pneumatic testing of pressure vessels other than cargo tanks should be considered on an individual case basis by the Administration. Such testing should 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.

4.10.11 All tanks should 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 Requirements with respect to inspection of secondary barriers should be decided by the Administration in each case.

4.10.13 In ships fitted with type B independent tanks, at least one tank and its support should 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 Administration 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 should 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 should be maintained and be available to the Administration.

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

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

4.10.17 The insulation materials of internal insulation tanks should be subjected to additional inspection in order to verify their surface conditions after the third loaded voyage of the ship, but not later than the first six months of the ship's service after building or a major repair work is undertaken on the internal insulation tanks.

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

4.11 Stress relieving for type C independent tanks

4.11.1 For type C independent tanks of carbon and carbon-manganese steel, post-weld heat treatment should be performed after welding if the design temperature is below $-10^{\circ}C$. Post-weld heat treatment in all other cases and for materials other than those mentioned above should be to the satisfaction of the Administration. The soaking temperature and holding time should be to the satisfaction of the Administration.

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, mechanical stress relieving by pressurizing may be carried out as an alternative to the heat treatment with the approval of the Administration and subject to the following conditions:

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

.2 The plate thicknesses should not exceed those given by a standard acceptable to the Administration.

.3 The performance of a detailed stress analysis to ascertain that the maximum primary membrane stress during the mechanical stress relieving, closely approaches, but does not exceed, 90 per cent of the yield stress of the material. Strain measurements during the stress relief pressurization may be required by the Administration for verifying the calculations.

.4 The procedure for mechanical stress relieving should be submitted beforehand to the Administration for approval.

4.12 Guidance formulae for acceleration components

The following formulae are given as guidance for the components of acceleration due to ship's motion corresponding to a probability level of 10^{-8} in the North Atlantic and apply to ships with a length exceeding 50 m.

Vertical acceleration as defined in 4.3.4.6

$$a_z = \pm a_o \sqrt{1 + \left(5.3 - \frac{45}{L_o}\right)^2 \left(\frac{x}{L_o} + 0.05\right)^2 \left(\frac{0.6}{C_B}\right)^{1.5}}$$

Transverse acceleration as defined in 4.3.4.6

$$a_y = \pm a_o \sqrt{0.6 + 2.5 \left(\frac{x}{L_o} + 0.05\right)^2 + K\left(1 + 0.6\, K\frac{z}{B}\right)^2}$$

Longitudinal acceleration as defined in 4.3.4.6

$$a_x = \pm a_o \sqrt{0.06 + A^2 - 0.25\, A}$$

with:

$$A = \left(0.7 - \frac{L_o}{1200} + 5\frac{z}{L_o}\right) \left(\frac{0.6}{C_B}\right)$$

where:

L_o	=	length of the ship for determination of scantlings as defined in Recognized Standards (m)
C_B	=	block coefficient
B	=	greatest moulded breadth of the ship (m)
x	=	longitudinal distance (m) from amidships to the centre of gravity of the tank with contents; x is positive forward of amidships, negative aft of amidships
z	=	vertical distance (m) from the ship's actual waterline to the centre of gravity of tank with content. z is positive above and negative below the waterline.

$$a_o = 0.2\frac{V}{\sqrt{L_o}} + \frac{34 - \frac{600}{L_o}}{L_o}$$

where: V = service speed (knots)

K = 1 in general. For particular loading conditions and hull forms, determination of K according to the formula below may be necessary.

K = 13GM/B, where $K \geqslant 1.0$ and GM = metacentric height (m)

a_x, a_y and a_z = maximum dimensionless accelerations (i.e. relative to the acceleration of gravity) in the respective directions and they are considered as acting separately for calculation purposes. a_z does not include the component due to the static weight, a_y includes the component due to the static weight in the transverse direction due to rolling and a_x includes the component due to the static weight in the longitudinal direction due to pitching.

4.13 Stress categories

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

4.13.1 Normal stress is the component of stress normal to the plane of reference.

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:

$$S_1 \leq 0.5\sqrt{Rt} \quad \text{and}$$
$$S_2 \geq 2.5\sqrt{Rt}$$

where:

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

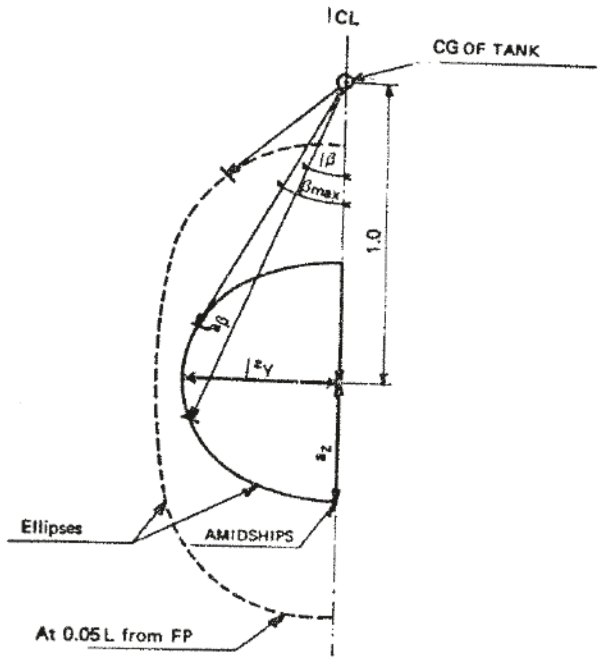
S_2 = distance in the meridional direction to another region where the limits for primary general membrane stress are exceeded

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.



a_β = resulting acceleration (static and dynamic) in arbitrary direction β

a_y = transverse component of acceleration

a_z = vertical component of acceleration

Figure 4.1 - Acceleration ellipse

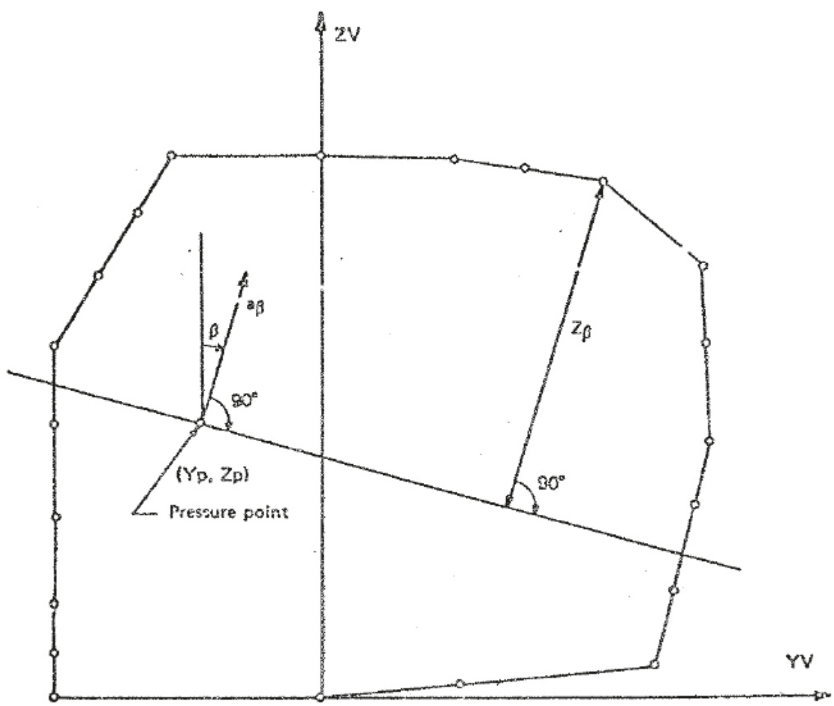
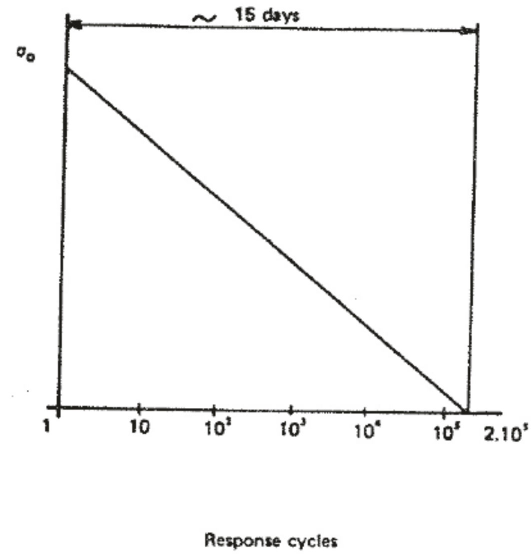


Figure 4.2 - Determination of internal pressure heads



σ_o = most probable maximum stress over the life of the ship

Response cycle scale is logarithmic; the value of 2.10^5 is given as an example of estimate.

Figure 4.3 - Simplified load distribution

CHAPTER 5 - PROCESS PRESSURE VESSELS AND LIQUID, VAPOUR, AND PRESSURE PIPING SYSTEMS

5.1 General

5.1.1 Administrations should take appropriate steps to ensure uniformity in the implementation and application of the provisions of this Chapter.*

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

5.2 Cargo and process piping

5.2.1 General

5.2.1.1 The requirements of this section 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 should 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 should be held to a minimum and, where located outside of cargo tanks, should be of the bellows type.

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* Reference is made to the published Rules of members and associate members of the International Association of Classification Societies and in particular to IACS Unified Requirement No G3.

5.2.1.3 Low temperature piping should be thermally isolated from the adjacent hull structure, where necessary, to prevent the temperature of the hull from falling below the design temperature of the hull material. Where liquid piping is dismantled regularly, or where liquid leakage may be anticipated, such as at shore connexions and at pump seals, protection for the hull beneath should be provided.

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

5.2.1.5 Suitable means should be provided to relieve the pressure and remove liquid contents 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 All pipelines or components which may be isolated in a liquid full condition should be provided with relief valves.

5.2.1.7 Relief valves discharging liquid cargo from the cargo piping system should discharge into the cargo tanks; alternatively they may discharge to the cargo vent mast if means are provided to detect and dispose of any liquid cargo which may flow into the vent system. Relief valves on cargo pumps should discharge to the pump suction.

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 should not be less than:

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

where:

t_o = theoretical thickness

$t_o = PD/(20\ Ke + P)$ (mm)

with:

P = design pressure (bar) referred to in 5.2.3

D = outside diameter (mm)

K = allowable stress (N/mm^2) referred to in 5.2.4

e = efficiency factor equal 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 on-destructive testing on welds is carried out in accordance with Recognized Standards. In other cases an efficiency factor value depending on the manufacturing process may be determined by the Administration.

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

$$b = \frac{Dt_o}{2.5r} \quad \text{(mm)}$$

with:

r = mean radius of the bend (mm)

c = corrosion allowance (mm). If corrosion or erosion is expected, the wall thickness of the piping should be increased over that required by other design requirements. This allowance should 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 t_o in 5.2.2.1 is the maximum pressure to which the system may be subjected in service.

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

.1 for vapour piping systems or components which may be separated from their relief valves and which may contain some liquid: the saturated vapour pressure at 45°C, or higher or lower if agreed upon by the Administration (see 4.2.6.2);

.2 for systems or components which may be separated from their relief valves and which contain only vapour at all times: the superheated vapour pressure at 45°C or higher or lower if agreed upon by the Administration (see 4.2.6.2), assuming an initial condition of saturated vapour in the system at the system operating pressure and temperature; or

.3 the MARVS of the cargo tanks and cargo processing systems; or

.4 the pressure setting of the associated pump or compressor discharge relief valve; or

.5 the maximum total discharge or loading head of the cargo piping system; or

.6 the relief valve setting on a pipeline system.

5.2.3.3 The design pressure should not be less than 10 bar except for open ended lines where it should be not less than 5 bar.

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:

$$\frac{R_m}{A} \text{ or } \frac{R_e}{B}$$

where:

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

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

The values of A and B should be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk as provided for in 1.5 and have values of at least A = 2.7 and B = 1.8.

5.2.4.2 The minimum wall thickness should 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 should be increased over that required by 5.2.2, or, if this is impracticable or would cause excessive local stresses, these loads should be reduced, protected against or eliminated by other design methods.

5.2.4.4 Flanges, valves and other fittings should be to a standard acceptable to the Administration, 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 by the Administration.

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

5.2.5 Stress analysis

When the design temperature is $-110^{\circ}C$ 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 should be submitted to the Administration. For temperatures of above $-110^{\circ}C$, a stress analysis may be required by the Administration in relation to such matters as the design or stiffness of the piping system and the choice of materials. In any case, consideration should 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 Administration.

5.2.6 Materials

5.2.6.1 The choice and testing of materials used in piping systems should 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 $-55^{\circ}C$ or greater and provided no liquid 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 $925^{\circ}C$ should not 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 should be provided.

5.3 Type tests on piping components

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

5.3.2.1 Each size and type of valves intended to be used at a working temperature below $-55^{\circ}C$ should 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 valves. During the test the satisfactory operation of the valve should be ascertained.

5.3.2.2 The following type tests should 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, should be pressure tested at not less than five times the design pressure without bursting. The duration of the test should not be less than five minutes.

.2 A pressure test 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 Administration may require the test to be at the minimum design temperature.

.3 A cyclic test (thermal movements) should 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 room temperature is permitted, when this testing is at least as severe as testing at the service temperature.

.4 A cyclic fatigue test (ship deformation) should 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/second. This test is only required when, due to the piping arrangement, ship deformation loads are actually experienced.

.5 The Administration 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 this documentation is to include sufficient test data to justify the design method used, with particular reference to correlation between calculation and test results.

5.4 Piping fabrication and joining details

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

5.4.2 The following direct connexion 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 $-10^{\circ}C$, butt welds should be either double welded or equivalent to a double welded butt joint. This may be accomplished by use of a backing ring, consumable insert gas back-up on the first pass. For design pressures in excess of 10 bar and design temperatures of $-10^{\circ}C$ or lower, backing rings should be removed.

.2 Slip-on welded joints with sleeves and related welding, having dimensions satisfactory to the Administration should only be used for open ended lines with external diameter of 50 mm or less and design temperatures not lower than $-55^{\circ}C$.

.3 Screwed couplings acceptable to the Administration should only be used for accessory lines and instrumentation lines with external diameters of 25 mm or less.

5.4.3.1 Flanges in flange connexion should be of the welded neck, slip-on or socket welded type.

5.4.3.2 Flanges should be selected as to type, and made and tested in accordance with a standard acceptable to the Administration. In particular, for all piping except open ended, the following restrictions apply:

.1 For design temperatures lower than $-55^{\circ}C$, only welded neck flanges should be used.

.2 For design temperatures lower than $-10^{o}C$, slip-on flanges should not be used in nominal sizes above 100 mm and socket welded flanges should not be used in nominal sizes above 50 mm.

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

5.4.5 Bellow and expansion joints should be provided to allow for expansion of piping.

.1 If necessary, bellows should be protected against icing.

.2 Slip joints should not be used except within the cargo tanks.

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

.1 Welding should be carried out in accordance with 6.3.

.2 Post-weld heat treatments should be required for all butt welds of pipes made with carbon, carbon-manganese and low alloy steels. The Administration 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 should be required:

.3.1 100 per cent radiographic inspection of butt welded joints for piping systems with service temperatures lower than $-10^{o}C$ and with inside diameters of more than 75 mm or wall thicknesses greater than 10 mm.

.3.2 For other butt welded joints of pipes, spot radiographic tests or other non-destructive tests should be carried out at the discretion of the Administration depending upon service, position and materials. In general at least 10 per cent of butt welded joints of pipes should 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 Administration 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 should be subjected to a hydrostatic test to at least 1.5 times the design pressure. However, 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 should 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 should be submitted to the Administration for approval.

5.5.3 After assembly on board, each cargo and process piping system should 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 should 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 tank should be provided with the following valves, as applicable:

.1 For cargo tanks with a MARVS not exceeding 0.7 bar, all liquid and vapour connexions, except safety relief valves and liquid level gauging devices, should have shut-off valves located as close to the tank as practicable. These valves may be remotely controlled but should be capable of local manual operation and provide full closure. One or more remotely controlled emergency shut-down valve should be provided on the ship for shutting down liquid and vapour cargo transfer between ship and shore. Such valves may be arranged to suit the ship's design and may be the same valve as required in 5.6.3 and should comply with the requirements of 5.6.4.

.2 For cargo tanks with a MARVS exceeding 0.7 bar, all liquid and vapour connexions, except safety relief valves and liquid level gauging devices, should be equipped with a manually operated stop valve and a remotely controlled emergency shut-down valve. These valves should 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 shut-down 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 pumps and compressors should be arranged to shut-down automatically if the emergency shut-down valves required by 5.6.1.1 and .2 are closed by the emergency shut-down system required by 5.6.4.

5.6.2 Cargo tank connexions for gauging or measuring devices need not be equipped with excess flow or emergency shut-down 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 remote operated emergency shut-down valve should be provided at each cargo hose connexion in use. Connexions 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 shut-down valves should 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 should be the control position required by 13.1.3 or cargo control room. The control system should also be provided with fusible elements designed to melt at temperatures between 98°C and 104°C which will cause the emergency shut-down valves to close in the event of fire. Locations for such fusible elements should include the tank domes and loading stations. Emergency shut-down valves should be of the fail-closed (closed on loss of power) type and be capable of local manual closing operation. Emergency shut-down valves in liquid piping should fully close under all service conditions within 30 seconds of actuation. Information about the closing time of the valves and their operating characteristics should be available onboard and the closing time should be verifiable and reproducible. Such valves should close smoothly.

5.6.5 Excess flow valves should close automatically at the rated closing flow of vapour or liquid as specified by the manufacturer. The piping including fittings, valves, and appurtenances protected by an excess flow valve, should 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 equilization of pressure, after an operating shut-down.

5.7 <u>Ship's cargo hoses</u>

5.7.1 Liquid and vapour hoses used for cargo transfer should be compatible with the cargo and suitable for the cargo temperature.

5.7.2 Hoses subject to tank pressure, or the discharge pressure of pumps or vapour compressors, should be designed for a bursting pressure not less than five 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, should be prototype tested to a pressure not less than five times its specified maximum working pressure. The hose temperature during this prototype test should be the intended extreme service temperature. Hoses used for prototype testing should not be used for cargo service. Thereafter, before being placed in service, each new length of cargo hose produced should be hydrostatically tested at ambient temperature to a pressure not less than 1.5 times its specified maximum working pressure nor more than two-fifths its bursting pressure. The hose should be stencilled or otherwise marked with its specified maximum working pressure and, if used in other than ambient temperature services, its maximum or minimum service temperature or both. The specified maximum working pressure should not be less than 10 bar.

5.8 Cargo transfer methods

5.8.1 Where cargo transfer is by means of cargo pumps not accessible for repair with the tanks in service, at least two separate means should be provided to transfer cargo from each cargo tank and the design should be such that failure of one cargo pump, or means of transfer, will not prevent the cargo transfer by another pump or pumps, or other cargo transfer means.

5.8.2 The procedure for transfer of cargo by gas pressurization should preclude lifting of the relief valves during such transfer. Gas pressurization may be accepted as a means of transfer of cargo for those tanks so designed that the design factor of safety is not reduced under the conditions prevailing during the cargo transfer operation.

5.9 Vapour return connexions

Connexions for vapour return lines to the shore installations should be provided.

CHAPTER 6 - MATERIALS OF CONSTRUCTION

6.1 General

6.1.1 Administrations should take appropriate steps to ensure uniformity in the implementation and application of the provisions of this chapter.*

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, secondary barriers and contiguous hull structures associated with the transportation of the products. The requirements for rolled materials, forgings and castings are given in 6.2 and tables 6.1 to 6.5. The requirements for weldments are given in 6.3.

6.1.3 The manufacture, testing, inspection and documentation should be in accordance with Recognized Standards and the specific requirements given in this Code.

6.1.4.1 Acceptance tests should include Charpy V-notch toughness tests unless otherwise specified by the Administration. The specified Charpy V-notch requirements are minimum average energy values for three full size (10 mm x 10 mm) specimens and minimum single energy values for individual specimens. Dimensions and tolerances of Charpy V-notch specimens should be in accordance with Recognized Standards. The testing and requirements for specimens smaller than 5.0 mm size should be in accordance with Recognized Standards. Minimum average values for sub-sized specimens should be:

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* Reference is made to the published Rules of members and associate members of the International Association of Classification Societies and in particular to IACS Unified Requirement No.W1.

Charpy V-notch specimen size	Minimum energy average of 3 specimens
10 x 10 mm	E
10 x 7.5 mm	5/6 E
10 x 5.0 mm	2/3 E

where: E = the energy values (J) specified in tables 6.1 to 6.4.

Only one individual value may be below the specified average value provided it is not less than 70 per cent of that value.

6.1.4.2 In all cases, the largest size Charpy specimens possible for the material thickness should be machined with the specimens located as near as practicable to a point midway between the surface and the centre of the thickness and the length of the notch perpendicular to the surface (see figure 6.1). If the average value of the three initial Charpy V-notch specimens fails to meet the stated requirements, or the value for more than one specimen is below the required average value, or when the value for one specimen is below the minimum value permitted for a single specimen, three additional specimens from the same material may be tested and the results combined with those previously obtained to form a new average. If this new average complies with the requirements and if no more than two individual results are lower than the required average and no more than one result is lower than the required value for a single specimen, the piece or batch may be accepted. At the discretion of the Administration 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 should be to the satisfaction of the Administration. For carbon-manganese steel and other materials with definitive yield points, consideration should 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 Administration.

6.1.8 Where post-weld heat treatment is specified or required, the properties of the base material should be determined in the heat treated condition in accordance with the applicable table of this chapter and the weld properties should be determined in the heat treated condition in accordance with 6.3. In cases where a post-weld heat treatment is applied, the test requirements may be modified at the discretion of the Administration.

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 Recognized Standards.

6.2 Material requirements

The requirements for materials of construction are shown in the tables as follows:

Table 6.1:	Plates, pipes (seamless and welded), sections and forgings for cargo tanks and process pressure vessels for design temperatures not lower than 0°C.
Table 6.2:	Plates, sections and forgings for cargo tanks, secondary barriers and process pressure vessels for design temperatures below 0°C and down to -55°C.
Table 6.3:	Plates, sections and forgings for cargo tanks, secondary barriers and process pressure vessels for design temperatures below -55°C and down to -165°C.
Table 6.4:	Pipes (seamless and welded), forgings and castings for cargo process piping for design temperatures below 0°C and down to -165°C.
Table 6.5:	Plates and sections for hull structures required by 4.9.1 and 4.9.4.

Table 6.1

PLATES, PIPES (SEAMLESS AND WELDED),1/ SECTIONS AND FORGINGS FOR CARGO TANKS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES NOT LOWER THAN 0°C		
CHEMICAL COMPOSITION AND HEAT TREATMENT		
CARBON-MANGANESE STEEL	Fully killed	
Fine grain steel where thickness exceeds 20 mm		
Small additions of alloying elements by agreement with the Administration		
Composition limits to be approved by the Administration		
Normalized, or quenched and tempered 2/		
TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS		
PLATES	Each "piece" to be tested	
SECTIONS AND FORGINGS	Batch test	
TENSILE PROPERTIES	Specified minimum yield stress not to exceed 410 N/mm^2 3/	
CHARPY V-NOTCH TEST		
PLATE	Transverse test pieces. Minimum average energy value (E) 27 J	
SECTIONS AND FORGINGS	Longitudinal test pieces. Minimum average energy value (E) 41 J	
TEST TEMPERATURE:	Thickness t (mm)	Test temperature (°C)
	$t \leq 20$	0
	$20 < t \leq 40$	-20

NOTES

1/ For seamless pipes and fittings normal practice applies. The use of longitudinal and spirally welded pipe should be specially approved by the Administration.

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

3/ Materials with specified minimum yield stress exceeding 410 N/mm^2 may be specially approved by the Administration. For these materials, particular attention should be given to the hardness of the weld and heat affected zone.

Table 6.2

PLATES, SECTIONS AND FORGINGS[1/] FOR CARGO TANKS, SECONDARY BARRIERS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES BELOW 0°C AND DOWN TO -55°C

Maximum thickness 25 mm[2/]

CHEMICAL COMPOSITION AND HEAT TREATMENT

CARBON-MANGANESE STEEL Fully killed. Aluminium treated fine grain steel.

Chemical composition (ladle analysis)

C	Mn	Si	S	P
0.16% max.[3/]	0.70-1.60%	0.10-0.50%	0.035% max.	0.035% max.

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

Ni	Cr	Mo	Cu	Nb	V
0.80% max.	0.25% max.	0.08% max.	0.35% max.	0.05% max.	0.10% max.

Normalized or quenched and tempered[4/]

TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS

PLATES	Each "piece" to be tested
SECTIONS	Batch test
CHARPY V-NOTCH TEST	Test temperatures 5°C below the design temperature or -20°C whichever is lower
PLATES	Transverse test pieces. Minimum average energy value (E) 27 J
SECTIONS AND FORGINGS[1/]	Longitudinal test pieces. Minimum average energy value (E) 41 J

NOTES

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

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

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

The impact energy value should 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 should 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 should be the same as that required for the adjacent tank-shell thickness.

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

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

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 FORGINGS 1/ FOR CARGO TANKS, SECONDARY BARRIERS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES BELOW -55°C AND DOWN TO -165°C 2/

Maximum thickness 25mm 3/

Minimum design temp. (°C)	Chemical composition 4/ and heat treatment	Impact test temp. (°C)
-60	1.5% Nickel steel - normalized	-65
-65	2.25% Nickel steel - normalized or normalized and tempered 5/	-70
-90	3.5% Nickel steel - normalized or normalized and tempered 5/	-95
-105	5% Nickel steel - normalized or normalized and tempered 5/ 6/	-110
-165	9% Nickel steel - double normalized and tempered or quenched and tempered	-196
-165	Austenitic steels, such as types 304, 304L, 316, 316L, 321 and 347 solution treated 7/	-196
-165	Aluminium alloys; such as type 5083 annealed	Not required
-165	Austenitic Fe-Ni alloy (36% nickel) Heat treatment as agreed	Not required

TENSILE AND TOUGHNESS (IMPACT) TEST 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) 27 J
SECTIONS AND FORGINGS	Longitudinal test pieces. Minimum average energy value (E) 41 J

NOTES

1/ The impact test required for forgings used in critical applications should be subject to special consideration by the Administration.

2/ The requirements for design temperatures below -165°C should be specially agreed with the Administration.

3/ For materials 1.5% Ni, 2.25% Ni, 3.5% Ni and 5% Ni, with thicknesses greater than 25 mm, the impact tests should be conducted as follows:

Material thickness (mm)	Test temperature (°C)
25 < t ⩽ 30	10° below design temperature
30 < t ⩽ 35	15° below design temperature
35 < t ⩽ 40	20° below design temperature

In no case should the test temperature be above that indicated in the table.

The energy value should 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 should be specially considered.

For 9% Ni, austenitic stainless steels and aluminium alloys, thicknesses greater than 25 mm may be used at the discretion of the Administration.

4/ The chemical composition limits should be approved by the Administration.

5/ A lower minimum design temperature for quenched and tempered steels may be specially agreed with the Administration.

6/ A specially heat treated, such as triple heat treated 5% Nickel steel may be used down to -165°C upon special agreement with the Administration, provided that the impact tests are carried out at -196°C.

7/ The impact test may be omitted subject to agreement with the Administration.

Table 6.4

PIPES (SEAMLESS AND WELDED),1/ FORGINGS2/ AND CASTINGS2/ FOR CARGO AND PROCESS PIPING FOR DESIGN TEMPERATURES BELOW 0°C AND DOWN TO -165°C3/			
Maximum thickness 25 mm			
Minimum design temp. (°C)	Chemical composition5/ and heat treatment	Impact test	
		Test temp. (°C)	Minimum average energy (E) (J)
-55	Carbon-manganese steel. Fully killed fine grain. Normalized or as agreed 6/	4/	27
-65	2.25% Nickel steel. Normalized or normalized and tempered 6/	-70	34
-90	3.5% Nickel steel. Normalized or normalized and tempered 6/	-95	34
-165	9% Nickel steel 7/. Double normalized and tempered or quenched and tempered	-196	41
	Austenitic steels, such as types 304, 304L, 316, 316L, 321 and 347. Solution treated 8/	-196	41
	Aluminium alloys, such as type 5083 annealed		Not required
TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS			
Each batch to be tested			
IMPACT TEST - Longitudinal test pieces			

NOTES

1/ The use of longitudinally or spirally welded pipe should be specially approved by the Administration.

2/ The requirements for forgings and castings may be subject to special consideration by the Administration.

3/ The requirements for design temperatures below -165°C should be specially agreed with the Administration.

4/ The test temperature should be 5°C below the design temperature or -20°C whichever is lower.

5/ The composition limits should be approved by the Administration.

6/ A lower design temperature may be specially agreed with the Administration for quenched and tempered materials.

7/ This chemical composition is not suitable for castings.

8/ Impact tests may be omitted subject to agreement with the Administration.

Table 6.5

PLATES AND SECTIONS FOR HULL STRUCTURES REQUIRED BY 4.9.1 AND 4.9.4							
Minimum design temperature of hull structure (°C)	Maximum thickness (mm) for steel grades in accordance with 6.1.9						
	A	B	D	E	AH	DH	EH
0 and above 1/ -5 and above 2/	Normal practice						
down to -5	15	25	30	50	25	45	50
down to -10	x	20	25	50	20	40	50
down to -20	x	x	20	50	x	30	50
down to -30	x	x	x	40	x	20	40
Below -30	In accordance with table 6.2 except that the thickness limitation given in table 6.2 and in footnote 2/ of that table does not apply.						

NOTES

"x" means steel grade not to be used.

1/ For the purpose of 4.9.4

2/ For 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 Administration, 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 should be in accordance with Recognized Standards unless otherwise agreed with the Administration. Deposited weld metal tests and butt weld tests should be required for all welding consumables, unless otherwise specially agreed with the Administration. The results obtained from tensile and Charpy V-notch impact tests should be in accordance with Recognized Standards. The chemical composition of the deposited weld metal should be recorded for information and approval.

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 should be representative of:

each base material

each type of consumable and welding process

each welding position.

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

6.3.3.2 The following welding procedure tests for cargo tanks and process pressure vessels should 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 Administration. However, longitudinal bend tests may be required in lieu of transverse bend tests in cases where the base material and weld metal have different strength levels.

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

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

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

6.3.4 Test requirements

6.3.4.1 Tensile tests: Generally, tensile strength should not be less than the specified minimum tensile strength for the appropriate parent materials. The Administration may also require that the transverse weld tensile strength should not 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 Administration.

6.3.4.3 Charpy V-notch impact tests: Charpy tests should be conducted at the temperature prescribed for the base material being joined. The results of weld metal impact tests, minimum average energy (E), should be no less than 27 J. The weld metal requirements for subsize specimens and single energy values should be in accordance with 6.1.4. The results of fusion line and heat affected zone impact tests should show a minimum average energy (E) in accordance with the transverse or longitudinal requirements of the base material, whichever is applicable, and for subsize specimens, the minimum average energy (E) should be in accordance with 6.1.4. If the material thickness does not permit machining either full size or standard subsize specimens, the testing procedure and acceptance standards should be in accordance with Recognized Standards.

6.3.5 Welding procedure tests for piping

Welding procedure tests for piping should be carried out and should be similar to those detailed for cargo tanks in 6.3.3. Unless otherwise specially agreed with the Administration, the test requirements should 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 should generally be performed for approximately each 50 m of butt weld joints and should be representative of each welding position. For secondary barriers, the same type production tests as required for primary tanks should be performed except that the number of tests may be reduced subject to agreement with the Administration. Tests, other than those specified in 6.3.6.2, .3 and .4, may be required for cargo tanks or secondary barriers at the discretion of the Administration.

6.3.6.2 The production tests for types A and B independent tanks and semi-membrane tanks should include the following tests:

.1 Bend tests, and where required for procedure tests one set of three Charpy V-notch tests should be made for each 50 m of weld. The Charpy V-notch tests should 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 should 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 Administration, by passing a drop weight test. In such cases, two drop weight specimens should 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 6.3.6.1 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 Administration, by passing a drop weight test. In such cases, two drop weight specimens should 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.

6.3.6.4 Production tests for integral and membrane tanks should be in accordance with Recognized Standards.

6.3.7 Non-destructive testing

6.3.7.1 For type A independent tanks and semi-membrane tanks where the design temperature is $-20^{\circ}C$ or less, and for type B independent tanks regardless of temperature, all full penetration butt welds of the shell plating of cargo tanks should be subjected to 100 per cent radiographic inspection.

6.3.7.2 Where the design temperature is higher than $-20^{\circ}C$, all full penetration butt welds in way of intersections and at least 10 per cent of the remaining full penetration welds of tanks structures should be subjected to radiographic inspection.

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

6.3.7.4 All test procedures and acceptance standards should be in accordance with Recognized Standards. The Administration 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 Administration may require ultrasonic testing in addition to normal radiographic inspection.

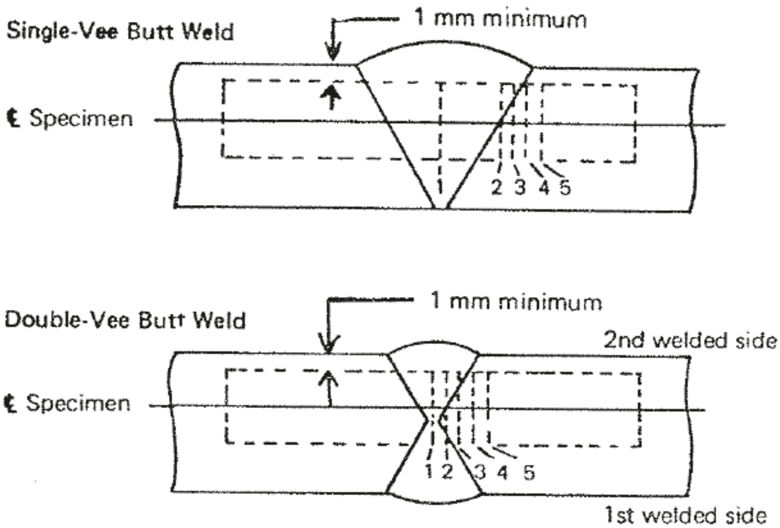
6.3.7.5 Inspection of type C independent tanks and process pressure vessels should be carried out in accordance with 4.10.9.

6.3.7.6 For integral and membrane tanks, special weld inspection procedures and acceptance criteria should be in accordance with Recognized Standards.

6.3.7.7 The inspection and non-destructive testing of the inner hull or the independent tank structures supporting internal insulation tanks should take into account the design criteria given in 4.4.7. The schedule for inspection and non-destructive testing should be to the satisfaction of the Administration.

6.3.7.8 Inspection of piping should be carried out in accordance with the requirements of Chapter 5.

6.3.7.9 The secondary barrier should be radiographed as considered necessary by the Administration. Where the outer shell of the hull is part of the secondary barrier, all sheer strake butts and the intersections of all butts and seams in the side shell should be tested by radiography.



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 Charpy specimens possible for the material thickness should 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 should be approximately one mm or greater. In addition for double-vee butt welds, specimens should be machined closer to the surface of the second welded side.

Figure 6.1 - Orientation of weld test specimen

CHAPTER 7 - CARGO PRESSURE/TEMPERATURE CONTROL

7.1 General

7.1.1 Unless the entire cargo system is designed to withstand the full gauge vapour pressure of the cargo under conditions of the upper ambient design temperatures, maintenance of the cargo tank pressure below the MARVS should 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 a system whereby the boil-off vapours are utilized as fuel for shipboard use or waste heat system subject to the provisions of Chapter 16. This system may be used at all times, including while in port and while manoeuvring, provided that a means of disposing of excess energy is provided, such as a steam dump system, that is satisfactory to the Administration;

.3 a system allowing the product to warm up and increase in pressure. The insulation or cargo tank design pressure or both should be adequate to provide for a suitable margin for the operating time and temperatures involved. The system should be acceptable to the Administration in each case;

.4 other systems acceptable to the Administration;

.5 in addition to the above means, the Administration may permit certain cargoes to be controlled by venting cargo vapours to the atmosphere at sea. This may also be permitted in port with the permission of the Port Administration.

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

sea 32°C

air 45°C.

For service in especially hot or cold zones these temperatures should be increased or reduced, as appropriate, by the Administration.

7.1.3 For certain highly dangerous cargoes specified in Chapter 17, the cargo containment system should be capable of withstanding the full vapour pressure of the cargo under conditions of the upper ambient design temperatures irrespective of any system provided for dealing with boiloff gas.

7.2 <u>Refrigeration systems</u>

7.2.1 A refrigeration system should 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 Administration, a stand-by unit (or units) affording spare capacity at least equal to the largest required single unit should be provided. A stand-by unit should 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 should be provided unless the normal heat exchanger for the unit has an excess capacity of at least 25 per cent of the largest required capacity. Separate piping systems are not required.

7.2.2.1 Where two or more refrigerated cargoes which may react chemically in a dangerous manner are carried simultaneously, special consideration should be given to the refrigeration systems to avoid the possibility of mixing cargoes. For the carriage of such cargoes, separate refrigeration systems, each complete with a stand-by unit as specified in 7.2.1, should be provided for each cargo. However, where cooling is provided by an indirect or combined system and leakage in the heat exchangers cannot cause mixing of the cargoes under any envisaged condition, separate refrigeration units need not be fitted.

7.2.2.2 Where two or more refrigerated cargoes are not mutually soluble under the conditions of carriage, so that their vapour pressures would be additive on mixing, special consideration should be given to the refrigeration systems to avoid the possibility of mixing cargoes.

7.2.3 Where cooling water is required in refrigeration systems, an adequate supply should be provided by a pump or pumps used exclusively for this purpose. This pump or these pumps should have at least two sea suction lines, where practicable leading from sea-chests, one port and one starboard. A spare pump of adequate capacity should 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 The refrigeration system may be arranged in one of the following ways:

.1 a direct system where evaporated cargo is compressed, condensed and returned to cargo tanks. For certain cargoes specified in Chapter 17 this system should not be used;

.2 an indirect system where cargo or evaporated cargo is cooled or condensed by refrigerant without being compressed;

.3 a combined system where evaporated cargo is compressed and condensed in a cargo/refrigerant heat exchanger and returned to the cargo tanks. For certain cargoes specified in Chapter 17 this system should not be used.

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.

CHAPTER 8 - CARGO TANK VENT SYSTEMS

8.1 General

All cargo tanks should be provided with a pressure relief system appropriate to the design of the cargo containment system and the cargo being carried. Hold spaces, inter-barrier spaces and cargo piping which may be subject to pressures beyond their design capabilities should also be provided with a suitable pressure relief system. The pressure relief system should 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 should be independent of the pressure relief valves.

8.2 Pressure relief systems

8.2.1 Each cargo tank with a volume exceeding 20 m^3 should 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 m^3, a single relief valve may be fitted.

8.2.2 Inter-barrier spaces should be provided with pressure relief devices to the satisfaction of the Administration.

8.2.3 The setting of the pressure relief valves should not be higher than the vapour pressure which has been used in the design of the tank.

8.2.4 Pressure relief valves should be connected to the highest part of the cargo tank above deck level. Pressure relief valves on cargo tanks with a design temperature below $0^{\circ}C$ should be arranged to prevent their becoming inoperative due to ice formation when they are closed. Due consideration should be given to the construction and arrangement of pressure relief valves on cargo tanks subject to low ambient temperatures.

8.2.5 Pressure relief valves should be prototype tested to ensure that the valves have the capacity required. Each valve should 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 should be set and sealed by a competent authority acceptable to the Administration and a record of this action, including the values of set pressure, should be retained aboard the ship.

8.2.6 In the case of cargo tanks permitted to have more than one relief valve setting this may be accomplished by:

.1 installing two or more properly set and sealed valves and providing means as necessary for isolating the valves not in use from the cargo tank; or

.2 installing relief valves whose settings may be changed by the insertion of previously approved spacer pieces or alternative springs or by other similar means not requiring pressure testing to verify the new set pressure. All other valve adjustments should be sealed.

8.2.7 The changing of the set pressure under the provisions of 8.2.6 should be carried out under the supervision of the master in accordance with procedures approved by the Administration and specified in the ship's operating manual. Changes in set pressures should be recorded in the ship's log and a sign posted in the cargo control room, if provided, and at each relief valve, stating the set pressure.

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

.1 suitable arrangemens 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 all valves if a suitably maintained spare valve is carried on board.

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

8.2.10 Cargo tank pressure relief valve vent exits should 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 Administration. All other vent exits connected to the cargo containment system should 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.

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

8.2.12 If cargoes which react in a hazardous manner with each other are carried simultaneously, a separate pressure relief system should be fitted for each cargo carried.

8.2.13 In the vent piping system, means for draining liquid from places where it may accumulate should be provided. The pressure relief valves and piping should be so arranged that liquid can under no circumstances accumulate in or near the pressure relief valves.

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

8.2.15 All vent piping should 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 should be taken into account in determining the flow capacity required by 8.5.

8.2.17 Pressure relief valves should be positioned on the cargo tank so that they will remain in the vapour phase under conditions of 15° list and 0.015 L trim, where L is as defined in 1.3.22.

8.3 Additional pressure relieving system for liquid level control

8.3.1 Where required by 15.1.4.2, an additional pressure relieving system to prevent the tank from becoming liquid full at any time during relief under the fire exposure conditions referred to in 8.5 should be fitted to each tank. This pressure relieving system should consist of:

.1 one or more relief valves set at a pressure corresponding to the gauge vapour pressure of the cargo at the reference temperature defined in 15.1.4.2; and

.2 an over-ride arrangement, whenever necessary, to prevent its normal operation. This arrangement should include fusible elements designed to melt at temperatures between 98°C and 104°C and to cause relief valves specified in 8.3.1.1 to become operable. The fusible elements should be located, in particular, in the vicinity of relief valves. The system should become operable upon loss of system power if provided. The over-ride arrangement should not be dependent on any source of ship's power.

8.3.2 The total relieving capacity of the additional pressure relieving system at the pressure mentioned in 8.3.1.1 should not be less than:

$$Q' = FG'A^{0.82} \quad (m^3/s)$$

where:

Q' = minimum required rate of discharge of air at standard conditions of 273 K and 1.013 bar.

$$G' = \frac{12.4}{(L + \rho_r m)D} \sqrt{\frac{Z.T'}{M}}$$

with:

ρ_r = relative density of liquid phase of product at relieving conditions (ρ_r= 1.0 for fresh water);

m = $-di/d\rho_r$ = gradient of decrease of liquid phase enthalpy against increase of liquid phase density (kJ/kg) at relieving conditions. For set pressures not higher than 2.0 bar the values in table 8.1 may be used. For products not listed in the table and for higher set pressures, the value of m should be calculated on the basis of the thermodynamic data of the product itself;

i = enthalpy of liquid (kJ/kg);

T'= temperature in Kelvin (K) at the relieving conditions, i.e. at the pressure at which the additional pressure relieving system is set;

F, A, L, D, Z and M are defined in 8.5.2.

8.3.3 Compliance with sub-paragraph 8.3.1.1 requires changing of the setting of the relief valves provided for in this section. This should be accomplished in accordance with the provisions of 8.2.6 and 8.2.7.

8.3.4 Relief valves mentioned under 8.3.1.1 above may be the same as the pressure relief valves mentioned in 8.2, provided the setting pressure and the relieving capacity are in compliance with the requirements of this section.

8.3.5 The exhaust of such pressure relief valves may be led to the venting system referred to in 8.2.9. If separate venting arrangements are fitted these should be in accordance with the requirements of 8.2.9 to 8.2.15.

TABLE 8.1 - FACTOR m

Product	$m = -di/d\rho_r$ (kJ/kg)
Ammonia, anhydrous	3400
Butadiene	1800
Butane	2000
Butylenes	1900
Ethane	2100
Ethylene	1500
Methane	2300
Methyl chloride	816
Nitrogen	400
Propane	2000
Propylene	1600
Propylene oxide	1550
Vinyl chloride	900

The values in this table may be used for set pressures not higher than 2.0 bar.

8.4 Vacuum protection systems

8.4.1 Cargo tanks designed to withstand a maximum external pressure differential exceeding 0.25 bar and capable of withstanding the maximum external pressure differential which can be attained at maximum discharge rates with no vapour return into the cargo tanks, or by operation of a cargo refrigeration system, need no vacuum relief protection.

8.4.2 Cargo tanks designed to withstand a maximum external pressure differential not exceeding 0.25 bar, or tanks which cannot withstand the maximum external pressure differential that can be attained at maximum discharge rates with no vapour return into the cargo tanks, or by operation of a cargo refrigeration system, or by sending boil-off vapour to the machinery spaces, should be fitted with:

.1 two independent pressure switches to sequentially alarm and subsequently stop all suction of cargo liquid or vapour from the cargo tank, and refrigeration equipment if fitted, by suitable means at a pressure sufficiently below the maximum external designed pressure differential of the cargo tank; or

.2 vacuum relief valves with a gas flow capacity at least equal to the maximum cargo discharge rate per cargo tank, set to open at a pressure sufficiently below the external design differential pressure of the cargo tank; or

.3 other vacuum relief systems acceptable to the Administration.

8.4.3 Subject to the requirements of Chapter 17, the vacuum relief valves should admit an inert gas, cargo vapour or air to the cargo tank and should be arranged to minimize the possibility of the entrance of water or snow. If cargo vapour is admitted, it should be from a source other than the cargo vapour lines.

8.4.4 The vacuum protection system should be capable of being tested to ensure that it operates at the prescribed pressure.

8.5 <u>Size of valves</u>

Pressure relief valves should have a combined relieving capacity for each cargo tank to discharge the greater of the following with not more than a 20 per cent 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 vapours generated under fire exposure computed using the following formula:

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

where:

Q = minimum required rate of discharge of air at standard conditions of 273 K and 1.013 bar.

F = fire exposure factor for different cargo tank types:

F = 1.0 for tanks without insulation located on deck;

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

F = 0.5 for uninsulated independent tanks installed in holds;

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

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

F = 0.1 for membrane and semi-membrane tanks.

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

G = gas factor

$$G = \frac{12.4}{LD}\sqrt{\frac{Z.T}{M}}$$

with:

T = temperature in Kelvin (K) at the relieving conditions, i.e. 120 per cent of the pressure at which the pressure relief valve is set.

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

D = constant based on relation of specific heats k, shown in table 8.2; if k is not known, D = 0.606 should be used. The constant D may also be calculated by the following formula:

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

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

M = molecular mass of the product

A = external surface area of the tank in (m^2) for different tank types:

for body of revolution type tanks:

A = external surface area;

for other than bodies of revolution type tanks:

A = external surface area less the projected bottom surface area;

for tanks consisting of an array of pressure vessel tanks:

- insulation on the ship's structure:

  A = external surface area of the hold less its projected area;

- insulation on the tank structure:

  A = external surface area of the array of pressure vessels excluding insulation, less the projected bottom area as shown in figure 8.1.

TABLE 8.2 - CONSTANT D

k	D	k	D
1.00	0.606	1.52	0.704
1.02	0.611	1.54	0.707
1.04	0.615	1.56	0.710
1.06	0.620	1.58	0.713
1.08	0.624	1.60	0.716
1.10	0.628	1.62	0.719
1.12	0.633	1.64	0.722
1.14	0.637	1.66	0.725
1.16	0.641	1.68	0.728
1.18	0.645	1.70	0.731
1.20	0.649	1.72	0.734
1.22	0.652	1.74	0.736
1.24	0.656	1.76	0.739
1.26	0.660	1.78	0.742
1.28	0.664	1.80	0.745
1.30	0.667	1.82	0.747
1.32	0.671	1.84	0.750
1.34	0.674	1.86	0.752
1.36	0.677	1.88	0.755
1.38	0.681	1.90	0.758
1.40	0.685	1.92	0.760
1.42	0.688	1.94	0.763
1.44	0.691	1.96	0.765
1.46	0.695	1.98	0.767
1.48	0.698	2.00	0.770
1.50	0.701	2.02	0.772
		2.20	0.792

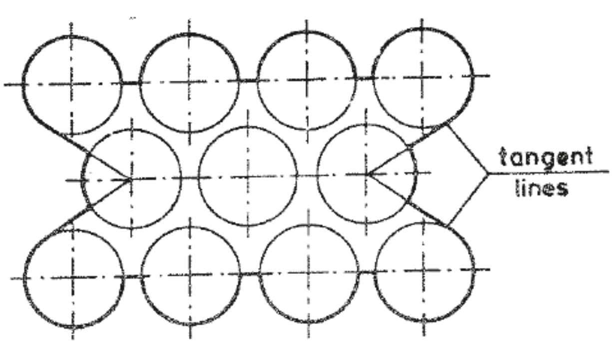


Figure 8.1

CHAPTER 9 - ENVIRONMENTAL CONTROL

9.1 Environmental control within cargo tanks and cargo piping systems

9.1.1 A piping system should 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 should 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 should be provided for each cargo tank in order to adequately monitor the progress of purging and gas-freeing. Gas sampling connexions should be valved and capped above the main deck.

9.1.3 For flammable gases, the system should 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 should enable the cargo tank to be purged with an inerting medium prior to filling with cargo vapour or liquid, without permitting a flammable mixture to exist at any time within the cargo tank.

9.1.4 Piping systems which may contain cargo should 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 ashore or from the ship.

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

9.2.1 Inter-barrier and hold spaces associated with cargo containment systems for flammable gases requiring full secondary barriers should be inerted with a suitable dry inert gas and kept inerted with make-up gas provided by a shipboard inert gas generation system, or by shipboard storage which should be sufficient for normal consumption for at least thirty days.

9.2.2.1 Inter-barrier and hold spaces associated with cargo containment systems for flammable gases requiring partial secondary barriers should 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 should be sufficient for normal consumption for at least thirty days; alternatively

9.2.2.2 Subject to the restrictions specified in Chapter 17, the Administration may allow the spaces referred to in 9.2.2.1 to be filled with dry air provided that the ship maintains a stored charge of inert gas or is fitted with an inert gas generation system sufficient to inert the largest of these spaces; and provided that the configuration of the spaces and the relevant vapour detection systems, together with the capability of the inerting arrangements, ensure any leakage from the cargo tanks will be rapidly detected and inerting effected before a dangerous condition can develop. Equipment for the provision of sufficient dry air of suitable quality to satisfy the expected demand should be provided.

9.2.3 For non-flammable gases, the spaces referred to in 9.2.1 and 9.2.2 may be maintained with a suitable dry air or inert atmosphere.

9.2.4 In case of internal insulation tanks, environmental control arrangements are not required for inter-barrier spaces and spaces between the secondary barrier and the inner hull or independent tank structures completely filled with insulation materials complying with 4.9.7.2.

9.3 Environmental control of spaces surrounding type C independent tanks

Spaces surrounding refrigerated cargo tanks not having secondary barriers should be filled with suitable dry inert gas or dry air and be maintained in this condition with make-up inert gas provided by a shipboard inert gas generation system, shipboard storage of inert gas, or dry air provided by suitable air drying equipment.

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 should 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 should be taken into consideration.

9.4.2 Where inert gas is also stored for fire-fighting purposes, it should be carried in separate containers and should not 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 should 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 should be provided to prevent the back flow of cargo vapour into the inert gas system.

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

9.5 Inert gas production on board

9.5.1 The equipment should be capable of producing inert gas with an oxygen content at no time greater than 5 per cent by volume subject to the special requirements of Chapter 17. A continuous reading oxygen content meter should be fitted to the inert gas supply from the equipment and should be fitted with an alarm set at a maximum of 5 per cent oxygen content by volume subject to the requirements of Chapter 17. Additionally, where inert gas is made by an onboard 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 should be monitored for traces of oxygen to avoid possible initial high oxygen enrichment of the gas when released for inerting purposes.

9.5.2 An inert gas system should have pressure controls and monitoring arrangements appropriate to the cargo containment system. A means acceptable to the Administration, located in the cargo area, of preventing the back flow of cargo gas should be provided.

9.5.3 Spaces containing inert gas generating plants should 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 tank area, two non-return valves, or equivalent devices should be fitted in the inert gas main in the cargo area as required in 9.5.2. Inert gas piping should not pass through accommodation spaces, service spaces or control stations.

9.5.4 Flame burning equipment for generating inert gas should not 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 Inert gas production on board

9.5.1 The equipment should be capable of producing inert gas with an oxygen content at no time greater than 5 per cent by volume subject to the special requirements of Chapter 17. A continuous reading oxygen content meter should be fitted to the inert gas supply from the equipment and should be fitted with an alarm set at a maximum of 5 per cent oxygen content by volume subject to the requirements of Chapter 17. Additionally, where inert gas is made by an onboard 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 should be monitored for traces of oxygen to avoid possible initial high oxygen enrichment of the gas when released for inerting purposes.

9.5.2 An inert gas system should have pressure controls and monitoring arrangements appropriate to the cargo containment system. A means acceptable to the Administration, located in the cargo area, of preventing the back flow of cargo gas should be provided.

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

10.2.1 Gas dangerous spaces and zones, general

Intrinsically safe electrical equipment and wiring may be fitted in all gas-dangerous spaces and zones as defined in 1.3.17.

10.2.2 Cargo containment systems

Submerged cargo pump motors and their supply cables may be fitted in cargo containment systems. Arrangements should be made to automatically shut down the motors in the event of low liquid level. This may be accomplished by sensing low pump discharge pressure, low motor current, or low liquid level. This shut-down should be alarmed at the cargo control station. Cargo pump motors should be capable of being isolated from their electrical supply during gas-freeing operations.

10.2.3 Hold spaces and certain other spaces

10.2.3.1 In hold spaces where cargo is carried in a cargo containment system requiring a secondary barrier, supply cables for submerged cargo pump motors may be installed.

10.2.3.2 In hold spaces where cargo is carried in a cargo containment system not requiring a secondary barrier and in spaces described in 1.3.17.5, the following may be installed:

.1 through runs of cables;

.2 lighting fittings with pressurized enclosures or of the flame-proof type. The lighting system should be divided between at least two branch circuits. All switches and protective devices should interrupt all poles or phases and be located in a gas-safe space; and

.3 electrical depth sounding or log devices and impressed current cathodic protection system anodes or electrodes. These devices should be housed in gas-tight enclosures;

and only in spaces described in 1.3.17.5:

.4 flame-proof motors for valve operation for cargo or ballast systems; and

.5 flame-proof general alarm audible indicators.

10.2.4 Cargo pump and cargo compressor rooms

10.2.4.1 Lighting fittings should have pressurized enclosures or should be of the flame-proof type. The lighting system should be divided between at least two branch circuits. All switches and protective devices should interrupt all poles or phases and be located in a gas-safe space.

10.2.4.2 Electrical motors for driving cargo pumps or cargo compressors should be separated from these spaces by a gas-tight bulkhead or deck. Flexible couplings or other means of maintaining alignment should be fitted to the shafts between the driven equipment and its motors and, in addition, suitable glands should be provided where the shafts pass through the gas-tight bulkhead or deck. Such electric motors and associated equipment should be located in a compartment complying with Chapter 12.

10.2.4.3 Where operational or structural requirements are such as to make it impossible to comply with the method described in 10.2.4.2, motors of the following certified safe types may be installed:

.1 increased safety type with flame-proof enclosure; and

.2 pressurized type.

10.2.4.4 General alarm audible indicators should have flame-proof enclosures.

10.2.5 Zones on open decks, spaces other than hold spaces

10.2.5.1 In zones on open decks or non-enclosed spaces on open deck, within 3 m of any cargo tank outlet, gas or vapour outlet, cargo pipe flange, cargo valves or entrances and ventilation openings to cargo pump rooms and cargo compressor rooms; in 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; in zones within 2.4 m of the outer surface of a cargo containment system where such surface is exposed to the weather the following may be installed:

.1 certified safe type equipment; and

.2 through runs of cables.

10.2.5.2 In enclosed or semi-enclosed spaces in which pipes containing cargo products are located and in compartments for cargo hoses the following may be installed:

.1 lighting fittings with pressurized enclosures, or of the flame-proof type. The lighting system should be divided between at least two branch circuits. All switches and protective devices should interrupt all poles or phases and be located in a gas-safe space; and

.2 through runs of cables.

10.2.5.3 In enclosed or semi-enclosed spaces having a direct opening into any gas-dangerous space or zone there should be installed electrical installations complying with the requirements for the space or zone to which the opening leads.

10.2.5.4 Electrical equipment within spaces protected by air-locks should be of the certified safe type unless arranged to be de-energized by measures required by 3.6.4.

CHAPTER 11 - FIRE PROTECTION AND FIRE EXTINCTION

11.1 Fire safety requirements

11.1.1 The requirements for tankers in Chapter II-2 of the 1981 SOLAS Amendments should apply to ships covered by the Code, irrespective of tonnage including ships of less than 500 gross tonnage, except that:

.1 Regulation 56.4 does not apply;

.2 Regulation 4 as applicable to cargo ships and Regulation 7 should apply as they would apply to tankers of 2,000 gross tonnage and over;

.3 The following Regulations of Chapter II-2 of the 1981 SOLAS Amendments related to tankers do not apply and are replaced by chapters and sections of the Code as detailed below:

Regulation	Replaced by
17	11.6
56.1 and 56.2	Chapter 3
60, 61, 62	11.3 and 11.4
63	11.5

11.1.2 All sources of ignition should 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 should be included in the cargo area.

11.2 <u>Fire water main equipment</u>

11.2.1 All ships, irrespective of size, carrying products which are subject to this Code should comply with the requirements of Regulations II-2/4 and II-2/7 of the 1981 SOLAS Amendments, except that the required fire pump capacity and fire main and water service pipe diameter should not be limited by the provisions of Regulations 4.2.1 and 4.4.1 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 4.4.2 should be met at a pressure of at least 5.0 bar.

11.2.2 The arrangements should 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 should be located to satisfy the above arrangements and to comply with the requirements of Regulations II-2/4.5.1 and II-2/4.8 of the 1981 SOLAS Amendments, with hose lengths not exceeding 33 m.

11.2.3 Stop valves should be fitted in any cross-over 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 should 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 should be resistant to corrosion by sea-water, for which purpose galvanized pipe, for example, may be used, and to the effect of fire.

11.2.5 Where the ship's engine room is unattended, arrangements should 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 On ships carrying flammable or toxic products or both, a water spray system for cooling, fire prevention and crew protection should be installed to cover:

.1 exposed cargo tank domes and any exposed parts of cargo tanks;

.2 exposed on-deck storage vessels for flammable or toxic products;

.3 cargo liquid 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 should be at least equal to the area of the drip trays provided; and

.4 boundaries of superstructures and deckhouses normally manned, cargo compressor rooms, cargo pump 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.

11.3.2 The system should be capable of covering all areas mentioned in 11.3.1 with a uniformly distributed water spray of at least 10 ℓ/m^2 per minute for horizontal projected surfaces and 4 ℓ/m^2 per minute for vertical surfaces. For structures having no clearly defined horizontal or vertical surfaces, the capacity of the water spray system should be the greater of the following:

.1 projected horizontal surface multiplied by 10 ℓ/m^2 per minute; or

.2 actual surface multiplied by 4 ℓ/m^2 per minute.

On vertical surfaces, spacing of nozzles protecting lower areas may take account of anticipated rundown from higher areas. Stop valves should 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, after of the cargo area. A section protecting any area included in 11.3.1.1 and .2 should cover the whole of the athwartship tank grouping which includes that area.

11.3.3 The capacity of the water spray pumps should 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 should 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 connexion, through a stop valve, should be made between the fire main and water spray main outside the cargo area.

11.3.4 Subject to the approval of the Administration, 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 should be resistant to corrosion by sea-water, for which purpose galvanized pipe, for example, may be used, and to the effect of fire.

11.4 Dry chemical powder fire extinguishing systems

11.4.1 Ships in which the carriage of flammable products is intended should 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 should be adequate for this purpose and satisfactory to the Administration.

11.4.2 The system should 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 should be activated by an inert gas such as nitrogen, used exclusively for this purpose and stored in pressure vessels adjacent to the powder containers.

11.4.3 The system for use in the cargo area should 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 the Administration may permit only one such unit to be fitted. A monitor should 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 should be capable of actuation at the hose storage reel or monitor. At least one hand hose line or monitor should be situated at the after end of the cargo area.

11.4.4 A fire extinguishing unit having two or more monitors, hand hose lines, or combinations thereof, should 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 Administration. Where two or more pipes are attached to a unit the arrangement should be such that any or all of the monitors and hand hose lines should be capable of simultaneous or sequential operation at their rated capacities.

11.4.5 The capacity of a monitor should be not less than 10 kg/s. Hand hose lines should 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 should be such as to allow operation by one man. The length of a hand hose line should not exceed 33 m. Where fixed piping is provided between the powder container and a hand hose line or monitor, the length of piping should not 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 should 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 should 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 should be in accordance with the following requirements:

Capacity of fixed monitors (kg/s) each	10	25	45
Maximum distance of coverage (m)	10	30	40

Hand hose lines should be considered to have a maximum effective distance of coverage equal to the length of hose. Special consideration should 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 should 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 to 11.4.6. This additional unit should 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 should be protected by hand hose lines.

11.5 Gas-dangerous enclosed spaces

11.5.1 Enclosed spaces normally entered where flammable liquid or vapour leakage may occur, such as cargo compressor and pump rooms, should be provided with a fixed installation which is capable of extinguishing a fire within the space. Additionally, this system or another fixed system should be capable of inerting the space following a fire to ensure that the fire does not recur. For purposes of design, the boundaries of the space should be assumed to remain intact. Carbon dioxide and steam smothering system should be avoided unless due consideration is given to the danger of static electricity.

11.5.2 Provision should be made for closure of ventilation and any other openings into the space and, where necessary, for an audible warning signal to be sounded within the space for the emergency escape of personnel before admission of the inerting/extinguishing medium.

11.6 Firemen's outfits

11.6.1 Every ship carrying flammable products should carry firemen's outfits complying with the requirements of Regulation II-2/17 of the 1981 SOLAS Amendments as follows:

Total cargo capacity	Number of outfits
below 2,000 m^3	2
between 2,000 m^3 and 5,000 m^3	4
above 5,000 m^3	5

11.6.2 Additional requirements for safety equipment are given in Chapter 14.

11.6.3 Any breathing apparatus required as part of a fireman's outfit should be a self-contained air-breathing apparatus having a capacity of at least 1,200 ℓ of free air.

CHAPTER 12 - MECHANICAL VENTILATION IN CARGO AREA

The requirements of this Chapter replace Regulation II-2/59.3 of the 1981 SOLAS Amendments.

12.1 Spaces required to be entered during normal cargo handling operations

12.1.1 Electric motor rooms, cargo compressor and pump rooms, other enclosed spaces which contain cargo handling equipment and similar spaces in which cargo handling operations are performed should be fitted with mechanical ventilation systems capable of being controlled from outside such spaces. Provision should 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 should be placed outside the compartment.

12.1.2 Mechanical ventilation inlets and outlets should 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 should the ventilation system 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 8 changes of air per hour.

12.1.3 Ventilation systems should 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 pumps, 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 should be of the positive pressure type.

12.1.5 In cargo compressor and pump rooms and in cargo control rooms if considered gas-dangerous, the ventilation should be of the negative pressure type.

12.1.6 Ventilation exhaust ducts from gas-dangerous spaces should 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.

12.1.7 Ventilation intakes should be so arranged as to minimize the possibility of re-cycling hazardous vapours from any ventilation discharge opening.

12.1.8 Ventilation ducts from gas-dangerous spaces should not be led through accommodation, service and machinery spaces or control stations, except as allowed in Chapter 16.

12.1.9 Electric motors driving fans should be placed outside the ventilation ducts if the carriage of flammable products is intended. Ventilation fans should not produce a source of vapour ignition in either the ventilated space or the ventilation system associated with the space. Ventilation fans and fan ducts, in way of fans only, for gas-dangerous spaces should be of non-sparking construction defined as:

.1 impellers or housing of non-metallic construction, due regard being paid to the elimination of static electricity;

.2 impellers and housing of non-ferrous materials;

.3 impellers and housing of austenitic (stainless steel); and

.4 ferrous impellers and housing with not less than 13 mm design tip clearance.

Any combination of an aluminium or magnesium alloy fixed or rotating component and a ferrous fixed or rotating component, regardless of tip clearance, is considered a sparking hazard and should not be used in these places.

12.1.10 Spare parts should 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 should be fitted in outside openings of ventilation ducts.

12.2 <u>Spaces not normally entered</u>

Hold spaces, inter-barrier spaces, void spaces, cofferdams, spaces containing cargo piping and other spaces where cargo vapours may accumulate, should 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 should be provided. Where necessary owing to the arrangement of spaces, such as hold spaces and inter-barrier spaces, essential ducting for such ventilation should be permanently installed. Fans or blowers should be clear of personnel access openings, and should comply with 12.1.9.

CHAPTER 13 - INSTRUMENTATION (GAUGING, GAS DETECTION)

13.1 General

13.1.1 Each cargo tank should be provided with means for indicating level, pressure and temperature of the cargo. Pressure gauges and temperature indicating devices should be installed in the liquid and vapour piping systems, in cargo refrigerating installations and in the inert gas systems as detailed in this chapter.

13.1.2 Where a secondary barrier is required, permanently intalled instrumentation should be provided to detect when the primary barrier fails to be liquid-tight at any location or when liquid cargo is in contact with the secondary barrier at any location. This instrumentation should consist of appropriate gas detecting devices according to 13.6. However, the instrumentation need not be capable of locating the area where liquid cargo leaks through the primary barrier or where liquid cargo is in contact with the secondary barrier.

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 should be concentrated in one control position.

13.1.4 Instruments should be tested to ensure reliability in the working conditions and recalibrated at regular intervals. Test procedures for instruments and the intervals between recalibration should be approved by the Administration.

13.2 Level indicators for cargo tanks

13.2.1 Each cargo tank should be fitted with at least one liquid 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 liquid level gauge is fitted it should be so arranged that any necessary maintenance can be carried out while the cargo tank is in service.

13.2.2 Cargo tank liquid level gauges may be of the following types subject to any special requirement for particular cargoes shown in column "g" in the table of Chapter 19:

.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 should be provided with a shut-off 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 liquid to escape to the atmosphere, such as fixed tube and slip tube gauges. When not in use, the devices should be kept completely closed. The design and installation should ensure that no dangerous escape of cargo can take place when opening the device. Such gauging devices should 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 Sighting ports with a suitable protective cover and situated above the liquid level with an internal scale may be allowed by the Administration as a secondary means of gauging for cargo tanks having a design vapour pressure not higher than 0.7 bar.

13.2.4 Tubular gauge glasses should not be fitted. Gauge glasses of the robust type as fitted on high pressure boilers and fitted with excess flow valves may be allowed by the Administration for deck tanks, subject to any provisions of Chapter 17.

13.3 Overflow control

13.3.1 Except as provided in 13.3.2, each cargo tank should be fitted with a high liquid level alarm operating independently of other liquid level indicators and giving an audible and visual warning when activated. Another sensor operating independently of the high liquid level alarm should automatically actuate a shut-off valve in a manner which will both avoid excessive liquid pressure in the loading line and prevent the tank from becoming liquid full. The emergency shut-down valve referred to in 5.6.4 may be used for this purpose. If another valve is used for this purpose, the same information as referred to in 5.6.4 should be available on board. During loading, whenever the use of these valves may possibly create a potential excess pressure surge in the loading system, the Administration and the Port Administration may agree to alternative arrangements such as limiting the loading rate, etc.

13.3.2 Unless required otherwise in Chapter 17, a high liquid level alarm and automatic shut-off of cargo tank filling need not be required when the cargo tank:

.1 is a pressure tank with a volume not more than 200 m^3; or

.2 is designed to withstand the maximum possible pressure during the loading operation and such pressure is below that of the start-to-discharge pressure of the cargo tank relief valve.

13.3.3 Electrical circuits, if any of level alarms should be capable of being tested prior to loading.

13.4 Pressure gauges

13.4.1 The vapour space of each cargo tank should be provided with a pressure gauge which should 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, should be provided on the navigating bridge. Maximum and minimum allowable pressures should be marked on the indicators. The alarms should be activated before the set pressures are reached. For cargo tanks fitted with pressure relief valves, which can be set at more than one set pressure in accordance with 8.2.6, high pressure alarms should be provided for each set pressure.

13.4.2 Each cargo pump discharge line and each liquid and vapour cargo manifold should be provided with at least one pressure gauge.

13.4.3 Local reading manifold pressure gauges should be provided to indicate the pressure between stop valves and hose connexions to the shore.

13.4.4 Hold spaces and inter-barrier spaces without open connexion to the atmosphere should be provided with pressure gauges.

13.5 Temperature indicating devices

13.5.1 Each cargo tank should be provided with at least two devices for indicating cargo temperatures, one placed at the bottom of the cargo tank and the second near the top of the tank, below the highest allowable liquid level. The temperature indicating devices should be marked to show the lowest temperature for which the cargo tank has been approved by the Administration.

13.5.2 When a cargo is carried in a cargo containment system with a secondary barrier at a temperature lower than −55°C, temperature indicating devices should be provided within the insulation or on the hull structure adjacent to cargo containment systems. The devices should give readings at regular intervals and, where applicable, audible warning of temperatures approaching the lowest for which the hull steel is suitable.

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, should 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 sub-paragraph.

13.5.4 The number and position of temperature indicating devices should be to the satisfaction of the Administration.

13.6 <u>Gas detection requirements</u>

13.6.1 Gas detection equipment acceptable to the Administration and suitable for the gases to be carried should be provided in accordance with column "f" in the table of Chapter 19.

13.6.2 In every installation, the positions of fixed sampling heads should 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.

13.6.3 Pipe runs from sampling heads should not be led though 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, should 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 located in a gas-safe space the following conditions should be met:

.1 gas-sampling lines should have shut-off valves or an equivalent arrangement to prevent cross-communication with gas-dangerous spaces; and

.2 exhaust gas from the detector should be discharged to the atmosphere in a safe location.

13.6.6 Gas detection equipment should be so designed that it may readily be tested. Testing and calibration should be carried out at regular intervals. Suitable equipment and span gas for this purpose should be carried on board. Where practicable, permanent connexions for such equipment should be fitted.

13.6.7 A permanently installed system of gas detection and audible and visual alarms should be provided for:

.1 cargo pump 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 and inter-barrier spaces for independent tanks other than type C;

.6 ventilation hoods and gas ducts where required by Chapter 16; and

.7 air-locks.

13.6.8 The gas detection equipment should 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 should be continuous. Common sampling lines to the detection equipment should not be fitted.

13.6.9 In the case of products which are toxic or both toxic and flammable, the Administration, except when column "h" in the table of Chapter 19 refers to 17.9, may authorize the use of portable equipment for detection of toxic products as an alternative to a permanently installed system, if such equipment is used before personnel enter the spaces listed in 13.6.7 and at 30 minute intervals while they remain therein.

13.6.10 For the spaces listed in 13.6.7, alarms should be activated for flammable products when the vapour concentration reaches 30 per cent of the lower flammable limit.

13.6.11 In the case of flammable products, where cargo containment systems other than independent tanks are used, hold spaces and inter-barrier spaces should be provided with a permanently installed gas detection system capable of measuring gas concentrations of 0 to 100 per cent by volume. The detection equipment, equipped with audible and visual alarms, should be capable of sampling and detecting from each sampling head sequentially at intervals not exceeding 30 minutes. Alarms should be activated when the vapour concentration reaches the equivalent of 30 per cent of the lower flammable limit in air or such other limit as may be approved by the Administration in the light of particular cargo containment arrangements. Common sampling lines to the detection equipment should not be fitted.

13.6.12 In the case of toxic gases, hold spaces and inter-barrier spaces should be provided with a permanently installed piping system for obtaining gas samples from the spaces. Gas from these spaces should be sampled and analysed from each sampling head location by means of fixed or portable equipment at intervals not exceeding 4 hours and in any event before personnel enter the space and at 30 minute intervals while they remain therein.

13.6.13 Every ship should be provided with at least two sets of portable gas detection equipment acceptable to the Administration and suitable for the products to be carried.

13.6.14 A suitable instrument for the measurement of oxygen levels in inert atmospheres should be provided.

CHAPTER 14 - PERSONNEL PROTECTION

14.1 Protective equipment

For protection of crew members engaged in loading and discharging operations, suitable protective equipment including eye protection should be provided, taking into account the character of the products.

14.2 Safety equipment

14.2.1 Sufficient, but not less than two complete sets of safety equipment in addition to the firemen's outfits required by 11.6.1 each permitting personnel to enter and work in a gas-filled space, should be provided.

14.2.2 One complete set of safety equipment should consist of:

.1 one self-contained air-breathing apparatus not using stored oxygen, having a capacity of at least 1,200 ℓ of free air;

.2 protective clothing, boots, gloves and tight-fitting goggles;

.3 steel-cored rescue line with belt; and

.4 explosion-proof lamp.

14.2.3 An adequate supply of compressed air should be provided and should consist either of:

.1 one set of fully charged air-bottles for each breathing apparatus required by 14.2.1;

a special air compressor suitable for the supply of high pressure air of the required purity, and

a charging manifold capable of dealing with sufficient spare breathing apparatus cylinders for the breathing apparatus required by 14.2.1; or

.2 fully charged spare air-bottles with a total free air capacity of at least 6,000 ℓ for each breathing apparatus required by 14.2.1.

14.2.4 Alternatively, the Administration may accept a low pressure air line system with hose connexion suitable for use with the breathing apparatus required by 14.2.1. This system should provide sufficient high pressure air capacity to supply, through pressure reduction devices, enough low pressure air to enable two men to work in a gas-dangerous space for at least one hour without using the cylinders of the breathing apparatus. Means should be provided for recharging the fixed air-bottles and the breathing apparatus cylinders from a special air compressor suitable for the supply of high pressure air of the required purity.

14.2.5 Protective equipment required in 14.1 and safety equipment required in 14.2.1 should be kept in suitable, clearly marked lockers located in readily accessible places.

14.2.6 The compressed air equipment should be inspected at least once a month by a responsible officer and the inspection recorded in the ship's log book, and inspected and tested by an expert at least once a year.

14.3 First aid equipment

14.3.1 A stretcher which is suitable for hoisting an injured person from spaces below deck should be kept in a readily accessible location.

14.3.2 Medical first aid equipment including oxygen resuscitation equipment and antidotes, if available, for products carried should be provided on board.

14.4 Personal protection requirements for individual products

14.4.1 Provisions of 14.4 are applicable to ships carrying products for which those paragraphs are listed in column "h" in the table of Chapter 19.

14.4.2 Respiratory and eye protection suitable for emergency escape purposes should be provided for every person on board subject to the following:

.1.1 filter type respiratory protection should be accepted, only when one filter is suitable for all designated cargoes that the ship is certified to carry;

.1.2 self-contained breathing apparatus should normally have a duration of service of at least 15 minutes;

.2 emergency escape respiratory protection should not be used for fire-fighting or cargo handling purposes and should be marked to that effect;

.3 two additional sets of the above respiratory and eye protection should be permanently located in the navigating bridge.

14.4.3 Suitably marked decontamination showers and an eye wash should be available on deck in convenient locations.

14.4.4 In ships of a cargo capacity of 2,000 m^3 and over two complete sets of safety equipment should be provided in addition to the equipment required by 11.6.1 and 14.2.1. At least three spare charged airbottles should be provided for each self-contained air-breathing apparatus required in this paragraph.

14.4.5 Personnel should be protected against the effects of a major cargo release by the provision of a space within the accommodation area designed and equipped to the satisfaction of the Administration.

14.4.6 For certain highly dangerous products, cargo control rooms should be of the gas-safe type only.

CHAPTER 15 - FILLING LIMITS FOR CARGO TANKS

15.1 General

15.1.1 No cargo tanks should be more than 98 per cent liquid full at the reference temperature, except as permitted by 15.1.3.

15.1.2 The maximum volume to which a cargo tank should be loaded is determined by the following formula:

$$V_L = 0.98\, V \frac{\rho_R}{\rho_L}$$

where:

V_L = maximum volume to which the tank may be loaded

V = volume of the tank

ρ_R = relative density of cargo at the reference temperature

ρ_L = relative density of cargo at the loading temperature and pressure.

15.1.3 The Administration may allow a higher filling limit than the limit of 98 per cent specified in 15.1.1 and 15.1.2 at the reference temperature, taking into account the shape of the tank, arrangements of pressure relief valves, accuracy of level and temperature gauging and the difference between the loading temperature and the temperature corresponding to the vapour pressure of the cargo at the set pressure of the pressure relief valves, provided the conditions specified in 8.2.17 are maintained.

15.1.4 For the purpose of this chapter only, "reference temperature" means:

.1 the temperature corresponding to the vapour pressure of the cargo at the set pressure of the pressure relief valves 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. If this reference temperature would result in the cargo tank becoming liquid full before the cargo reaches a temperature corresponding to the vapour pressure of the cargo at the set pressure of the relief valves required in 8.2, an additional pressure relief valve complying with 8.3 should be fitted.

15.2 Information to be provided to the master

The maximum allowable tank filling limits for each cargo tank should be indicated for each product which may be carried, for each loading temperature which may be applied and for the applicable maximum reference temperature, on a list to be approved by the Administration. Pressures at which the pressure relief valves, including those valves required by 8.3, have been set should also be stated on the list. A copy of the list should be permanently kept on board by the master.

CHAPTER 16 - USE OF CARGO AS FUEL

16.1 General

16.1.1 Methane (LNG) is the only cargo whose vapour or boil-off gas may be utilized in main propelling machinery spaces and boiler rooms and in such spaces or rooms may be utilized only in boilers, inert gas generators, and combustion engines.

16.1.2 The provisions of this chapter do not preclude the use of vapour or boil-off gas for other services in other locations, such as cargo reliquefaction and inert gas generation, provided that such other services and locations are specially considered by the Administration.

16.2 Gas fuel supply

16.2.1 Gas fuel lines should not pass through accommodation spaces, service spaces or control stations. Gas lines may pass through or extend into other spaces provided they fulfil one of the following:

.1 the gas fuel line should be a double wall piping system with the gas fuel contained in the inner pipe. The space between the concentric pipes should be pressurized with inert gas at a pressure greater than the fuel pressure. Suitable alarms should be provided to indicate a loss of pressure between the pipes; or

.2 the gas fuel lines should be installed in a mechanically exhaust ventilated pipe or duct. The air space between the outer and inner walls of piping or ducts should be equipped with mechanical ventilation having a capacity of at least 30 air changes per hour. The ventilation system should be arranged to maintain a pressure less than the atmospheric pressure. The fan motors should be placed outside the ventilation pipe or duct. The ventilation outlet should be placed in a position where no flammable gas-air mixture may be ignited. The ventilation inlet should be so arranged that gas or gas-air mixture will not be drawn into the system. The ventilation should always be in operation when there is gas in the supply pipeline. Continuous gas detection should be provided to indicate leaks and to shut down the gas fuel supply to the machinery space in accordance with 16.2.9. The exhaust fan for this duct should be so arranged that the gas fuel supply to the machinery space will be cut off if the required air flow is not established and maintained.

16.2.2 If a gas leak occurs, the gas fuel supply should not be operated until the leak has been found and repaired. Instructions to this effect should be placed in a prominent position in the machinery space.

16.2.3 The double wall piping system or the ventilation duct provided for the gas fuel lines should terminate at the ventilation hood or casing required by 16.2.4.

16.2.4 A ventilation hood or casing should be provided for the areas occupied by flanges, valves, etc., and for the gas fuel piping at gas utilization units, such as boilers, diesel engines, gas turbines, which is not enclosed in the double wall piping system or ventilated duct. If this ventilation hood or casing is not served by the exhaust ventilation fan serving a duct as specified in 16.2.1.2, then it should be equipped with an exhaust ventilation system and continuous gas detection should be provided to indicate leaks and to shut down the gas fuel supply to the machinery space in accordance with 16.2.9. The exhaust fan should be so arranged that the gas fuel supply to the machinery space will be cut off if the exhaust ventilation is not functioning so as to produce the required air flow. The hood or casing should be installed or mounted to permit the ventilating air to sweep across the gas utilization unit and be exhausted at the top of the hood or casing.

16.2.5 Make-up air for the required ventilation air system and discharge of the air from the ventilation system should be taken from and led to a safe location.

16.2.6 Each gas utilization unit should be provided with a set of three automatic valves. Two of these valves should be in series in the gas fuel pipe to the consuming equipment. The other valve should 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 should be so arranged that failure of necessary forced draft, 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 cause the vent valve to open automatically. Alternatively, the function of one of the valves in series and of the valve in the vent line 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.

16.2.7 A master gas fuel valve that can be closed from within the machinery space should be provided outside the machinery space. The valve should be so arranged 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.

16.2.8 Provision should be made for inerting and gas-freeing that portion of the gas fuel piping system located in the machinery space.

16.2.9 Gas detection systems provided in accordance with the requirements of 16.2.1 and 16.2.4 should alarm at 30 per cent of the lower flammability limit and shut down the gas fuel supply to the machinery space before the gas concentration reaches 60 per cent of the lower flammability limit.

16.2.10 All details of the gas fuel system should be submitted to the Administration for approval.

CHAPTER 17 - SPECIAL REQUIREMENTS

17.1 General

The provisions of this chapter are applicable where reference is made in column "h" in the table of Chapter 19. These are requirements additional to the general requirements of the Code.

17.2 Materials of construction

Materials which may be exposed to cargo during normal operations should be resistant to the corrosive action of the gases. In addition, the following materials of construction for cargo tanks, and associated pipelines, valves, fittings and other items of equipment should not be used for certain products as specified in column "h" in the table of Chapter 19:

.1 mercury, copper and copper bearing alloys, and zinc;

.2 copper, silver, mercury, magnesium and other acetylide-forming metals;

.3 aluminium and aluminium bearing alloys;

.4 copper, copper alloys, zinc and galvanized steel;

.5 aluminium, copper and alloys of either;

.6 copper and copper bearing alloys with greater than one per cent copper.

17.3 Independent tanks

17.3.1 Products should be carried in independent tanks only.

17.3.2 Products should be carried in type C independent tanks and the provisions of 7.1.3 apply. The design pressure of the cargo tank should take into account any padding pressure or vapour discharge unloading pressure.

17.4 Refrigeration systems

17.4.1 Only the indirect system described in 7.2.4.2 should be used.

17.4.2 For ships engaged in the carriage of products which readily form dangerous peroxides, recondensed cargo should be allowed to form stagnant pockets of uninhibited liquid. This may be achieved either by:

.1 using the indirect system described in 7.2.4.2 with the condenser inside the cargo tank; or

.2 using the direct system or combined system described in 7.2.4.1 and .3 respectively, or the indirect system described in 7.2.4.2 with the condenser outside the cargo tank, and designing the condensate system to avoid any places in which liquid could collect and be retained. Where this is impossible inhibited liquid should be added upstream of such a place.

If the ship is to carry consecutive cargoes of such products with a ballast passage between, all uninhibited liquid should be removed prior to the ballast voyage. If a second cargo is to be carried between such consecutive cargoes the reliquefaction system should be thoroughly drained and purged before loading the second cargo. Purging should be carried out using either inert gas or vapour from the second cargo, if compatible. Practical steps should be taken to ensure that polymers or peroxides do not accumulate in the ship's system.

17.5 Deck cargo piping

One hundred per cent radiography of all butt welded joints in cargo piping exceeding 75 mm in diameter is required.

17.6 Exclusion of air from vapour spaces

Air should be removed from the cargo tanks and associated piping before loading and then subsequently excluded by:

.1 introducing inert gas to maintain a positive pressure. Storage or production capacity of the inert gas should be sufficient to meet normal operating requirements and relief valve leakage. The oxygen content of inert gas should at no time be greater than 0.2 per cent by volume; or

.2 control of cargo temperatures such that a positive pressure is maintained at all times.

17.7 Moisture control

For gases which are non-flammable and may become corrosive or react dangerously with water, moisture control should be provided to ensure that cargo tanks are dry before loading and that during discharge, dry air or cargo vapour is introduced to prevent negative pressures. For the purposes of this paragraph, dry air is air which has a dew point of $-45^{\circ}C$ or below at atmospheric pressure.

17.8 Inhibition

Care should be taken to ensure that the cargo is sufficiently inhibited to prevent polymerization at all times during the voyage. Ships should be provided with a certificate from the manufacturer stating:

.1 name and amount of inhibitor added;

.2 date inhibitor was added and the normally expected duration of its effectiveness;

.3 any temperature limitations affecting the inhibitor;

.4 the action to be taken should the length of the voyage exceed the effective life-time of the inhibitors.

17.9 Permanently installed toxic gas detectors

17.9.1 Gas sampling lines should not be led into or through gas-safe spaces. Alarms referred to in 13.6.7 should be activated when the vapour concentration reaches the threshold limiting value.

17.9.2 The alternative of using portable equipment in accordance with 13.6.9 should not be permitted.

17.10 Flame screens on vent outlets

Cargo tank vent outlets should be provided with readily renewable and effective flame screens or safety heads of an approved type when carrying a cargo referenced to this section. Due attention should be paid in the design of flame screens and vent heads to the possibility of the blockage of these devices by the freezing of cargo vapour or by icing up in adverse weather conditions. Ordinary protection screens should be fitted after removal of the flame screens.

17.11 Maximum allowable quantity of cargo per tank

When carrying a cargo referenced to this section, the quantity of the cargo should not exceed 3,000 m^3 in any one tank.

17.12 Submerged electric cargo pumps

The vapour space of cargo tanks equipped with submerged electric motor pumps should be inerted to a positive pressure prior to loading, during carriage and during unloading of flammable liquids.

17.13 Ammonia

Because high concentrations of ammonia in confined spaces can be flammable, the provisions of Chapter 10 for flammable products should be applied except in zones on the open deck. Liquid ammonia should never be sprayed into a tank containing air as there is a risk of creating a static electrical charge which could cause ignition. To minimize the risk of stress corrosion cracking occurring when ammonia is carried at a temperature above $-20^{\circ}C$ (vapour pressure 1.9 bar), the oxygen content of the vapour space in pressure vessels and in pipelines made of carbon-manganese steel (and other steels which require special consideration) should be reduced to the minimum practicable before liquid ammonia is introduced. The condensate system of tanks operating at $-33^{\circ}C$ may be affected unless they have been thermally stress relieved.

17.14 Chlorine

17.14.1 Cargo containment system

17.14.1.1 The capacity of each tank should not exceed 600 m^3 and the total capacity of all cargo tanks should not exceed 1,200 m^3.

17.14.1.2 The tank design vapour pressure should not be less than 13.5 bar (see also 7.1.3 and 17.3.2).

17.14.1.3 Parts of tanks protruding above the upper deck should be provided with protection against thermal radiation taking into account total engulfment by fire.

17.14.1.4 Each tank should be provided with two safety relief valves. A bursting disc of appropriate material should be installed between the tank and the safety relief valves. The rupture pressure of the bursting disc should be 1 bar lower than the opening pressure of the safety relief valve, which should be set at the design vapour pressure of the tank but not less than 13.5 bar. The space between the bursting disc and the relief valve should be connected through an excess flow valve to a pressure gauge and a gas detection system. Provision should be made to keep this space at or near the atmospheric pressure during normal operation.

17.14.1.5 Outlets from safety relief valves should be arranged in such a way as to minimize the hazards on board the ship as well as to the environment. Leakage from the relief valves should be led through the absorption plant to reduce the gas concentration as far as possible. The relief valve exhaust line should be arranged at the forward end of the ship to discharge outboard at deck level with an arrangement to select either port or starboard side, with a mechanical interlock to ensure that one line is always open.

17.14.1.6 The Administration and the port Administration may require that chlorine is carried in refrigerated state at a specified maximum pressure.

17.14.2 Cargo piping systems

17.14.2.1 Cargo discharge should be performed by means of compressed chlorine vapour from shore, dry air or another acceptable gas or fully submerged pumps. The pressure in the vapour space of the tank during discharging should not exceed 10.5 bar. Cargo discharge compressors on board ships should not be accepted by the Administration.

17.14.2.2 The design pressure of the cargo piping system should be not less than 21 bar. The internal diameter of the cargo pipes should not exceed 100 mm. Only pipe bends should be accepted for compensation of pipeline thermal movement. The use of flanged joints should be restricted to a minimum, and when used the flanges should be of the welding neck type with tongue and groove.

17.14.2.3 Relief valves of the cargo piping system should discharge to the absorption plant (see also 8.2.16).

17.14.3 Materials

17.14.3.1 The cargo tanks and cargo piping systems are to be made of steel suitable for the cargo and for a temperature of $-40^{\circ}C$, even if a higher transport temperature is intended to be used.

17.14.3.2 The tanks should be thermally stress relieved. Mechanical stress relief should not be accepted as an equivalent.

17.14.4 Instrumentation - safety devices

17.14.4.1 The ship should be provided with a chlorine absorbing plant with connexions to the cargo piping system and the cargo tanks. The absorbing plant should be capable of neutralizing at least two per cent of the total cargo capacity at a reasonable absorption rate.

17.14.4.2 During the gas-freeing of cargo tanks, vapours should not be discharged to the atmosphere.

17.14.4.3 A gas detecting system should be provided capable of monitoring chlorine concentrations of at least 1 ppm by volume. Suction points should be located:

.1 near the bottom of the cargo hold spaces;

.2 in the pipes from the safety relief valves;

.3 at the outlet from the gas absorbing plant;

.4 at the inlet to the ventilation systems for the accommodation, service and machinery spaces and control stations;

.5 on deck at the forward end, in the middle and at the after end of the cargo area. (Only required to be used during cargo handling and gas-freeing operations.)

The gas detection system should be provided with audible and visual alarm with a set point of 5 ppm.

17.14.4.4 Each cargo tank should be fitted with a high pressure alarm giving audible alarm at a pressure equal to 10.5 bar.

17.14.5 Personnel protection

In addition to the requirements given in Chapter 14 the following requirements should be met:

.1 The enclosed space required by 14.4.5 should be easily and quickly accessible from the open deck and from accommodation spaces and should be capable of being rapidly closed gas-tight. Access to this space from the deck and from the remainder of the accommodation spaces should be by means of an air-lock. The space should be so designed as to accommodate the entire crew of the ship and be provided with a source of uncontaminated air for a period of not less than four hours. One of the decontamination showers required by 14.4.3 should be located near the air-lock to the space.

.2 A compressor and the necessary equipment for filling the air-bottles should be provided.

.3 One set of oxygen therapy equipment should be carried in the space referred to in 17.14.5.1.

17.14.6 Filling limits for cargo tanks

17.14.6.1 The requirements of 15.1.4.2 do not apply when it is intended to carry chlorine.

17.14.6.2 The chlorine content of the gas in the vapour space of the cargo tank after loading should be greater than 80 per cent by volume.

17.15 Diethyl ether vinyl/ethyl ether

17.15.1 The cargo should be discharged only by deepwell pumps or by hydraulically operated submerged pumps. These pumps should be of a type designed to avoid liquid pressure against the shaft gland.

17.15.2 Inert gas displacement may be used for discharging cargo from type C independent tanks provided the cargo system is designed for the expected pressure.

17.16 Ethylene oxide

17.16.1 For the carriage of ethylene oxide the requirements of 17.20 apply analogously with the additions and modifications as given in this section.

17.16.2 Deck tanks should not be used for the carriage of ethylene oxide.

17.16.3 Stainless steels types 416 and 442 as well as cast iron should not be used in ethylene oxide cargo containment and piping systems.

17.16.4 Before loading, tanks should be thoroughly and effectively cleaned to remove all traces of previous cargoes from tanks and associated pipework, except where the immediate prior cargo has been ethylene oxide, propylene oxide or mixtures of these products. Particular care should be taken in the case of ammonia in mild steel tanks.

17.16.5 Ethylene oxide should be discharged only by deepwell pumps or inert gas displacement. The arrangement of pumps should comply with 17.20.6.3.

17.16.6 Ethylene oxide should be carried refrigerated only and maintained at temperatures of less than 30°C.

17.16.7 Pressure relief valves should be set at 5.5 bar gauge.

17.16.8 The protective padding of nitrogen gas as required by 17.20.16 should be such that the nitrogen concentration in the vapour space of the cargo tank will at no time be less than 45 per cent by volume.

17.16.9 Before loading and at all times when cargo tank contains ethylene oxide liquid or vapour, the cargo tank should be inerted with nitrogen.

17.16.10 The water spray system required by paragraph 17.20.18 and that required by 11.3 should operate automatically in a fire involving the cargo containment system.

17.16.11 A jettisoning arrangement should be provided to allow the emergency discharge of ethylene oxide in the event of uncontrollable self-reaction.

17.17 Isopropylamine, monoethylamine

Separate piping systems should be provided. Separate means that a cargo piping or cargo vent system, for example, is one that 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 should 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.

Operational methods should not be used within the cargo tanks.

17.18 Methyl acetylene-propadiene mixtures

17.18.1 Methyl acetylene-propadiene mixtures should be suitably stabilized for transport. Additionally, upper limits of temperature and pressure during the refrigeration should be specified for the mixtures.

17.18.2 Examples of acceptable, stabilized compositions are:

.1 Composition 1

.1.1 maximum methyl acetylene to propadiene molar ratio of 3 to 1;

.1.2 maximum combined concentration of methyl acetylene and propadiene of 65 mole per cent;

.1.3 minimum combined concentration of propane, butane, and isobutane of 24 mole per cent, of which at least one-third (on a molar basis) must be butanes and one-third propane; and

.1.4 maximum combined concentration of propylene and butadiene of 10 mole per cent.

.2 Composition 2

.2.1 maximum methyl acetylene and propadiene combined concentration of 30 mole per cent;

.2.2 maximum methyl acetylene concentration of 20 mole per cent;

.2.3 maximum propadiene concentration of 20 mole per cent;

.2.4 maximum propylene concentration of 45 mole per cent;

.2.5 maximum butadiene and butylenes combined concentration of 2 mole per cent;

.2.6 minimum saturated C_4 hydrocarbon concentration of 4 mole per cent; and

.2.7 minimum propane concentration of 25 mole per cent.

17.18.3 Other compositions may be accepted provided the stability of the mixture is demonstrated to the satisfaction of the Administration.

17.18.4 A ship carrying methyl acetylene-propadiene mixtures should preferably have an indirect refrigeration system as specified in 7.2.4.2. Alternatively, a ship not provided with indirect refrigeration may utilize direct vapour compression refrigeration subject to pressure and temperature limitations depending on the composition. For the example composition given in 17.18.4.2, the following features should be provided:

.1 A vapour compressor that does not raise the temperature and pressure of the vapour above 60°C and 17.5 bar gauge during its operation, and that does not allow vapour to stagnate in the compressor while it continues to run.

.2 Discharge piping from each compressor stage or each cylinder in the same stage of a reciprocating compressor should have:

.2.1 two temperature actuated shutdown switches set to operate at 60°C or less;

.2.2 a pressure actuated shutdown switch set to operate at 17.5 bar gauge or less; and

.2.3 a safety relief valve set to relieve at 18.0 bar gauge or less.

.3 The relief valve required by 17.18.4.2.3 should vent to a mast meeting the requirements of 8.2.9, 8.2.10, 8.2.13 and 8.2.14 and should not relieve into the compressor suction line.

.4 An alarm that sounds in the cargo control position and in the navigating bridge when a high pressure switch, or a high temperature switch operates.

17.18.5 The piping system, including the cargo refrigeration system, for tanks to be loaded with methyl acetylene-propadiene mixture should be completely separate from piping and refrigeration systems for other tanks. If the piping system for the tanks to be loaded with methyl acetylene-propadiene mixture is not independent, the required piping separation should be accomplished by the removal of spool pieces, valves or other pipe sections and the installation of blank flanges at these locations. The required separation applies to all liquid and vapour vent lines and any other possible connexions such as common inert gas supply lines.

17.19 Nitrogen

Materials of construction and ancillary equipment such as insulation should be resistant to the effects of high oxygen concentrations caused by condensation and enrichment at the low temperatures attained in parts of the cargo system. Due consideration should be given to ventilation in such areas where condensation might occur to avoid the stratification of oxygen enriched atmosphere.

17.20 Propylene oxide and mixtures of ethylene oxide/propylene oxide with ethylene oxide content of not more than 30 per cent by volume

17.20.1 Products transported under the provisions of this section should be acetylene free.

17.20.2 For the purposes of this section the term "independent" means that a piping system or venting systems, for example, is in no way connected to another system and that there are no means available for the potential connexion to other systems.

17.20.3.1 Unless cargo tanks are properly cleaned, these products should not be carried in tanks which have contained as one of the three previous cargoes any product known to catalyse polymerization, such as:

.1 ammonia, anhydrous and ammonia solutions;

.2 amines and amine solutions;

.3 oxidizing substances (e.g. chlorine).

17.20.3.2 Before loading, tanks should be thoroughly and effectively cleaned to remove all traces of previous cargoes from tanks and associated pipework, except where the immediate prior cargo has been propylene oxide or ethylene oxide/propylene oxide mixtures. Particular care should be taken in the case of ammonia in mild steel tanks.

17.20.3.3 In all cases, the effectiveness of cleaning procedures for tanks and associated pipework should be checked by suitable testing or inspection to ascertain that no traces of acidic or alkaline materials remain that might create a hazardous situation in the presence of these products.

17.20.3.4 Tanks should be entered and inspected prior to each initial loading of these products to ensure freedom from contamination, including heavy rust deposits. When cargo tanks are in continuous service for these products, such inspections should be performed at intervals of not more than two years.

17.20.3.5 Tanks for the carriage of these products should be of steel or stainless steel construction.

17.20.3.6 Tanks which have contained these products may be used for other cargoes after thorough cleaning of tanks and associated pipework systems by washing or purging.

17.20.4.1 All valves, flanges, fittings and accessory equipment should be of a type suitable for use with these products and should be constructed of steel or stainless steel or other material acceptable to the Administration. The chemical composition of all material used should be submitted to the Administration for approval prior to fabrication. Discs or disc faces, seats and other wearing parts of valves should be made of stainless steel containing not less than 11 per cent chromium.

17.20.4.2 Gaskets should be constructed of materials which do not react with, dissolve in, or lower the auto-ignition temperature of these products and which are fire resistant and possess adequate mechanical behaviour. The surface presented to the cargo should be polytetrafluoroethylene (PTFE) or materials giving a similar degree of safety by their inertness. Spirally-wound stainless steel with a filler of PTFE or similar fluorinated polymer may be accepted by the Administration.

17.20.4.3 Insulation and packing if used should be of a material which does not react with, dissolve in, or lower the auto-ignition temperature of these products.

17.20.4.4 The following materials are generally found unsatisfactory for gaskets, packing and similar uses in containment systems for these products and would require testing before being approved by the Administration:

.1 Neoprene or natural rubber if it comes into contact with the products;
.2 Asbestos or binders used with asbestos;
.3 Materials containing oxides of magnesium, such as mineral wools.

17.20.5 Filling and discharge piping should extend to within 100 mm of the bottom of the tank or any sump pit.

17.20.6.1 The products should be loaded and discharged in such a manner that venting of the tanks to atmosphere does not occur. If vapour return to shore is used during tank loading, the vapour return system connected to a containment system for the product should be independent of all other containment systems.

17.20.6.2 During discharging operations, the pressure in the cargo tank should be maintained above 0.07 bar.

17.20.6.3 The cargo should be discharged only by deepwell pumps, hydraulically operated submerged pumps, or inert gas displacement. Each cargo pump should be arranged to ensure that the product does not heat significantly if the discharge line from the pump is shut off or otherwise blocked.

17.20.7 Tanks carrying these products should be vented independently of tanks carrying other products. Facilities should be provided for sampling the tank contents without opening the tank to atmosphere.

17.20.8 Cargo hoses used for transfer of these products should be marked "FOR ALKYLENE OXIDE TRANSFER ONLY".

17.20.9 Hold spaces should be monitored for these products. Hold spaces surrounding type A and B independent tanks should also be inerted and monitored for oxygen. The oxygen content of these spaces should be maintained below 2 per cent. Portable sampling equipment is satisfactory.

17.20.10 Prior to disconnecting shore-lines, the pressure in liquid and vapour lines should be relieved through suitable valves installed at the loading header. Liquid and vapour from these lines should not be discharged to atmosphere.

17.20.11 Tanks should be designed for the maximum pressure expected to be encountered during loading, carriage or unloading of cargo.

17.20.12 Tanks for the carriage of propylene oxide with a design vapour pressure of less than 0.6 bar and tanks for the carriage of ethylene oxide/propylene oxide mixtures with a design vapour pressure of less than 1.2 bar should have a cooling system to maintain the cargo below the reference temperature. For reference temperature see 15.1.4.1.

17.20.13 For type C independent tanks pressure relief valve settings should not be less than 0.2 bar and not greater than 7.0 bar for the carriage of propylene oxide and not greater than 5.3 bar for the carriage of ethylene oxide/propylene oxide mixtures.

17.20.14.1 The piping system for tanks to be loaded with these products should be completely separate from piping systems for all other tanks, including empty tanks, and from all cargo compressors. If the piping system for the tanks to be loaded with the product is not independent as defined in 17.20.2 the required piping separation should be accomplished by the removal of spool pieces, valves, or other pipe sections and the installation of blank flanges at these locations. The required separation applies to all liquid and vapour piping, liquid and vapour vent lines and any other possible connexions such as common inert gas supply lines.

17.20.14.2 The product should be transported only in accordance with cargo handling plans that have been approved by the Administration. Each intended loading arrangement should be shown on a separate cargo handling plan. Cargo handling plans should show the entire cargo piping system and the locations for installation of blank flanges needed to meet the above piping separation requirements. A copy of each approved cargo handling plan should be kept on board the ship. The International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk should be endorsed to include reference to the approved cargo handling plans.

17.20.14.3 Before loading the product, certification verifying that the required piping separation has been achieved should be obtained from a competent authority, acceptable to the Administration, and carried on board the ship. Each connexion between a blank flange and pipeline flange should be fitted with a wire and seal by the competent authority's representative to ensure that inadvertent removal of the blank flange is impossible.

17.20.15 The maximum allowable tank filling limits for each cargo tank should be indicated for each loading temperature which may be applied and for the applicable maximum reference temperature, on a list to be approved by the Administration. A copy of the list should be permanently kept on board by the master.

17.20.16 The cargo should be carried under a suitable protective padding of nitrogen gas. An automatic nitrogen make-up system should be installed to prevent the tank pressure falling below 0.07 bar in the event of product temperature fall due to ambient conditions or malfunctioning of refrigeration system. Sufficient nitrogen should be available on board to satisfy the demand of the automatic pressure control. Nitrogen of commercially pure quality (99.9 per cent by volume) should be used for padding. A battery of nitrogen bottles connected to the cargo tanks through a pressure reduction valve satisfies the intention of the expression "automatic" in this context.

17.20.17 The cargo tank vapour space should be tested prior to and after loading to ensure that the oxygen content is 2 per cent by volume or less.

17.20.18 A water spray system of sufficient capacity should be provided to blanket effectively the area surrounding the loading manifold, the exposed deck piping associated with product handling and the tank domes. The arrangement of piping and nozzles should be such as to give a uniform distribution rate of 10 $\ell/m^2 min$. The water spray system should be capable of both local and remote manual operation and the arrangement should ensure that any spilled cargo is washed away. Additionally, a water hose with pressure to the nozzle, when atmospheric temperatures permit, should be connected ready for immediate use during loading and unloading operations.

17.21 Vinyl chloride

In cases where polymerization of vinyl chloride is prevented by addition of an inhibitor, 17.8 is applicable. In cases where no or insufficient inhibitor has been added, any inert gas used for the purposes of 17.6 should contain not more oxygen than 0.1 per cent. Before loading is started, inert gas samples from the tanks and piping should be analysed. When vinyl chloride is carried, a positive pressure should always be maintained in the tanks, also during ballast voyages between successive carriages.

CHAPTER 18 - OPERATING REQUIREMENTS

18.1 Cargo information

18.1.1 Information should be on board and available to all concerned, giving the necessary data for the safe carriage of cargo. Such information should include for each product carried:

.1 a full description of the physical and chemical properties necessary for the safe containment of the cargo;

.2 action to be taken in the event of spills or leaks;

.3 counter-measures against accidental personal contact;

.4 fire-fighting procedures and fire-fighting media;

.5 procedures for cargo transfer, gas-freeing, ballasting, tank cleaning and changing cargoes;

.6 special equipment needed for the safe handling of the particular cargo;

.7 minimum inner hull steel temperatures; and

.8 emergency procedures.

18.1.2 Products required to be inhibited should be refused if the certificate required by 17.8 is not supplied.

18.2 Compatibility

18.2.1 The master should ascertain that the quantity and character of each product to be loaded are within the limits indicated in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk provided for in 1.5 and in the Loading and Stability booklet provided for in 2.2.5 and that products are listed in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk if so required under section 3 of the Certificate.

18.2.2 Care should be taken to avoid dangerous chemical reactions if cargoes are mixed. This is of particular significance in respect of:

.1 tank cleaning procedures required between successive cargoes in the same tank; and

.2 simultaneous carriage of cargoes which react when mixed. This should be permitted only if the complete cargo systems including, but not limited to, cargo pipework, tanks, vent systems and refrigeration systems are physically separate.

18.3 Personnel training*

18.3.1 Personnel involved in cargo operations should be adequately trained in handling procedures.

18.3.2 All personnel should be adequately trained in the use of protective equipment provided on board and have basic training in the procedures, appropriate to their duties, necessary under emergency conditions.

18.3.3 Officers should be trained in emergency procedures to deal with conditions of leakage, spillage or fire involving the cargo and a sufficient number of them should be instructed and trained in essential first aid for the cargoes carried.

18.4 Entry into spaces

18.4.1 Pesonnel should not enter cargo tanks, hold spaces, void spaces, cargo handling spaces or other enclosed spaces where gas may accumulate, unless:

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* Reference is made to the provisions of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 and in particular to the "Mandatory Minimum Requirements for the Training and Qualifications of Masters, Officers and Ratings of Chemical Tankers" - Regulation V/2, Chapter V of the Annex to that Convention and to Resolution 11 of the International Conference on Training and Certification of Seafarers, 1978.

.1 the gas content of the atmosphere in such space is determined by means of fixed or portable equipment to ensure oxygen sufficiency and the absence of toxic atmosphere; or

.2 personnel wear breathing apparatus and other necessary protective equipment and the entire operation is under the close supervision of a responsible officer.

18.4.2 Personnel entering any space designated as gas-dangerous on a ship carrying flammable products should not introduce any potential source of ignition into the space unless it has been certified gas-free and is maintained in that condition.

18.4.3.1 For internal insulation tanks, special fire precautions should be taken in the event of hot work carried out in the vicinity of the tanks. For this purpose gas absorbing and de-absorbing characteristics of the insulation material should be taken into account.

18.4.3.2 For internal insulation tanks, repairs should be carried out in accordance with the procedures provided for in paragraph 4.4.7.6.

18.5 Carriage of cargo at low temperature

18.5.1 When carrying cargoes at low temperatures:

.1 if provided, the heating arrangements associated with cargo containment systems should be operated in such a manner as to ensure that the temperature does not fall below that for which the material of the hull structure is designed;

.2 loading should be carried out in such a manner as to ensure that unsatisfactory temperature gradients do not occur in any cargo tank, piping, or other ancillary equipment; and

.3 when cooling down tanks from temperatures at or near ambient, the cool down procedure laid down for that particular tank, piping and ancillary equipment should be followed closely.

18.6 Protective equipment

Personnel should be made aware of the hazards associated with the cargo being handled and should be instructed to act with care and use the appropriate protective equipment as mentioned in 14.1 during cargo handling.

18.7 Systems and controls

Cargo emergency shutdown and alarm systems involved in cargo transfer should be tested and checked before cargo handling operations begin. Essential cargo handling controls should also be tested and checked prior to transfer operations.

18.8 Cargo transfer operations

18.8.1 Transfer operations including emergency procedures should be discussed between ship personnel and the persons responsible at the shore facility prior to commencement and communications maintained throughout the transfer operations.

18.8.2 The closing time of the valve referred to in 13.3.1 (i.e. time from shut-down signal initiation to complete valve closure) should not be greater than:

$$\frac{3600\ U}{LR} \quad (s)$$

where: U = ullage volume at operating signal level (m^3)
LR = maximum loading rate agreed between ship and shore facility (m^3/h).

The loading rate should be adjusted to limit surge pressure on valve closure to an acceptable level taking into account the loading hose or arm, the ship and the shore piping systems where relevent.

18.9 Additional operating requirements

Additional operating requirements will be found in the following paragraphs of the Code:

3.8.4, 3.8.5, 7.1.1.5, 8.2.5, 8.2.7, 9.4.2, 12.1.1, 12.1.10, 13.1.3, 14.2.5, 14.2.6, 14.3.1, 15.1, 15.2, 16.2.2, 17.4.2, 17.6, 17.7, 17.12, 17.13, 17.14, 17.15, 17.16, 17.17, 17.18, 17.20.

CHAPTER 19 - SUMMARY OF MINIMUM REQUIREMENTS

Explanatory Notes to the Summary of Minimum Requirements

UN Numbers	The UN Numbers as listed in the table of Chapter 19 are intended for information only.		
Vapour detection required (column f)	F	-	Flammable vapour detection
	T	-	Toxic vapour detection
	O	-	Oxygen analyser
	F+T	-	Flammable and toxic vapour detection
Gauging - types permitted (column g)	I	-	Indirect or closed, as described in 13.2.2.1 & .2
	C	-	Indirect, or closed, as described in 13.2.2.1, .2 & .3
	R	-	Indirect, closed or restricted, as described in 13.2.2.1, .2, .3 & .4
Refrigerant gases			Non-toxic and non-flammable gases such as: dichlorodifluoromethane (1028) dichloromonofluoromethane (1029) dichlorotetrafluoroethane (1958) monochlorodifluoromethane (1018) monochlorotetrafluoroethane (1021) monochlorotrifluoromethane (1022)

Unless otherwise specified gas mixtures containing less than 5 per cent total acetylenes may be transported with no further requirements than those provided for the major components.

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a Product name	b UN number	c Ship type	d Independent tank type C required	e Control of vapour space within cargo tanks	f Vapour detection	g Gauging	h Special requirements
Acetaldehyde	1089	2G/ 2PG	-	Inert	F + T	C	14.4.3, 14.4.4, 17.4.1, 17.6
Ammonia, anhydrous	1005	2G/ 2PG	-	-	T	C	14.4.2, 14.4.3, 14.4.4, 17.2.1, 17.13
Butadiene	1010	2G/ 2PG	-	Inert	F	R	17.2.2, 17.4.2, 17.6, 17.8
Butane	1011	2G/ 2PG	-	-	F	R	
Butane/propane mixtures	1011/ 1978	2G/ 2PG	-	-	F	R	
Butylenes	1012	2G/ 2PG	-	-	F	R	
Chlorine	1017	1G	Yes	Dry	T	I	14.4, 17.3.2, 17.4.1, 17.5, 17.7, 17.9, 17.14
Diethyl ether*	1155	2G/ 2PG	-	Inert	F + T	C	14.4.2, 14.4.3, 17.2.6, 17.3.1, 17.6.1, 17.10, 17.11, 17.15
Dimethylamine	1032	2G/ 2PG	-	-	F + T	C	14.4.2, 14.4.3, 14.4.4, 17.2.1
Ethane	1961	2G	-	-	F	R	
Ethyl chloride	1037	2G/ 2PG	-	-	F + T	R	
Ethylene	1038	2G	-	-	F	R	
Ethylene oxide	1040	1G	Yes	Inert	F + T	C	14.4.2, 14.4.3, 14.4.4, 14.4.6, 17.2.2, 17.3.2, 17.4.1, 17.5, 17.6, 17.16
Ethylene oxide/propylene oxide mixture with ethylene oxide content of not more than 30 per cent by volume	2983	2G/ 2PG	-	Inert	F + T	C	14.4.3, 17.3.1, 17.4.1, 17.6, 17.10, 17.11, 17.20

* This cargo is covered also by the IBC Co

a	b	c			f	g	
Product name	UN number	Ship type	Independent tank type C required	Control of vapour space within cargo tanks	Vapour detection	Gauging	Special requirements
Isoprene*	1218	2G/ 2PG	–	–	F	R	14.4.3, 17.8, 17.10, 17.12
Isopropylamine*	1221	2G/ 2PG	–	–	F + T	C	14.4.2, 14.4.3, 17.2.4, 17.10, 17.11, 17.12, 17.17
Methane (LNG)	2043	2G	–	–	F	C	
Methyl acetylene-propadiene mixture	1060	2G/ 2PG	–	–	F	R	17.18
Methyl bromide	1062	1G	Yes	–	F + T	C	14.4, 17.2.3, 17.3.2, 17.4.1, 17.5, 17.9
Methyl chloride	1063	2G/ 2PG	–	–	F + T	C	17.2.3
Monoethylamine*	1036	2G/ 2PG	–	–	F + T	C	14.4.2, 14.4.3, 14.4.4, 17.2.1, 17.3.1, 17.10, 17.11, 17.12, 17.17
Nitrogen	2040	3G	–	–	O	C	17.19
Propane	1978	2G/ 2PG	–	–	F	R	
Propylene	1077	2G/ 2PG	–	–	F	R	
Propylene oxide*	1280	2G/ 2PG	–	Inert	F + T	C	14.4.3, 17.3.1, 17.4.1, 17.6, 17.10, 17.11, 17.20
Refrigerant gases (see notes)	–	3G	–	–	–	R	
Sulphur dioxide	1079	1G	Yes	Dry	T	C	14.4, 17.3.2, 17.4.1, 17.5, 17.7, 17.9
Vinyl chloride	1086	2G/ 2PG	–	–	F + T	C	14.4.2, 14.4.3, 17.2.2, 17.2.3, 17.3.1, 17.6, 17.21
Vinyl ethyl ether*	1302	2G/ 2PG	–	Inert	F + T	C	14.4.2, 14.4.3, 17.2.2, 17.3.1, 17.6.1, 17.8, 17.10, 17.11, 17.15
Vinylidene chloride*	1303	2G/ 2PG	–	Inert	F + T	R	14.4.2, 14.4.3, 17.2.5, 17.8, 17.10, 17.11

* This cargo is covered also by the IBC Code.

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Appendix

MODEL FORM OF INTERNATIONAL CERTIFICATE OF FITNESS FOR THE CARRIAGE OF LIQUEFIED GASES IN BULK

INTERNATIONAL CERTIFICATE OF FITNESS FOR THE CARRIAGE OF LIQUEFIED GASES IN BULK

(Official seal)

Issued under the provisions of the
INTERNATIONAL CODE FOR THE CONSTRUCTION AND
EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK
(resolution MSC..(48))

under the authority of the Government of

....
(full official designation of country)

by ....
(full official designation of the competent person or organization authorized by the Administration)

Name of ship	Distinctive number or letter	Port of registry	Cargo capacity (m^3)	Ship type (section 2.1 of the Code)[1/]

Date on which keel was laid or on which the ship was at a similar stage of construction or (in the case of a converted ship) date on which conversion to a gas carrier was commenced:

....

The ship also complies fully with the following amendments to the Code:

....
....

The ship is exempted from compliance with the following provisions of the Code:

....
....

The Certificate should be drawn up in the official language of the issuing country. If the language used is neither English nor French, the text should include a translation into one of these languages.

THIS IS TO CERTIFY:

1 .1 That the ship has been surveyed in accordance with the provisions of section 1.5 of the Code;

.2 that the survey showed that the structure, equipment, fittings, arrangements and materials of the ship and the conditions thereof are in all respects satisfactory and that the ship complies with the relevant provisions of the Code.

2 That the following design criteria have been used:

.1 ambient air temperature ....°C[2]

.2 ambient water temperature ....°C[2]

.3

Tank type and number	Stress factors[3]				Materials[3]	MARVS
	A	B	C	D		
Cargo piping						

NB Tank numbers referred to in this list are identified on the annexed, signed and dated tank plan numbered 2A.

.4 Mechanical properties of the cargo tank material were determined at ....°C[4]

3 That the ship is suitable for the carriage in bulk of the following products, provided that all relevant operational provisions of the Code are observed:[5]

Products	Conditions of carriage (tank numbers, etc.)

Continued on the annexed signed and dated sheet(s) number 1A
Tank numbers referred to in this list are identified on the annexed signed and dated tank plan numbered 2A

4 That in accordance with sections 1.4/2.8.2* the provisions of the Code are modified in respect of the ship in the following manner:

5 That the ship must be loaded:

*.1 in accordance with the loading conditions provided in the approved loading manual, stamped and dated .... and signed by a responsible officer of the Administration, or of an organization recognized by the Administration;

*.2 in accordance with the loading limitations appended to this Certificate.

Where it is required to load the ship other than in accordance with the above instruction, then the necessary calculations to justify the proposed loading conditions should be communicated to the certifying Administration who may authorize in writing the adoption of the proposed loading condition.**

---

* delete as appropriate.

** Instead of being incorporated in the Certificate, this text may be appended to the Certificate if duly signed and stamped.

This Certificate is valid until ....

Issued at ....
(place of issue of Certificate)

.... 19..
(Date of issue)

....
(Signature of authorized official issuing the Certificate)

(Seal or stamp of issuing Authority, as appropriate)

Notes on completion of certificate:

1/ "Ship type": Any entry under this column must be related to all relevant recommendations, e.g. an entry "Type 2G" should mean Type 2G in all respects prescribed by the Code.

2/ Paragraphs 2.1 and 2.2: The ambient temperatures accepted or required by the Administration for the purposes of 4.8.1 of the Code to be inserted.

3/ Paragraph 2.3: Stress factors and materials as accepted or required by the Administration for the purposes of 4.5.1.4 and 4.5.1.6 of the Code to be inserted.

4/ Paragraph 2.4: Temperature accepted by the Administration for the purposes of 4.5.1.7 to be inserted.

5/ Paragraph 3: Only products listed in Chapter 19 of the Code or which have been evaluated by the Administration in accordance with paragraph 1.1.6 of the Code should be listed. In respect of the latter "new" products, any special requirements provisionally prescribed should be noted.

ENDORSEMENT FOR MANDATORY ANNUAL SURVEYS

THIS IS TO CERTIFY that a mandatory annual survey requird by 1.5.2.1.4 of the Code, the ship was found to comply with the relevant provisions of the International Gas Carrier Code.

Signed: ....
(Signature of authorized official)

Place: ....

Date: ....

(Seal or stamp of the Authority, as appropriate)

Signed: ....
(Signature of authorized official)

Place: ....

Date: ....

(Seal or stamp of the Authority, as appropriate)

Signed: ....
(Signature of authorized official)

Place: ....

Date: ....

(Seal or stamp of Authority, as appropriate)

Signed: ....
(Signature of authorized official)

Place: ....

Date: ....

(Seal or stamp of Authority, as appropriate)

NOTE: An intermediate survey may take the place of a mandatory annual survey where the relevant provisions of 1.5.2.1.3 and 1.5.2.1.4 are complied with.

ENDORSEMENT FOR INTERMEDIATE SURVEYS

THIS IS TO CERTIFY that at an Intermediate Survey required by 1.5.2.1.3 of the Code, the ship was found to comply with the relevant provisions of the International Gas Carrier Code.

Signed: ....
(Signature of authorized official)

Place: ....

Date: ....

(Seal or stamp of the Authority, as appropriate)

Signed: ....
(Signature of authorized official)

Place: ....

Date: ....

(Seal or stamp of Authority, as appropriate)

ANNEX 10

AMENDMENTS TO THE BASIC TEXT OF THE IGC CODE (MSC 48/5/2)

Throughout the Code:

1 where mixtures of gases or chemicals are given in the text they should be joined by a hyphen ("..........-..........");

2 the abbreviation of per cent (%) should only follow figures used for percentage;

3 For tonnage the term "tons gross tonnage" should be used throughout;

4 any reference to pressure/vacuum or similar accepted technical terms, should be joined by an oblique stroke;

5 capitals should be used wherever the term "Recognized Standards" appears;

6 wherever the term "1981 SOLAS Amendments" appears, it should read "1983 SOLAS Amendments".

List of contents

Appendix	insert "INTERNATIONAL" between "OF" and "CERTIFICATE"

Preamble

First line	last word should read "standard"
Fifth line	insert "to" between "ship" and "its"

Chapter 1

Regulations:

1.1.1	fourth line	replace "certain other substances" with "other products"
1.1.2	second line	replace "were" with "are" (twice)
1.1.2	last line	replace "[1 May 1986] with "1 July 1986"

1.1.4 Replace text with the following:

"1.1.4.1 When cargo tanks contain products for which the Code requires a type IG-ship, neither flammable liquids having a flashpoint of 60°C (closed cup test) or less, nor flammable products listed in Chapter 19, should be carried in tanks located within the protective zones described in 2.6.1.1.

1.1.4.2 Similarly, when cargo tanks contain products for which the Code requires a type 2G/2PG-ship, the above mentioned flammable liquids should not be carried in tanks located within the protective zones described in 2.6.1.2.

1.1.4.3 In each case the restriction applies to the protective zones within the longitudinal extent of the hold spaces for the cargo tanks loaded with products for which the Code requires a type 1G or 2G/2PG-ship.

1.1.4.4 The above mentioned flammable liquids and products may be carried within these protective zones when the quantity retained in the cargo tanks of products for which the Code requires a type 1G or 2G/2PG-ship is solely used for cooling, circulation or fuelling purposes."

1.1.5	first line	reference should be "1.1.7.1"
1.1.7.2	second line	reference should read "1.1.7.1.2"
1.3.6	fifth line	insert "at" between "or" and "the"
1.3.15	first line	replace "those" with "the"

Insert new 1.3.20 to read:

""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."

Re-number "1.3.20" to "1.3.30" to read "1.3.21" to "1.3.31"

1.3.27	last line	insert "gauge" after pressure figures expressed in "bar"

Insert new 1.3.32 to read:

""Separate" - means that a cargo piping system or cargo vent, 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 should not be used within a cargo tank and should 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."

Re-number	"1.3.31" to read "1.3.33" "1.3.32.1" to read "1.3.34" "1.3.32.2" to read "1.3.35" "1.3.33" to "1.3.37" to read "1.3.36" to "1.3.40"	
1.5.1.2.2, 1.5.1.3, 1.5.3.3	Replace "Port Administration" with "Port State Authority"	
1.5.1.2.2	Replace the present footnote with "Port State Authority has the meaning as presented in Chapter I, Regulation 19 of the 1978 1978 Protocol to the 1974 SOLAS Convention."	
1.5.1.3	third line	replace "cetificate" with "certificate"
1.5.2.1.3	twelfth line	replace "Firness" with "Fitness"

<u>Chapter 2</u>

Regulations:

2.1.1	eighth line	replace "hull" with "shell"
2.1.2.3	sixth line	insert "gauge" after pressure figures expressed in "bar"
2.1.4	first line	replace "it" with "a ship"
2.3.2	first line	replace "section" with "chapter"
2.8.2	last line	replace "1.5" with "1.5.4"
2.9.1.1	fourth line	replace "those" with "openings"
2.9.2	figure 2.1	note to left should read "whichever is less"

<u>Chapter 3</u>

Regulations:

3.1.5.2	at the end	insert ";"
3.1.5.3	third line	delete "arrangement"
3.1.5.4	second line	after "3.8" insert "and emergency cargo jettisoning piping systems in accordance with 3.1.6"
3.1.5.5	third line	replace "arrangement" with "piping system"

Re-number "3.1.5.6" as "3.1.6" and re-number "3.1.6" as "3.1.7"

New 3.1.6	first line	should read: "Any emergency cargo jettisoning piping system should comply with 3.1.5 as appropriate and may be led aft"
New 3.1.6	fourth line	replace "arrangement" with "piping system"
3.2.1	fourth line	insert "the entry of" between "avoid" and "gas" and replace "entering" with "to"
3.2.4	seventh line	replace "Port lights" with "Windows and side scuttles"
3.2.4	ninth and eleventh lines	replace "navigating bridge" with "wheelhouse"
3.3.1.2	fifth line	last word should read "breadth"
3.3.1.3	first and second lines	replace "this paragraph" with "3.3.1.2"
3.3.1.3	fourth line	insert "the entry of" between "avoid" and "gas" change "located so" to "so located"
3.3.1.3	fifth line	replace "from entering" with "to"

3.4.1.2.1 Amend to read:

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

3.4.1.2.2 Amend to read:

"3.4.1.2.2 if the entrance does not comply with 3.2.4, the control room should have no access to the spaces described above and the boundaries to such spaces should be insulated to 'A-60' Class integrity."

3.7.2	first line	"inter-barrier" should read as one word and throughout the whole text of the Code.
3.8.1.1	fifth line	reference should read "1.3.38"
3.8.4	eighth line	replace "Port lights" with "Side scuttles"

<u>Chapter 4</u>

Regulations:

4.3.2.1	first line	insert "gauge" after pressure figures expressed in "bar"

4.4.6.1	first line	first word should read "scantlings"
4.4.7.2.3	second line	"recognized standards" should be capitalized and throughout the text of the IGC Code
4.5.1.9	third line from bottom	subscript "dny" should read "dyn"
4.7.3	footnote (1) to table	third line, reference should read "4.2.1.3"
4.10.8.3	third line	replace "these" with "those"

Chapter 5

Regulations:

5.2.3.1	second line	insert "gauge" between "maximum" and "pressure"
5.2.3.3	first and second lines	insert "gauge" after pressure figures expressed in "bar"
5.3.2.2.5	fifth line	
5.4.2.1	fifth line	insert "or inert" between "insert" and "gas"

5.4.3.2 Modify the first sentence as follows:

"Flanges should comply with standards acceptable to the Administration as to their type, manufacture and test."

5.5.2	third line	delete "However", capitalize "when"
5.6.1.1	first line	insert "gauge" after pressure figures expressed in "bar"
5.6.1.2	first line	
5.7.3	last line	

Chapter 6

Table 6.3 note 6/ should read:

"A specially heat treated 5% nickel steel, for example triple heat treated 5% nickel steel, may be used down to -165°C upon special agreement with the Administration, provided that the impact tests are carried out at -196°C."

Regulations:

6.3.7.1 no change

Re-number "6.3.7.2" to read "6.3.7.1.1"
"6.3.7.3" to read "6.3.7.1.2"
"6.3.7.4" to read "6.3.7.1.3"
"6.3.7.5" to "6.3.7.9" to read "6.3.7.2" to "6.3.7.6"

Chapter 7

Regulation:

7.1.2	penultimate line	insert "design" between "these" and "temperatures"

Chapter 8

Regulations:

8.2.8.3	fourth line	should read: "provided by the combined capacity of all valves, if a suitably maintained spare valve is"
8.2.17	third line	reference should read "1.3.23"

Chapter 9

Regulation:

9.2.3	second line	reference should read "9.2.2.1"

Chapter 10

Regulations:

10.1.2	third line	replace "should" with "need"
10.1.4	first line	delete "or both"

Chapter 11

Regulations:

11.2.1	last line	insert "gauge" after pressure figures expressed in "bar"
11.3.2	third line from end	replace "after" with "aft"
11.4.3	fourth and fifth lines	amend to read: "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 Administration. A monitor should be"

Chapter 12

Regulation:

12.1.9.3 delete brackets around "stainless steel"

Chapter 13

Regulations:

13.3.2	first line	delete "Unless required otherwise in Chapter 17"
13.3.3	first line	add a "," after "if any"
13.6.5	penultimate line	insert "such equipment is" between "When" and "located"
13.6.11	seventh line	insert "location" between "head" and "sequentially"

Chapter 14

Regulations:

14.2.3.1	sixth line	replace "cylinders" with "air bottles"
14.2.4	sixth and eighth lines	replace "cylinders" with "air bottles"
14.4	heading	change "personal" to "personnel"

14.4.3 Add the following sentence: "The showers and eye wash should be operable in all ambient conditions."

Chapter 16

Regulations:

16.2.1.2	seventh line	last word should be "ventilated"
16.2.3	first line	"ventilation" should read "ventilated"

16.2.4 Amend the first sentence to read:

"16.2.4 A ventilation hood or casing should be provided for the areas occupied by flanges, valves, etc., and for the gas fuel piping, which is not enclosed in the double wall piping system or ventilated duct, at gas utilization units, such as boilers, diesel engines and gas turbines."

Chapter 17

Regulations:

17.4.2	first line	replace "for ships" with "for a ship"
17.4.2	second line	insert "not" between "should" and "be"

17.4.2	last paragraph beginning "If the ship ..." should be numbered "17.4.3" and should start "If the ship is to carry consecutively products as specified in 17.4.2 with a ..."	
	In the last line substitute "cargo" for "ship's"	
17.14.1.4, 17.14.2.1, 17.14.2.2, 17.14.4.4	sixth line fourth line second line second line	insert "gauge" after pressure figures expressed in "bar"
17.15	heading	insert "and" after "diethyl ether"
		delete the "/" after "vinyl"
17.16.4	last sentence, amend to read: "Particular care should be taken in the case of ammonia in tanks made of steel other than stainless steel."	
17.16.7	amend to read:	
	"17.16.7 Pressure relief valves should be set at a pressure of not less than 5.5 bar gauge. The maximum set pressure should be specially approved by the Administration."	
17.16.8	first line	change reference to "17.20.15"
17.16.10	first line	change reference to "17.20.17"
17.17	heading	insert "and" after "Isopropylamine"
17.17	first sentence	add after "provided" the words "as defined in 1.3.32." Delete the rest of the paragraph.
17.18.4	last sentence, amend to read: "For the example compositions given in 17.18.2, the following features should be provided:"	
17.18.5	amend text to read:	
	"17.18.5 The piping system, including the cargo refrigeration system, for tanks to be loaded with methyl acetylene-propadiene mixtures should be either independent (as defined in 1.3.20) or separate (as defined in 1.3.32) from piping and refrigeration systems for other tanks. This segregation applies to all liquid and vapour vent lines and any other possible connections, such as common inert gas supply lines."	
17.20	heading	last word should read "weight"
17.20.2	delete	

Re-number	"17.20.3.1" to "17.20.3.6" to read "17.20.2.1" to "17.20.2.6"
17.20.2.2	amend last sentence to read: "Particular care should be taken in the case of ammonia in tanks made of steel other than stainless steel."
17.20.2.4	first sentence — delete "including" and add at the end: "and any visible structural defects"
Re-number	"17.20.4.1" to "17.20.4.4" to read "17.20.3.1" to "17.20.3.4"
Re-number	"17.20.5" to read "17.20.4"
Re-number	"17.20.6.1" to "17.20.6.3" to read "17.20.5.1" to "17.20.5.3"
17.20.5.2	second line — insert "gauge" after pressure figures expressed in "bar"
Re-number	"17.20.7" to "17.20.13" to read "17.20.6" to "17.20.12"
17.20.12	insert new text as follows: "Pressure relief valve settings should not be less than 0.2 bar gauge and for type C independent cargo tanks not greater than 7.0 bar gauge for the carriage of propylene oxide and not greater than 5.3 bar gauge for the carriage of ethylene oxide/propylene oxide mixtures."
Re-number	"17.20.14.1" to "17.20.14.3" to read "17.20.13.1" to "17.20.13.3"
17.20.13.1	reference should read: "1.3.20"
17.20.13.2	first line — replace "product" with "products"
17.20.13.3	Amend the paragraph as follows: "17.20.13.3 Before loading the product, certification verifying that the required piping separation has been achieved should be obtained from a responsible person acceptable to the Port Administration and carried on board the ship. Each connection between a blank flange and pipeline flange should be fitted with a wire and seal by the responsible person to ensure that inadvertent removal of the blank flange is impossible."
17.20.15	third line — insert "gauge" after pressure figures expressed in "bar"
Re-number	"17.20.15" to "17.20.18" to read "17.20.14" to "17.20.17"

Chapter 18

Regulations:

18.1	insert new 18.1.3 as follows:	
	"18.1.3 A copy of this Code or national regulations incorporating the provisions of this Code should be on board every ship covered by this Code."	
18.2.2.2	last line	delete "physically" and add after "separate" "as defined in 1.3.32"
18.3	footnote	replace "Chemical Tankers" with "Liquefied Gas Carriers"
		replace "Regulation V/2" with "Regulation V/3"
		replace "Resolution 11" with "Resolution 12"
18.9	second line	replace "13.1.3" with "13.1.4"

Chapter 19 - SUMMARY OF MINIMUM REQUIREMENTS

Entry/column 'a'	Amendment
Acetaldehyde	Column 'h' - amend "17.6" to read "17.6.1"
Butadiene	Column 'e' - amend "Inert" to read "-" Column 'h' - insert "17.4.3"
Ethylene oxide	Column 'h' - amend "17.6" to read "17.6.1"
Ethylene oxide/propylene oxide mixture with ethylene oxide content of not more than 30% by volume	Column 'a' - amend entry to read: "Ethylene oxide/propylene oxide mixtures with ethylene oxide content of not more than 30% by weight" Column 'h' - amend "17.6" to read "17.6.1"
Propylene oxide	Column 'h' - amend "17.6" to read "17.6.1"
Vinylidene chloride	Column 'h' - insert "17.6.1"

Appendix - MODEL FORM OF INTERNATIONAL CERTIFICATE

In the first line of endorsement for mandatory annual surveys insert "at" between "that" and "a".

"(Resolution MSC..(48))", complete to read "(Resolution MSC.5(48))"

Section 2.3 Note at the bottom of the table should read:

"NB Tank numbers referred to in this list are identified on Attachment 2, signed and dated tank plan."

Section 3 Notes at the bottom of the table should read:

"Continued on Attachment 1, additional signed and dated sheets. Tank numbers referred to in this list are identified on Attachment 2, signed and dated tank plan."

Insert as Attachment 1 to the model form of the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk the following:

"ATTACHMENT 1 TO THE INTERNATIONAL CERTIFICATE
OF FITNESS FOR THE CARRIAGE OF
LIQUEFIED GASES IN BULK

Continued list of products to those specified in Section 3, and their condition of carriage.

Products	Conditions of carriage (tank numbers, etc.)

DATE ....
(AS FOR CERTIFICATE)

....
SIGNATURE OF OFFICIAL
ISSUING THE CERTIFICATE
AND/OR SEAL OF ISSUING
AUTHORITY"

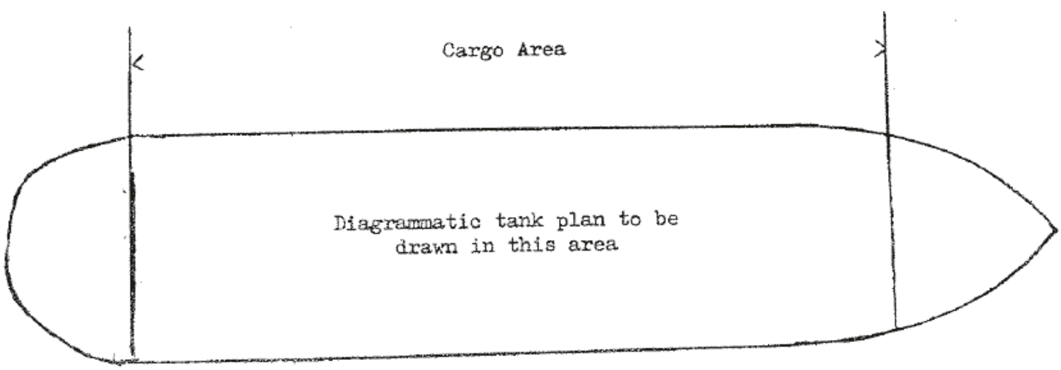
Insert as Attachment 2 to the model form of the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk the following:

"ATTACHMENT 2 TO THE INTERNATIONAL CERTIFICATE
OF FITNESS FOR THE CARRIAGE OF
LIQUEFIED GASES IN BULK

<u>TANK PLAN</u> (SPECIMEN)

NAME OF SHIP: ....

DISTINCTIVE NUMBER OR LETTERS: ....



DATE ....
(AS FOR CERTIFICATE)

....
SIGNATURE OF OFFICIAL
ISSUING THE CERTIFICATE
AND/OR SEAL OF ISSUING
AUTHORITY "

Title	RESOLUTIONs / MSC Resolutions / Res.MSC.17(58)
Note	Amends Res.MSC.5(48)

RESOLUTION MSC.17(58)

adopted on 24 May 1990

ADOPTION OF AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK (IGC CODE) (Harmonized System of Survey and Certification)

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention of the International Maritime Organization concerning the functions of the Committee,

RECALLING ALSO resolution MSC.5(48) by which the Committee adopted the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk(IGC Code),

NOTING part C of chapter VII of the International convention for the Safety of Life at Sea, 1974 (SOLAS 1974) as amended, by which amendments to the IGC Code shall be adopted, brought into force and take effect in accordance with article VIII of that Convention,

NOTING FURTHER resolution 10 of the International Conference on tanker Safety and Pollution Prevention, 1978 and resolution 4 of the International Conference on the Harmonized System of Survey and Certification, 1988, which recommended that IMO take the necessary action to introduce the harmonized system of survey and certification into various conventions and codes,

HAVING CONSIDERED at its fifty-eighth session amendments to the IGC Code proposed and circulated in accordance with article VIII(b)(i) of SOLAS 1974,

1. ADOPTS, in accordance with article VIII(b)(vi) of SOLAS 1974, amendments to the IGC Code, the text of which is set out in the Annex to the present resolution;

2. REQUESTS the Secretary-General, in conformity with article VIII(b)(v) of SOLAS 1974, to transmit to all Contracting Governments to the Convention certified copies of the present resolution and the text of the amendments contained in the Annex;

3. DETERMINES, in accordance with article VIII(b)(vi)(2)(bb) of SOLAS 1974, that the amendments shall be deemed to have been accepted on the date six months after the conditions for the entry into force of both the 1988 SOLAS Protocol and the 1988 Load Line Protocol are met, provided that the date of acceptance is not before 1 August 1991, unless prior to that date, objections are communicated to the Organization as provided for in article VIII(b)(vi)(2);

4. INVITES Contracting Governments to note that, in accordance with article VIII(b)(vii)(2) of SOLAS 1974, the amendments shall enter into force six months after their acceptance in accordance with the preceding paragraph;

5. REQUESTS that the Secretary-General inform all Contracting Governments when the Conditions for the entry into force of both the 1988 SOLAS Protocol and the 1988 Load Line Protocol are met and, in conformity with article VIII(g) of SOLAS 1974, when the amendments to the IGC Code contained in the Annex to the present resolution will enter into force;

6. REQUESTS FURTHER the Secretary-General to transmit to the Members of the Organization which are not Contracting Governments to SOLAS 1974 copies of the resolution and its Annex and to inform them when the amendments enter into force.

ANNEX

AMENDMENTS TO THE IGC CODE

1.3 Definitions

New definition should be added as follows:

"1.3.3.3 "Anniversary date" means the day and the month of each year which will correspond to the date of expiry of the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk."

1.5 Surveys and Certification

The existing text of section 1.5 should be replaced by the following:

"1.5.1.1 The survey of ships, so far as regards the enforcement of the provisions of the Regulations and the granting of exemptions therefrom, should be carried out by officers of the Administration. The Administration may, however, entrust the surveys either to surveyors nominated for the purpose or to organizations recognized by it.

1.5.1.2 The Administration nominating surveyors or recognizing organizations to conduct surveys should, as a minimum, empower any nominated surveyor or recognized organization to:

.1 require repairs to a ship; and

.2 carry out surveys if requested by the appropriate authorities of port State.

The Administrations should notify the organization of the specific responsibilities and conditions of the authority delegated to nominated surveyors or recognized organizations for circulation to the Contracting Governments.

1.5.1.3 When a nominated surveyor or recognized organization determines that the condition of the ship or its equipment does not correspond substantially with the particulars or the International certificate o f Fitness for the carriage of Liquefied Gases in Bulk or is such that the ship is not fit to proceed to sea without danger to the ship, or persons on board, or without presenting unreasonable threat of harm to the marine environment, such surveyor or organization should immediately ensure that corrective action is taken and should in due course notify the Administration. If such corrective action is not taken the relevant certificate should be withdrawn and the Administration should be notified immediately; and, if the ship is in a port of another Contracting Government, the Port Administration concerned should also be notified immediately. When an officer of the State should also be notified immediately. When an officer of the Administration, a nominated surveyor or a recognized organization has notified the appropriate authorities of the port State, the Government of the port State concerned should give such officer, surveyor or organization any necessary assistance to carry out their obligations under this paragraph. When applicable, the Government of the port State concerned should take such steps as will ensure that the ship does not sail until it can proceed to sea or leave the port for the purpose of proceeding to the nearest appropriate repair yard available without danger to the ship or persons on board or without presenting an unreasonable threat of harm to the marine environment.

1.5.1.4 In every case, the Administration should guarantee the completeness and efficiency of the survey, and should undertake to ensure the necessary arrangements to satisfy this obligation.

1.5.2 Survey requirements

1.5.2.1 The structure, equipment, fittings, arrangements and material(other than items in respect of which a Cargo ship Safety Construction Certificate, Cargo Ship Safety Equipment Certificate and Cargo Ship radiotelegraphy Certificate or Radiotelephony Certificate are issued) of a gas carrier should be subjected to the following surveys:

.1 An initial survey before the ship is put in service or before the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk is issued for the first time, which should include a complete examination of its structure, equipment, fittings, arrangements and material in so far as the ship is covered by the Code. This survey should be such as to ensure that the structure, equipment, fittings, arrangements and material fully comply with the applicable provisions of the Code.

.2 A periodical survey at intervals specified by the Administration, by not exceeding five years, except where regulation 1.5.6.2.2, 1.5.6.5, 1.5.6.6 or 1.5.6.7 is applicable. The renewal survey should be such as to ensure that the structure, equipment, fitting, arrangements and material comply with the applicable provisions of the Code.

.3 An intermediate survey within 3 months before or after the second anniversary date or within 3 months before or after the third anniversary date of the Certificate which should take the place of one of the annual surveys specified in 1.5.2.1.4. The intermediate survey should be such as to ensure that the safety equipment, and other equipment, and associated pump and piping systems fully comply order. Such intermediate surveys should be endorsed on the Certificate issued under 1.5.4. or 1.5.5;

.4 An annual survey within three months before or after the anniversary date of the Certificate, including a general inspection of the structure, equipment, fittings, arrangements and material referred to in 1.5.2.1.1 to ensure that they have been maintained in accordance which the ship is intended. Such annual surveys should be endorsed on the Certificate issued under 1.5.4 or 1.5.5;

.5 An additional survey, either general or partial according to the circumstances, should be made when required after an investigation prescribed in 1.5.3.3, or whenever any important repairs or renewals are made. Such a survey should ensure that the necessary repairs or renewals have been effectively made, that the material and workmanship of such repairs or renewals are satisfactory; and that the ship is fit to proceed to sea without danger to the ship or persons on board or without presenting unreasonable threat of harm to the marine environment.

1.5.3 Maintenance of conditions after survey

1.5.3.1 The condition of the ship and its equipment should be maintained to conform with the provisions of the Code to ensure that the ship will remain fit to proceed to sea without danger to the ship or persons on board or without presenting unreasonable threat of harm to the marine environment.

1.5.3.2 After any survey of the ship under 1.5.2 has been completed, no change should be made in the structure, equipment, fittings, arrangements and material covered by the survey, without the sanction of the Administration, except by direct replacement.

1.5.3.3 Whenever an accident occurs to a ship or a defect is discovered, either of, which affects the safety of the ship or the efficiency or completeness of its life-saving appliances or other equipment, the master or owner of the ship should report at the earliest opportunity to the Administration, the nominated surveyor or recognized organization responsible for issuing the relevant certificate, who should cause investigations to be initiated to determine whether a survey, as required by 1.5.2.1.5, is necessary. If the ship is in a port of another Contracting Government, the master or owner should also report immediately to the Port Administration concerned and the nominated surveyor or recognized organization should ascertain that such a report has been made.

1.5.4 Issue and endorsement of International Certificate of Fitness

1.5.4.1 A certificate called an International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk, should be issued after an initial or renewal survey to a gas carrier engaged in international voyages which complies with the relevant provisions of the Code.

1.5.4.2 An International Certificate of Fitness for the Carriage for the Carriage of Liquefied Gases in Bulk should be drawn up in the form corresponding to the model given in the Appendix. If the language used is neither English nor French, the text should include the translation into one of these languages.

1.5.4.3 The certificate issued under the provisions of this section should be available on board for inspection at all times.

1.5.4.4 Notwithstanding any other provisions of the amendments to this Code, adopted by the Maritime Safety Committee (MSC) by resolution MSC.17(58), any International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk, which is current when these amendments enter into force, should remain valid until it expires under the terms of this Code prior to the amendments entering into force.

1.5.5 Issue or endorsement of International Certificate of Fitness by another Government

1.5.5.1 A Contracting Government may, at the request of another Government cause a ship entitled to fly the flag of the other Government to be surveyed and, if satisfied that the requirements of the Code are complied with, issue or authorize the issue of the certificate to the ship, and, where appropriate, endorse or authorize the endorsement of the certificate on the ship in accordance with the Code. Any certificate so issued should contain a statement to the effect that It has been issued at the request of the Government of the State the flag of which the ship is entitled to fly.

1.5.6 Duration and validity of International Certificate of Fitness

1.5.6.1 An International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk should be issued for a period specified by the Administration which should not exceed five years.

1.5.6.2.1 Notwithstanding the provisions of 1.5.6.1 of this regulation, when the renewal survey is completed within 3 months before the expiry date of the existing Certificate, the new Certificate should be valid from the date of completion of the renewal survey to a date not exceeding 5 years from the date of expiry of the existing Certificate.

1.5.6.2.2 When the renewal survey is completed after the expiry date of the existing Certificate, the new Certificate should be valid from the date of completion of the renewal survey to a date not exceeding 5 years from the date of expiry of the existing Certificate.

1.5.6.2.3 When the renewal survey is completed more than 3 months before the expiry date of the existing Certificate, the new Certificate should be valid from the date of completion of the renewal survey to a date not exceeding 5 years from the date of completion of the renewal survey.

1.5.6.3 If a Certificate is issued for a period of less than 6 years, the Administration may extend the validity of the Certificate beyond the expiry date to the maximum period specified in 1.5.6.1, provided that the surveys referred to in regulation 1.5.2.1.3 and 1.5.2.1.4, applicable when a Certificate is issued for a period of 5 years, are carried out as appropriate.

1.5.6.4 If a renewal survey has been completed and a new Certificate cannot be issued or placed on board the ship before the expiry date of the existing Certificate, the person or organization authorized by the Administration may endorse the existing Certificate and such a Certificate should be accepted as valid for a further period which should not exceed 5 months from the expiry date.

1.5.6.5 If a ship, at the time when a Certificate expires, is not in a port in which it is to be surveyed, the Administration may extend the period of validity of the Certificate but this extension should be granted only for the purpose of allowing the ship to complete its voyage to the port in which it is to be surveyed, and then only in cases where it appears proper and reasonable to do so. No Certificate should be extended for a period longer than 3 months, and a ship to which an extension is granted should not, on its arrival in the port in which sit is to be surveyed, be entitled by virtue of such extension to leave that port without having a new Certificate. When the renewal survey is completed, the new Certificate should be valid to a date exceeding 5 years from the date of expiry of the existing Certificate before not the extension was granted.

1.5.6.6 A Certificate issued to a ship engaged on short voyages, which has not been extended under the foregoing provisions of this section, may be extended by the Administration for a period of grace of up to one month from the date of expiry stated on it. When the renewal survey is completed, the new Certificate should be valid to a date not exceeding 5 years from the date of expiry of the existing Certificate before the extension was granted.

1.5.6.7 In special circumstances, as determined by the Administration, a new Certificate need not be dated from the date of expiry of the existing Certificate as required by 1.5.6.2.2, 1.5.6.5 or 1.5.6.6. In these special circumstances, the new Certificate should be valid to a date not exceeding 5 years from the date of completion of the renewal survey.

1.5.6.8 If an annual or intermediate survey is completed before the period specified in 1.5.2, then:

.1 the anniversary date shown on the Certificate should be amended by endorsement to a date which should not be more than 3 months later than the date on which the survey was completed;

.2 the subsequent annual or intermediate survey required by 1.5.2 should be completed at the intervals prescribed by that section using the new anniversary date;

.3 the expiry date may remain unchanged provided one or more annual or intermediate surveys, as appropriate, are carried out so that the maximum intervals between the surveys prescribed by 1.5.2 are not exceeded.

1.5.6.9 A Certificate issued under 1.5.4 or 1.5.5 should cease to be valid in any of the following cases:

.1 if the relevant surveys are not completed within the periods specified under 1.5.2;

.2 if the Certificate is not endorsed in accordance with 1.5.2.1.3 or 1.5.2.1.4;

.3 upon transfer of the ship to the flag of another State. A new Certificate should only be issued when the Government issuing the new Certificate is fully satisfied that the ship is in compliance with the provisions of 1.5.3.1 and 1.5.3.2. In the case of a transfer between Contracting Governments, if requested within 3 months after the transfer has taken place, the Government of the State whose flag the ship was formerly entitled to fly should, as soon as possible, transmit to the Administration copies of the Certificate carried by the ship before the transfer and, if available, copies of the relevant survey reports."

Appendix

MODEL FORM OF INTERNATIONAL CERTIFICATE OF FITNESS FOR THE CARRIAGE OF LIQUEFIED GASES IN BULK

The existing Model Form of Certificate should be replaced by the following:

INTERNATIONAL CERTIFICATE OF FITNESS FOR THE
CARRIAGE OF LIQUEFIED GASES IN BULK

(Official seal)

Issued under the provisions of the
INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT
OF SHIPS CARRYING LIQUEFIED GASES IN BULK
(resolution MSC.5(48) as amended by resolution MSC.17(58))
under the authority of the Government of

....

(full designation of country)

by ....

(full designation of the competent person or organization authorized under the provisions of the Code)

Particulars of ship [1/]

Name of ship ....

Distinctive number of letters ....

Port of registry ....

Cargo capacity (m^3) ....

Ship type (Code paragraph 2.1.2) ....

IMO Number [2/] ....

Date on which keel was laid or ship was at a similar stage of construction or, (in the case of a converted ship) date on which conversion to a gas carrier was commenced ....

The ship also complies fully with the following amendments to the Code:

....

....

This ship is exempted from compliance with the following provisions of the Code:

....

....

THIS IS TO CERTIFY:

1 .1 That the ship has been surveyed in accordance with the provisions of section 1.5 of the Code;

.2 that the survey showed that the structure, equipment, fittings, arrangements and materials of the ship and the conditions thereof are in all respects satisfactory and that the ship complies with the relevant provisions of the Code.

2 That the following design criteria have been used:

.1 ambient air temperature...°C

.2 ambient water temperature ....°C

.3

Tank type and number	Stress factors				Materials	MARVS
	A	B	C	D		
Cargo piping						

NB: Tank numbers referred to in this list are identified on attachment 2, signed and dated tank plan.

.4 Mechanical properties of the cargo tank material were determined at ....°C

3 That the ship is suitable for the carriage in bulk of the following products, provided that all relevant operational provisions of the Code are observed.

Products	Conditions of carriage (tank numbers, etc.)
Continued on attachment 1. [3/] Tank numbers referred to in this list are identified on attachment 2.	

4 That in accordance with 1.4/2.8.2 [3/] , the provisions of the Code are modified in respect of the ship in the following manner:

5 That the ship must be loaded:

.1 in accordance with the loading conditions provided in the approved loading manual, stamped and dated .... and signed by a responsible officer of the Administration, or of an organization recognized by the Administration; [3/]

.2 in accordance with the loading limitations appended to this Certificate. [3/]

Where is required to load the ship other than in accordance with the above instruction, then the necessary calculations t justify the proposed loading conditions should be communicated to the certifying Administration who may authorized in writing the adoption of the proposed loading condition. [4/]

This Certificate is valid until .... [5/] subject to surveys in accordance with 1.5 of the Code.

Issued at ....

(Place of issue of Certificate)

....

(Date of issue) (Signature of duly authorized official issuing the Certificate)

(Seal or stamp of the authority, as appropriate)

Notes on completion of Certificate:

1 "Ship type": any entry under this line must be related to all relevant recommendations, e.g. an entry "Type 2G" should mean type 2G in all respects prescribed by the Code.

2 Paragraph 2.1 and 2.2: the ambient temperature accepted or required by the Administration for the purposes of 4.8.1 of the Code to be inserted.

3 Paragraph 2.3: stress factors and materials as accepted or required by the Administration for the purposes of 4.5.1.4 and 4.5.1.6 of the Code to be inserted.

4 Paragraph 2.4: temperature accepted by the Administration for the purposes of 4.5.1.7 to be inserted.

5 Paragraph 3: only products listed in chapter 19 of the Code or which have been evaluated by the Administration in accordance with paragraph 1.1.6 of the Code or their compatible mixtures having physical properties within the limitations of tank design should be listed. In respect of the latter "new" products, only special requirements provisionally prescribed should be noted.

ENDORSEMENT FOR ANNUAL AND INTERMEDIATE SURVEYS

THIS IS TO CERTIFY that, at a survey required by 1.5.2 of the Code the ship was found to comply with the relevant provisions of the Code:

Annual survey: Signed...
(Signature of authorized official)
Place...
Date...
(Seal or stamp of the authority, as appropriate)

Annual/Intermediate [3/] survey: Signed...
(Signature of authorized official)
Place...
Date...
(Seal or stamp of the authority, as appropriate)

Annual/Intermediate [3/] survey: Signed...
(Signature of authorized official)
Place...
Date...
(Seal or stamp of the authority, as appropriate)

Annual survey: Signed...
(Signature of authorized official)
Place...
Date...
(Seal or stamp of the authority, as appropriate)

<u>Annual/intermediate survey in accordance with 1.5.6.8.3</u>

THIS IS TO CERTIFY that, at an annual/intermediate [3/] survey in acoordance with 1.5.6.8.3 of the Code, the ship was found to comply with the relevant provisions of the Code.

Signed...
(Signature of authorized official)
Place...
Date...
(Seal or stamp of the authority, as appropriate)

<u>Endorsement to extend the Certificate if valid for less than 5 years where 1.5.6.3 applies</u>

The ship complies with the relevant provisions of the Code, and this Certificate should, in accordance with 1.5.6.3 of the Code, be accepted as valid until ....

Signed...
(Signature of authorized official)

Place...
Date..

(Seal or stamp of the authority, as appropriate)

Endorsement where the renewal survey has been completed and 1.5.6.4 applies

The ship complies with the relevant provisions of the Code, and this Certificate should, in accordance with 1.5.6.4 of the Code, be accepted as valid until ....

Signed...
(Signature of authorized official)

Place...
Date..

(Seal or stamp of the authority, as appropriate)

Endorsement to extend the validity of the Certificate until reaching the port of survey or for a period of grace where 1.5.6.5/1.5.6.6 applies

This Certificate should, in accordance with 1.5.6.5/1.5.6.6 [3/] of the Code, be accepted as valid until ....

Signed...
(Signature of authorized official)

Place...
Date..

(Seal or stamp of the authority, as appropriate)

Endorsement for advancement of anniversary date where 1. 5. 6. 8 applies

In accordance with 1.5.6.8 of the Code, the new anniversary date is..

Signed...
(Signature of authorized official)

Place...
Date..

(Seal or stamp of the authority, as appropriate)

In accordance with 1.5.6.8 of the Code, the new anniversary date is ....

Signed...
(Signature of authorized official)

Place...
Date..

(Seal or stamp of the authority, as appropriate)

1/ Alternatively, the particulars of the ship may be placed horizontally in boxes.

2/ In accordance with resolution A.600(15) - IMO Ship Identification Number Scheme, this information may be included voluntarily.

3/ Delete as appropriate.

4/ Instead of being incorporated in the Certificate, this text may be appended to the Certificate if duly signed and stamped.

5/ The date of expiry as specified by the Administration in accordance with 1.5.6.1 of the Code. The day and the month of this date correspond to the anniversary date as defined in 1.3.3.3 of the Code, unless amended in accordance with 1.5.6.8 of the Code.

ATTACHMENT 1

TO THE

INTERNATIONAL CERTIFICATE OF FITNESS FOR THE CARRIAGE OF LIQUEFIED GASES IN BULK

Continued list of products to those specified in section 3, and the conditions of their carriage

	Conditions of carriage

Products	(tank numbers, etc.)

Date ....

(as for Certificate) (Signature of official issuing the Certificate and/or seal or stamp of issuing authority)

ATTACHMENT 2

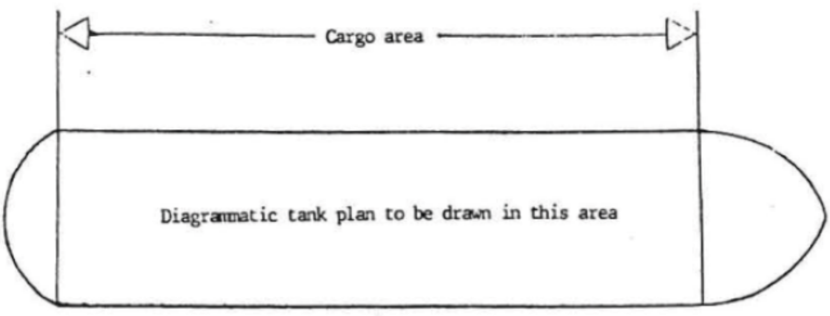
TO THE

INTERNATIONAL CERTIFICATE OF FITNESS FOR THE CARRIAGE OF LIQUEFIED GASES IN BULK

TANK PLAN (Specimen)

Name of ship: ....

Distinctive number or letters: ....



Date ....

(as for Certificate) (Signature of official issuing the Certificate and/or seal or stamp of issuing authority)

***

Title	RESOLUTIONs / MSC Resolutions / Res.MSC.30(61)
Note	Amends Res.MSC.5(48)

RESOLUTION MSC.30(61)

adopted on 11 December 1992

ADOPTION OF AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK (IGC CODE)

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention of the International Maritime Organization concerning the functions of the Committee,

RECALLING ALSO resolution MSC.5(48) by which the Committee adopted the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk(IGC Code),

RECALLING FURTHER article VIII(b) and regulation VII/11.1 of the International Convention for the Safety of Life at Sea(SOLAS), 1974, as amended, concerning the procedure for amending the IGC Code,

BEING DESIROUS of keeping the IGC Code up to date,

HAVING CONSIDERED, at its sixty-first session, amendments to the Code proposed and circulated in accordance with article VIII(b)(i) of the SOLAS Convention,

1. ADOPTS, in accordance with article VIII(b)(iv) of SOLAS Convention amendments to the Code, the text of which is set out in the Annex to the present resolution;

2. DETERMINES, in accordance with article VIII(b)(vi)(2)(bb) of SOLAS Convention, that the amendments shall be deemed to have been accepted on 1 January 1994 unless, prior to that date, more than one third of the Contracting Governments to the SOLAS Convention or Contracting Governments the combined merchant fleets of which constitute not less than fifty per cent of the gross tonnage of the world's merchant fleet, have notified their objections to the amendments;

3. INVITES Contracting Governments to note that, in accordance with article VIII(b)(vii)(2) of the SOLAS Convention, the amendments shall enter into force on 1 July 1994 upon their acceptance in accordance with paragraph 2 above;

4. REQUESTS the Secretary-General, in conformity with article VIII(b)(v) of the SOLAS Convention, to transmit certified copies of the present resolution and the text of the amendments contained in the annex to all Contracting Governments to the SOLAS Convention;

5. FURTHER REQUESTS the Secretary-General to transmit copies of the resolution and its annex to Members of the Organization, which are not Contracting Governments to the SOLAS Convention.

ANNEX

AMENDMENTS TO THE IGC CODE

(Paragraph numbers and amended text refer to the authentic text of the IGC Code in the English language)

1.1.2 Replace "1 July 1986" by "1 October 1994" and add the following: "Ships constructed before 1

October 1994 are to comply with resolution MSC.5(48) adopted on 17 June 1983."

2.7.8.1 Amend reference to read 2.9.1.1.

2.7.8.2 Amend reference to read 2.9.2.1.

2.9.2.1 Fifth line, replace "m/rad." with "m.rad".

3.2.4 Second line, insert ", machinery spaces" between "spaces" and "and".

Fourth line, insert "(L)" between "length" and "of the ship".

Fourth and fifth lines, replace "house" with "superstructure or deckhouse".

Seventh line, replace "houses" with "superstructures or deckhouses".

3.2.5 Second line, replace "are to" with "or deckhouse should".

3.2.6 Third line, replace "are to" with "should".

3.8.4 Sixth line, replace "house" with "superstructure or deckhouse".

4.3.2 Replace "h_{eq}", "h_{gd}" and "$(h_{gd})_{max}$" by "P_{eq}", "P_{gd}" and "$(P_{gd})_{max}$"

4.3.2.1 First line, delete "head"

4.3.2.2 Third line, insert "liquid" after "internal".

Fourth line, delete "head"

Last paragraph, second line, insert "components" between "acceleration" and "in"; replace "needs" with "need".

Replace the last sentence of the definition of Zβwith the following:

"Tank domes considered to be part of the accepted total tank volume should be take into account when determining Zβunless the total volume of tank domes Vd does not exceed the following value:

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

where:

Vt = tank volume without any domes

FL = filling limit according to chapter 15"

4.4.5.1 Last paragraph, replace "analyses" with "analysis" in three places.

4.4.5.6 Note Cw, delete " = ".

4.7.6.1 Last two lines, replace "in way of" with "adjacent to".

4.8.1 Third line, replace "service" with "design".

4.8.2 Fourth line, replace "service" with "design".

4.9.9 Last line, insert "cargo" between "the" and "containment".

4.10.9.1 Amend the second line to read "and workmanship such as out-of roundness, local deviations from the".

4.10.9.2.1 Last line, replace "or" with "of".

4.10.18 Last line, replace "rises" with "raisers".

4.11.2 Replace paragraph 4.11.2 with the following:

"4.11.2 "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, mechanical stress relieving by pressurizing may be carried out as an alternative to the heat treatment with the approval of the Administration and subject to the following conditions

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

.2 The mechanical stress relieving process should preferably be 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 should be water.

.3 For the water temperature, paragraph 4.10.10.3.2 applies

.4 Stress relieving should be performed while the tank is supported by ist regular saddles or supproting 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 supproted by its regular saddles or supproting structure.

.5 The maximum stress relieving pressure should be held for two hours per 25 mm of thickness but in no case less than two hours.

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

- equivalent general primary membrane stress: 0.9 Re

- equivalent stress composed of primary bending stress plus membrane stress: 1.35 Re where Re 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 location of strain gauges should be included in the mechanical stress relieving procedure to be submitted in accordance with 4.11.2.14.

.8 The test procedure should 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 should be checked for cracks by dye penetrant or magnetic particle inspection after mechanical stress relieving. Particular attention in this respect should be given to plates exceeding 30 mm in thickness.

.10 Steels which have a ratio of yield stress to ultimate tensile strength greater than 0.8 should generally not 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 The thickness of the shell and heads of the tank should not exceed 40 mm. Higher thicknesses may be accepted for parts which are thermally stress relieved.

.13 Local buckling should be guarded against particularly when tori-spherical heads are used for tanks and domes.

.14 The procedure for mechanical stress relieving should be submitted beforehand to the Administration for approval."

5.2.1.1 First line, replace "this section" with "sections 5.2 to 5.5".

5.2.3.2 Last line, replace "system" with "systems".

5.4.6 Heading, replace "treatments" with "treatment".

5.4.6.2 First line, replace "treatments" with "treatment".

5.4.6.3.1 Second line, replace "service" with "design".

Add the following to existing paragraph 5.4.6.3.1:

"When such butt welded joints of piping sections are made by automatic welding procedures in the pipe fabrication shop, upon special approval by the Administration, 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 should be increased to 100% and should 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."

5.4.6.3.2 First line, after "pipes" add "not covered by 5.4.6.3.1"

Table 6.1 Line 16, replace "PLATE" with "PLATES".

Table 6.2 Line 17, replace "SECTIONS" with "SECTIONS AND FORGINGS".

6.3.6.3 First line, amend the reference to read "6.3.6.2.1".

8.2.8.3 Last line, insert "spare" between "maintained" and "valve".

8.3.1.1 First line, correct the spelling of "pressure".

8.5.2 Definition of "D" : replace "K" with "k".

9.5.3 Fourth line, delete "tank".

10.2.5.2 First and second lines : replace "cargo products" with "cargoes".

11.1.1.1 Amend reference to read "56.6".

11.3 Add the following new paragraph after 11.3.5:

"11.3.6 Remote starting of pumps supplying the water spray system and remote operation of any normally closed valves in the system should 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."

11.5 Replace 11.5 with the following:

"11.5 Cargo compressor and rooms

"11.5.1 The cargo compressor and pump rooms of any ship should be provided with a carbon dioxide system as specified in regulation II-2/5.1 and 2 of the 1974 SOLAS Convention, as amended. A notice should 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 regulation II-2/5.1.6 of the 1983 SOLAS amendments should be safe for use in a flammable cargo vapour-air mixture. For the purpose of this requirement, an extinguishing system should be provided which would be suitable for machinery spaces. However, the amount of carbon dioxide gas carried should 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.

11.5.2 Cargo compressor and pump rooms of ships which are dedicated to the carriage of a restricted number of cargoes should be protected by an appropriate fire-extinguishing system approved by the Administration."

11.6.1 In the table, delete "below 2,000m³ 2" replace "between 2,000m³ and 5,000m³" with "5,000m³ and below".

Chapter 12 preamble, replace "replace" with "should be substituted for".

13.6.11 Sixth line, replace "sampling and detecting" with "monitoring".

14.2.3.1 First line, insert "spare" between "charged" and "air".

14.3.2 Replace the regulation number with "** 14.3.2" and add a reference at the foot of the page as follows:

** Reference is made to the Medical First Aid Guide for Use in Accidents involving Dangerous Goods (MFAG) which includes the MFAG numbers of products covered by the Code and the emergency procedures to be applied in the event of an incident. MFAG numbers related to products covered by the IGC Code are given in the table of minimum requirements (chapter 19)

14.4.2.1.1 Replace with the following:

".1.1 filter type respiratory protection is unacceptable".

15.1.2 First line, replace "should" with "may".

15.1.4.2 Penultimate line, replace "relief valve" with "relieving system".

15.2 First line, replace "tank filling" with "loading"

Chapter 16 The existing text of chapter 16 is replaced with the following:

"16.1 General

16.1.1 Methane (LNG) is the only cargo whose vapour or boil-off gas may be utilized in machinery spaces of category A and in such spaces may be utilized only in boilers, inert gas generators, and combustion engines and gas turbines.

16.1.2 The provisions do not preclude the use of gas fuel for auxiliary services in other locations, provided that such other services and locations should be subject to special consideration by the Administration.

16.2 Arrangement of machinery spaces of category A

16.2.1 Spaces in which gas fuel is utilized should be fitted with a mechanical ventilation system and should be arranged in such a way as to prevent the formation of dead spaces. Such ventilation should 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 should be separated from those intended for other spaces.

16.2.2 Gas detectors should be fitted in these spaces, particularly in the zones where air circulation is reduced. The gas detection system should 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 should be of the intrinsically safe type.

16. Gas fuel supply

16.3.1 Gas fuel piping should not 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 should be a double wall piping system with the gas fuel contained in the inner pipe. The space between the concentric pipes should be pressurized with inert gas at a pressure greater than the gas fuel pressure. Suitable alarms should be provided to indicate a loss of inert gas pressure between the pipes ; or

.2 the gas fuel piping should be installed within a ventilated pipe or duct. The air space between the gas fuel piping and the inner wall of this pipe or duct should be equipped with mechanical exhaust ventilation having a capacity of at least 30 air changes per hour. The ventilation system should be arranged to maintain a pressure less than the atmospheric pressure. The fan motors should be placed outside the ventilated pipe or duct. The ventilation outlet should be placed in a position where no flammable gas-air mixture may be ignited. The ventilation should always be in operation when there is gas fuel in the piping. Continuous gas detection should 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 should close automatically, if the required air flow is not established and maintained by the exhaust ventilation system..

16.3.2 If a gas leak occurs, the gas fuel supply should not be restored until the leak has been found and repaired. Instructions to this effect should 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 should terminate at the ventilation hood or casing required by 16.3.4.

16.3.4 A ventilation hood or casing should be provided for the areas occupied by flanges, valves, etc., and for the gas fuel piping, at gas fuel utilization units, such as boilers, diesel engines and 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 should be equipped with an exhaust ventilation system and continuous gas detection should 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 should close automatically if the required air flow is not established and maintained by the exhaust ventilation system. The ventilation hood or casing should 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 should be respectively from and to a safe location.

16.3.6 Each gas utilization unit should be provided with a set of three automatic valves. Two of these valves should be in series in the gas fuel pipe to the consuming equipment. The third valve should 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 should be so arranged that failure of the necessary forced draft, 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 cause the vent valve to open automatically. Alternatively, the function of one of the valves in series and of the valve in the vent line 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 should be arranged for manual reset.

16.3.7 A master gas fuel valve that can be closed from within the machinery space should be provided within the cargo area. The valve should 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 should comply with 5.2 - 5.5 as far as found applicable. The piping should, 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 should have full penetration butt-welded joints and should be fully radiographed.

16.3.9 Provision should 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 should comply with 13.6.2 and 13.6.4 through 13.6.8 as applicable; they should 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, compressors, filters, etc.) for making up the gas for its use as fuel, and the related storage tanks should be located in the cargo area in accordance with the requirement of 3.1.5.4. If the equipment is in an enclosed space, the space should be ventilated according to 12.1 of the Code and be equipped with a fixed fire-extinguishing system according to 11.5 and with a gas detection system according to 13.6, as applicable.

16.4.2 The compressors should be capable of being remotely stopped from a position which is always and easily accessible, and also from the engine-room. In addition, the compressors should be capable of automatically stopping when the suction pressure reaches a certain value depending on the set pressure of the vacuum relief valves of the cargo tanks. The automatic shut-down device of the compressors should have a manual resetting. Volumetric compressors should be fitted with pressure relief valves discharging into the suction line of the compressor. The size of the pressure relief valves should be determined in such a way that, with the delivery valve kept closed, the maximum pressure does not exceed by more than 10% the maximum working pressure, The requirements of 5.6.1.3 apply to these compressors.

16.4.3 If the heating medium for the gas fuel evaporator or heater is returned to spaces outside the cargo area it should first go through a degassing tank. The degassing tank should be located in the cargo area. Provisions should be made to detect and alarm the presence of gas in the tank. The vent outlet should be in a safe position and fitted with a flame screen.

16.4.4 Piping and pressure vessels in the gas fuel conditioning system should comply with chapter 5.

16.5 Special requirements for main boilers

16.5.1 Each boiler should have a separate uptake.

16.5.2 A system suitable to ensure the forced draught in the boilers should be provided. The particulars of such a system should be to the satisfaction of the Administration.

16.5.3 Combustion chambers of boilers should be of suitable form such as not to present pockets where gas may accumulate.

16.5.4 The burner systems should be of dual type, suitable to burn either oil fuel or gas fuel alone or oil and gas fuel simultaneously. Only oil fuel should 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 should be possible to change over easily and quickly from gas fuel operation to oil fuel operation. Gas nozzles should be fitted in such a way that gas fuel is ignited by the flame of the oil fuel burner. A flame scanner should 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 should be fitted. An installation should be provided for purging the gas supply piping to the burners by means of inert gas or steam, after the extinguishing of these burners.

16.5.5 Alarm devices should be fitted in order to monitor a possible decrease in liquid fuel oil pressure or a possible failure of the related pumps.

16.5.6 Arrangements should 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 should also be made to enable the boilers to be manually purged and these arrangements should be to the satisfaction of the Administration.

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.

17.1 Replace reference to column "h" by "i".

17.2 Replace reference to column "h" by "i".

17.3 Replace present section 17.13 of the IGC Code with the following:

"17.13 Ammonia

17.13.1 Anhydrous ammonia may cause stress corrosion cracking in containment and process systems made of carbon manganese steel or nickel steel. To minimize the risk of this occurring, measures detailed in 17.13.2 to 17.13.8 should be taken as appropriate.

17.13.2 Where carbon-manganese steel is used, cargo tanks, process pressure vessels and cargo piping should be made of fine-grained steel with a specified minimum yield strength not exceeding 355 N/mm^2 and with an actual yield strength not exceeding 440 N/mm^2. One of the following constructional or operational measures should also be taken:

.1 lower strength material with a specified minimum tensile strength not exceeding 410 N/mm^2 should be used ; or

.2 cargo tanks, etc., should be post-weld stress relief heat treated ; or

.3 carriage temperature should be maintained preferably at a temperature close to the product's boiling point of -33°C but in no case at a temperature above -20°C ; or

.4 the ammonia should contain not less than 0.1% w/w water.

17.13.3 If carbon-manganese steels with higher yield properties are used other than those specified in 17.13.2, the completed cargo tanks, piping, etc., should be given a post-weld stress relief heat treatment.

T(°C)	O2(%v/v)
-30 and below	0.90
-20	0.50
-10	0.28
0	0.16
10	0.10
20	0.05
30	0.03

17.13.4 Process pressure vessels and piping of the condensate part of the refrigeration system should be given a post-weld stress relief heat treatment when made of materials mentioned in 17.13.1.

17.13.5 The tensile and yield properties of the welding consumables should exceed those of the tank or piping material by the smallest practical amount.

17.13.6 Nickel steel containing more than 5% nickel and carbon-manganese steel not complying with the requirements of 17.13.2 and 17.13.3are particularly susceptible to ammonia stress corrosion cracking and should not be used for containment and piping systems for the carriage of this product.

17.13.7 Nickel steel containing not more than 5% nickel may be used provided the carriage temperature complies with the requirements specified in 17.13.2.3.

17.13.8 In order to minimize the risk of ammonia stress corrosion cracking, it is advisable to keep the dissolved oxygen content below 2.5 ppm/w/w. This can best be achieved by reducing the average oxygen content in the tanks prior to the introduction of liquid ammonia to less than the values given as a function of the carriage temperature Tin the table below : oxygen percentages for intermediate temperatures may be obtained by direct interpolation".

17.14.3.1 First line, replace "are to" with "should".

17.14.4.3.1 Delete "cargo".

17.14.5.1 fourth line, delete "remainder of the".

17.16.5 Replace "17.20.6.3" by "17.20.5.3".

17.20.5 Second line, delete "pit".

17.20.14.1 fourth line, replace "the product" with "these products".

17.20.14.3 first line, amend to read "Before each initial loading of these Products and before every subsequent return to such service, ...".

17.20.18 Eighth line, replace " atmospheric" with "ambient".

Insert the following after the third sentence:

"Remote manual operation should be arranged such that remote starting of pumps supplying water spray system and remote operation of any normally closed valves in the system can be carried out from a suitable location outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the areas protected".

18.1.1.7 Insert "allowable" between "minimum" and "inner".

18.2.1 First line, replace "character" with "characteristics". Last line, replace "if so" with "as".

Chapter 19 Summary of minimum requirements, revise the table of minimum requirements to include a new column "h" showing MFAG numbers, as follows:

a Product name	h MFAG table No.
Acetaldehyde	300
Ammonia, anhydrous	725
Butadiene	310
Butane	310
Butane-propane mixtures	310
Butylenes	310
Chlorine	740
Diethyl ether	330
Dimethylamine	320
Ethane	310
Ethyl chloride	340
Ethylene	310
Ethylene oxide	365
Ethylene oxide-propylene oxide mixtures with ethylene oxide content of not more than 30% by weight	365
Isoprene	310
Isopropylamine	320

Methane (LNG)	620
Methyl acetylene-propadiene mixtures	310
Methyl bromide	345
Methyl chloride	340
Monoethylamine	320
Nitrogen	620
Propane	310
Propylene	310
Propylene oxide	365
Refrigerant gases (see notes)	350
Sulphur dioxide	635
Vinyl chloride	340
Vinyl ethyl ether	330
Vinylidene chloride	340

Special requirements column becomes "i".

Add a new explanatory note:

> "MFAG numbers are provided for information on the emergency procedures to be applied in the event of an incident with the products covered by the IGC Code. Where amy of the products listed are carried at low temperature from which frostbite may occur MFAG No.620 is also applicable".

Chapter 19 Table of minimum requirements, insert an asterisk in column "a" for Ethylene oxide - propylene oxide mixtures with ethylene oxide content of not more than 20% by weight.

Add the following to the table of the summary of minimum requirements:

a	b	c	d	e	f	g	h	i
Pentanes (all isomers)*	1265	2G/2PG	-	-	F	R	310	14.4.4, 17.10, 17.12
Pentene (all isomers)*	1265	2G/2PG	-	-	F	R	310	14.4.4, 17.10, 17.12

Delete the reference to "Chapter 19" after paragraph 18.2.1 and at the top of page13.

<u>Appendix</u>

Model form of certificate, footnote 5, third line, insert "or their compatible mixtures having physical proportions within the limitations of tank design" between "Code" and "should".

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Title	RESOLUTIONs / MSC Resolutions / Res.MSC.32(63)
Note	Amends Res.MSC.5(48)

RESOLUTION MSC.32(63)

adopted on 23 May 1994

ADOPTION OF AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK (IGC CODE)

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the functions of the Committee,

RECALLING ALSO resolution MSC.5(48), by which the Committee adopted the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in bulk (IGC CODE),

RECALLING FURTHER article VIII(b) and regulation VII/11.1 of the International Convention for the Safety of Life at Sea (SOLAS), 1974, as amended, concerning the procedure for amending the IGC Code,

BEING DESIROUS of keeping the IGC Code up to date,

HAVING CONSIDERED, at its sixty-third session, amendments to the Code proposed and circulated in accordance with article VIII(b)(i) of the SOLAS Convention,

1. ADOPTS, in accordance with article VIII(b)(iv) of the SOLAS Convention, amendments to the Code, the text of which is set out in the Annex to the present resolution;

2. DETERMINES, in accordance with article VIII(b)(vi)(2)(bb) of the SOLAS Convention, that the amendments shall be deemed to have been accepted on 1 January 1998 unless, prior to that date, more than one third of the Contracting Governments to the SOLAS Convention or contracting Governments the combined merchant fleets of which constitute not less than fifty per cent of the gross tonnage of the world's merchant fleet, have notified their objections to the amendments;

3. INVITES Contracting Governments to note that, in accordance with article VIII(b)(vii)(2) of the SOLAS Convention, the amendments shall enter into force on 1 July 1998 upon their acceptance in accordance with paragraph 2 above;

4. REQUESTS the Secretary-General, in conformity with article VIII(b)(v) of the SOLAS Convention, to transmit certified copies of the present resolution and the text of the amendments contained in the Annex to all contracting Governments to the SOLAS Convention;

5. FURTHER REQUESTS the Secretary-General to transmit copies of the resolution and its Annex to Members of the Organization which are not Contracting Governments to the SOLAS Convention.

ANNEX

AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK (IGC CODE)

Amendments related to application

1. Existing paragraphs 1.1.2 and 1.1.3 are replaced by the following:

"1.1.2 Unless expressly provided otherwise, the Code applies to ships the keels of which are laid or which are at a stage at which:

.1 construction identifiable with the ship begins; and

.2 assembly of that ship has commenced comprising at least 50 tonnes or 1% of the estimated mass of all structural material, whichever is the less;

on or after 1 July 1998. Ships constructed before 1 July 1998 are to comply with resolution MSC.5(48) adopted on 17 June 1983 subject to amendments by resolution MSC.30(61) adopted on 11 December 1992.

1.1.3 A ship, irrespective of the date of construction, which is converted to a gas carrier on or after 1 July 1998 should be treated as a gas carrier constructed on the date on which such conversion commences."

Amendments related to filling limits

2. Existing chapter 15 is replaced by the following:

"CHAPTER 15

FILLING LIMITS FOR CARGO TANKS

15.1 General

15.1.1 No cargo tanks may have a higher filling limit (FL) than 98% at the reference temperature, except as permitted by 15.1.3.

15.1.2 The maximum loading limit (LL) to which a cargo tank may be loaded should be determined by the following formula :

$$LL = FL\frac{\rho_R}{\rho_L}$$

where :

LL= loading limit expressed in percent which means the maximum allowable liquid volume relative to the tank volume to which the tank may be loaded

FL = filling limits as specified in 15.1.1 or 15.1.3

P_R =relative density of cargo at the reference temperature; and

P_L =relative density of cargo at the loading temperature and pressure.

15.1.3 The Administration may allow a higher filling limit (FL) than the limit of 98% specified in 15.1.1at the reference temperature, taking into account the shape of the tank, arrangements of pressure relief valves, accuracy of level and temperature gauging and the difference between the loading temperature and the temperature corresponding to the vapour pressure of the cargo at the set pressure of the pressure relief valves, provided the conditions specified in 8.2.17 are maintained.

15.1.4 For the purpose of this chapter only, "reference temperature" means:

.1 The temperature corresponding to the vapour pressure of the cargo at the set pressure of the pressure relief valves 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. If this reference temperature would result in the cargo tank becoming liquid full before the cargo reaches a temperature corresponding to the vapour pressure of the cargo at the set pressure of the relief valves required in 8.2, an additional pressure relieving system complying with 8.3 should be fitted.

15.1.5 The Administration may allow type C tanks to be loaded according to the following formula provided that the tank vent system has been approved in accordance with 8.2.18:

$$LL = FL\frac{\rho_R}{\rho_L}$$

where :

LL= loading limit as specified in 15.1.2;

FL = filling limits as specified in 15.1.1 or 15.1.3;

P_R =relative density of cargo at the highest temperature which the cargo may reach upon termination of loading, during transport, or at unloading, under the ambient design temperature conditions described in 7.1.2; and

P_L =as specified in 15.1.2.

This paragraph does not apply to products requiring a type 1G ship.

15.2 Information to be provided to the master The maximum allowable loading limits for each cargo tank should be indicated for each product which may be carried, for each loading temperature which may be applied and for the applicable maximum reference temperature, on a list to be approved by the Administration. Pressures at which the pressure relief valves, including those valves required by 8.3, have been set should also be stated on the list. A copy of the list should be permanently kept on board by the master.

15.3 Chapter 15 applies to all ships regardless of the date of construction."

3. The following words are added at the end of existing paragraph 8.2.17:

"at the maximum allowable filling limit (FL)".

4. The following new paragraph 8.2.18 is added after existing paragraph 8.2.17:

"8.2.18 The adequacy of the vent system fitted on tanks loaded in accordance with

15.1.5 is to be demonstrated using the guidelines developed by the Organization*. A relevant certificate should be permanently kept on board the ship. For the purposes of this paragraph, vent system means:

.1 the tank outlet and the piping to the pressure relief valve ;

.2 the pressure relief valve ;

.3 the piping from the pressure relief valve to the location of discharge to the atmosphere and including any interconnections and piping which joins other tanks.

This paragraph may apply to all ships regardless of the date of construction."

* Refer to the guidelines to be developed by the Organization.

Amendments related to cargo tank vent systems

5. Existing paragraph 8.2.3 is replaced by the following:

"8.2.3 In general, the setting of the pressure relief valves should not 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."

6. The following sentences are added to existing paragraph 8.2.4:

"Valves should be constructed of materials with a melting point above 925°C. Consideration of lower melting point materials for internal parts and seals should be given if their use provides significant improvement to the general operation of the valve."

7. Existing paragraph 8.2.9 is replaced by the following:

"8.2.9 Each pressure relief valve installed on a cargo tank should be connected to a venting system, which should 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 should not 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 liquid lines."

8. The following sentences are added to existing paragraph 8.2.16:

"The pressure drop in the vent line from the tank to the pressure relief valve inlet should not exceed 3% of the valve set pressure. For unbalanced pressure relief valves the back pressure in the discharge line should not 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."

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Title	RESOLUTIONs / MSC Resolutions / Res.MSC.59(67)
Note	Amends Res.MSC.5(48)

RESOLUTION MSC.59(67)

(adopted on 5 December 1996)

ADOPTION OF AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK (IGC CODE)

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the functions of the Committee,

RECALLING ALSO resolution MSC.5(48) by which it adopted the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code),

RECALLING FURTHER article VIII(b) and regulation VIII/11.1 of the International Convention for the Safety of Life at Sea (SOLAS), 1974, as amended, concerning the procedure for amending the IGC Code,

BEING DESIROUS of keeping the IGC Code up to date,

HAVING CONSIDERED, at its sixty-seventh session, amendments to the Code proposed and circulated in accordance with article VIII(b)(i) of the SOLAS Convention,

1. ADOPTS, in accordance with article VIII(b)(iv) of the SOLAS Convention, amendments to the Code the text of which is set out in the Annex to the present resolution;

2. DETERMINES, in accordance with article VIII(b)(vi)(2)(bb) of the Convention, that the amendments shall be deemed to have been accepted on 1 January 1998, unless, prior to that date, more than one third of the Contracting Governments to the SOLAS Convention or Contracting Governments the combined merchant fleets of which constitute not less than 50% of the gross tonnage of the world's merchant fleet, have notified their objections to the amendments;

3. INVITES Contracting Governments to note that, in accordance with article VIII(b)(vii)(2) of the SOLAS Convention, the amendments shall enter into force on 1 July 1998 upon their acceptance in accordance with paragraph 2 above;

4. REQUESTS the Secretary-General, in conformity with article VIII(b)(v) of the SOLAS Convention, to transmit certified copies of the present resolution and the text of the amendments contained in the Annex to all Contracting Governments to the SOLAS Convention;

5. FURTHER REQUESTS the Secretary-General to transmit copies of this resolution and its Annex to Members of the Organization, which are not Contracting Governments to the SOLAS Convention.

ANNEX

AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK(IGC CODE)

CHAPTER1 - GENERAL

1 The following new paragraph 1.3.29.3. is added after existing paragraph 1.3.30.2:

"1.3.30.3 Recognized standards are applicable international or national standards acceptable to the Administration or standards laid down and maintained by an organization which complies with the standards adopted by the Organization* and which is recognized by the Administration."

* Refer to the Minimum Standards for Recognized Organizations Acting on Behalf of the Administration, set out in appendix 1 to the Guidelines for the Authorization of Organizations Acting on Behalf of the Administration, adopted by the Organization by resolution A.739(18).

CHAPTER2 - SHIP SURVIVAL CAPABILITY AND LOCATION OF CARGO TANKS

2 In paragraph 2.3.3, the words "should be of a type acceptable to the Administration and" are deleted and the words "and should comply with recognized standards" are added at the and of the paragraph.

CHAPTER3 - SHIP ARRANGEMENTS

3 In paragraph 3.8.1, the words "to the approval of the Administration and" are deleted.

CHAPTER4 - CARGO CONTAINMENT

4 In paragraph 4.2.4.2, in the first sentence, the words "Recognized Standards*" are replaced by the words "recognized standards".

5 In paragraph 4.2.4.3, in the second sentence, the words "(gravity tests)" are replaced by the words "(gravity tanks)".

6 In paragraph 4.2.4.4, the expression "55 N/mm² for ferritic/martensitic steel" is replaced by the expression "55 N/mm² for ferritic-perlitic, martensitic and austenitic steels".

7 In the introductory phrase of paragraph 4.11.2, the words "with the approval of the Administration" are deleted.

CHAPTER5 - PROCESS PRESSURE VESSELS AND LIQUID, VAPOUR AND PRESSURE PIPING SYSTEMS

8 In paragraph 5.2.2.1, in the definition of the efficiency factor "e", the existing text of the last sentence is replaced by the following:

"In other cases an efficiency factor of less than 1.0, in accordance with recognized standards, may be required depending on the manufacturing process."

9 In the paragraph 5.2.4.4, in the first sentence, the words "be to a standard acceptable to the Administration" are replaced by the words "should comply with recognized standards" and at the

end of the second sentence, the words "by the Administration"are deleted.

10 In paragraph 5.4.1, the existing text of the second sentence is replaced by the following:

"Relaxations from these requirements may be accepted, in accordance with recognized standards, for piping inside cargo tanks and open-ended piping."

11 In paragraph 5.4.2.2, the words "satisfactory to the Administration" are replaced by the words" in accordance with recognized standards".

12 In paragraph 5.4.2.3, the words "acceptable to the Administration" are replaced by the words "complying with recognized standards".

13 In paragraph 5.4.3.2, in the first sentence, the words "standards acceptable to the Administration" are replaced by the words "recognized standards".

14 In paragraph 5.6.4, in the sixth sentence, the words "with 30s of actuation" are replaced by the words "within 30s of actuation".

CHAPTER8 - CARGO TANK VENT SYSTEMS

15 In paragraph 8.2.2, the words "to the satisfaction of the Administration" are replaced by the words "complying with recognized standards".

CHAPTER11 - FIRE PROTECTION AND FIRE EXTINCTION

16 In paragraph 11.2.4, in the second sentence, the words "All pipes, valves nozzles" are replaced by the words "All pipes, valves, nozzles".

CHAPTER13 - INSTRUMENTATION (GAUGING, GAS DETECTION)

17 In paragraph 13.3.1, in the last sentence the word "Administration" is deleted and the words "port Administration" are replaced by the words "port State authority".

18 In paragraph 13.6.9, the expression "column h" is replaced by the expression "column I".

CHAPTER14 - PERSONNEL PROTECTION

19 In paragraph 14.4.1, the expression "column h" is replaced by the expression "column I".

CHAPTER16 - USE OF CARGO AS FUEL

20 In paragraph 16.5.6, in the second sentence, the words "and these arrangements should be to the satisfaction of the Administration" are deleted.

CHAPTER17 - SPECIAL REQUIREMENTS

21 In paragraph 17.20.4.1, in the first sentence, the words "of other material acceptable to the Administration" are replaced by the words "in accordance with recognized standards," and the second sentence is deleted.

22 In paragraph 17.20.15, in the first sentence, the words "filling limits" are replaced by the

words "loading limits".

CHAPTER19 - SUMMARY OF MINIMUM REQUIREMENTS

23 In column "f" of the table, for the product "Butadiene", the entry "F" is replaced by the entry "F+T".

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Title	RESOLUTIONs / MSC Resolutions / Res.MSC.103(73)
Note	Amends.Res.MSC.5(48)

RESOLUTION MSC.103(73)

(adopted on 5 December 2000)

ADOPTION OF AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK (IGC CODE)

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the functions of the Committee,

RECALLING ALSO resolution MSC.5(48) by which it adopted the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code),

RECALLING FURTHER article VIII(b) and regulation VII/11.1 of the International Convention for the Safety of Life at Sea (SOLAS), 1974 (hereinafter referred to as "the Convention") concerning the procedure for amending the IGC Code,

BEING DESIROUS of keeping the IGC Code up to date,

HAVING CONSIDERED, at its seventy-third session, amendments to the IGC Code proposed and circulated in accordance with article VIII(b)(i) of the Convention,

1. ADOPTS, in accordance with article VIII(b)(iv) of the Convention, amendments to the IGC Code, the text of which is set out in the Annex to the present resolution;

2. DETERMINES, in accordance with article VIII(b)(vi)(2)(bb) of the Convention, that the amendments shall be deemed to have been accepted on 1 January 2002, unless, prior to that date, more than one third of the Contracting Governments to the Convention or Contracting Governments the combined merchant fleets of which constitute not less than 50% of the gross tonnage of the world's merchant fleet, have notified their objections to the amendments;

3. INVITES Contracting Governments to note that, in accordance with article VIII(b)(vii)(2) of the Convention, the amendments shall enter into force on 1 July 2002 upon their acceptance in accordance with paragraph 2 above;

4. REQUESTS the Secretary-General, in conformity with article VIII(b)(v) of the Convention, to transmit certified copies of the present resolution and the text of the amendments contained in the Annex to all Contracting Governments to the Convention;

5. FURTHER REQUESTS the Secretary-General to transmit copies of this resolution and its Annex to Members of the Organization, which are not Contracting Governments to the Convention.

ANNEX

AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK (IGC

CODE)

CHAPTER 3

SHIP ARRANGEMENTS

1 The following text is inserted after the title of paragraph 3.7:

"(Paragraph 3.7.2.2 applies to ships constructed on or after 1 July 2002)"

2 The existing text of paragraph 3.7.2 is replaced by the following:

"3.7.2.1 The hold or interbarrier spaces of Type A independent tank ships should be provided with a drainage system suitable for handling liquid cargo in the event of cargo tank leakage or rupture. Such arrangements should provide for the return of any cargo leakage to the liquid cargo piping.

3.7.2.2 Arrangements referred to in 3.7.2.1 should be provided with a removable spool piece.

3 The existing text of paragraph 3.7.4 is replaced by the following:

"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 should not be open to machinery spaces."

CHAPTER 4

CARGO CONTAINMENT

4 The third sentence of paragraph 4.8.3 is replaced by the following:

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

5 The first sentence of paragraph 4.10.10.3.7 is replaced by the following:

"Pneumatic testing of pressure vessels other than cargo tanks should only be considered on an individual case basis by the Administration."

CHAPTER 5

PROCESS PRESSURE VESSELS AND LIQUID, VAPOUR, AND PRESSURE PIPING SYSTEMS

6 The following text is inserted after the title of paragraph 5.6:

"(Paragraph 5.6.5 applies to ships constructed on or after 1 July 2002)"

7 A new paragraph 5.6.5 is inserted after existing paragraph 5.6.4:

"5.6.5 The closure time of 30 s for the emergency shutdown valve referred to in 5.6.4 should 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 should be such as to avoid surge pressure in pipelines. Such valves should close in such a manner as to cut off the flows smoothly.

8 Existing paragraph 5.6.5 is renumbered as paragraph 5.6.6.

5.7 Ship's cargo hoses

9 Existing paragraph 5.7.3 is replaced by the following:

"5.7.3 For cargo hoses installed on board ships on or after 1 July 2002, each new type of cargo hose, complete with end-fittings, should be prototype-tested at a normal ambient temperature with 200 pressure cycles from zero to at least twice the specified maximum working pressure. After this cycle pressure test has been carried out, the prototype test should demonstrate a bursting pressure of at least 5 times its specified maximum working pressure at the extreme service temperature. Hoses used for prototype testing should not be used for cargo service. Thereafter, before being placed in service, each new length of cargo hose produced should be hydrostatically tested at ambient temperature to a pressure not less than 1.5 times its specified maximum working pressure but not more than two-fifths of its bursting pressure. The hose should be stencilled or otherwise marked with the date of testing, its specified maximum working pressure and, if used in services other than the ambient temperature services, its maximum and minimum service temperature, as applicable. The specified maximum working pressure should not be less than 10 bar gauge."

CHAPTER 8

CARGO TANK VENT SYSTEMS

10 The existing text of the first sentence of paragraph 8.2.7 is replaced by the following:

"The changing of the set pressure under the provisions of 8.2.6, and the corresponding resetting of the alarms referred to in 13.4.1, should be carried out under the supervision of the master in accordance with procedures approved by the Administration and specified in the ship's operating manual."

CHAPTER 9

ENVIRONMENTAL CONTROL

11 The following sentence is added at the end of paragraph 9.5.3:

"When not in use, the inert gas system should be made separate from the cargo system in the cargo area except for connections to the hold spaces or interbarrier spaces."

CHAPTER 11

FIRE PROTECTION AND FIRE EXTINCTION

12 The second sentence of paragraph 11.2.4 is replaced by the following:

"All pipes, valves, nozzles and other fittings in the fire-fighting systems should be resistant to the effects of fire and to corrosion by water."

CHAPTER 13

INSTRUMENTATION (GAUGING, GAS DETECTION)

13 The last three sentences of paragraph 13.3.1 are replaced by the following:

"The emergency shutdown valve referred to in 5.6.1 and 5.6.3 may be used for this purpose. If another valve is used for this purpose, the same information as referred to in 5.6.4 should be available on board. During loading, whenever the use of these valves may possibly create a potential excess pressure surge in the loading system, the port State authority may agree to alternative arrangements such as limiting the loading rate, etc."

CHAPTER 14

PERSONNEL PROTECTION

14 Existing paragraph 14.3.2 is replaced by the following:

"14.3.2 The ship should have on board medical first-aid equipment, including oxygen resuscitation equipment and antidotes for cargoes to be carried, based on the guidelines developed by the Organization*.

* Reference is made to the Medical First Aid Guide for Use in Accidents Involving Dangerous Goods (MFAG), which provides advice on the treatment of casualties in accordance with the symptoms exhibited as well as equipment and antidotes that may be appropriate for treating the casualty."

CHAPTER 18

OPERATING REQUIREMENTS

15 Existing paragraph 18.3.3 is replaced by the following:

"18.3.3 Officers should be trained in emergency procedures to deal with conditions of leakage, spillage or fire involving the cargo, based on the guidelines developed by the Organization*, and a sufficient number of them should be instructed and trained in essential first aid for cargoes carried.

* Refer to the Medical First Aid Guide for Use in Accidents Involving Dangerous Goods (MFAG), which provides advice on the treatment of casualties in accordance with the symptoms exhibited as well as equipment and antidotes that may be appropriate for treating the casualty, and to the relevant provisions of the STCW Code, parts A and B."

16 In paragraph 18.9, the reference to paragraph 17.4.3 is added to the list of references.

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Title	RESOLUTIONs / MSC Resolutions / Res.MSC.177(79)
Note	Amends Res.MSC.5(48)

RESOLUTION MSC.177(79)

(adopted on 10 December 2004)

ADOPTION OF AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK (IGC CODE)

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the functions of the Committee,

NOTING resolution MSC.5(48), by which it adopted the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (hereinafter referred to as "the IGC Code"), which has become mandatory under chapter VII of the International Convention for the Safety of Life at Sea (SOLAS), 1974 (hereinafter referred to as "the Convention"),

NOTING ALSO article VIII(b) and regulation VII/11.1 of the Convention concerning the procedure for amending the IGC Code,

HAVING CONSIDERED, at its seventy-ninth session, amendments to the IGC Code proposed and circulated in accordance with article VIII(b)(i) of the Convention,

1. ADOPTS, in accordance with article VIII(b)(iv) of the Convention, amendments to the IGC Code, the text of which is set out in the Annex to the present resolution;

2. DETERMINES, in accordance with article VIII(b)(vi)(2)(bb) of the Convention, that the amendments shall be deemed to have been accepted on 1 January 2006 unless, prior to that date, more than one third of the Contracting Governments to the Convention or Contracting Governments the combined merchant fleets of which constitute not less than 50% of the gross tonnage of the world's merchant fleet, have notified their objections to the amendments;

3. INVITES Contracting Governments to note that, in accordance with article VIII(b)(vii)(2) of the Convention, the amendments shall enter into force on 1 July 2006 upon their acceptance in accordance with paragraph 2 above;

4. REQUESTS the Secretary-General, in conformity with article VIII(b)(v) of the Convention, to transmit certified copies of the present resolution and the text of the amendments contained in the Annex to all Contracting Governments to the Convention;

5. FURTHER REQUESTS the Secretary-General to transmit copies of this resolution and its Annex to Members of the Organization, which are not Contracting Governments to the Convention.

ANNEX

AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK (IGC CODE)

CHAPTER 3 - SHIP ARRANGEMENTS

(Following amendment applies to ships constructed on or after 1 January 2007)

1 In paragraph 3.6.4, the reference to "10.2.5.4" is replaced by "10.1.4".

CHAPTER 10 - ELECTRICAL INSTALLATIONS

(Following amendments apply to ships constructed on or after 1 January 2007)

2 In paragraph 10.1.4, the words "when the exceptions listed in 10.2 are permitted" in the first sentence are deleted.

3 The following new sentence is added at the end of paragraph 10.1.4:

"Electrical equipment, cables and wiring should not be installed in hazardous locations unless it conforms with the standards not inferior to those acceptable to the Organization*. However, for locations not covered by such standards, electrical equipment, cables and wiring which do not conform to the standards may be installed in hazardous locations based on a risk assessment to the satisfaction of the Administration, to ensure that an equivalent level of safety is assured."

* Refer to the standards published by the International Electrotechnical Commission, IEC 60092-502:1999 'Electrical installations in ships - Tankers'.

4 Existing paragraph 10.2 is deleted.**

** Note by the Secretariat:

In paragraph 10.1.2, at the end of the first sentence, the following footnote is added:

" * Refer to the relevant standards of the International Electrotechnical Commission, in particular publication 60092-502."

In paragraph 10.1.3, the footnote at the end of the paragraph is deleted.

APPENDIX

Model form of International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk

5 In the form of the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk, the following new section is inserted between the section commencing with the words "This certificate is valid until" and the section commencing with the words "Issued at":

"Completion date of the survey on which this certificate is based: ___________ (dd/mm/yyyy)"

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Title	RESOLUTIONs / MSC Resolutions / Res.MSC.220(82)
Note	Amends Res.MSC.5(48)

RESOLUTION MSC.220(82)

(adopted on 8 December 2006)

ADOPTION OF AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the functions of the Committee,

NOTING resolution MSC.5(48), by which it adopted the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (hereinafter referred to as "the IGC Code"), which has become mandatory under chapter VII of the International Convention for the Safety of Life at Sea (SOLAS), 1974 (hereinafter referred to as "the Convention"),

NOTING ALSO article VIII(b) and regulation VII/11.1 of the Convention concerning the procedure for amending the IGC Code,

HAVING CONSIDERED, at its eighty-second session, amendments to the IGC Code proposed and circulated in accordance with article VIII(b)(i) of the Convention,

1. ADOPTS, in accordance with article VIII(b)(iv) of the Convention, amendments to the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, the text of which is set out in the Annex to the present resolution;

2. DETERMINES, in accordance with article VIII(b)(vi)(2)(bb) of the Convention, that the amendments shall be deemed to have been accepted on 1 January 2008 unless, prior to that date, more than one third of the Contracting Governments to the Convention or Contracting Governments the combined merchant fleets of which constitute not less than 50% of the gross tonnage of the world's merchant fleet, have notified their objections to the amendments;

3. INVITES Contracting Governments to note that, in accordance with article VIII(b)(vii)(2) of the Convention, the amendments shall enter into force on 1 July 2008 upon their acceptance in accordance with paragraph 2 above;

4. REQUESTS the Secretary-General, in conformity with article VIII(b)(v) of the Convention, to transmit certified copies of the present resolution and the text of the amendments contained in the Annex to all Contracting Governments to the Convention;

5. FURTHER REQUESTS the Secretary-General to transmit copies of this resolution and its Annex to Members of the Organization, which are not Contracting Governments to the Convention.

ANNEX

AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK

CHAPTER 1

GENERAL

1.3 Definitions

1 In paragraph 1.3.2, the words "regulation II-2/3.3 of the 1983 SOLAS amendments" are replaced by "SOLAS regulation II-2/3.2".

2 Paragraph 1.3.34 is replaced by the following new paragraph 1.3.34:

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

CHAPTER 3

SHIP ARRANGEMENTS

3.3 Cargo pump-rooms and cargo compressor rooms

3 In paragraph 3.3.1.1, the words "regulation II-2/58 of the 1983 SOLAS amendments" are replaced by "SOLAS regulation II-2/9.2.4".

CHAPTER 11

FIRE PROTECTION AND FIRE EXTINCTION

11.1 Fire safety requirements

4 In paragraph 11.1.1, the words "chapter II-2 of the 1983 SOLAS amendments" are replaced by "SOLAS chapter II-2", and subparagraphs .1 to .3 are replaced by the following new subparagraphs:

".1 regulations 4.5.1.6 and 4.5.10 do not apply;

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

.3 regulation 10.5.6 should apply to ships of 2,000 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 the Code as detailed below:

Regulation	**Replaced by**
10.10	11.6
4.5.1.1 and 4.5.1.2	chapter 3
4.5.5 and 10.8	11.3 and 11.4
10.9	11.5

.5 regulations 13.3.4 and 13.4.3 should apply to ships of 500 gross tonnage and over."

11.2 Fire water main equipment

5 In paragraph 11.2.1, the words "regulations II-2/4 and II-2/7 of the 1983 SOLAS amendments" are replaced by "SOLAS regulations II-2/10.2, 10.4 and 10.5", the words "regulations 4.2.1 and 4.4.1" are replaced by "regulations II-2/10.2.2.4.1 and II-2/10.2.1.3" and "regulation 4.4.2" is replaced by "regulation II-2/10.2.1.6".

6 In paragraph 11.2.2, the words "regulations II-2/4.5.1 and II-2/4.8 of the 1983 SOLAS amendments, with hose lengths not exceeding 33 m" are replaced by "SOLAS regulations II-2/10.2.1.5.1 and II-2/10.2.3.3, with hose lengths as specified in regulation II-2/10.2.3.1.1".

11.5 Cargo compressor and pump-rooms

7 In paragraph 11.5.1, the words "regulation II-2/5.1 and .2 of the 1974 SOLAS Convention, as amended" are replaced by "SOLAS regulation II-2/10.9.1.1", the words "regulation II-2/5.1.6 of the 1983 SOLAS amendments" are replaced by "SOLAS regulation II-2/10.9.1.1.1".

8 In paragraph 11.6, in the heading, the word "Firemen's" is replaced by the word "Fire-fighter's".

9 In paragraph 11.6.1, the word "firemen's" is replaced by the word "fire-fighter's" and the words "regulation II-2/17 of the 1983 SOLAS amendments" are replaced by "SOLAS regulation II-2/10.10".

CHAPTER 12

MECHANICAL VENTILATION IN THE CARGO AREA

10 The words after the heading "The requirements of this chapter should be substituted for regulation II-2/59.3 of the 1983 SOLAS amendments" are replaced by the words "The requirements of this chapter should be substituted for SOLAS regulations II-2/4.5.2.6 and II-2/4.5.4".

CHAPTER 19

SUMMARY OF MINIMUM REQUIREMENTS

11 The following products are added to the table in chapter 19:

a	b	c	d	e	f	g	h	i
Product name	UN number	Ship type	Independent tank type C required	Control of vapour space within cargo tanks	Vapour detection	Cauging	MFAG table No.	Special requirements
Dimethyl ether	-	2G/2PG	-	-	F+T	C	-	
Carbon dioxide	-	3G	Yes	-	-	C	-	

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RESOLUTION MSC.370(93)
(adopted on 22 May 2014)

AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK (IGC CODE)

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the functions of the Committee,

NOTING resolution MSC.5(48), by which it adopted the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (hereinafter referred to as "the IGC Code"), which has become mandatory under chapter VII of the International Convention for the Safety of Life at Sea (SOLAS), 1974 (hereinafter referred to as "the Convention"),

NOTING ALSO article VIII(b) and regulation VII/11.1 of the Convention concerning the procedure for amending the IGC Code,

HAVING CONSIDERED, at its ninety-third session, amendments to the IGC Code proposed and circulated in accordance with article VIII(b)(i) of the Convention,

1 ADOPTS, in accordance with article VIII(b)(iv) of the Convention, amendments to the IGC Code, the text of which is set out in the annex to the present resolution;

2 DETERMINES, in accordance with article VIII(b)(vi)(2)(bb) of the Convention, that the amendments shall be deemed to have been accepted on 1 July 2015 unless, prior to that date, more than one third of the Contracting Governments to the Convention or Contracting Governments the combined merchant fleets of which constitute not less than 50% of the gross tonnage of the world's merchant fleet, have notified their objections to the amendments;

3 INVITES Contracting Governments to note that, in accordance with article VIII(b)(vii)(2) of the Convention, the amendments shall enter into force on 1 January 2016 upon their acceptance in accordance with paragraph 2 above;

4 REQUESTS the Secretary-General, in conformity with article VIII(b)(v) of the Convention, to transmit certified copies of the present resolution and the text of the amendments contained in the annex to all Contracting Governments to the Convention;

5 ALSO REQUESTS the Secretary-General to transmit copies of this resolution and its annex to Members of the Organization, which are not Contracting Governments to the Convention.

ANNEX

AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK (IGC CODE)

The complete text of the IGC Code is replaced by the following:

"Contents

Preamble

1 The purpose of this Code is to provide an international standard for the safe carriage, by sea in bulk, of liquefied gases and certain other substances that are listed in chapter 19. Through consideration of the products carried, it prescribes the design and construction standards of the ships involved and the equipment they should carry to minimize the risk to the ship, its crew and the environment.

2 The basic philosophy is one of ship types related to the hazards of the products covered by the Code. Each of the products may have one or more hazard properties, which include flammability, toxicity, corrosivity and reactivity. A further possible hazard may arise where products are transported under cryogenic or pressure conditions.

3 Severe collisions or strandings could lead to cargo tank damage and result in uncontrolled release of the product. Such a release could result in evaporation and dispersion of the product and, in some cases, could cause brittle fracture of the ship's hull. The requirements in the Code are intended to minimize this risk as far as is practicable, based upon present knowledge and technology.

4 Throughout the development of the Code, it was recognized that it must be based on sound naval architectural and engineering principles and the best understanding available as to the hazards of the various products covered. Gas carrier design technology is not only a complex technology but is rapidly evolving and the Code shall not remain static. The Organization will periodically review the Code, continually taking into account both experience and future development.

5 Requirements for new products and their conditions of carriage will be circulated as recommendations, on an interim basis, when adopted by the Maritime Safety Committee of the Organization, prior to the entry into force of the appropriate amendments, under the terms of article VIII of the International Convention for the Safety of Life at Sea, 1974.

6 The Code primarily deals with ship design and equipment. To ensure the safe transport of the products the total system must, however, be appraised. Other important facets of the safe transport of the products, such as training, operation, traffic control and handling in port, are being or will be examined further by the Organization.

7 The development of the Code has been greatly assisted by a number of organizations in consultative status, such as the Society of International Gas Tanker and Terminal Operators Limited (SIGTTO) and other organizations, such as members of the International Association of Classification Societies (IACS).

8 Chapter 18 of the Code dealing with operation of liquefied gas carriers highlights the regulations in other chapters that are operational in nature and mentions those other important safety features that are peculiar to gas carrier operations.

9 The layout of the Code is in line with the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code), adopted by the Maritime Safety Committee at its forty-eighth session. Gas carriers may also carry in bulk liquid chemicals covered by the IBC Code, as prescribed in the IGC Code.

10 Floating production, storage and offloading (FPSO) facilities, which are designed to handle liquefied gases in bulk, do not fall under the IGC Code. However, designers of such units may consider using the IGC Code to the extent that the Code provides the most appropriate risk mitigation measures for the operations the unit is to perform. Where other more appropriate risk mitigation measures are determined that are contrary to this Code, they shall take precedence over the Code.

CHAPTER 1

GENERAL

Goal

To provide an international standard for the safe carriage, by sea in bulk, of liquefied gases by laying down the design and construction standards of ships involved in such carriage and the equipment, they shall carry to minimize the risk to the ship, its crew and to the environment, having regard to the nature of the products including flammability, toxicity, asphyxiation, corrosivity, reactivity and low temperature and vapour pressure.

1.1 Application and implementation

1.1.1 The Code applies to ships regardless of their size, including those of less than 500 gross tonnage, engaged in the carriage of liquefied gases having a vapour pressure exceeding 0.28 MPa absolute at a temperature of 37.8°C and other products, as shown in chapter 19, when carried in bulk.

1.1.2.1 Unless expressly provided otherwise, the Code applies to ships whose keels are laid, or which are at a similar stage of construction where:

.1 construction identifiable with the ship begins; and

.2 assembly of that ship has commenced, comprising at least 50 tonnes or 1% of the estimated mass of all structural material, whichever is less,

on or after 1 July 2016.

1.1.2.2 For the purpose of the Code, the expression "ships constructed" means ships the keels of which are laid or which are at a similar stage of construction.

1.1.2.3 Unless expressly provided otherwise, for ships constructed on or after 1 July 1986 and before 1 July 2016, the Administration shall ensure that the requirements which are applicable under this Code, as adopted by resolution MSC.5(48) as amended by resolutions MSC.17(58), MSC.30(61), MSC.32(63), MSC.59(67), MSC.103(73), MSC.177(79) and MSC.220(82), are complied with.

1.1.3 A ship, irrespective of the date of construction, which is converted to a gas carrier on or after 1 July 2016, shall be treated as a gas carrier constructed on the date on which such conversion commences.

1.1.4.1 When cargo tanks contain products for which the Code requires a type 1G ship, neither flammable liquids having a flashpoint of 60°C (closed cup test) or less, nor flammable products listed in chapter 19, shall be carried in tanks located within the protective zones described in 2.4.1.1.

1.1.4.2 Similarly, when cargo tanks contain products for which the Code requires a type 2G/2PG ship, the flammable liquids as described in 1.1.4.1, shall not be carried in tanks located within the protective zones described in 2.4.1.2.

1.1.4.3 In each case, for cargo tanks loaded with products for which the Code requires a type 1G or 2G/2PG ship, the restriction applies to the protective zones within the longitudinal extent of the hold spaces for those tanks.

1.1.4.4 The flammable liquids and products described in 1.1.4.1 may be carried within these protective zones when the quantity of products retained in the cargo tanks, for which the Code requires a type 1G or 2G/2PG ship is solely used for cooling, circulation or fuelling purposes.

1.1.5 Except as provided in 1.1.7.1, when it is intended to carry products covered by this Code and products covered by the *International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk* (IBC Code), adopted by resolution MSC.4(48), as may be amended by the Organization, the ship shall comply with the requirements of both Codes appropriate to the products carried.

1.1.6.1 Where it is proposed to carry products that may be considered to come within the scope of this Code that are not at present designated in chapter 19, the Administration and the port Administrations involved in such carriage shall establish a Tripartite Agreement based on a provisional assessment and lay down preliminary suitable conditions of carriage based on the principles of the Code.

1.1.6.2 For the evaluation of such products, the manufacturer of the product shall submit to the Administration a completed assessment form (see appendix 1), which includes the proposed ship type and carriage requirements.

1.1.6.3 When a provisional assessment for a pure or technically pure product has been completed and agreed with the other parties, the Administration shall submit the assessment form and a proposal for a new and complete entry in the IGC Code, to the relevant sub-committee of the Organization (see appendix 1).

1.1.6.4 After provisional assessment by Tripartite Agreement and express or tacit agreement has been established, an addendum to the relevant ship's certificate may be issued (see appendix 3).

1.1.7.1 The requirements of this Code shall take precedence when a ship is designed and constructed for the carriage of the following products:

.1 those listed exclusively in chapter 19 of the Code; and

.2 one or more of the products that are listed both in the Code and in the International Bulk Chemical Code. These products are marked with an asterisk in column "a" in the table contained within chapter 19.

1.1.7.2 When a ship is intended to exclusively carry one or more of the products referred to in 1.1.7.1.2, the requirements of the International Bulk Chemical Code, as amended, shall apply.

1.1.8 The ship's compliance with the requirements of the International Gas Carrier Code shall be shown by its International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk, as described in 1.4. Compliance with the amendments to the Code, as appropriate, shall also be indicated in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk.

1.1.9 Where reference is made in the Code to a paragraph, all the provisions of the subparagraph of that designation shall apply.

1.1.10 When a ship is intended to operate for periods at a fixed location in a re-gasification and gas discharge mode or a gas receiving, processing, liquefaction and storage mode, the Administration and port Administrations involved in the operation shall take appropriate steps to ensure implementation of the provisions of the Code as are applicable to the proposed arrangements. Furthermore, additional requirements shall be established based on the principles of the Code as well as recognized standards that address specific risks not envisaged by it. Such risks may include, but not be limited to:

.1 fire and explosion;

.2 evacuation;

.3 extension of hazardous areas;

.4 pressurized gas discharge to shore;

.5 high-pressure gas venting;

.6 process upset conditions;

.7 storage and handling of flammable refrigerants;

.8 continuous presence of liquid and vapour cargo outside the cargo containment system;

.9 tank over-pressure and under-pressure;

.10 ship-to-ship transfer of liquid cargo; and

.11 collision risk during berthing manoeuvres.

1.1.11 Where a risk assessment or study of similar intent is utilized within the Code, the results shall also include, but not be limited to, the following as evidence of effectiveness:

.1 description of methodology and standards applied;

.2 potential variation in scenario interpretation or sources of error in the study;

.3 validation of the risk assessment process by an independent and suitable third party;

.4 quality system under which the risk assessment was developed;

.5 the source, suitability and validity of data used within the assessment;

.6 the knowledge base of persons involved within the assessment;

.7 system of distribution of results to relevant parties; and

.8 validation of results by an independent and suitable third party.

1.1.12 Although the Code is legally treated as a mandatory instrument under the SOLAS Convention, the provisions of section 4.28 and appendices 1, 3 and 4 of the Code are recommendatory or informative.

1.2 Definitions

Except where expressly provided otherwise, the following definitions apply to the Code. Additional definitions are provided in chapters throughout the Code.

1.2.1 *Accommodation spaces* are those spaces used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobby rooms, barber shops, pantries without cooking appliances and similar spaces.

1.2.2 *"A" class divisions* are divisions as defined in regulation II-2/3.2 of the SOLAS Convention.

1.2.3 *Administration* means the Government of the State whose flag the ship is entitled to fly. For *Administration (port)*, see *port Administration.*

1.2.4 *Anniversary date* means the day and the month of each year that will correspond to the date of expiry of the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk.

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

1.2.6 *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)* shall be measured in metres.

1.2.7 *Cargo area* is that part of the ship which contains the cargo containment system and cargo pump and compressor rooms and includes the deck areas over the full length and breadth of the part of the ship over these 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 foremost hold space are excluded from the cargo area.

1.2.8 *Cargo containment system* is the arrangement for containment of cargo including, where fitted, a primary and secondary barrier, associated insulation and any intervening spaces, and adjacent structure, if necessary, for the support of these elements. If the secondary barrier is part of the hull structure, it may be a boundary of the hold space.

1.2.9 *Cargo control room* is a space used in the control of cargo handling operations.

1.2.10 *Cargo machinery spaces* are the spaces where cargo compressors or pumps, cargo processing units, are located, including those supplying gas fuel to the engine-room.

1.2.11 *Cargo pumps* are pumps used for the transfer of liquid cargo including main pumps, booster pumps, spray pumps, etc.

1.2.12 *Cargoes* are products listed in chapter 19, that are carried in bulk by ships subject to the Code.

1.2.13 *Cargo service spaces* are spaces within the cargo area, used for workshops, lockers and store-rooms that are of more than 2 m^2 in area.

1.2.14 *Cargo tank* is the liquid-tight shell designed to be the primary container of the cargo and includes all such containment systems whether or not they are associated with the insulation or/and the secondary barriers.

1.2.15 *Closed loop sampling* is a cargo sampling system that minimizes the escape of cargo vapour to the atmosphere by returning product to the cargo tank during sampling.

1.2.16 *Cofferdam* is the isolating space between two adjacent steel bulkheads or decks. This space may be a void space or a ballast space.

1.2.17 *Control stations* are those spaces in which ship's radio, 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.

1.2.18 *Flammable products* are those identified by an "F" in column "*f*" in the table of chapter 19.

1.2.19 *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.

1.2.20 *FSS Code* is the Fire Safety Systems Code meaning the *International Code for Fire Safety Systems*, adopted by the Maritime Safety Committee of the Organization by resolution MSC.98(73), as amended.

1.2.21 *Gas carrier* is a cargo ship constructed or adapted and used for the carriage in bulk of any liquefied gas or other products listed in the table of chapter 19.

1.2.22 *Gas combustion unit (GCU)* is a means of disposing excess cargo vapour by thermal oxidation.

1.2.23 *Gas consumer* is any unit within the ship using cargo vapour as a fuel.

1.2.24 *Hazardous area* is an area in which an explosive gas atmosphere is, or may be expected to be present, in quantities that require special precautions for the construction, installation and use of electrical equipment. When a gas atmosphere is present, the following hazards may also be present: toxicity, asphyxiation, corrosivity, reactivity and low temperature. These hazards shall also be taken into account and additional precautions for the ventilation of spaces and protection of the crew will need to be considered. Examples of hazardous areas include, but are not limited to, the following:

.1 the interiors of cargo containment systems and any pipework of pressure-relief or other venting systems for cargo tanks, pipes and equipment containing the cargo;

.2 interbarrier spaces;

.3 hold spaces where the cargo containment system requires a secondary barrier;

.4 hold spaces where the cargo containment system does not require a secondary barrier;

.5 a space separated from a hold space by a single gastight steel boundary where the cargo containment system requires a secondary barrier;

.6 cargo machinery spaces;

.7 areas on open deck, or semi-enclosed spaces on open deck, within 3 m of possible sources of gas release, such as cargo valve, cargo pipe flange, cargo machinery space ventilation outlet, etc.;

.8 areas on open deck, or semi-enclosed spaces on open deck within 1.5 m of cargo machinery space entrances, cargo machinery space ventilation inlets;

.9 areas on 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;

.10 an area within 2.4 m of the outer surface of a cargo containment system where such surface is exposed to the weather;

.11 enclosed or semi-enclosed spaces in which pipes containing cargoes are located, except those where pipes containing cargo products for boil-off gas fuel burning systems are located;

.12 an enclosed or semi-enclosed space having a direct opening into any hazardous area;

.13 void spaces, cofferdams, trunks, passageways and enclosed or semi-enclosed spaces, adjacent to, or immediately above or below, the cargo containment system;

.14 areas on open deck or semi-enclosed spaces on open deck above and in the vicinity of any vent riser outlet, within a vertical cylinder of unlimited height and 6 m radius centred upon the centre of the outlet and within a hemisphere of 6 m radius below the outlet; and

.15 areas on open deck within spillage containment surrounding cargo manifold valves and 3 m beyond these up to a height of 2.4 m above deck.

1.2.25 *Non-hazardous area* is an area other than a hazardous area.

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

1.2.27 *IBC Code* means the *International Code for the Construction and Equipment of Ships carrying Dangerous Chemicals in Bulk*, adopted by the Maritime Safety Committee of the Organization by resolution MSC.4(48), as amended.

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

1.2.29 *Insulation space* is the space, which may or may not be an interbarrier space, occupied wholly or in part by insulation.

1.2.30 *Interbarrier space* is the space between a primary and a secondary barrier, whether or not completely or partially occupied by insulation or other material.

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

1.2.32 *Machinery spaces of category A* are those spaces, and trunks to those spaces, which contain either:

.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 or any oil-fired equipment other than boilers, such as inert gas generators, incinerators, etc.

1.2.33 *Machinery spaces* are machinery spaces of category A and 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 the trunks to such spaces.

1.2.34 *MARVS* is the maximum allowable relief valve setting of a cargo tank (gauge pressure).

1.2.35 *Nominated surveyor* is a surveyor nominated/appointed by an Administration to enforce the provisions of the SOLAS Convention regulations with regard to inspections and surveys and the granting of exemptions therefrom.

1.2.36 *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 0.18 MPa gauge.

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

1.2.38 *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.

1.2.39 *Port Administration* means the appropriate authority of the country for the port where the ship is loading or unloading.

1.2.40 *Primary barrier* is the inner element designed to contain the cargo when the cargo containment system includes two boundaries.

1.2.41 *Products* is the collective term used to cover the list of gases indicated in chapter 19 of this Code.

1.2.42 *Public spaces* are those portions of the accommodation that are used for halls, dining rooms, lounges and similar permanently enclosed spaces.

1.2.43 *Recognized organization* is an organization authorized by an Administration in accordance with SOLAS regulation XI-1/1.

1.2.44 *Recognized standards* are applicable international or national standards acceptable to the Administration, or standards laid down and maintained by the recognized organization.

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

1.2.46 *Secondary barrier* is the liquid-resisting outer element of a cargo containment system, designed to afford temporary containment of any envisaged leakage of liquid cargo through the primary barrier and to prevent the lowering of the temperature of the ship's structure to an unsafe level. Types of secondary barrier are more fully defined in chapter 4.

1.2.47 *Separate systems* are those cargo piping and vent systems that are not permanently connected to each other.

1.2.48 *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.

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

1.2.50 *Tank cover* is the protective structure intended to either 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.

1.2.51 *Tank dome* is the upward extension of a portion of a cargo tank. In the case of below-deck cargo containment systems, the tank dome protrudes through the weather deck or through a tank cover.

1.2.52 *Thermal oxidation method* means a system where the boil-off vapours are utilized as fuel for shipboard use or as a waste heat system subject to the provisions of chapter 16 or a system not using the gas as fuel complying with this Code.

1.2.53 *Toxic products* are those defined by a "T" in column "*f*" in the table of chapter 19.

1.2.54 *Turret compartments* are those spaces and trunks that contain equipment and machinery for retrieval and release of the disconnectable turret mooring system, high-pressure hydraulic operating systems, fire protection arrangements and cargo transfer valves.

1.2.55 *Vapour pressure* is the equilibrium pressure of the saturated vapour above the liquid, expressed in Pascals (Pa) absolute at a specified temperature.

1.2.56 *Void space* is an enclosed space in the cargo area external to a cargo containment system, other than a hold space, ballast space, oil fuel tank, cargo pumps or compressor room, or any space in normal use by personnel.

1.3 Equivalents

1.3.1 Where the Code requires that a particular fitting, material, appliance, apparatus, item of equipment or type thereof shall be fitted or carried in a ship, or that any particular provision shall be made, or any procedure or arrangement shall be complied with, the Administration 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 the Code. However, the Administration may not allow operational methods or procedures to be made as an alternative to a particular fitting, material, appliance, apparatus, item of equipment, or type thereof that is prescribed by the Code, unless such a substitution is specifically allowed by the Code.

1.3.2 When the Administration so allows, any fitting, material, appliance, apparatus, item of equipment, or type thereof, or provision, procedure or arrangement or novel design or application to be substituted, it shall communicate to the Organization the particulars thereof, together with a report on the evidence submitted, so that the Organization may circulate the same to other Contracting Governments to the SOLAS Convention for the information of their officers.

1.4 Surveys and certification

1.4.1 *Survey procedure*

1.4.1.1 The survey of ships, so far as regards the enforcement of the provisions of the Code and granting of exemptions therefrom, shall be carried out by officers of the Administration. The Administration may, however, entrust the surveys either to surveyors nominated for the purpose or to organizations recognized by it.

1.4.1.2 The recognized organization, referred to in 1.2.43, shall comply with the provisions of the SOLAS Convention and with the Code for recognized organizations (RO Code).

1.4.1.3 The Administration nominating surveyors or recognizing organizations to conduct surveys shall, as a minimum, empower any nominated surveyor or recognized organization to:

.1 require repairs to a ship; and

.2 carry out surveys if requested by the appropriate authorities of a port State.

The Administration shall notify the Organization of the specific responsibilities and conditions of the authority delegated to nominated surveyors or recognized organizations, for circulation to the Contracting Governments.

1.4.1.4 When a nominated surveyor or recognized organization determines that the condition of a ship or its equipment does not correspond substantially with the particulars of the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk, or is such that the ship is not fit to proceed to sea without danger to the ship or persons on board, or without presenting unreasonable threat of harm to the marine environment, the surveyor or organization shall immediately ensure that corrective action is taken and shall, in due course, notify the Administration. If such corrective action is not taken, the certificate shall be withdrawn and the Administration shall be notified immediately. If the ship is in a port of another Contracting Government, the appropriate authorities of the port State shall be notified immediately. When an officer of the Administration, a nominated surveyor or a recognized organization has notified the appropriate authorities of the port State, the Government of the port State concerned shall give the officer, surveyor or organization any necessary assistance to carry out their obligations under this paragraph. When applicable, the Government of the port State concerned shall take such steps as will ensure that the ship does not sail until it can proceed to sea or leave the port for the purpose of proceeding to the nearest appropriate repair yard available without danger to the ship or persons on board or without presenting an unreasonable threat of harm to the marine environment.

1.4.1.5 In every case, the Administration shall guarantee the completeness and efficiency of the survey and shall undertake to ensure the necessary arrangements to satisfy this obligation.

1.4.2 *Survey requirements*

The structure, equipment, fittings, arrangements and material (other than items in respect of which a Cargo Ship Safety Construction Certificate, Cargo Ship Safety Equipment Certificate and Cargo Ship Safety Radio Certificate; or Cargo Ship Safety Certificate, required by the SOLAS Convention, are issued) of a gas carrier shall be subjected to the following surveys:

.1 An initial survey before the ship is put in service or before the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk is issued for the first time, which shall include a complete examination of its structure, equipment, fittings, arrangements and materials in so far as the ship is covered by the Code. This survey shall be such as to ensure that the structure, equipment, fittings, arrangements and material fully comply with the applicable provisions of the Code.

.2 A renewal survey at intervals specified by the Administration, but not exceeding five years, except where regulation 1.4.6.2.1, 1.4.6.5, 1.4.6.6 or 1.4.6.7 is applicable. The renewal survey shall be such as to ensure that the structure, equipment, fittings, arrangements and material fully comply with the applicable provisions of the Code.

.3 An intermediate survey within three months before or after the second anniversary date, or within three months before or after the third anniversary date of the certificate, which shall take the place of one of the annual surveys specified in 1.4.2.4. The intermediate survey shall be such as to ensure that the safety equipment, and other equipment, and associated pump and piping systems fully comply with the applicable provisions of the Code and are in good working order. Such intermediate surveys shall be endorsed on the certificate issued under 1.4.4 or 1.4.5.

.4 An annual survey within three months before or after each anniversary date of the certificate, including a general inspection of the structure, equipment, fittings, arrangements and material referred to in 1.4.2.1 to ensure that they have been maintained in accordance with 1.4.3 and that they remain satisfactory for the service for which the ship is intended. Such annual surveys shall be endorsed on the certificate issued under 1.4.4 or 1.4.5.

.5 An additional survey, either general or partial according to the circumstances, shall be made when required after an investigation prescribed in 1.4.3.3, or whenever any important repairs or renewals are made. Such a survey shall ensure that the necessary repairs or renewals have been effectively made, that the materials and workmanship of such repairs or renewals are satisfactory, and that the ship is fit to proceed to sea without danger to the ship or persons on board or without presenting unreasonable threat of harm to the marine environment.

1.4.3 ***Maintenance of conditions after survey***

1.4.3.1 The condition of the ship and its equipment shall be maintained to conform with the provisions of the Code and to ensure that the ship will remain fit to proceed to sea without danger to the ship or persons on board or without presenting unreasonable threat of harm to the marine environment.

1.4.3.2 After any survey of the ship, as described in 1.4.2, has been completed, no change shall be made in the structure, equipment, fittings, arrangements and material covered by the survey without the sanction of the Administration, except by direct replacement.

1.4.3.3 Whenever an accident occurs to a ship or a defect is discovered, either of which affects the safety of the ship or the efficiency or completeness of its life-saving appliances or other equipment covered by the Code, the master or owner of the ship shall report at the earliest opportunity to the Administration, the nominated surveyor or recognized organization responsible for issuing the certificate, who shall cause investigations to be initiated to determine whether a survey, as required by 1.4.2.5, is necessary. If the ship is in a port of another Contracting Government, the master or owner shall also report immediately to the appropriate authorities of the port State and the nominated surveyor or recognized organization shall ascertain that such a report has been made.

1.4.4 *Issue and endorsement of an International Certificate of Fitness of Liquefied Gases in Bulk*

1.4.4.1 An International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk shall be issued, after an initial or renewal survey, to a gas carrier engaged on international voyages that comply with the relevant provisions of the Code.

1.4.4.2 Such a certificate shall be drawn up in the form corresponding to the model given in appendix 2. If the language used is not English, French or Spanish, the text shall include a translation into one of these languages.

1.4.4.3 The certificate issued under the provisions of this section shall be available on board for examination at all times.

1.4.4.4 Notwithstanding any other provisions of the amendments to the Code, adopted by the Maritime Safety Committee by resolution MSC.17(58), any International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk that is current when these amendments enter into force shall remain valid until it expires under the terms of this Code prior to the amendments entering into force.

1.4.5 *Issue or endorsement of an International Certificate of Fitness of Liquefied Gases in Bulk by another Government*

1.4.5.1 A Contracting Government to the SOLAS Convention may, at the request of another Contracting Government, cause a ship entitled to fly the flag of the other State to be surveyed and, if satisfied that the requirements of the Code are complied with, issue or authorize the issue of the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk to the ship and, where appropriate, endorse or authorize the endorsement of the certificate on board the ship in accordance with the Code. Any certificate so issued shall contain a statement to the effect that it has been issued at the request of the Government of the State whose flag the ship is entitled to fly.

1.4.6 *Duration and validity of an International Certificate of Fitness of Liquefied Gases in Bulk*

1.4.6.1 An International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk shall be issued for a period specified by the Administration, which shall not exceed five years.

1.4.6.2.1 Notwithstanding the provisions of 1.4.6.1, when the renewal survey is completed within three months before the expiry date of the existing certificate, the new certificate shall be valid from the date of completion of the renewal survey to a date not exceeding five years from the date of expiry of the existing certificate.

1.4.6.2.2 When the renewal survey is completed after the expiry date of the existing certificate, the new certificate shall be valid from the date of completion of the renewal survey to a date not exceeding five years from the date of expiry of the existing certificate.

1.4.6.2.3 When the renewal survey is completed more than three months before the expiry date of the existing certificate, the new certificate shall be valid from the date of completion of the renewal survey to a date not exceeding five years from the date of completion of the renewal survey.

1.4.6.3 If a certificate is issued for a period of less than five years, the Administration may extend the validity of the certificate beyond the expiry date to the maximum period specified in 1.4.6.1, provided that the surveys referred to in regulations 1.4.2.3 and 1.4.2.4, applicable when a certificate is issued for a period of five years, are carried out as appropriate.

1.4.6.4 If a renewal survey has been completed and a new certificate cannot be issued or placed on board the ship before the expiry date of the existing certificate, the person or organization authorized by the Administration may endorse the existing certificate. Such a certificate shall be accepted as valid for a further period which shall not exceed five months from the expiry date.

1.4.6.5 If a ship is not in a port in which it is to be surveyed at the time when a certificate expires, the Administration may extend the period of validity of the certificate. However, the extension shall be granted only for the purpose of allowing the ship to complete its voyage to the port in which it is to be surveyed, and then only in cases where it appears proper and reasonable to do so.

1.4.6.6 A certificate, issued to a ship engaged on short voyages, that has not been extended under the foregoing provisions of this section may be extended by the Administration for a period of grace of up to one month from the date of expiry stated on it. When the renewal survey is completed, the new certificate shall be valid to a date not exceeding five years from the date of expiry of the existing certificate before the extension was granted.

1.4.6.7 In special circumstances, as determined by the Administration, a new certificate need not be dated from the date of expiry of the existing certificate as required by 1.4.6.2.2, 1.4.6.5 or 1.4.6.6. In these special circumstances, the new certificate shall be valid to a date not exceeding five years from the date of completion of the renewal survey.

1.4.6.8 If an annual or intermediate survey is completed before the period specified in 1.4.2, then:

.1 the anniversary date shown on the certificate shall be amended by endorsement to a date that shall not be more than three months later than the date on which the survey was completed;

.2 the subsequent annual or intermediate survey required by 1.4.2 shall be completed, at the intervals prescribed by that section, using the new anniversary date; and

.3 the expiry date may remain unchanged, provided one or more annual or intermediate surveys, as appropriate, are carried out so that the maximum intervals between the surveys prescribed by 1.4.2 are not exceeded.

1.4.6.9 A certificate issued under 1.4.4 or 1.4.5 shall cease to be valid in any of the following cases:

.1 if the relevant surveys are not completed within the periods specified in 1.4.2;

.2 if the certificate is not endorsed in accordance with 1.4.2.3 or 1.4.2.4; and

.3 upon transfer of the ship to the flag of another State. A new certificate shall only be issued when the Government issuing the new certificate is fully satisfied that the ship is in compliance with the provisions of 1.4.3.1 and 1.4.3.2. In the case of a transfer between Contracting Governments to the SOLAS Convention, if requested within three months after the transfer has taken place, the Government of the State whose flag the ship was formerly entitled to fly shall, as soon as possible, transmit to the Administration copies of the certificate carried by the ship before the transfer and, if available, copies of the relevant survey reports.

CHAPTER 2

SHIP SURVIVAL CAPABILITY AND LOCATION OF CARGO TANKS

Goal

To ensure that the cargo tanks are in a protective location in the event of minor hull damage, and that the ship can survive the assumed flooding conditions.

2.1 General

2.1.1 Ships subject to the Code shall survive the hydrostatic effects of flooding following assumed hull damage caused by some external force. In addition, to safeguard the ship and the environment, the cargo tanks shall be protected from penetration in the case of minor damage to the ship resulting, for example, from contact with a jetty or tug, and also given a measure of protection from damage in the case of collision or grounding, 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 shall be dependent upon the degree of hazard presented by the product to be carried. In addition, the proximity of the cargo tanks to the ship's shell shall be dependent upon the volume of the cargo tank.

2.1.2 Ships subject to the Code shall be designed to one of the following standards:

.1 A *type 1G ship* is a gas carrier intended to transport the products indicated in chapter 19 that require maximum preventive measures to preclude their escape.

.2 A *type 2G ship* is a gas carrier intended to transport the products indicated in chapter 19, that require significant preventive measures to preclude their escape.

.3 A *type 2PG ship* is a gas carrier of 150 m in length or less intended to transport the products indicated in chapter 19 that require significant preventive measures to preclude their escape, and where the products are carried in type C independent tanks designed (see 4.23) for a MARVS of at least 0.7 MPa gauge and a cargo containment system design temperature of -55°C or above. A ship of this description that is over 150 m in length is to be considered a type 2G ship.

.4 A *type 3G ship* is a gas carrier intended to carry the products indicated in chapter 19 that require moderate preventive measures to preclude their escape.

Therefore, a type 1G ship is a gas carrier intended for the transportation of products considered to present the greatest overall hazard and types 2G/2PG and type 3G for products of progressively lesser hazards. Accordingly, a type 1G ship shall survive the most severe standard of damage and its cargo tanks shall be located at the maximum prescribed distance inboard from the shell plating.

2.1.3 The ship type required for individual products is indicated in column "*c*" in the table of chapter 19.

2.1.4 If a ship is intended to carry more than one of the products listed in chapter 19, the standard of damage shall correspond to the product having the most stringent ship type requirements. The requirements for the location of individual cargo tanks, however, are those for ship types related to the respective products intended to be carried.

2.1.5 For the purpose of this Code, the position of the moulded line for different containment systems is shown in figures 2.5 (a) to (e).

2.2 Freeboard and stability

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

2.2.2 The stability of the ship, in all seagoing conditions and during loading and unloading cargo, shall comply with the requirements of the International Code on Intact Stability. This includes partial filling and loading and unloading at sea, when applicable. Stability during ballast water operations shall fulfil stability criteria.

2.2.3 When calculating the effect of free surfaces of consumable liquids for loading conditions, it shall be assumed that, for each type of liquid, at least one transverse pair or a single centre tank has a free surface. The tank or combination of tanks to be taken into account shall be those where the effect of free surfaces is the greatest. The free surface effect in undamaged compartments shall be calculated by a method according to the International Code on Intact Stability.

2.2.4 Solid ballast shall 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, its disposition shall be governed by the need to enable access for inspection and 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 shall be supplied with a loading and stability information booklet. This booklet shall contain details of typical service conditions, loading, unloading and ballasting operations, provisions for evaluating other conditions of loading and a summary of the ship's survival capabilities. The booklet shall also contain sufficient information to enable the master to load and operate the ship in a safe and seaworthy manner.

2.2.6 All ships, subject to the Code shall be fitted with a stability instrument, capable of verifying compliance with intact and damage stability requirements, approved by the Administration having regard to the performance standards recommended by the Organization.

.1 ships constructed before 1 July 2016 shall comply with this paragraph at the first scheduled renewal survey of the ship after 1 July 2016 but not later than 1 July 2021;

.2 notwithstanding the requirements of paragraph 2.2.6.1 a stability instrument installed on a ship constructed before 1 July 2016 need not be replaced provided it is capable of verifying compliance with intact and damage stability, to the satisfaction of the Administration; and

.3 for the purposes of control under SOLAS regulation XI-1/4, the Administration shall issue a document of approval for the stability instrument.

2.2.7 The Administration may waive the requirements of paragraph 2.2.6 for the following ships, provided the procedures employed for intact and damage stability verification maintain the same degree of safety, as being loaded in accordance with the approved conditions. Any such waiver shall be duly noted on the International Certificate of Fitness referred to in paragraph 1.4.4:

.1 ships which are on a dedicated service, with a limited number of permutations of loading such that all anticipated conditions have been approved in the stability information provided to the master in accordance with the requirements of paragraph 2.2.5;

.2 ships where stability verification is made remotely by a means approved by the Administration;

.3 ships which are loaded within an approved range of loading conditions; or

.4 ships constructed before 1 July 2016 provided with approved limiting KG/GM curves covering all applicable intact and damage stability requirements.

2.2.8 ***Conditions of loading***

Damage survival capability shall be investigated on the basis of loading information submitted to the Administration for all anticipated conditions of loading and variations in draught and trim. This shall include ballast and, where applicable, cargo heel.

2.3 Damage assumptions

2.3.1 The assumed maximum extent of damage shall be:

.1	Side damage		
.1.1	Longitudinal extent:	$1/3\ L^{2/3}$ or 14.5 m, whichever is less	
.1.2	Transverse extent: measured inboard from the moulded line of the outer shell at right angles to the centreline at the level of the summer waterline	B/5 or 11.5 m, whichever is less	
.1.3	Vertical extent: from the moulded line of the outer shell	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 14.5 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 2.4.3)	B/15 or 2 m, whichever is less measured from the moulded line of the bottom shell plating at centreline (see 2.4.3)

2.3.2 ***Other damage***

2.3.2.1 If any damage of a lesser extent than the maximum damage specified in 2.3.1 would result in a more severe condition, such damage shall be assumed.

2.3.2.2 Local damage anywhere in the cargo area extending inboard distance "*d*" as defined in 2.4.1, measured normal to the moulded line of the outer shell shall be considered. Bulkheads shall be assumed damaged when the relevant subparagraphs of 2.6.1 apply. If a damage of a lesser extent than "*d*" would result in a more severe condition, such damage shall be assumed.

2.4 Location of cargo tanks

2.4.1 Cargo tanks shall be located at the following distances inboard:

.1 Type 1G ships: from the moulded line of the outer shell, not less than the transverse extent of damage specified in 2.3.1.1.2 and, from the moulded line of the bottom shell at centreline, not less than the vertical extent of damage specified in 2.3.1.2.3, and nowhere less than "*d*" where "*d*" is as follows:

.1 for Vc below or equal 1,000 m^3, $d = 0.8$ m;

.2 for 1,000 m^3 < Vc < 5,000 m^3, $d = 0.75 + Vc \times 0.2/4{,}000$ m;

.3 for 5,000 m^3 ≤ Vc < 30,000 m^3, d = 0.8 + Vc/25,000 m; and

.4 for Vc ≥ 30,000 m^3, d = 2 m,

where:

- Vc corresponds to 100% of the gross design volume of the individual cargo tank at 20°C, including domes and appendages (see figures 2.1 and 2.2). For the purpose of cargo tank protective distances, the cargo tank volume is the aggregate volume of all the parts of tank that have a common bulkhead(s); and

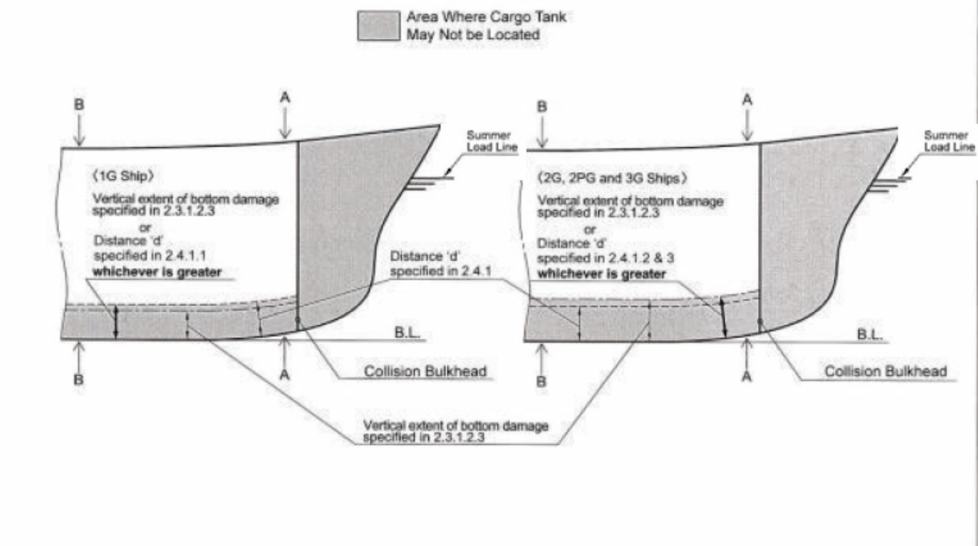
- "*d*" is measured at any cross section at a right angle from the moulded line of outer shell.

Tank size limitations may apply to type 1G ship cargoes in accordance with chapter 17.

.2 Types 2G/2PG: from the moulded line of the bottom shell at centreline not less than the vertical extent of damage specified in 2.3.1.2.3 and nowhere less than "*d*" as indicated in 2.4.1.1 (see figures 2.1 and 2.3).

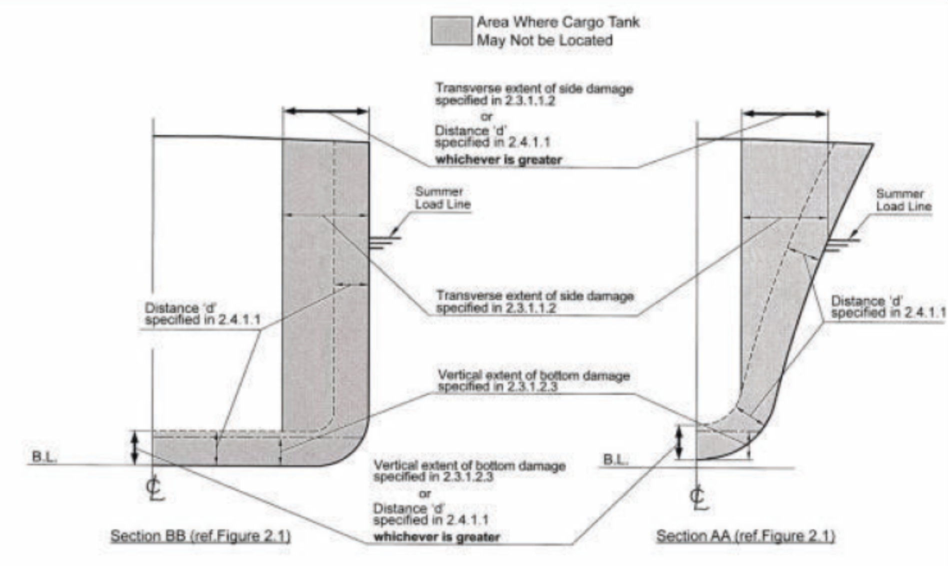
.3 Type 3G ships: from the moulded line of the bottom shell at centreline not less than the vertical extent of damage specified in 2.3.1.2.3 and nowhere less than "*d*", where "*d*" = 0.8 m from the moulded line of outer shell (see figures 2.1 and 2.4).

2.4.2 For the purpose of tank location, the vertical extent of bottom damage shall be measured to the inner bottom when membrane or semi-membrane tanks are used, otherwise to the bottom of the cargo tanks. The transverse extent of side damage shall be measured to the longitudinal bulkhead when membrane or semi-membrane tanks are used, otherwise to the side of the cargo tanks. The distances indicated in 2.3 and 2.4 shall be applied as in figures 2.5(a) to (e). These distances shall be measured plate to plate, from the moulded line to the moulded line, excluding insulation.



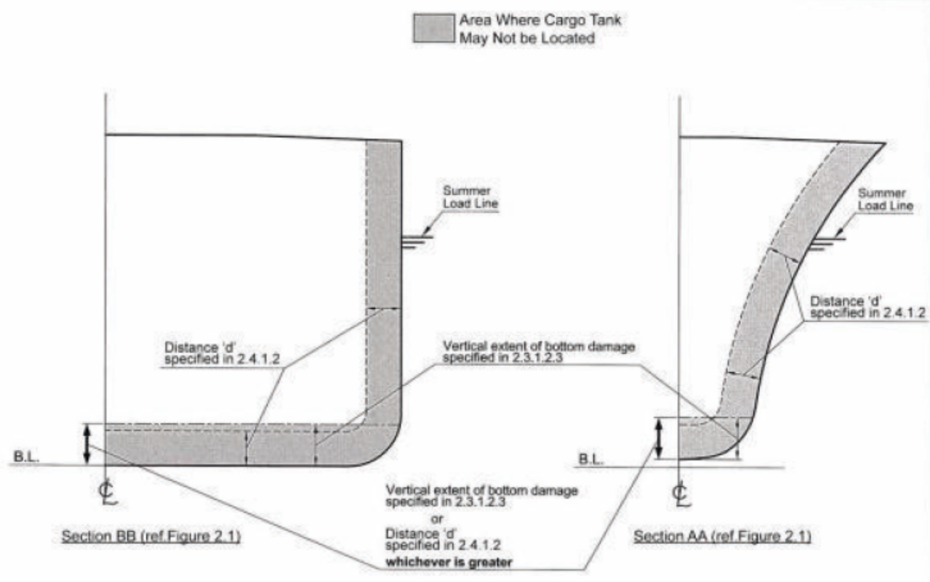
Centreline Profile - Type 1G, 2G, 2PG and 3G Ships

Figure 2.1 - *Cargo tank location requirements*



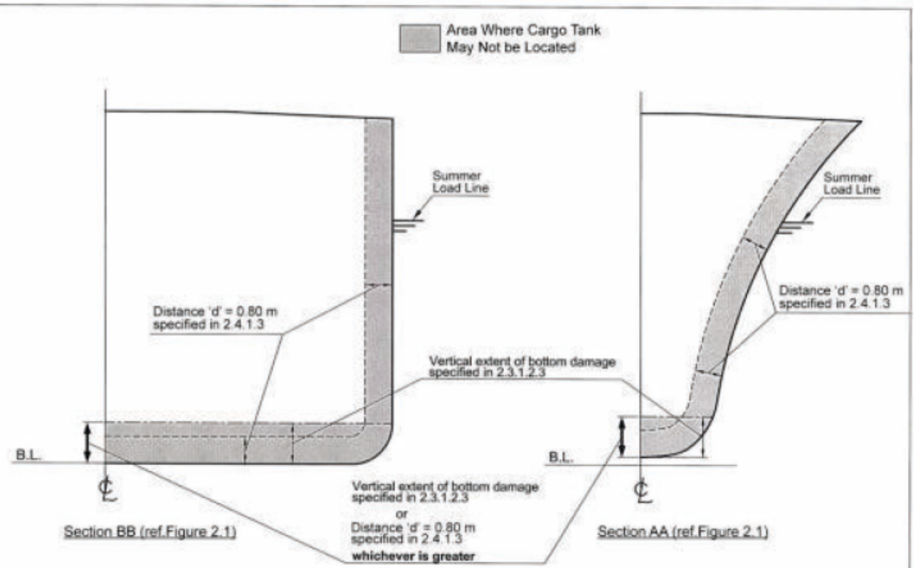
Transverse Sections - Type 1G Ship

Figure 2.2 - *Cargo tank location requirements*



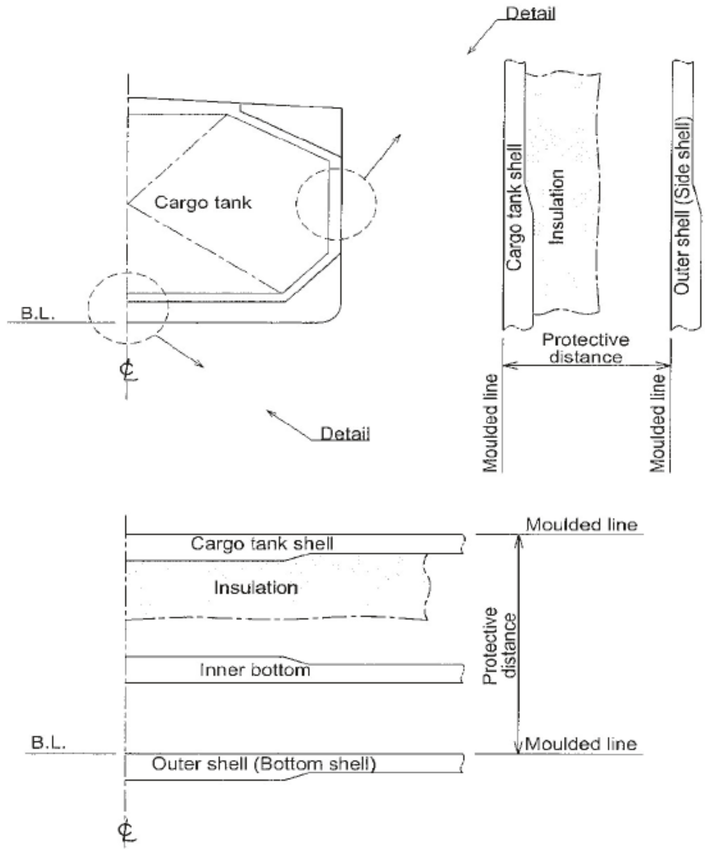
Transverse Sections - Type 2G and 2PG Ships

Figure 2.3 - *Cargo tank location requirements*



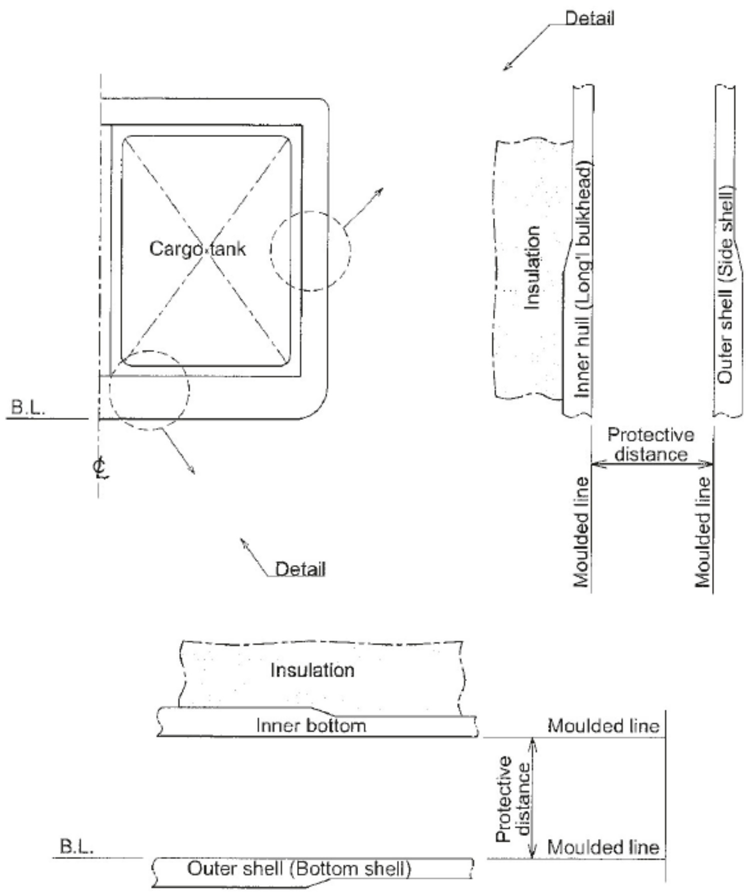
Transverse Sections - Type 3G Ship

Figure 2.4 - *Cargo tank location requirements*



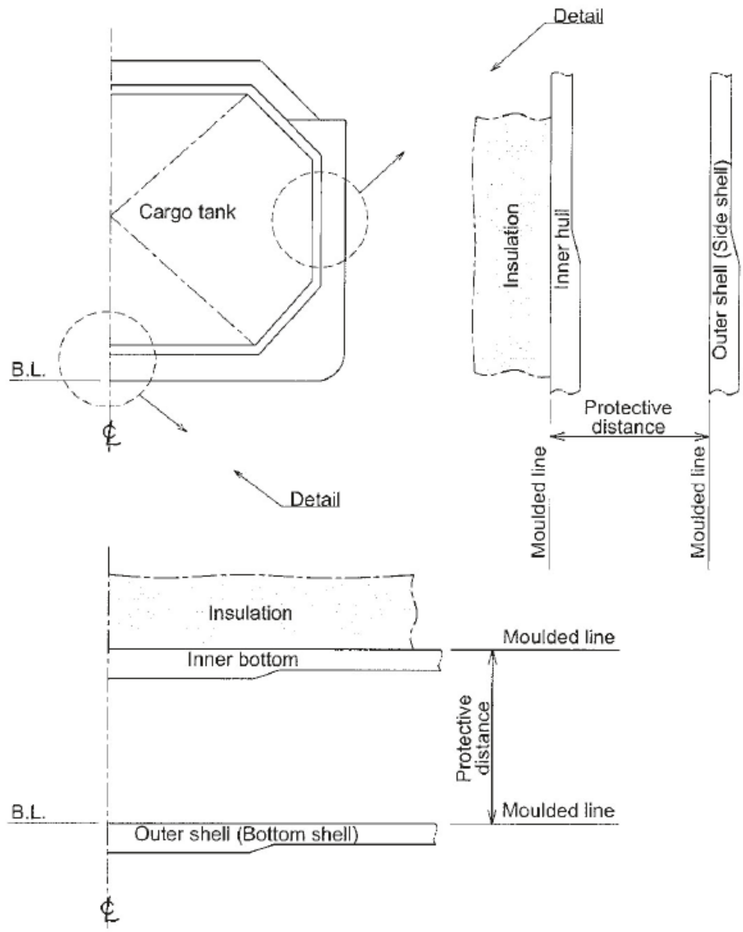
Independent prismatic tank

Figure 2.5(a) - *Protective distance*



Semi-membrane tank

Figure 2.5(b) - *Protective distance*



Membrane tank

Figure 2.5(c) - *Protective distance*

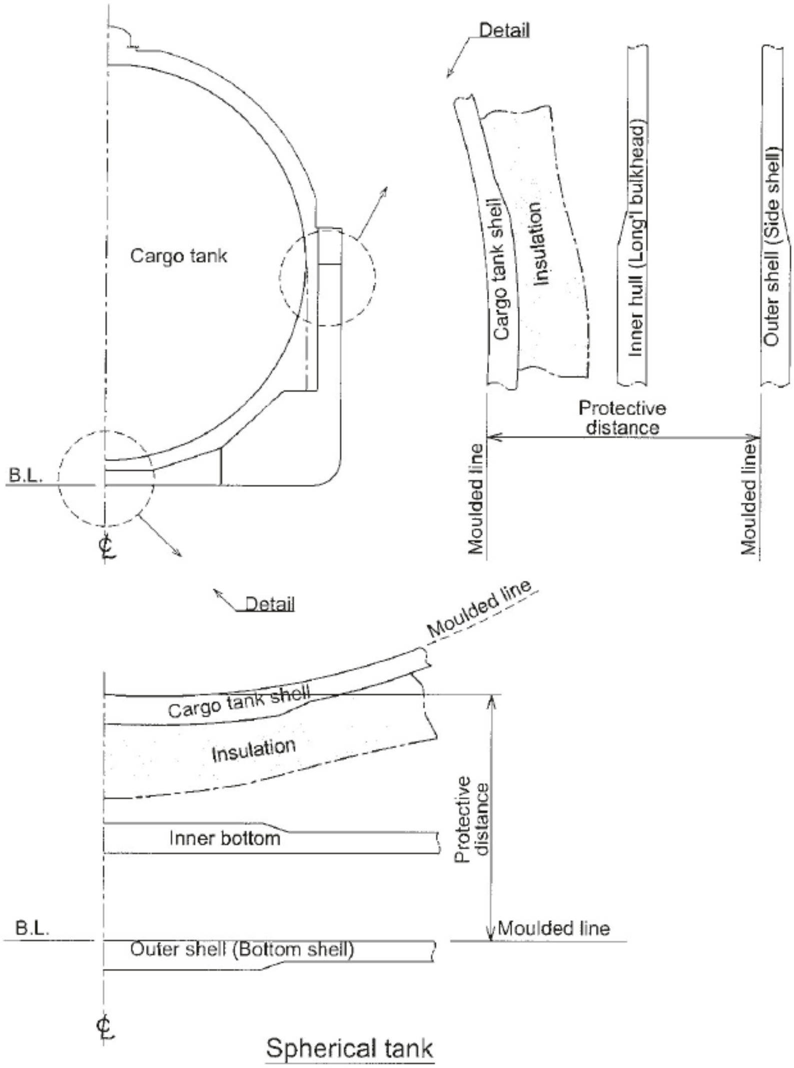
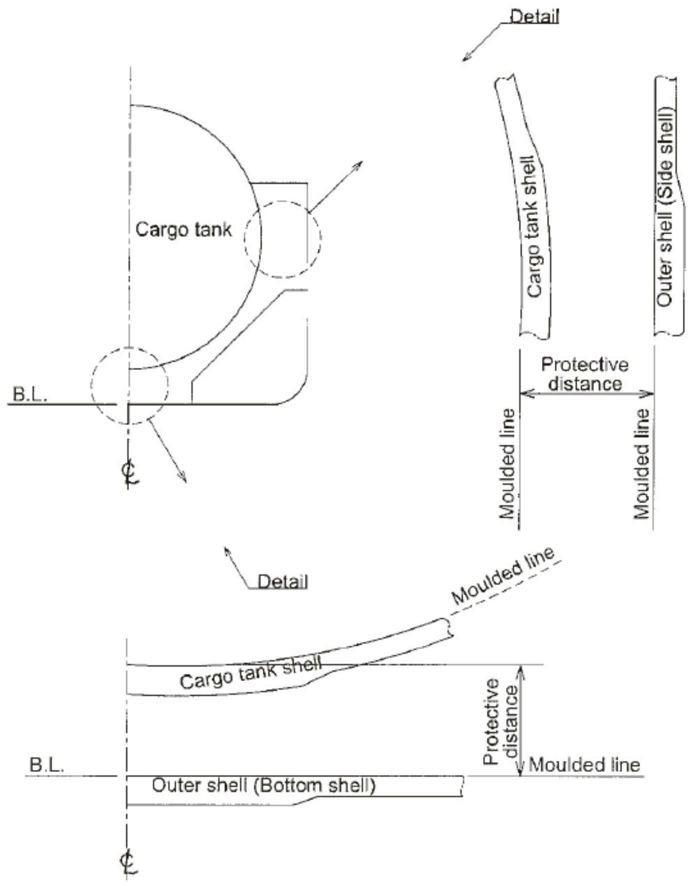


Figure 2.5(d) - *Protective distance*



Pressure type tank

Figure 2.5(e) - *Protective distance*

2.4.3 Except for type 1G ships, suction wells installed in cargo tanks may protrude into the vertical extent of bottom damage specified in 2.3.1.2.3 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 shall not exceed 350 mm. Suction wells installed in accordance with this paragraph may be ignored when determining the compartments affected by damage.

2.4.4 Cargo tanks shall not be located forward of the collision bulkhead.

2.5 Flood assumptions

2.5.1 The requirements of 2.7 shall be confirmed by calculations that 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.

2.5.2 The permeabilities of spaces assumed to be damaged shall be as follows:

Spaces	Permeabilities
Stores	0.6
Accommodation	0.95
Machinery	0.85
Voids	0.95
Hold spaces	0.95[1]
Consumable liquids	0 to 0.95[2]
Other liquids	0 to 0.95[2]

Note 1 Other values of permeability can be considered based on the detailed calculations. Interpretations of regulation of part B-1 of SOLAS chapter II-1 (MSC/Circ.651) are referred.

Note 2 The permeability of partially filled compartments shall be consistent with the amount of liquid carried in the compartment.

2.5.3 Wherever damage penetrates a tank containing liquids, it shall 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.

2.5.4 Where the damage between transverse watertight bulkheads is envisaged, as specified in 2.6.1.4, 2.6.1.5, and 2.6.1.6, transverse bulkheads shall be spaced at least at a distance equal to the longitudinal extent of damage specified in 2.3.1.1.1 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 shall 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 shall be assumed damaged if the watertight bulkhead boundaries are within the extent of vertical or horizontal penetration required by 2.3. Also, any transverse bulkhead shall 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 the after peak tank top shall not be regarded as a step for the purpose of this paragraph.

2.5.5 The ship shall be designed to keep unsymmetrical flooding to the minimum consistent with efficient arrangements.

2.5.6 Equalization arrangements requiring mechanical aids such as valves or cross-levelling pipes, if fitted, shall not be considered for the purpose of reducing an angle of heel or attaining the minimum range of residual stability to meet the requirements of 2.7.1, and sufficient residual stability shall be maintained during all stages where equalization is used. Spaces linked by ducts of large cross-sectional area may be considered to be common.

2.5.7 If pipes, ducts, trunks or tunnels are situated within the assumed extent of damage penetration, as defined in 2.3, arrangements shall be such that progressive flooding cannot thereby extend to compartments other than those assumed to be flooded for each case of damage.

2.5.8 The buoyancy of any superstructure directly above the side damage shall be disregarded. However, the unflooded parts of superstructures beyond the extent of damage may be taken into consideration, provided that:

.1 they are separated from the damaged space by watertight divisions and the requirements of 2.7.1.1 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 2.7.2.1. However, the immersion of any other openings capable of being closed weathertight may be permitted.

2.6 Standard of damage

2.6.1 Ships shall be capable of surviving the damage indicated in 2.3 with the flood assumptions in 2.5, to the extent determined by the ship's type, according to the following standards:

.1 a type 1G ship shall be assumed to sustain damage anywhere in its length;

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

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

.4 a type 2PG ship shall be assumed to sustain damage anywhere in its length except involving transverse bulkheads spaced further apart than the longitudinal extent of damage as specified in 2.3.1.1.1;

.5 a type 3G ship of 80 m in length or more shall be assumed to sustain damage anywhere in its length, except involving transverse bulkheads spaced further apart than the longitudinal extent of damage specified in 2.3.1.1.1; and

.6 a type 3G ship less than 80 m in length shall be assumed to sustain damage anywhere in its length, except involving transverse bulkheads spaced further apart than the longitudinal extent of damage specified in 2.3.1.1.1 and except damage involving the machinery space when located after.

2.6.2 In the case of small type 2G/2PG and 3G ships that do not comply in all respects with the appropriate requirements of 2.6.1.3, 2.6.1.4 and 2.6.1.6, special dispensations may only be considered by the Administration provided that alternative measures can be taken which maintain the same degree of safety. The nature of the alternative measures shall be approved and clearly stated and be available to the port Administration. Any such dispensation shall be duly noted on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk referred to in 1.4.4.

2.7 Survival requirements

Ships subject to the Code shall be capable of surviving the assumed damage specified in 2.3, to the standard provided in 2.6, in a condition of stable equilibrium and shall satisfy the following criteria.

2.7.1 In any stage of flooding:

.1 the waterline, taking into account sinkage, heel and trim, shall be below the lower edge of any opening through which progressive flooding or downflooding may take place. Such openings shall include air pipes and openings that 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 that maintain the high integrity of the deck, remotely operated watertight sliding doors and sidescuttles of the non-opening type;

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

.3 the residual stability during intermediate stages of flooding shall not be less than that required by 2.7.2.1.

2.7.2 At final equilibrium after flooding:

.1 the righting lever curve shall 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 shall not be less than 0.0175 m-radians. 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). Unprotected openings shall not 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 2.7.1.1 and other openings capable of being closed weathertight may be permitted; and

.2 the emergency source of power shall be capable of operating.

CHAPTER 3

SHIP ARRANGEMENTS

Goal

To ensure that the cargo containment and handling system are located such that the consequences of any release of cargo will be minimized, and to provide safe access for operation and inspection.

3.1 Segregation of the cargo area

3.1.1 Hold spaces shall be segregated from machinery and boiler spaces, accommodation spaces, service spaces, control stations, chain lockers, domestic water tanks and from stores. Hold spaces shall be located forward of machinery spaces of category A. Alternative arrangements, including locating machinery spaces of category A forward, may be accepted, based on SOLAS regulation II-2/17, after further consideration of involved risks, including that of cargo release and the means of mitigation.

3.1.2 Where cargo is carried in a cargo containment system not requiring a complete or partial secondary barrier, 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, oil fuel tanks or a single gastight bulkhead of all-welded construction forming an "A-60" class division. A gastight "A-0" class division is acceptable if there is no source of ignition or fire hazard in the adjoining spaces.

3.1.3 Where cargo is carried in a cargo containment system requiring a complete or partial secondary barrier, segregation of hold spaces from spaces referred to in 3.1.1, or spaces either below or outboard of the hold spaces that contain a source of ignition or fire hazard, shall be effected by cofferdams or oil fuel tanks. A gastight "A-0" class division is acceptable if there is no source of ignition or fire hazard in the adjoining spaces.

3.1.4 Turret compartments segregation from spaces referred to in 3.1.1, or spaces either below or outboard of the turret compartment that contain a source of ignition or fire hazard, shall be effected by cofferdams or an A-60 class division. A gastight "A-0" class division is acceptable if there is no source of ignition or fire hazard in the adjoining spaces.

3.1.5 In addition, the risk of fire propagation from turret compartments to adjacent spaces shall be evaluated by a risk analysis (see 1.1.11) and further preventive measures, such as the arrangement of a cofferdam around the turret compartment, shall be provided if needed.

3.1.6 When cargo is carried in a cargo containment system requiring a complete or partial secondary barrier:

.1 at temperatures below -10ºC, hold spaces shall be segregated from the sea by a double bottom; and

.2 at temperatures below -55ºC, the ship shall also have a longitudinal bulkhead forming side tanks.

3.1.7 Arrangements shall 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 shall be located within the cargo area. The bulkhead of accommodation spaces, service spaces or control stations that face the cargo area shall 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 on a ship having a containment system requiring a secondary barrier.

3.2.2 To guard against the danger of hazardous vapours, due consideration shall be given to the location of air intakes/outlets 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.

3.2.3 Access through doors, gastight or otherwise, shall not be permitted from a non-hazardous area to a hazardous area except for access to service spaces forward of the cargo area through airlocks, as permitted by 3.6.1, when accommodation spaces are aft.

3.2.4.1 Entrances, air inlets and openings to accommodation spaces, service spaces, machinery spaces and control stations shall not face the cargo area. They shall be located on the end bulkhead not facing the cargo area or on the outboard side of the superstructure or deckhouse 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 deckhouse facing the cargo area. This distance, however, need not exceed 5 m.

3.2.4.2 Windows and sidescuttles facing the cargo area and on the sides of the superstructures or deckhouses within the distance mentioned above shall 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 designed in a manner that a rapid and efficient gas and vapour tightening of the wheelhouse can be ensured.

3.2.4.3 For ships dedicated to the carriage of cargoes that have neither flammable nor toxic hazards, the Administration may approve relaxations from the above requirements.

3.2.4.4 Accesses to forecastle spaces containing sources of ignition may be permitted through a single door facing the cargo area, provided the doors are located outside hazardous areas as defined in chapter 10.

3.2.5 Windows and sidescuttles facing the cargo area and on the sides of the superstructures and deckhouses within the limits specified in 3.2.4, except wheelhouse windows, shall be constructed to "A-60" class. Wheelhouse windows shall be constructed to not less than "A-0" class (for external fire load). Sidescuttles in the shell below the uppermost continuous deck and in the first tier of the superstructure or deckhouse shall be of fixed (non-opening) type.

3.2.6 All air intakes, outlets and other openings into the accommodation spaces, service spaces and control stations shall be fitted with closing devices. When carrying toxic products, they shall be capable of being operated from inside the space. The requirement for fitting air intakes and openings with closing devices operated from inside the space for toxic products need not apply to spaces not normally manned, such as deck stores, forecastle stores, workshops. In addition, the requirement does not apply to cargo control rooms located within the cargo area.

3.2.7 Control rooms and machinery spaces of turret systems may be located in the cargo area forward or aft of cargo tanks in ships with such installations. Access to such spaces containing sources of ignition may be permitted through doors facing the cargo area, provided the doors are located outside hazardous areas or access is through airlocks.

3.3 Cargo machinery spaces and turret compartments

3.3.1 Cargo machinery spaces shall be situated above the weather deck and located within the cargo area. Cargo machinery spaces and turret compartments shall be treated as cargo pump-rooms for the purpose of fire protection according to SOLAS regulation II-2/9.2.4, and for the purpose of prevention of potential explosion according to SOLAS regulation II-2/4.5.10.

3.3.2 When cargo machinery spaces are located at the after end of the aftermost hold space or at the forward end of the foremost hold space, the limits of the cargo area, as defined in 1.2.7, shall be extended to include the cargo machinery spaces for the full breadth and depth of the ship and the deck areas above those spaces.

3.3.3 Where the limits of the cargo area are extended by 3.3.2, the bulkhead that separates the cargo machinery spaces from accommodation and service spaces, control stations and machinery spaces of category A shall be located so as to avoid the entry of gas to these spaces through a single failure of a deck or bulkhead.

3.3.4 Cargo compressors and cargo pumps may be driven by electric motors in an adjacent non-hazardous space separated by a bulkhead or deck, if the seal around the bulkhead penetration ensures effective gastight segregation of the two spaces. Alternatively, such equipment may be driven by certified safe electric motors adjacent to them if the electrical installation complies with the requirements of chapter 10.

3.3.5 Arrangements of cargo machinery spaces and turret compartments shall 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. At least two widely separated escape routes and doors shall be provided in cargo machinery spaces, except that a single escape route may be accepted where the maximum travel distance to the door is 5 m or less.

3.3.6 All valves necessary for cargo handling shall be readily accessible to personnel wearing protective clothing. Suitable arrangements shall be made to deal with drainage of pump and compressor rooms.

3.3.7 Turret compartments shall be designed to retain their structural integrity in case of explosion or uncontrolled high-pressure gas release (overpressure and/or brittle fracture), the characteristics of which shall be substantiated on the basis of a risk analysis with due consideration of the capabilities of the pressure relieving devices.

3.4 Cargo control rooms

3.4.1 Any cargo control room shall 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:

.1 the cargo control room is a non-hazardous area;

.2 if the entrance complies with 3.2.4.1, the control room may have access to the spaces described above; and

.3 if the entrance does not comply with 3.2.4.1, the cargo control room shall have no access to the spaces described above and the boundaries for such spaces shall be insulated to "A-60" class.

3.4.2 If the cargo control room is designed to be a non-hazardous area, instrumentation shall, as far as possible, be by indirect reading systems and shall, in any case, be designed to prevent any escape of gas into the atmosphere of that space. Location of the gas detection system within the cargo control room will not cause the room to be classified as a hazardous area, if installed in accordance with 13.6.11.

3.4.3 If the cargo control room for ships carrying flammable cargoes is classified as a hazardous area, sources of ignition shall be excluded and any electrical equipment shall be installed in accordance with chapter 10.

3.5 Access to spaces in the cargo area

3.5.1 Visual inspection of at least one side of the inner hull structure shall be possible without the removal of any fixed structure or fitting. If such a visual inspection, whether combined with those inspections required in 3.5.2, 4.6.2.4 or 4.20.3.7 or not, is only possible at the outer face of the inner hull, the inner hull shall not be a fuel-oil tank boundary wall.

3.5.2 Inspection of one side of any insulation in hold spaces shall 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, cargo tanks and other spaces classified as hazardous areas, shall be such as to allow entry and inspection of any such space by personnel wearing protective clothing and breathing apparatus and shall also allow for the evacuation of injured and/or unconscious personnel. Such arrangements shall comply with the following:

.1 Access shall be provided as follows:

.1 access to all cargo tanks. Access shall be direct from the weather deck;

.2 access through horizontal openings¸ hatches or manholes. The dimensions shall 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 shall be not less than 600 mm x 600 mm;

.3 access through vertical openings or manholes providing passage through the length and breadth of the space. The minimum clear opening shall be not less than 600 mm x 800 mm at a height of not more than 600 mm from the bottom plating unless gratings or other footholds are provided; and

.4 circular access openings to type C tanks shall have a diameter of not less than 600 mm.

.2 The dimensions referred to in 3.5.3.1.2 and 3.5.3.1.3 may be decreased, if the requirements of 3.5.3 can be met to the satisfaction of the Administration.

.3 Where cargo is carried in a containment system requiring a secondary barrier, the requirements of 3.5.3.1.2 and 3.5.3.1.3 do not apply to spaces separated from a hold space by a single gastight steel boundary. Such spaces shall be provided only with direct or indirect access from the weather deck, not including any enclosed non-hazardous area.

.4 Access required for inspection shall be a designated access through structures below and above cargo tanks, which shall have at least the cross-sections as required by 3.5.3.1.3.

.5 For the purpose of 3.5.1 or 3.5.2, the following shall apply:

.1 where it is required to pass between the surface to be inspected, flat or curved, and structures such as deck beams, stiffeners, frames, girders, etc., the distance between that surface and the free edge of the structural elements shall 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, shall be at least 450 mm for a curved tank surface (e.g. for a type C tank), or 600 mm for a flat tank surface (e.g. for a type A tank) (see figure 3.1);

.2 where it is not required 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 shall be at least 50 mm or half the breadth of the structure's face plate, whichever is the larger (see figure 3.2);

.3 if for inspection of a curved surface where it is required to pass between that surface and another surface, flat or curved, to which no structural elements are fitted, the distance between both surfaces shall be at least 380 mm (see figure 3.3). Where it is not required to pass between that curved surface and another surface, a smaller distance than 380 mm may be accepted taking into account the shape of the curved surface;

.4 if for inspection of an approximately flat surface where it is required to pass between two approximately flat and approximately parallel surfaces, to which no structural elements are fitted, the distance between those surfaces shall be at least 600 mm. Where fixed access ladders are fitted, a clearance of at least 450 mm shall be provided for access (see figure 3.4);

.5 the minimum distances between a cargo tank sump and adjacent double bottom structure in way of a suction well shall not be less than those shown in figure 3.5 (figure 3.5 shows that the distance between the plane surfaces of the sump and the well is a minimum of 150 mm and that the clearance between the edge between the inner bottom plate, and the vertical side of the well and the knuckle point between the spherical or circular surface and sump of the tank is at least 380 mm). If there is no suction well, the distance between the cargo tank sump and the inner bottom shall not be less than 50 mm;

.6 the distance between a cargo tank dome and deck structures shall not be less than 150 mm (see figure 3.6);

.7 fixed or portable staging shall be installed as necessary for inspection of cargo tanks, cargo tank supports and restraints (e.g. anti-pitching, anti-rolling and anti-flotation chocks), cargo tank insulation etc. This staging shall not impair the clearances specified in 3.5.3.5.1 to 3.5.3.5.4; and

.8 if fixed or portable ventilation ducting shall be fitted in compliance with 12.1.2, such ducting shall not impair the distances required under 3.5.3.5.1 to 3.5.3.5.4.

3.5.4 Access from the open weather deck to non-hazardous areas shall be located outside the hazardous areas as defined in chapter 10, unless the access is by means of an airlock in accordance with 3.6.

3.5.5 Turret compartments shall be arranged with two independent means of access/egress.

3.5.6 Access from a hazardous area below the weather deck to a non-hazardous area is not permitted.

3.6 Airlocks

3.6.1 Access between hazardous area on the open weather deck and non-hazardous spaces shall be by means of an airlock. This shall consist of two self-closing, substantially gastight, steel doors without any holding back arrangements, capable of maintaining the overpressure, at least 1.5 m but no more than 2.5 m apart. The airlock space shall be artificially ventilated from a non-hazardous area and maintained at an overpressure to the hazardous area on the weather deck.

3.6.2 Where spaces are protected by pressurization, the ventilation shall be designed and installed in accordance with recognized standards.

3.6.3 An audible and visible alarm system to give a warning on both sides of the airlock shall be provided. The visible alarm shall indicate if one door is open. The audible alarm shall sound if doors on both sides of the air lock are moved from the closed positions.

3.6.4 In ships carrying flammable products, electrical equipment that is located in spaces protected by airlocks and not of the certified safe type, shall be de-energized in case of loss of overpressure in the space.

3.6.5 Electrical equipment for manoeuvring, anchoring and mooring, as well as emergency fire pumps that are located in spaces protected by airlocks, shall be of a certified safe type.

3.6.6 The airlock space shall be monitored for cargo vapours (see 13.6.2).

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

3.7 Bilge, ballast and oil fuel arrangements

3.7.1 Where cargo is carried in a cargo containment system not requiring a secondary barrier, suitable drainage arrangements for the hold spaces that are not connected with the machinery space shall be provided. Means of detecting any leakage shall be provided.

3.7.2 Where there is a secondary barrier, suitable drainage arrangements for dealing with any leakage into the hold or insulation spaces through the adjacent ship structure shall be provided. The suction shall not lead to pumps inside the machinery space. Means of detecting such leakage shall be provided.

3.7.3 The hold or interbarrier spaces of type A independent tank ships shall be provided with a drainage system suitable for handling liquid cargo in the event of cargo tank leakage or rupture. Such arrangements shall provide for the return of any cargo leakage to the liquid cargo piping.

3.7.4 Arrangements referred to in 3.7.3 shall be provided with a removable spool piece.

3.7.5 Ballast spaces, including wet duct keels used as ballast piping, oil fuel tanks and non-hazardous 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 is led directly overboard with no valves or manifolds in either line that could connect the line from the duct keel to lines serving non-hazardous spaces. Pump vents shall not be open to machinery spaces.

3.8 Bow and stern loading and unloading arrangements

3.8.1 Subject to the requirements of this section and chapter 5, cargo piping may be arranged to permit bow or stern loading and unloading.

3.8.2 Bow or stern loading and unloading lines that are led past accommodation spaces, service spaces or control stations shall not be used for the transfer of products requiring a type 1G ship. Bow or stern loading and unloading lines shall not be used for the transfer of toxic products as specified in 1.2.53, where the design pressure is above 2.5 MPa.

3.8.3 Portable arrangements shall not be permitted.

3.8.4.1 Entrances, air inlets and openings to accommodation spaces, service spaces, machinery spaces and controls stations, shall not face the cargo shore connection location of bow or stern loading and unloading arrangements. They shall 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 deckhouse facing the cargo shore connection location of the bow or stern loading and unloading arrangements. This distance need not exceed 5 m.

3.8.4.2 Windows and sidescuttles facing the shore connection location and on the sides of the superstructure or deckhouse within the distance mentioned above shall be of the fixed (non-opening) type.

3.8.4.3 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 shall be kept closed.

3.8.4.4 Where, in the case of small ships, compliance with 3.2.4.1 to 3.2.4.4 and 3.8.4.1 to 3.8.4.3 is not possible, the Administration may approve relaxations from the above requirements.

3.8.5 Deck openings and air inlets and outlets to spaces within distances of 10 m from the cargo shore connection location shall be kept closed during the use of bow or stern loading or unloading arrangements.

3.8.6 Firefighting arrangements for the bow or stern loading and unloading areas shall be in accordance with 11.3.1.4 and 11.4.6.

3.8.7 Means of communication between the cargo control station and the shore connection location shall be provided and, where applicable, certified for use in hazardous areas.

Figure 3.1

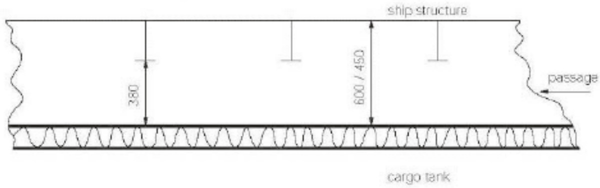


Figure 3.2

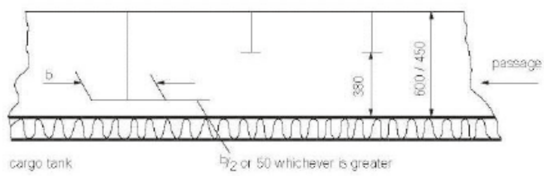


Figure 3.3

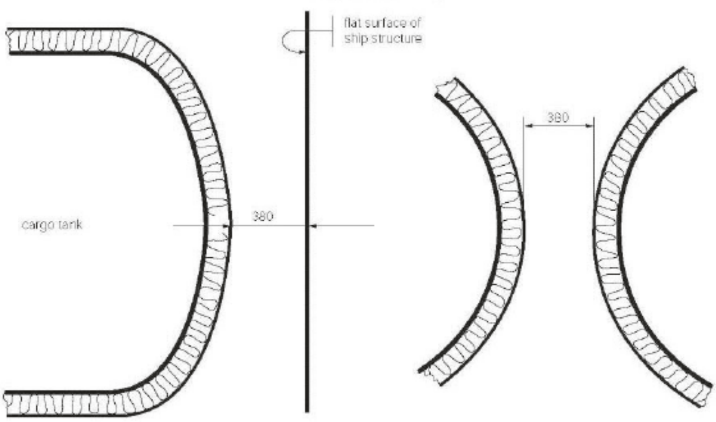


Figure 3.4

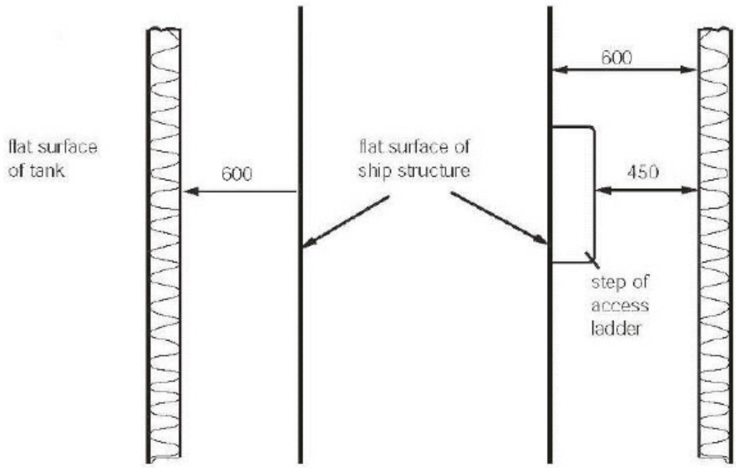
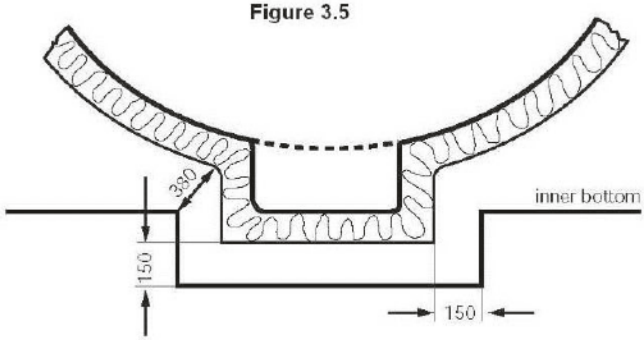


Figure 3.5



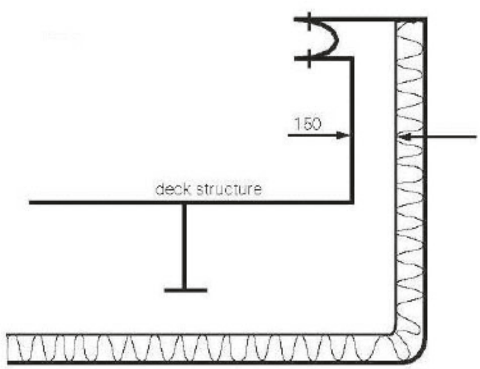


Figure 3.6

CHAPTER 4

CARGO CONTAINMENT

Goal

To ensure the safe containment of cargo under all design and operating conditions having regard to the nature of the cargo carried. This will include measures to:

.1 provide strength to withstand defined loads;

.2 maintain the cargo in a liquid state;

.3 design for or protect the hull structure from low temperature exposure; and

.4 prevent the ingress of water or air into the cargo containment system.

4.1 Definitions

4.1.1 *A cold spot* is a part of the hull or thermal insulation surface where a localized temperature decrease occurs with respect to the allowable minimum temperature of the hull or of its adjacent hull structure, or to design capabilities of cargo pressure/temperature control systems required in chapter 7.

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

4.1.3 *Design temperature* for selection of materials is the minimum temperature at which cargo may be loaded or transported in the cargo tanks.

4.1.4 *Independent tanks* are self-supporting tanks. They do not form part of the ship's hull and are not essential to the hull strength. There are three categories of independent tank, which are referred to in 4.21, 4.22 and 4.23.

4.1.5 *Membrane tanks* are non-self-supporting tanks that consist of a thin liquid and gastight layer (membrane) supported through insulation by the adjacent hull structure. Membrane tanks are covered in 4.24.

4.1.6 *Integral tanks* are tanks that form a structural part of the hull and are influenced in the same manner by the loads that stress the adjacent hull structure. Integral tanks are covered in 4.25.

4.1.7 *Semi-membrane tanks* are non-self-supporting tanks in the loaded condition and consist of a layer, parts of which are supported through insulation by the adjacent hull structure. Semi-membrane tanks are covered in 4.26.

4.1.8 In addition to the definitions in 1.2, the definitions given in this chapter shall apply throughout the Code.

4.2 Application

Unless otherwise specified in part E, the requirements of parts A to D shall apply to all types of tanks, including those covered in part F.

PART A
CARGO CONTAINMENT

4.3 Functional requirements

4.3.1 The design life of the cargo containment system shall not be less than the design life of the ship.

4.3.2 Cargo containment systems shall be designed for North Atlantic environmental conditions and relevant long-term sea state scatter diagrams for unrestricted navigation. Lesser environmental conditions, consistent with the expected usage, may be accepted by the Administration for cargo containment systems used exclusively for restricted navigation. Greater environmental conditions may be required for cargo containment systems operated in conditions more severe than the North Atlantic environment.

4.3.3 Cargo containment systems shall be designed with suitable safety margins:

.1 to withstand, in the intact condition, the environmental conditions anticipated for the cargo containment system's design life and the loading conditions appropriate for them, which include full homogeneous and partial load conditions, partial filling within defined limits and ballast voyage loads; and

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

4.3.4 The cargo containment system structural strength shall be assessed against failure modes, including but not limited to plastic deformation, buckling and fatigue. The specific design conditions which shall be considered for the design of each cargo containment system are given in 4.21 to 4.26. There are three main categories of design conditions:

.1 Ultimate design conditions – the cargo containment system structure and its structural components shall withstand loads liable to occur during its construction, testing and anticipated use in service, without loss of structural integrity. The design shall take into account proper combinations of the following loads:

.1 internal pressure;

.2 external pressure;

.3 dynamic loads due to the motion of the ship;

.4 thermal loads;

.5 sloshing loads;

.6 loads corresponding to ship deflections;

.7 tank and cargo weight with the corresponding reaction in way of supports;

.8 insulation weight;

.9 loads in way of towers and other attachments; and

.10 test loads.

.2 Fatigue design conditions – the cargo containment system structure and its structural components shall not fail under accumulated cyclic loading.

.3 The cargo containment system shall meet the following criteria:

.1 Collision – the cargo containment system shall be protectively located in accordance with 2.4.1 and withstand the collision loads specified in 4.15.1 without deformation of the supports, or the tank structure in way of the supports, likely to endanger the tank structure.

.2 Fire – the cargo containment systems shall sustain, without rupture, the rise in internal pressure specified in 8.4.1 under the fire scenarios envisaged therein.

.3 Flooded compartment causing buoyancy on tank – the anti-flotation arrangements shall sustain the upward force, specified in 4.15.2, and there shall be no endangering plastic deformation to the hull.

4.3.5 Measures shall be applied to ensure that scantlings required meet the structural strength provisions and be maintained throughout the design life. Measures may include, but are not limited to, material selection, coatings, corrosion additions, cathodic protection and inerting. Corrosion allowance need not be required in addition to the thickness resulting from the structural analysis. However, where there is no environmental control, such as inerting around the cargo tank, or where the cargo is of a corrosive nature, the Administration or recognized organization acting on its behalf may require a suitable corrosion allowance.

4.3.6 An inspection/survey plan for the cargo containment system shall be developed and approved by the Administration or recognized organization acting on its behalf. The inspection/survey plan shall identify areas that need inspection during surveys throughout the cargo containment system's life and, in particular, all necessary in-service survey and maintenance that was assumed when selecting cargo containment system design parameters. Cargo containment systems shall be designed, constructed and equipped to provide adequate means of access to areas that need inspection as specified in the inspection/survey plan. Cargo containment systems, including all associated internal equipment, shall be designed and built to ensure safety during operations, inspection and maintenance (see 3.5).

4.4 Cargo containment safety principles

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

4.4.2 However, the size and configuration or arrangement of the secondary barrier may be reduced where an equivalent level of safety is demonstrated in accordance with the requirements of 4.4.3 to 4.4.5, as applicable.

4.4.3 Cargo containment systems for which the probability for structural failures to develop into a critical state has been determined to be extremely low, but where the possibility of leakages through the primary barrier cannot be excluded, shall be equipped with a partial secondary barrier and small leak protection system capable of safely handling and disposing of the leakages. The arrangements shall comply with the following requirements:

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

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

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

4.4.5 No secondary barrier is required where the cargo temperature at atmospheric pressure is at or above -10°C.

4.5 Secondary barriers in relation to tank types

Secondary barriers in relation to the tank types defined in 4.21 to 4.26 shall be provided in accordance with the following table.

<table>
<tr><th>Cargo temperature at atmospheric pressure</th><th>-10°C and above</th><th>Below -10°C down to -55°C</th><th>Below -55°C</th></tr>
<tr><td>Basic tank type</td><td>No secondary barrier required</td><td>Hull may act as secondary barrier</td><td>Separate secondary barrier where required</td></tr>
<tr><td>Integral
Membrane
Semi-membrane
Independent:
-type A
-type B
-type C</td><td></td><td colspan="2">Tank type not normally allowed[1]
Complete secondary barrier
Complete secondary barrier[2]

Complete secondary barrier
Partial secondary barrier
No secondary barrier required</td></tr>
<tr><td colspan="4">Note 1: A complete secondary barrier shall normally be required if cargoes with a temperature at atmospheric pressure below -10°C are permitted in accordance with 4.25.1.

Note 2: In the case of semi-membrane tanks that comply in all respects with the requirements applicable to type B independent tanks, except for the manner of support, the Administration may, after special consideration, accept a partial secondary barrier.</td></tr>
</table>

4.6 Design of secondary barriers

4.6.1 Where the cargo temperature at atmospheric pressure is not below -55°C, the hull structure may act as a secondary barrier based on the following:

.1 the hull material shall be suitable for the cargo temperature at atmospheric pressure as required by 4.19.1.4; and

.2 the design shall be such that this temperature will not result in unacceptable hull stresses.

4.6.2 The design of the secondary barrier shall be such that:

.1 it is capable of containing any envisaged leakage of liquid cargo for a period of 15 days, unless different criteria apply for particular voyages, taking into account the load spectrum referred to in 4.18.2.6;

.2 physical, mechanical, or operational events within the cargo tank that could cause failure of the primary barrier shall not impair the due function of the secondary barrier, or vice versa;

.3 failure of a support or an attachment to the hull structure will not lead to loss of liquid tightness of both the primary and secondary barriers;

.4 it is capable of being periodically checked for its effectiveness by means acceptable to the Administration or recognized organization acting on its behalf. This may be by means of a visual inspection or a pressure/vacuum test or other suitable means carried out according to a documented procedure agreed with the Administration or the recognized organization acting on its behalf;

.5 the methods required in .4 above shall be approved by the Administration or recognized organization acting on its behalf and shall include, where applicable to the test procedure:

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

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

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

  .4 effects of thermal and mechanical cyclic loading on the effectiveness of the proposed test; and

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

4.7 Partial secondary barriers and primary barrier small leak protection system

4.7.1 Partial secondary barriers as permitted in 4.4.3 shall be used with a small leak protection system and meet all the requirements in 4.6.2. The small leak protection system shall include means to detect a leak in the primary barrier, provision such as a spray shield to deflect any liquid cargo down into the partial secondary barrier, and means to dispose of the liquid, which may be by natural evaporation.

4.7.2 The capacity of the partial secondary barrier shall be determined, based on the cargo leakage corresponding to the extent of failure resulting from the load spectrum referred to in 4.18.2.6, after the initial detection of a primary leak. Due account may be taken of liquid evaporation, rate of leakage, pumping capacity and other relevant factors.

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

4.8 Supporting arrangements

4.8.1 The cargo tanks shall be supported by the hull in a manner that prevents bodily movement of the tank under the static and dynamic loads defined in 4.12 to 4.15, where applicable, while allowing contraction and expansion of the tank under temperature variations and hull deflections without undue stressing of the tank and the hull.

4.8.2 Anti-flotation arrangements shall be provided for independent tanks and capable of withstanding the loads defined in 4.15.2 without plastic deformation likely to endanger the hull structure.

4.8.3 Supports and supporting arrangements shall withstand the loads defined in 4.13.9 and 4.15, but these loads need not be combined with each other or with wave-induced loads.

4.9 Associated structure and equipment

4.9.1 Cargo containment systems shall be designed for the loads imposed by associated structure and equipment. This includes pump towers, cargo domes, cargo pumps and piping, stripping pumps and piping, nitrogen piping, access hatches, ladders, piping penetrations, liquid level gauges, independent level alarm gauges, spray nozzles, and instrumentation systems (such as pressure, temperature and strain gauges).

4.10 Thermal insulation

4.10.1 Thermal insulation shall be provided, as required, to protect the hull from temperatures below those allowable (see 4.19.1) and limit the heat flux into the tank to the levels that can be maintained by the pressure and temperature control system applied in chapter 7.

4.10.2 In determining the insulation performance, due regard shall be given to the amount of the acceptable boil-off in association with the reliquefaction plant on board, main propulsion machinery or other temperature control system.

PART B
DESIGN LOADS

4.11 General

This section defines the design loads to be considered with regard to the requirements in 4.16, 4.17 and 4.18. This includes:

.1 load categories (permanent, functional, environmental and accidental) and the description of the loads;

.2 the extent to which these loads shall be considered depending on the type of tank, and is more fully detailed in the following paragraphs; and

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

4.12 Permanent loads

4.12.1 ***Gravity loads***

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

4.12.2 ***Permanent external loads***

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

4.13 Functional loads

4.13.1 Loads arising from the operational use of the tank system shall be classified as functional loads. All functional loads that are essential for ensuring the integrity of the tank system, during all design conditions, shall be considered. As a minimum, the effects from the following criteria, as applicable, shall be considered when establishing functional loads:

.1 internal pressure;

.2 external pressure;

.3 thermally induced loads;

.4 vibration;

.5 interaction loads;

.6 loads associated with construction and installation;

.7 test loads;

.8 static heel loads; and

.9 weight of cargo.

4.13.2 ***Internal pressure***

.1 In all cases, including 4.13.2.2, P_o shall not be less than MARVS.

.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_o shall not be less than the gauge vapour pressure of the cargo at a temperature of 45°C except as follows:

.1 lower values of ambient temperature may be accepted by the Administration or recognized organization acting on its behalf for ships operating in restricted areas. Conversely, higher values of ambient temperature may be required; and

.2 for ships on voyages of restricted duration, P_o may be calculated based on the actual pressure rise during the voyage, and account may be taken of any thermal insulation of the tank.

.3 Subject to special consideration by the Administration and to the limitations given in 4.21 to 4.26, for the various tank types, a vapour pressure P_h higher than P_o may be accepted for site specific conditions (harbour or other locations), where dynamic loads are reduced. Any relief valve setting resulting from this paragraph shall be recorded in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk.

.4 The internal pressure P_{eq} results from the vapour pressure P_o or P_h plus the maximum associated dynamic liquid pressure P_{gd}, but not including the effects of liquid sloshing loads. Guidance formulae for associated dynamic liquid pressure P_{gd} are given in 4.28.1.

4.13.3 ***External pressure***

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

4.13.4 ***Thermally induced loads***

4.13.4.1 Transient thermally induced loads during cooling down periods shall be considered for tanks intended for cargo temperatures below -55°C.

4.13.4.2 Stationary thermally induced loads shall be considered for cargo containment systems where the design supporting arrangements or attachments and operating temperature may give rise to significant thermal stresses (see 7.2).

4.13.5 ***Vibration***

The potentially damaging effects of vibration on the cargo containment system shall be considered.

4.13.6 ***Interaction loads***

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

4.13.7 ***Loads associated with construction and installation***

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

4.13.8 ***Test loads***

Account shall be taken of the loads corresponding to the testing of the cargo containment system referred to in 4.21 to 4.26.

4.13.9 ***Static heel loads***

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

4.13.10 ***Other loads***

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

4.14 Environmental loads

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

4.14.1 ***Loads due to ship motion***

4.14.1.1 The determination of dynamic loads shall take into account the long-term distribution of ship motion in irregular seas, which the ship will experience during its operating life. Account may be taken of the reduction in dynamic loads due to necessary speed reduction and variation of heading.

4.14.1.2 The ship's motion shall include surge, sway, heave, roll, pitch and yaw. The accelerations acting on tanks shall be estimated at their centre of gravity and include the following components:

.1 vertical acceleration: motion accelerations of heave, pitch and, possibly, roll (normal to the ship base);

.2 transverse acceleration: motion accelerations of sway, yaw and roll and gravity component of roll; and

.3 longitudinal acceleration: motion accelerations of surge and pitch and gravity component of pitch.

4.14.1.3 Methods to predict accelerations due to ship motion shall be proposed and approved by the Administration or recognized organization acting on its behalf.

4.14.1.4 Guidance formulae for acceleration components are given in 4.28.2.

4.14.1.5 Ships for restricted service may be given special consideration.

4.14.2 ***Dynamic interaction loads***

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

4.14.3 ***Sloshing loads***

4.14.3.1 The sloshing loads on a cargo containment system and internal components shall be evaluated based on allowable filling levels.

4.14.3.2 When significant sloshing-induced loads are expected to be present, special tests and calculations shall be required covering the full range of intended filling levels.

4.14.4 ***Snow and ice loads***

Snow and icing shall be considered, if relevant.

4.14.5 ***Loads due to navigation in ice***

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

4.15 Accidental loads

Accidental loads are defined as loads that are imposed on a cargo containment system and its supporting arrangements under abnormal and unplanned conditions.

4.15.1 ***Collision loads***

The collision load shall be determined based on the cargo containment system under fully loaded condition with an inertial force corresponding to 0.5 g in the forward direction and 0.25 g in the aft direction, where "g" is gravitational acceleration.

4.15.2 ***Loads due to flooding on ship***

For independent tanks, loads caused by the buoyancy of an empty tank in a hold space flooded to the summer load draught shall be considered in the design of the anti-flotation chocks and the supporting hull structure.

PART C
STRUCTURAL INTEGRITY

4.16 General

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

4.16.2 The structural integrity of cargo containment systems shall be demonstrated by compliance with 4.21 to 4.26, as appropriate, for the cargo containment system type.

4.16.3 The structural integrity of cargo containment system types that are of novel design and differ significantly from those covered by 4.21 to 4.26 shall be demonstrated by compliance with 4.27 to ensure that the overall level of safety provided in this chapter is maintained.

4.17 Structural analyses

4.17.1 ***Analysis***

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

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

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

4.17.2 ***Load scenarios***

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

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

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

$$\sigma_x = \sigma_{x.st} \pm \sqrt{\sum (\sigma_{x.dyn})^2}$$
$$\sigma_y = \sigma_{y.st} \pm \sqrt{\sum (\sigma_{y.dyn})^2}$$
$$\sigma_z = \sigma_{z.st} \pm \sqrt{\sum (\sigma_{z.dyn})^2}$$

$$\tau_{xy} = \tau_{xy.st} \pm \sqrt{\sum \left(\tau_{xy.dyn}\right)^2}$$
$$\tau_{xz} = \tau_{xz.st} \pm \sqrt{\sum \left(\tau_{xz.dyn}\right)^2}$$
$$\tau_{yz} = \tau_{yz.st} \pm \sqrt{\sum \left(\tau_{yz.dyn}\right)^2}$$

where:

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

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

4.18 Design conditions

All relevant failure modes shall be considered in the design for all relevant load scenarios and design conditions. The design conditions are given in the earlier part of this chapter, and the load scenarios are covered by 4.17.2.

4.18.1 *Ultimate design condition*

Structural capacity may be determined by testing, or by analysis, taking into account both the elastic and plastic material properties, by simplified linear elastic analysis or by the Code provisions.

4.18.1.1 Plastic deformation and buckling shall be considered.

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

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

4.18.1.3 For the purpose of ultimate strength assessment, the following material parameters apply:

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

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

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

.2 The above properties shall correspond to the minimum specified mechanical properties of the material, including the weld metal in the as-fabricated condition. Subject to special consideration by the Administration or recognized organization acting on its behalf, account may be taken of the enhanced yield stress and tensile strength at low temperature. The temperature on which the material properties are based shall be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk required in 1.4.

4.18.1.4 The equivalent stress σ_C (von Mises, Huber) shall be determined by:

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

where:

σ_x = total normal stress in x-direction;
σ_y = total normal stress in y-direction;
σ_z = total normal stress in z-direction;
τ_{xy} = total shear stress in x-y plane;
τ_{xz} = total shear stress in x-z plane; and
τ_{yz} = total shear stress in y-z plane.

The above values shall be calculated as described in 4.17.3.

4.18.1.5 Allowable stresses for materials other than those covered by chapter 6 shall be subject to approval by the Administration or recognized organization acting on its behalf in each case.

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

4.18.2 ***Fatigue design condition***

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

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

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

where:

n_i = number of stress cycles at each stress level during the life of the tank;
N_i = number of cycles to fracture for the respective stress level according to the Wohler (S-N) curve;
$n_{Loading}$ = number of loading and unloading cycles during the life of the tank, not to be less than 1000. Loading and unloading cycles include a complete pressure and thermal cycle;
$N_{Loading}$ = number of cycles to fracture for the fatigue loads due to loading and unloading; and
C_w = maximum allowable cumulative fatigue damage ratio.

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

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

4.18.2.4.1 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.

4.18.2.4.2 The S-N curves shall be based on a 97.6% probability of survival corresponding to the mean-minus-two-standard-deviation curves of relevant experimental data up to final failure. Use of S-N curves derived in a different way requires adjustments to the acceptable C_w values specified in 4.18.2.7 to 4.18.2.9.

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

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

If simplified dynamic loading spectra are used for the estimation of the fatigue life, they shall be specially considered by the Administration or recognized organization acting on its behalf.

4.18.2.6.1 Where the size of the secondary barrier is reduced, as is provided for in 4.4.3, fracture mechanics analyses of fatigue crack growth shall be carried out to determine:

.1 crack propagation paths in the structure;

.2 crack growth rate;

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

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

.5 the time required for detectable cracks to reach a critical state.

The fracture mechanics are, in general, based on crack growth data taken as a mean value plus two standard deviations of the test data.

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

4.18.2.6.3 Crack propagation analysis under the condition specified in 4.18.2.7: the simplified load distribution and sequence over a period of 15 days may be used. Such distributions may be obtained as indicated in figure 4.4. Load distribution and sequence for longer periods, such as in 4.18.2.8 and 4.18.2.9 shall be approved by the Administration or recognized organization acting on its behalf.

4.18.2.6.4 The arrangements shall comply with 4.18.2.7 to 4.18.2.9, as applicable.

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

C_w shall be less than or equal to 0.5.

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

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

C_w shall be less than or equal to 0.5.

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

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

C_w shall be less than or equal to 0.1.

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

4.18.3 ***Accident design condition***

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

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

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

4.18.3.3 Loads mentioned in 4.13.9 and 4.15 need not be combined with each other or with wave-induced loads.

PART D
MATERIALS AND CONSTRUCTION

4.19 Materials

Goal

To ensure that the cargo containment system, primary and secondary barriers, the thermal insulation, adjacent ship structure and other materials in the cargo containment system are constructed from materials of suitable properties for the conditions they will experience, both in normal service and in the event of failure of the primary barrier, where applicable.

4.19.1 ***Materials forming ship structure***

4.19.1.1 To determine the grade of plate and sections used in the hull structure, a temperature calculation shall be performed for all tank types when the cargo temperature is below -10°C. The following assumptions shall be made in this calculation:

.1 the primary barrier of all tanks shall be assumed to be at the cargo temperature;

.2 in addition to .1, where a complete or partial secondary barrier is required, it shall be assumed to be at the cargo temperature at atmospheric pressure for any one tank only;

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

.4 still air and seawater conditions shall be assumed, i.e. no adjustment for forced convection;

.5 degradation of the thermal insulation properties over the life of the ship due to factors such as thermal and mechanical ageing, compaction, ship motions and tank vibrations, as defined in 4.19.3.6 and 4.19.3.7, shall be assumed;

.6 the cooling effect of the rising boil-off vapour from the leaked cargo shall be taken into account, where applicable;

.7 credit for hull heating may be taken in accordance with 4.19.1.5, provided the heating arrangements are in compliance with 4.19.1.6;

.8 no credit shall be given for any means of heating, except as described in 4.19.1.5; and

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

The ambient temperatures used in the design, described in this paragraph, shall be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk required in 1.4.4.

4.19.1.2 The shell and deck plating of the ship and all stiffeners attached thereto shall be in accordance with recognized standards. If the calculated temperature of the material in the design condition is below -5°C due to the influence of the cargo temperature, the material shall be in accordance with table 6.5.

4.19.1.3 The materials of all other hull structures for which the calculated temperature in the design condition is below 0°C, due to the influence of cargo temperature and that do not form the secondary barrier, shall also be in accordance with table 6.5. This includes hull structure supporting the cargo tanks, inner bottom plating, longitudinal bulkhead plating, transverse bulkhead plating, floors, webs, stringers and all attached stiffening members.

4.19.1.4 The hull material forming the secondary barrier shall be in accordance with table 6.2. Where the secondary barrier is formed by the deck or side shell plating, the material grade required by table 6.2 shall be carried into the adjacent deck or side shell plating, where applicable, to a suitable extent.

4.19.1.5 Means of heating structural materials may be used to ensure that the material temperature does not fall below the minimum allowed for the grade of material specified in table 6.5. In the calculations required in 4.19.1.1, credit for such heating may be taken in accordance with the following:

.1 for any transverse hull structure;

.2 for longitudinal hull structure referred to in 4.19.1.2 and 4.19.1.3 where colder ambient temperatures are specified, provided the material remains suitable for the ambient temperature conditions of +5°C for air and 0°C for seawater with no credit taken in the calculations for heating; and

.3 as an alternative to .2, for longitudinal bulkhead between cargo tanks, credit may be taken for heating, provided the material remain suitable for a minimum design temperature of -30°C, or a temperature 30°C lower than that determined by 4.19.1.1 with the heating considered, whichever is less. In this case, the ship's longitudinal strength shall comply with SOLAS regulation II-1/3-1 for both when those bulkhead(s) are considered effective and not.

4.19.1.6 The means of heating referred to in 4.19.1.5 shall comply with the following requirements:

.1 the heating system shall be arranged so that, in the event of failure in any part of the system, standby heating can be maintained equal to not less than 100% of the theoretical heat requirement;

.2 the heating system shall be considered as an essential auxiliary. All electrical components of at least one of the systems provided in accordance with 4.19.1.5.1 shall be supplied from the emergency source of electrical power; and

.3 the design and construction of the heating system shall be included in the approval of the containment system by the Administration or recognized organization acting on its behalf.

4.19.2 ***Materials of primary and secondary barriers***

4.19.2.1 Metallic materials used in the construction of primary and secondary barriers not forming the hull, shall be suitable for the design loads that they may be subjected to, and be in accordance with, table 6.1, 6.2 or 6.3.

4.19.2.2 Materials, either non-metallic or metallic but not covered by tables 6.1, 6.2 and 6.3, used in the primary and secondary barriers may be approved by the Administration or recognized organization acting on its behalf, considering the design loads that they may be subjected to, their properties and their intended use.

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

.1 compatibility with the cargoes;

.2 ageing;

.3 mechanical properties;

.4 thermal expansion and contraction;

.5 abrasion;

.6 cohesion;

.7 resistance to vibrations;

.8 resistance to fire and flame spread; and

.9 resistance to fatigue failure and crack propagation.

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

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

4.19.2.5.2 Guidance on the use of non-metallic materials in the construction of primary and secondary barriers is provided in appendix 4.

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

4.19.3 ***Thermal insulation and other materials used in cargo containment systems***

4.19.3.1 Load-bearing thermal insulation and other materials used in cargo containment systems shall be suitable for the design loads.

4.19.3.2 Thermal insulation and other materials used in cargo containment systems shall have the following properties, as applicable, to ensure that they are adequate for the intended service:

.1 compatibility with the cargoes;

.2 solubility in the cargo;

.3 absorption of the cargo;

.4 shrinkage;

.5 ageing;

.6 closed cell content;

.7 density;

.8 mechanical properties, to the extent that they are subjected to cargo and other loading effects, thermal expansion and contraction;

.9 abrasion;

.10 cohesion;

.11 thermal conductivity;

.12 resistance to vibrations;

.13 resistance to fire and flame spread; and

.14 resistance to fatigue failure and crack propagation.

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

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

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

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

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

4.20 Construction processes

Goal

To define suitable construction processes and test procedures in order to ensure, as far as reasonably practical, that the cargo containment system will perform satisfactorily in service in accordance with the assumptions made at the design stage.

4.20.1 *Weld joint design*

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

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

.1 all longitudinal and circumferential joints shall be of butt welded, full penetration, double vee or single vee type. Full penetration butt welds shall be obtained by double welding or by the use of backing rings. If used, backing rings shall be removed except from very small process pressure vessels. Other edge preparations may be permitted, depending on the results of the tests carried out at the approval of the welding procedure; and

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

4.20.1.3 Where applicable, all the construction processes and testing, except that specified in 4.20.3, shall be done in accordance with the applicable provisions of chapter 6.

4.20.2 ***Design for gluing and other joining processes***

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

4.20.3 ***Testing***

4.20.3.1 All cargo tanks and process pressure vessels shall be subjected to hydrostatic or hydropneumatic pressure testing in accordance with 4.21 to 4.26, as applicable for the tank type.

4.20.3.2 All tanks shall be subject to a tightness test which may be performed in combination with the pressure test referred to in 4.20.3.1.

4.20.3.3 Requirements with respect to inspection of secondary barriers shall be decided by the Administration or recognized organization acting on its behalf in each case, taking into account the accessibility of the barrier (see 4.6.2).

4.20.3.4 The Administration may require that for ships fitted with novel type B independent tanks, or tanks designed according to 4.27 at least one prototype tank and its supporting structures shall be instrumented with strain gauges or other suitable equipment to confirm stress levels. Similar instrumentation may be required for type C independent tanks, depending on their configuration and on the arrangement of their supports and attachments.

4.20.3.5 The overall performance of the cargo containment system shall be verified for compliance with the design parameters during the first full loading and discharging of the cargo, in accordance with the survey procedure and requirements in 1.4 and the requirements of the Administration or recognized organization acting on its behalf. Records of the performance of the components and equipment essential to verify the design parameters, shall be maintained and be available to the Administration.

4.20.3.6 Heating arrangements, if fitted in accordance with 4.19.1.5 and 4.19.1.6, shall be tested for required heat output and heat distribution.

4.20.3.7 The cargo containment system shall be inspected for cold spots during, or immediately following, the first loaded voyage. Inspection of the integrity of thermal insulation surfaces that cannot be visually checked shall be carried out in accordance with recognized standards.

PART E
TANK TYPES

4.21 Type A independent tanks

4.21.1 ***Design basis***

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

4.21.1.2 If the cargo temperature at atmospheric pressure is below -10°C, a complete secondary barrier shall be provided as required in 4.5. The secondary barrier shall be designed in accordance with 4.6.

4.21.2 ***Structural analysis***

4.21.2.1 A structural analysis shall be performed taking into account the internal pressure as indicated in 4.13.2, and the interaction loads with the supporting and keying system as well as a reasonable part of the ship's hull.

4.21.2.2 For parts, such as supporting structures, not otherwise covered by the requirements of the Code, stresses shall be determined by direct calculations, taking into account the loads referred to in 4.12 to 4.15 as far as applicable, and the ship deflection in way of supporting structures.

4.21.2.3 The tanks with supports shall be designed for the accidental loads specified in 4.15. These loads need not be combined with each other or with environmental loads.

4.21.3 ***Ultimate design condition***

4.21.3.1 For tanks primarily constructed of plane surfaces, the nominal membrane stresses for primary and secondary members (stiffeners, web frames, stringers, girders), when calculated by classical analysis procedures, shall not exceed the lower of $R_m/2.66$ or $R_e/1.33$ for nickel steels, carbon-manganese steels, austenitic steels and aluminium alloys, where R_m and R_e are defined in 4.18.1.3. However, if detailed calculations are carried out for the primary members, the equivalent stress σ_c, as defined in 4.18.1.4, may be increased over that indicated above to a stress acceptable to the Administration or recognized organization acting on its behalf. Calculations shall take into account the effects of bending, shear, axial and torsional deformation as well as the hull/cargo tank interaction forces due to the deflection of the double bottom and cargo tank bottoms.

4.21.3.2 Tank boundary scantlings shall meet at least the requirements of the Administration or recognized organization acting on its behalf for deep tanks taking into account the internal pressure as indicated in 4.13.2 and any corrosion allowance required by 4.3.5.

4.21.3.3 The cargo tank structure shall be reviewed against potential buckling.

4.21.4 ***Accident design condition***

4.21.4.1 The tanks and the tank supports shall be designed for the accidental loads and design conditions specified in 4.3.4.3 and 4.15, as relevant.

4.21.4.2 When subjected to the accidental loads specified in 4.15, the stress shall comply with the acceptance criteria specified in 4.21.3, modified as appropriate, taking into account their lower probability of occurrence.

4.21.5 ***Testing***

All type A independent tanks shall be subjected to a hydrostatic or hydropneumatic test. This test shall be performed such that the stresses approximate, as far as practicable, the design stresses, and that the pressure at the top of the tank corresponds at least to the MARVS. When a hydropneumatic test is performed, the conditions shall simulate, as far as practicable, the design loading of the tank and of its support structure, including dynamic components, while avoiding stress levels that could cause permanent deformation.

4.22 Type B independent tanks

4.22.1 *Design basis*

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

4.22.1.2 If the cargo temperature at atmospheric pressure is below -10°C, a partial secondary barrier with a small leak protection system shall be provided as required in 4.5. The small leak protection system shall be designed according to 4.7.

4.22.2 *Structural analysis*

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

.1 plastic deformation;

.2 buckling;

.3 fatigue failure; and

.4 crack propagation.

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

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

4.22.2.3 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 shall be performed, unless the data is available from similar ships.

4.22.3 *Ultimate design condition*

4.22.3.1 Plastic deformation

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

σ_m	$\leq f$
σ_L	$\leq 1.5f$
σ_b	$\leq 1.5F$
$\sigma_L+\sigma_b$	$\leq 1.5F$
$\sigma_m+\sigma_b$	$\leq 1.5F$
$\sigma_m+\sigma_b+\sigma_g$	$\leq 3.0F$
$\sigma_L+\sigma_b+\sigma_g$	$\leq 3.0F$

where:

σ_m = equivalent primary general membrane stress;

σ_L = equivalent primary local membrane stress;

σ_b = equivalent primary bending stress;

σ_g = equivalent secondary stress;

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

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

with R_m and R_e as defined in 4.18.1.3. With regard to the stresses σ_m, σ_L, σ_b and σ_g, the definition of stress categories in 4.28.3 are referred. The values A and B shall be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk and shall have at least the following minimum values:

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

The above figures may be altered, taking into account the design condition considered in acceptance with the Administration.

4.22.3.1.2 For type B independent tanks, primarily constructed of plane surfaces, the allowable membrane equivalent stresses applied for finite element analysis shall not exceed:

.1 for nickel steels and carbon-manganese steels, the lesser of $R_m/2$ or $R_e/1.2$;

.2 for austenitic steels, the lesser of $R_m/2.5$ or $R_e/1.2$; and

.3 for aluminium alloys, the lesser of $R_m/2.5$ or $R_e/1.2$.

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

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

4.22.3.2 ***Buckling***

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

4.22.4 ***Fatigue design condition***

4.22.4.1 Fatigue and crack propagation assessment shall be performed in accordance with 4.18.2. The acceptance criteria shall comply with 4.18.2.7, 4.18.2.8 or 4.18.2.9, depending on the detectability of the defect.

4.22.4.2 Fatigue analysis shall consider construction tolerances.

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

4.22.5 ***Accident design condition***

4.22.5.1 The tanks and the tank supports shall be designed for the accidental loads and design conditions specified in 4.3.4.3 and 4.15, as applicable.

4.22.5.2 When subjected to the accidental loads specified in 4.15, the stress shall comply with the acceptance criteria specified in 4.22.3, modified as appropriate, taking into account their lower probability of occurrence.

4.22.6 ***Testing***

Type B independent tanks shall be subjected to a hydrostatic or hydropneumatic test as follows:

.1 the test shall be performed as required in 4.21.5 for type A independent tanks; and

.2 in addition, the maximum primary membrane stress or maximum bending stress in primary members under test conditions shall not exceed 90% of the yield strength of the material (as fabricated) at the test temperature. To ensure that this condition is satisfied, when calculations indicate that this stress exceeds 75% of the yield strength, the prototype test shall be monitored by the use of strain gauges or other suitable equipment.

4.22.7 ***Marking***

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

4.23 Type C independent tanks

4.23.1 ***Design basis***

4.23.1.1 The design basis for type C independent tanks is based on pressure vessel criteria modified to include fracture mechanics and crack propagation criteria. The minimum design pressure defined in 4.23.1.2 is intended to ensure that the dynamic stress is sufficiently low, so that an initial surface flaw will not propagate more than half the thickness of the shell during the lifetime of the tank.

4.23.1.2 The design vapour pressure shall not be less than:

$$P_o = 0.2 + AC(\rho_r)^{1.5} \quad \text{(MPa)}$$

where:

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

with:

σ_m = design primary membrane stress;

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

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

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

h, $0.75b$ or 0.45ℓ,

with:

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

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

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

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

When a specified design life of the tank is longer than 10^8 wave encounters, $\Delta\sigma_A$ shall be modified to give equivalent crack propagation corresponding to the design life.

4.23.1.3 The Administration may allocate a tank complying with the criteria of type C tank minimum design pressure as in 4.23.1.2, to a type A or type B, dependent on the configuration of the tank and the arrangement of its supports and attachments.

4.23.2 ***Shell thickness***

4.23.2.1 The shell thickness shall be as follows:

.1 For pressure vessels, the thickness calculated according to 4.23.2.4 shall be considered as a minimum thickness after forming, without any negative tolerance.

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

.3 The welded joint efficiency factor to be used in the calculation according to 4.23.2.4 shall be 0.95 when the inspection and the non-destructive testing referred to in 6.5.6.5 are carried out. This figure may be increased up to 1 when account is taken of other considerations, such as the material used, type of joints, welding procedure and type of loading. For process pressure vessels, the Administration or recognized organization acting on its behalf may accept partial non-destructive examinations, but not less than those of 6.5.6.5, depending on such factors as the material used, the design temperature, the nil-ductility transition temperature of the material, as fabricated, and the type of joint and welding procedure, but in this case an efficiency factor of not more than 0.85 shall be adopted. For special materials, the above-mentioned factors shall be reduced, depending on the specified mechanical properties of the welded joint.

4.23.2.2 The design liquid pressure defined in 4.13.2 shall be taken into account in the internal pressure calculations.

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

$$P_e = P_1+P_2+P_3+P_4 \quad \text{(MPa)},$$

where:

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

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

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

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

4.23.2.4 Scantlings based on internal pressure shall be calculated as follows: the thickness and form of pressure-containing parts of pressure vessels, under internal pressure, as defined in 4.13.2, including flanges, shall be determined. These calculations shall in all cases be based on accepted pressure vessel design theory. Openings in pressure-containing parts of pressure vessels shall be reinforced in accordance with recognized standards.

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

.1 Pressure vessel scantlings shall be determined in accordance with 4.23.2.1 to 4.23.2.4 and 4.23.3.

.2 Calculations of the loads and stresses in way of the supports and the shell attachment of the support shall be made. Loads referred to in 4.12 to 4.15 shall be used, as applicable. Stresses in way of the supporting structures shall be to a recognized standard acceptable to the Administration or recognized organization acting on its behalf. In special cases, a fatigue analysis may be required by the Administration or recognized organization acting on its behalf.

.3 If required by the Administration or recognized organization acting on its behalf, secondary stresses and thermal stresses shall be specially considered.

4.23.3 *Ultimate design condition*

4.23.3.1 Plastic deformation

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

$$\begin{aligned}
\sigma_m &\leq f \\
\sigma_L &\leq 1.5f \\
\sigma_b &\leq 1.5f \\
\sigma_L+\sigma_b &\leq 1.5f \\
\sigma_m+\sigma_b &\leq 1.5f \\
\sigma_m+\sigma_b+\sigma_g &\leq 3.0f \\
\sigma_L+\sigma_b+\sigma_g &\leq 3.0f,
\end{aligned}$$

where:

σ_m = equivalent primary general membrane stress;
σ_L = equivalent primary local membrane stress;
σ_b = equivalent primary bending stress;
σ_g = equivalent secondary stress; and

f = the lesser of R_m/A or R_e/B,
with R_m and R_e as defined in 4.18.1.3. With regard to the stresses σ_m, σ_L, σ_b *and* σ_g, the definition of stress categories in 4.28.3 are referred. The values A and B shall be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk and shall have at least the following minimum values:

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

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

4.23.4 *Fatigue design condition*

For large type C independent tanks, where the cargo at atmospheric pressure is below -55°C, the Administration or recognized organization acting on its behalf may require additional verification to check their compliance with 4.23.1.1 regarding static and dynamic stress.

4.23.5 *Accident design condition*

4.23.5.1 The tanks and the tank supporting structures shall be designed for the accidental loads and design conditions specified in 4.3.4.3 and 4.15, as applicable.

4.23.5.2 When subjected to the accidental loads specified in 4.15, the stress shall comply with the acceptance criteria specified in 4.23.3.1, modified as appropriate taking into account their lower probability of occurrence.

4.23.6 *Testing*

4.23.6.1 Each pressure vessel shall be subjected to a hydrostatic test at a pressure measured at the top of the tanks, of not less than 1.5 P_o. In no case during the pressure test shall the calculated primary membrane stress at any point exceed 90% of the yield stress of the material. To ensure that this condition is satisfied where calculations indicate that this stress will exceed 0.75 times the yield strength, the prototype test shall be monitored by the use of strain gauges or other suitable equipment in pressure vessels other than simple cylindrical and spherical pressure vessels.

4.23.6.2 The temperature of the water used for the test shall be at least 30°C above the nil-ductility transition temperature of the material, as fabricated.

4.23.6.3 The pressure shall be held for 2 h per 25 mm of thickness, but in no case less than 2 h.

4.23.6.4 Where necessary for cargo pressure vessels, a hydropneumatic test may be carried out under the conditions prescribed in 4.23.6.1 to 4.23.6.3.

4.23.6.5 Special consideration may be given to the testing of tanks in which higher allowable stresses are used, depending on service temperature. However, the requirements of 4.23.6.1 shall be fully complied with.

4.23.6.6 After completion and assembly, each pressure vessel and its related fittings shall be subjected to an adequate tightness test which may be performed in combination with the pressure testing referred to in 4.23.6.1.

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

4.23.7 *Marking*

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

4.24 Membrane tanks

4.24.1 *Design basis*

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

4.24.1.2 A systematic approach based on analysis and testing shall be used to demonstrate that the system will provide its intended function in consideration of the events identified in service as specified in 4.24.2.1.
4.24.1.3 If the cargo temperature at atmospheric pressure is below -10°C, a complete secondary barrier shall be provided as required in 4.5. The secondary barrier shall be designed according to 4.6.

4.24.1.4 The design vapour pressure P_o shall not normally exceed 0.025 MPa. If the hull scantlings are increased accordingly and consideration is given, where appropriate, to the strength of the supporting thermal insulation, P_o may be increased to a higher value, but less than 0.07 MPa.

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

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

4.24.1.7 The circulation of inert gas throughout the primary insulation space and the secondary insulation space, in accordance with 9.2.1, shall be sufficient to allow for effective means of gas detection.

4.24.2 ***Design considerations***

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

.1 Ultimate design events:

  .1 tensile failure of membranes;

  .2 compressive collapse of thermal insulation;

  .3 thermal ageing;

  .4 loss of attachment between thermal insulation and hull structure;

  .5 loss of attachment of membranes to thermal insulation system;

  .6 structural integrity of internal structures and their supporting structures; and

  .7 failure of the supporting hull structure.

.2 Fatigue design events:

  .1 fatigue of membranes including joints and attachments to hull structure;

  .2 fatigue cracking of thermal insulation;

  .3 fatigue of internal structures and their supporting structures; and

  .4 fatigue cracking of inner hull leading to ballast water ingress.

.3 Accident design events:

  .1 accidental mechanical damage (such as dropped objects inside the tank while in service);

  .2 accidental overpressurization of thermal insulation spaces;
  .3 accidental vacuum in the tank; and

  .4 water ingress through the inner hull structure.

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

4.24.2.2 The necessary physical properties (mechanical, thermal, chemical, etc.) of the materials used in the construction of the cargo containment system shall be established during the design development in accordance with 4.24.1.2.

4.24.3 *Loads and load combinations*

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

4.24.4 *Structural analyses*

4.24.4.1 Structural analyses and/or testing for the purpose of determining the ultimate strength and fatigue assessments of the cargo containment and associated structures, e.g. structures as defined in 4.9, shall be performed. The structural analysis shall provide the data required to assess each failure mode that has been identified as critical for the cargo containment system.

4.24.4.2 Structural analyses of the hull shall take into account the internal pressure as indicated in 4.13.2. Special attention shall be paid to deflections of the hull and their compatibility with the membrane and associated thermal insulation.

4.24.4.3 The analyses referred to in 4.24.4.1 and 4.24.4.2 shall be based on the particular motions, accelerations and response of ships and cargo containment systems.

4.24.5 *Ultimate design condition*

4.24.5.1 The structural resistance of every critical component, subsystem or assembly shall be established, in accordance with 4.24.1.2, for in-service conditions.

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

4.24.5.3 The inner hull scantlings shall meet the requirements for deep tanks, taking into account the internal pressure as indicated in 4.13.2 and the specified appropriate requirements for sloshing load as defined in 4.14.3.

4.24.6 *Fatigue design condition*

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

4.24.6.2 The fatigue calculations shall be carried out in accordance with 4.18.2, with relevant requirements depending on:

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

.2 availability for inspection.

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

4.24.6.4 Structural elements subject to periodic inspection, and where an unattended fatigue crack can develop to cause simultaneous or cascading failure of both membranes, shall satisfy the fatigue and fracture mechanics requirements stated in 4.18.2.8.

4.24.6.5 Structural element not accessible for in-service inspection, and where a fatigue crack can develop without warning to cause simultaneous or cascading failure of both membranes, shall satisfy the fatigue and fracture mechanics requirements stated in 4.18.2.9.

4.24.7 *Accident design condition*

4.24.7.1 The containment system and the supporting hull structure shall be designed for the accidental loads specified in 4.15. These loads need not be combined with each other or with environmental loads.

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

4.24.8 *Design development testing*

4.24.8.1 The design development testing required in 4.24.1.2 shall include a series of analytical and physical models of both the primary and secondary barriers, including corners and joints, tested to verify that they will withstand the expected combined strains due to static, dynamic and thermal loads. This will culminate in the construction of a prototype-scaled model of the complete cargo containment system. Testing conditions considered in the analytical and physical models shall represent the most extreme service conditions the cargo containment system will be likely to encounter over its life. Proposed acceptance criteria for periodic testing of secondary barriers required in 4.6.2 may be based on the results of testing carried out on the prototype-scaled model.

4.24.8.2 The fatigue performance of the membrane materials and representative welded or bonded joints in the membranes shall be determined by tests. The ultimate strength and fatigue performance of arrangements for securing the thermal insulation system to the hull structure shall be determined by analyses or tests.

4.24.9 *Testing*

4.24.9.1 In ships fitted with membrane cargo containment systems, all tanks and other spaces that may normally contain liquid and are adjacent to the hull structure supporting the membrane, shall be hydrostatically tested.

4.24.9.2 All hold structures supporting the membrane shall be tested for tightness before installation of the cargo containment system.

4.24.9.3 Pipe tunnels and other compartments that do not normally contain liquid need not be hydrostatically tested.

4.25 Integral tanks

4.25.1 *Design basis*

Integral tanks that form a structural part of the hull and are affected by the loads that stress the adjacent hull structure shall comply with the following:

.1 the design vapour pressure P_o as defined in 4.1.2 shall not normally exceed 0.025 MPa. If the hull scantlings are increased accordingly, P_o may be increased to a higher value, but less than 0.07 MPa;

.2 integral tanks may be used for products, provided the boiling point of the cargo is not below -10°C. A lower temperature may be accepted by the Administration or recognized organization acting on its behalf subject to special consideration, but in such cases a complete secondary barrier shall be provided; and

.3 products required by chapter 19 to be carried in type 1G ships shall not be carried in integral tanks.

4.25.2 ***Structural analysis***

The structural analysis of integral tanks shall be in accordance with recognized standards.

4.25.3 ***Ultimate design condition***

4.25.3.1 The tank boundary scantlings shall meet the requirements for deep tanks, taking into account the internal pressure as indicated in 4.13.2.

4.25.3.2 For integral tanks, allowable stresses shall normally be those given for hull structure in the requirements of the Administration or recognized organization acting on its behalf.

4.25.4 ***Accident design condition***

4.25.4.1 The tanks and the tank supports shall be designed for the accidental loads specified in 4.3.4.3 and 4.15, as relevant.

4.25.4.2 When subjected to the accidental loads specified in 4.15, the stress shall comply with the acceptance criteria specified in 4.25.3, modified as appropriate, taking into account their lower probability of occurrence.

4.25.5 ***Testing***

All integral tanks shall be hydrostatically or hydropneumatically tested. The test shall 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.

4.26 Semi-membrane tanks

4.26.1 ***Design basis***

4.26.1.1 Semi-membrane tanks are non-self-supporting tanks when in the loaded condition and consist of a layer, parts of which are supported through thermal insulation by the adjacent hull structure, whereas the rounded parts of this layer connecting the above-mentioned supported parts are designed also to accommodate the thermal and other expansion or contraction.

4.26.1.2 The design vapour pressure P_o shall not normally exceed 0.025 MPa. If the hull scantlings are increased accordingly, and consideration is given, where appropriate, to the strength of the supporting thermal insulation, P_o may be increased to a higher value, but less than 0.07 MPa.

4.26.1.3 For semi-membrane tanks the relevant requirements in this section for independent tanks or for membrane tanks shall be applied as appropriate.

4.26.1.4 In the case of semi-membrane tanks that comply in all respects with the requirements applicable to type B independent tanks, except for the manner of support, the Administration may, after special consideration, accept a partial secondary barrier.

PART F
CARGO CONTAINMENT SYSTEMS OF NOVEL CONFIGURATION

4.27 Limit state design for novel concepts

4.27.1 Cargo containment systems that are of a novel configuration that cannot be designed using sections 4.21 to 4.26 shall be designed using this section and parts A and B of this chapter, and also parts C and D, as applicable. Cargo containment system design according to this section shall be based on the principles of limit state design which is an approach to structural design that can be applied to established design solutions as well as novel designs. This more generic approach maintains a level of safety similar to that achieved for known containment systems as designed using 4.21 to 4.26.

4.27.2.1 The limit state design is a systematic approach where each structural element is evaluated with respect to possible failure modes related to the design conditions identified in 4.3.4. A limit state can be defined as a condition beyond which the structure, or part of a structure, no longer satisfies the requirements.

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

.1 Ultimate limit states (ULS), which correspond to the maximum load-carrying capacity or, in some cases, to the maximum applicable strain or deformation; under intact (undamaged) conditions.

.2 Fatigue limit states (FLS), which correspond to degradation due to the effect of time varying (cyclic) loading.

.3 Accident limit states (ALS), which concern the ability of the structure to resist accidental situations.

4.27.3 The procedure and relevant design parameters of the limit state design shall comply with the Standards for the Use of limit state methodologies in the design of cargo containment systems of novel configuration (LSD Standard), as set out in appendix 5.

PART G
GUIDANCE

4.28 Guidance notes for chapter 4

4.28.1 ***Guidance to detailed calculation of internal pressure for static design purpose***

4.28.1.1 This section provides guidance for the calculation of the associated dynamic liquid pressure for the purpose of static design calculations. This pressure may be used for determining the internal pressure referred to in 4.13.2.4, where:

.1 (P_{gd})max is the associated liquid pressure determined using the maximum design accelerations.

.2 $(P_{gd}$ site$)$max is the associated liquid pressure determined using site specific accelerations.

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

$$P_{eq1} = P_o + (P_{gd})\text{max} \qquad \text{(MPa)},$$

$$P_{eq2} = P_h + (P_{gd}\ \text{site})\text{max} \qquad \text{(MPa)}.$$

4.28.1.2 The internal liquid pressures are those created by the resulting acceleration of the centre of gravity of the cargo due to the motions of the ship referred to in 4.14.1. The value of internal liquid pressure P_{gd} resulting from combined effects of gravity and dynamic accelerations should be calculated as follows:

$$P_{gd} = \alpha_\beta Z_\beta \frac{\rho}{1.02 \times 10} \qquad \text{(MPa)},$$

where:

a_β = dimensionless acceleration (i.e. relative to the acceleration of gravity), resulting from gravitational and dynamic loads, in an arbitrary direction β (see figure 4.1).

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

Z_β = largest liquid height (m) above the point where the pressure is to be determined measured from the tank shell in the β direction (see figure 4.2).

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

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

with:

V_t = tank volume without any domes; and
FL = filling limit according to chapter 15.

ρ = maximum cargo density (kg/m^3) at the design temperature.

The direction that gives the maximum value (P_{gd})max or $(P_{gd}$site)max should be considered. The above formula applies only to full tanks.

4.28.1.3 Equivalent calculation procedures may be applied.

4.28.2 ***Guidance formulae for acceleration components***

4.28.2.1 The following formulae are given as guidance for the components of acceleration due to ship's motions corresponding to a probability level of 10^{-8} in the North Atlantic and apply to ships with a length exceeding 50 m and at or near their service speed:

- vertical acceleration, as defined in 4.14.1:

$$a_z = \pm a_0 \sqrt{1 + \left(5.3 - \frac{45}{L_0}\right)^2 \left(\frac{x}{L_0} + 0.05\right)^2 \left(\frac{0.6}{C_B}\right)^{1.5} + \left(\frac{0.6 y K^{1.5}}{B}\right)^2},$$

- transverse acceleration, as defined in 4.14.1:

$$a_y = \pm a_0 \sqrt{0.6 + 2.5\left(\frac{x}{L_0} + 0.05\right)^2 + K\left(1 + 0.6K\frac{z}{B}\right)^2}$$

- longitudinal acceleration, as defined in 4.14.1:

$$a_x = \pm a_0 \sqrt{0.06 + A^2 - 0.25A},$$

where:

$$a_0 = 0.2\frac{V}{\sqrt{L_0}} + \frac{34 - \left(\frac{600}{L_0}\right)}{L_0}$$

L_0 = length of the ship for determination of scantlings as defined in recognized standards (m);

C_B = block coefficient;

B = greatest moulded breadth of the ship (m);

x = longitudinal distance (m) from amidships to the centre of gravity of the tank with contents; x is positive forward of amidships, negative aft of amidships;

y = transverse distance (m) from centreline to the centre of gravity of the tank with contents;

z = vertical distance (m) from the ship's actual waterline to the centre of gravity of tank with contents; z is positive above and negative below the waterline;

K = 1 in general. For particular loading conditions and hull forms, determination of K according to the following formula may be necessary:

K = 13GM/B, where $K \geq 1$ and GM = metacentric height (m);

$$A = \left(0.7 - \frac{L_0}{1200} + 5\frac{z}{L_0}\right)\left(\frac{0.6}{C_B}\right)$$; and

V = service speed (knots);

a_x, a_y, a_z = maximum dimensionless accelerations (i.e. relative to the acceleration of gravity) in the respective directions. They are considered as acting separately for calculation purposes, and a_z does not include the component due to the static weight, a_y includes the component due to the static weight in the transverse direction due to rolling and a_x includes the component due to the static weight in the longitudinal direction due to pitching. The accelerations derived from the above formulae are applicable only to ships at or near their service speed, not while at anchor or otherwise near stationary in exposed locations.

4.28.3 *Stress categories*

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

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

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

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

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

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

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

4.28.3.8 *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 $1.1f$;

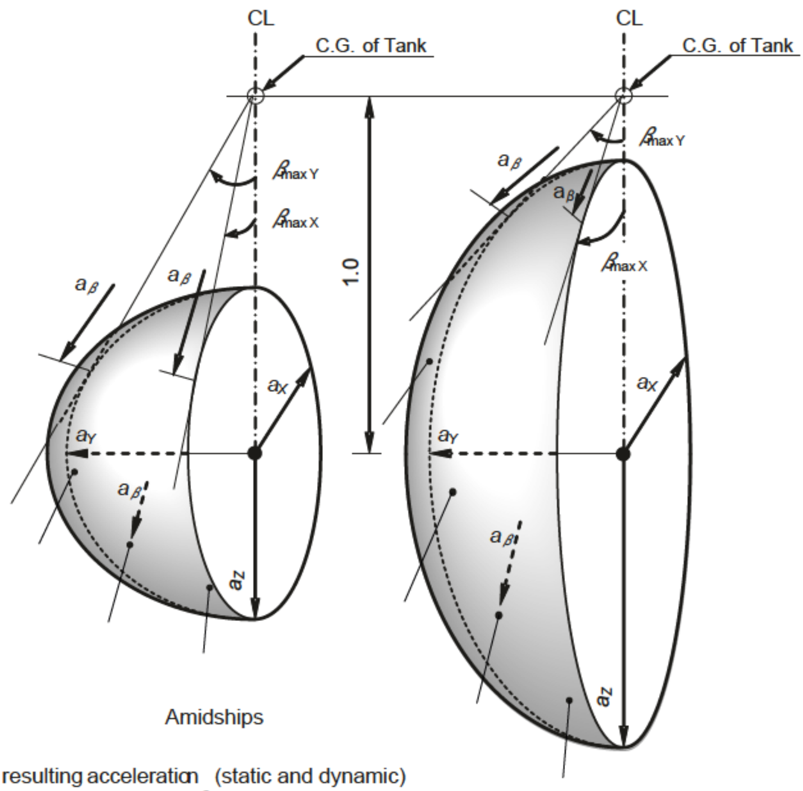
S_2 = distance in the meridional direction to another region where the limits for primary general membrane stress are exceeded;

R = mean radius of the vessel;

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

f = allowable primary general membrane stress.

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



a_β = resulting acceleration (static and dynamic) in arbitrary direction β
a_X = longitudinal component of acceleration
a_Y = transverse component of acceleration
a_Z = vertical component of acceleration

At 0.05L from FP

Figure 4.1 – Acceleration ellipsoid

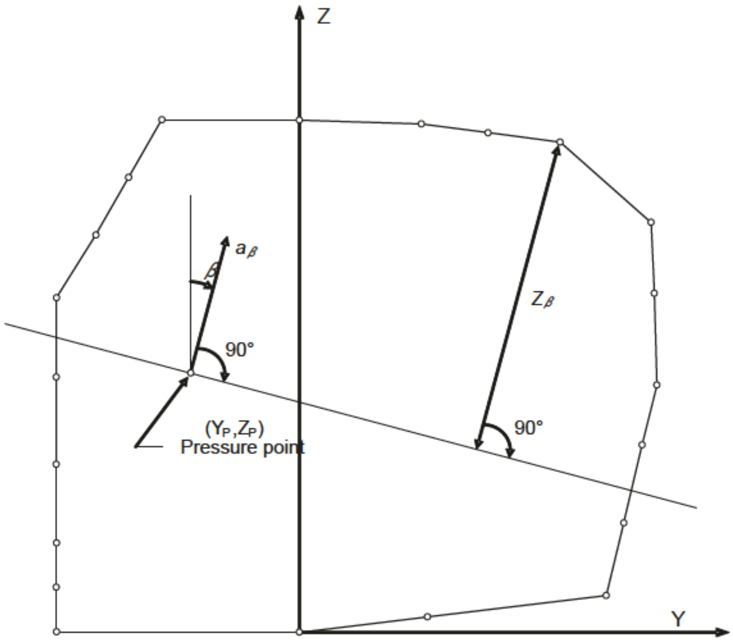


Figure 4.2 – Determination of internal pressure heads

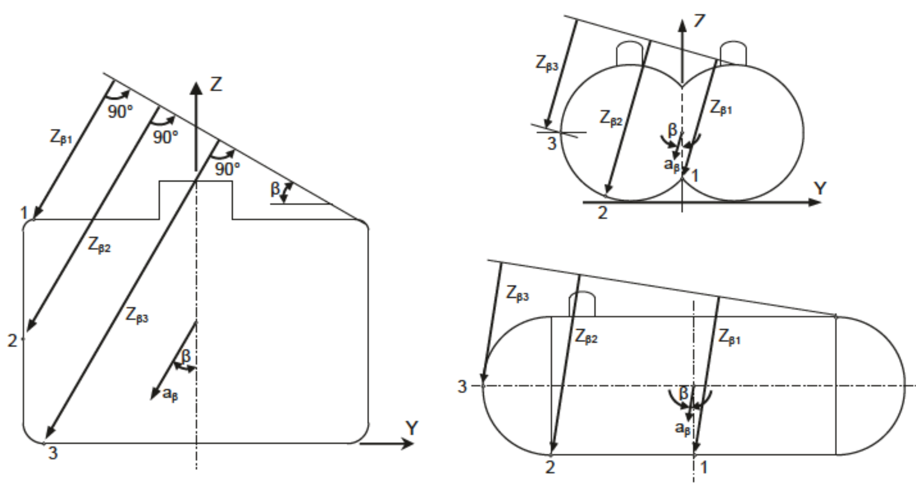
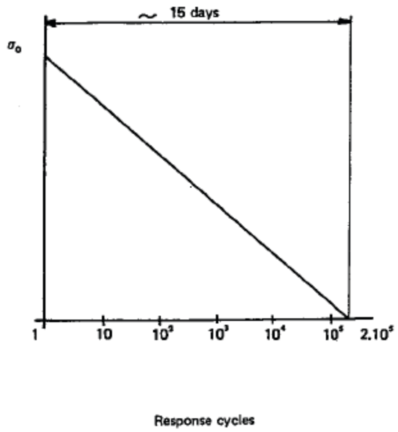


Figure 4.3 – Determination of liquid height Z_β for points 1, 2 and 3



σ_o = most probable maximum stress over the life of the ship
Response cycle scale is logarithmic; the value of 2.10^5 is given as an example of estimate.

Figure 4.4 – Simplified load distribution

CHAPTER 5

PROCESS PRESSURE VESSELS AND LIQUIDS, VAPOUR AND PRESSURE PIPING SYSTEMS

Goal

To ensure the safe handling of all cargo and process liquid and vapour, under all operating conditions, to minimize the risk to the ship, crew and to the environment, having regard to the nature of the products involved. This will:

.1 ensure the integrity of process pressure vessels, piping systems and cargo hoses;

.2 prevent the uncontrolled transfer of cargo;

.3 ensure reliable means to fill and empty the containment systems; and

.4 prevent pressure or vacuum excursions of cargo containment systems, beyond design parameters, during cargo transfer operations.

5.1 General

5.1.1 The requirements of this chapter shall apply to products and process piping, including vapour piping, gas fuel piping and vent lines of safety valves or similar piping. Auxiliary piping systems not containing cargo are exempt from the general requirements of this chapter.

5.1.2 The requirements for type C independent tanks provided in chapter 4 may also apply to process pressure vessels. If so required, the term "pressure vessels" as used in chapter 4, covers both type C independent tanks and process pressure vessels.

5.1.3 Process pressure vessels include surge tanks, heat exchangers and accumulators that store or treat liquid or vapour cargo.

5.2 System requirements

5.2.1 The cargo handling and cargo control systems shall be designed taking into account the following:

.1 prevention of an abnormal condition escalating to a release of liquid or vapour cargo;

.2 the safe collection and disposal of cargo fluids released;

.3 prevention of the formation of flammable mixtures;

.4 prevention of ignition of flammable liquids or gases and vapours released; and

.5 limiting the exposure of personnel to fire and other hazards.

5.2.2 ***Arrangements: general***

5.2.2.1 Any piping system that may contain cargo liquid or vapour shall:

.1 be segregated from other piping systems, except where interconnections are required for cargo-related operations such as purging, gas-freeing or inerting. The requirements of 9.4.4 shall be taken into account with regard to preventing back-flow of cargo. In such cases, precautions shall be taken to ensure that cargo or cargo vapour cannot enter other piping systems through the interconnections;

.2 except as provided in chapter 16, not pass through any accommodation space, service space or control station or through a machinery space other than a cargo machinery space;

.3 be connected to the cargo containment system directly from the weather decks except where pipes installed in a vertical trunkway or equivalent are used to traverse void spaces above a cargo containment system and except where pipes for drainage, venting or purging traverse cofferdams;

.4 be located in the cargo area above the weather deck except for bow or stern loading and unloading arrangements in accordance with 3.8, emergency cargo jettisoning piping systems in accordance with 5.3.1, turret compartment systems in accordance with 5.3.3 and except in accordance with chapter 16; and

.5 be located inboard of the transverse tank location requirements of 2.4.1, except for athwartship shore connection piping not subject to internal pressure at sea or emergency cargo jettisoning piping systems.

5.2.2.2 Suitable means shall be provided to relieve the pressure and remove liquid cargo from loading and discharging crossover headers; likewise, any piping between the outermost manifold valves and loading arms or cargo hoses to the cargo tanks, or other suitable location, prior to disconnection.

5.2.2.3 Piping systems carrying fluids for direct heating or cooling of cargo shall not be led outside the cargo area unless a suitable means is provided to prevent or detect the migration of cargo vapour outside the cargo area (see 13.6.2.6).

5.2.2.4 Relief valves discharging liquid cargo from the piping system shall discharge into the cargo tanks. Alternatively, they may discharge to the cargo vent mast, if means are provided to detect and dispose of any liquid cargo that may flow into the vent system. Where required to prevent overpressure in downstream piping, relief valves on cargo pumps shall discharge to the pump suction.

5.3 Arrangements for cargo piping outside the cargo area

5.3.1 *Emergency cargo jettisoning*

If fitted, an emergency cargo jettisoning piping system shall comply with 5.2.2, as appropriate, and may be led aft, external to accommodation spaces, service spaces or control stations or machinery spaces, but shall not pass through them. If an emergency cargo jettisoning piping system is permanently installed, a suitable means of isolating the piping system from the cargo piping shall be provided within the cargo area.

5.3.2 *Bow and stern loading arrangements*

5.3.2.1 Subject to the requirements of 3.8, this section and 5.10.1, cargo piping may be arranged to permit bow or stern loading and unloading.

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

5.3.3 *Turret compartment transfer systems*

For the transfer of liquid or vapour cargo through an internal turret arrangement located outside the cargo area, the piping serving this purpose shall comply with 5.2.2, as applicable, 5.10.2 and the following:

.1 piping shall be located above the weather deck, except for the connection to the turret;

.2 portable arrangements shall not be permitted; and

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

5.3.4 *Gas fuel piping systems*

Gas fuel piping in machinery spaces shall comply with all applicable sections of this chapter in addition to the requirements of chapter 16.

5.4 Design pressure

5.4.1 The design pressure P_o, used to determine minimum scantlings of piping and piping system components, shall be not less than the maximum gauge pressure to which the system may be subjected in service. The minimum design pressure used shall not be less than 1 MPa gauge, except for open-ended lines or pressure relief valve discharge lines, where it shall be not less than the lower of 0.5 MPa gauge, or 10 times the relief valve set pressure.

5.4.2 The greater of the following design conditions shall be used for piping, piping systems and components, based on the cargoes being carried:

.1 for vapour piping systems or components that may be separated from their relief valves and which may contain some liquid, the saturated vapour pressure at a design temperature of 45°C. Higher or lower values may be used (see 4.13.2.2); or

.2 for systems or components that may be separated from their relief valves and which contain only vapour at all times, the superheated vapour pressure at 45°C. Higher or lower values may be used (see 4.13.2.2), assuming an initial condition of saturated vapour in the system at the system operating pressure and temperature; or

.3 the MARVS of the cargo tanks and cargo processing systems; or

.4 the pressure setting of the associated pump or compressor discharge relief valve; or

.5 the maximum total discharge or loading head of the cargo piping system considering all possible pumping arrangements or the relief valve setting on a pipeline system.

5.4.3 Those parts of the liquid piping systems that may be subjected to surge pressures shall be designed to withstand this pressure.

5.4.4 The design pressure of the outer pipe or duct of gas fuel systems shall not be less than the maximum working pressure of the inner gas pipe. Alternatively, for gas fuel piping systems with a working pressure greater than 1 MPa, the design pressure of the outer duct shall not be less than the maximum built-up pressure arising in the annular space considering the local instantaneous peak pressure in way of any rupture and the ventilation arrangements.

5.5 Cargo system valve requirements

5.5.1.1 Every cargo tank and piping system shall be fitted with manually operated valves for isolation purposes as specified in this section.

5.5.1.2 In addition, remotely operated valves shall also be fitted, as appropriate, as part of the emergency shutdown (ESD) system the purpose of which is to stop cargo flow or leakage in the event of an emergency when cargo liquid or vapour transfer is in progress. The ESD system is intended to return the cargo system to a safe static condition so that any remedial action can be taken. Due regard shall be given in the design of the ESD system to avoid the generation of surge pressures within the cargo transfer pipework. The equipment to be shut down on ESD activation includes manifold valves during loading or discharge, any pump or compressor, etc., transferring cargo internally or externally (e.g. to shore or another ship/barge) and cargo tank valves, if the MARVS exceeds 0.07 MPa.

5.5.2 *Cargo tank connections*

5.5.2.1 All liquid and vapour connections, except for safety relief valves and liquid level gauging devices, shall have shutoff valves located as close to the tank as practicable. These valves shall provide full closure and shall be capable of local manual operation. They may also be capable of remote operation.

5.5.2.2 For cargo tanks with a MARVS exceeding 0.07 MPa gauge, the above connections shall also be equipped with remotely controlled ESD valves. These valves shall be located as close to the tank as practicable. A single valve may be substituted for the two separate valves, provided the valve complies with the requirements of 18.10.2 and provides full closure of the line.

5.5.3 ***Cargo manifold connections***

5.5.3.1 One remotely controlled ESD valve shall be provided at each cargo transfer connection in use to stop liquid and vapour transfer to or from the ship. Transfer connections not in use shall be isolated with suitable blank flanges.

5.5.3.2 If the cargo tank MARVS exceeds 0.07 MPa, an additional manual valve shall be provided for each transfer connection in use, and may be inboard or outboard of the ESD valve to suit the ship's design.

5.5.4 Excess flow valves may be used in lieu of ESD valves, if the diameter of the protected pipe does not exceed 50 mm. Excess flow valves shall close automatically at the rated closing flow of vapour or liquid as specified by the manufacturer. The piping including fittings, valves and appurtenances protected by an excess flow valve shall have a capacity greater than the rated closing flow of the excess flow valve. Excess flow valves may be designed with a bypass not exceeding the area of a 1 mm diameter circular opening to allow equalization of pressure after a shutdown activation.

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

5.5.6 All pipelines or components which may be isolated in a liquid full condition shall be protected with relief valves for thermal expansion and evaporation.

5.5.7 All pipelines or components which may be isolated automatically due to a fire with a liquid volume of more than 0.05 m^3 entrapped shall be provided with PRVs sized for a fire condition.

5.6 Cargo transfer arrangements

5.6.1 Where cargo transfer is by means of cargo pumps that are not accessible for repair with the tanks in service, at least two separate means shall be provided to transfer cargo from each cargo tank, and the design shall be such that failure of one cargo pump or means of transfer will not prevent the cargo transfer by another pump or pumps, or other cargo transfer means.

5.6.2 The procedure for transfer of cargo by gas pressurization shall preclude lifting of the relief valves during such transfer. Gas pressurization may be accepted as a means of transfer of cargo for those tanks where the design factor of safety is not reduced under the conditions prevailing during the cargo transfer operation. If the cargo tank relief valves or set pressure are changed for this purpose, as it is permitted in accordance with 8.2.7 and 8.2.8, the new set pressure shall not exceed P_h as is defined in 4.13.2.

5.6.3 ***Vapour return connections***

Connections for vapour return to the shore installations shall be provided.

5.6.4 *Cargo tank vent piping systems*

The pressure relief system shall be connected to a vent piping system designed 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.

5.6.5 *Cargo sampling connections*

5.6.5.1 Connections to cargo piping systems for taking cargo liquid samples shall be clearly marked and shall be designed to minimize the release of cargo vapours. For vessels permitted to carry toxic products, the sampling system shall be of a closed loop design to ensure that cargo liquid and vapour are not vented to atmosphere.

5.6.5.2 Liquid sampling systems shall be provided with two valves on the sample inlet. One of these valves shall be of the multi-turn type to avoid accidental opening, and shall be spaced far enough apart to ensure that they can isolate the line if there is blockage, by ice or hydrates for example.

5.6.5.3 On closed loop systems, the valves on the return pipe shall also comply with 5.6.5.2.

5.6.5.4 The connection to the sample container shall comply with recognized standards and be supported so as to be able to support the weight of a sample container. Threaded connections shall be tack-welded, or otherwise locked, to prevent them being unscrewed during the normal connection and disconnection of sample containers. The sample connection shall be fitted with a closure plug or flange to prevent any leakage when the connection is not in use.

5.6.5.5 Sample connections used only for vapour samples may be fitted with a single valve in accordance with 5.5, 5.8 and 5.13, and shall also be fitted with a closure plug or flange.

5.6.5.6 Sampling operations shall be undertaken as prescribed in 18.9.

5.6.6 *Cargo filters*

The cargo liquid and vapour systems shall be capable of being fitted with filters to protect against damage by extraneous objects. Such filters may be permanent or temporary, and the standards of filtration shall be appropriate to the risk of debris, etc., entering the cargo system. Means shall be provided to indicate that filters are becoming blocked, and to isolate, depressurize and clean the filters safely.

5.7 Installation requirements

5.7.1 *Design for expansion and contraction*

Provision shall be made to protect the piping, piping system and components and cargo tanks from excessive stresses due to thermal movement and from movements of the tank and hull structure. The preferred method outside the cargo tanks is by means of offsets, bends or loops, but multi-layer bellows may be used if offsets, bends or loops are not practicable.

5.7.2 *Precautions against low temperature*

Low temperature piping shall be thermally isolated from the adjacent hull structure, where necessary, to prevent the temperature of the hull from falling below the design temperature of the hull material. Where liquid piping is dismantled regularly, or where liquid leakage may be anticipated, such as at shore connections and at pump seals, protection for the hull beneath shall be provided.

5.7.3 *Water curtain*

For cargo temperatures below -110°C, a water distribution system shall be fitted in way of the hull under the shore connections to provide a low-pressure water curtain for additional protection of the hull steel and the ship's side structure. This system is in addition to the requirements of 11.3.1.4, and shall be operated when cargo transfer is in progress.

5.7.4 *Bonding*

Where tanks or cargo piping and piping equipment are separated from the ship's structure by thermal isolation, provision shall be made for electrically bonding both the piping and the tanks. All gasketed pipe joints and hose connections shall be electrically bonded. Except where bonding straps are used, it shall be demonstrated that the electrical resistance of each joint or connection is less than 1MΩ.

5.8 Piping fabrication and joining details

5.8.1 *General*

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

5.8.2 *Direct connections*

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 colder than -10°C, butt welds shall be either double welded or equivalent to a double welded butt joint. This may be accomplished by use of a backing ring, consumable insert or inert gas backup on the first pass. For design pressures in excess of 1 MPa and design temperatures of -10°C or colder, backing rings shall be removed;

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

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

5.8.3 *Flanged connections*

5.8.3.1 Flanges in flanged connections shall be of the welded neck, slip-on or socket welded type.

5.8.3.2 Flanges shall comply with recognized standards for their type, manufacture and test. For all piping, except open ended, the following restrictions apply:

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

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

5.8.4 *Expansion joints*

Where bellows and expansion joints are provided in accordance with 5.7.1, the following requirements apply:

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

.2 slip joints shall not be used except within the cargo tanks.

5.8.5 *Other connections*

Piping connections shall be joined in accordance with 5.8.2 to 5.8.4, but for other exceptional cases the Administration may consider alternative arrangements.

5.9 Welding, post-weld heat treatment and non-destructive testing

5.9.1 *General*

Welding shall be carried out in accordance with 6.5.

5.9.2 *Post-weld heat treatment*

Post-weld heat treatment shall be required for all butt welds of pipes made with carbon, carbon-manganese and low alloy steels. The Administration or recognized organization acting on its behalf may waive the requirements for thermal stress relieving of pipes with wall thickness less than 10 mm in relation to the design temperature and pressure of the piping system concerned.

5.9.3 *Non-destructive testing*

In addition to normal controls before and during the welding, and to the visual inspection of the finished welds, as necessary for proving that the welding has been carried out correctly and according to the requirements of this paragraph, the following tests shall be required:

.1 100% radiographic or ultrasonic inspection of butt-welded joints for piping systems with design temperatures colder than -10°C, or with inside diameters of more than 75 mm, or wall thicknesses greater than 10 mm;

.2 when such butt-welded joints of piping sections are made by automatic welding procedures approved by the Administration or recognized organization acting on its behalf, then a progressive reduction in the extent of radiographic or ultrasonic inspection can be agreed, but in no case to less than 10% of each joint. If defects are revealed, the extent of examination shall be increased to 100% and shall include inspection of previously accepted welds. This approval can only be granted if well-documented quality assurance procedures and records are available to assess the ability of the manufacturer to produce satisfactory welds consistently; and

.3 for other butt-welded joints of pipes not covered by 5.9.3.1 and 5.9.3.2, spot radiographic or ultrasonic inspection or other non-destructive tests shall be carried out depending upon service, position and materials. In general, at least 10% of butt-welded joints of pipes shall be subjected to radiographic or ultrasonic inspection.

5.10 Installation requirements for cargo piping outside the cargo area

5.10.1 *Bow and stern loading arrangements*

The following requirements shall apply to cargo piping and related piping equipment located outside the cargo area:

.1 cargo piping and related piping equipment outside the cargo area shall have only welded connections. The piping outside the cargo area shall run on the weather decks and shall be at least 0.8 m inboard, except for athwartships shore connection piping. Such piping shall 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 shall also be capable of being separated by means of a removable spool piece and blank flanges, when not in use; and

.2 the piping shall be full penetration butt-welded and subjected to full radiographic or ultrasonic inspection, regardless of pipe diameter and design temperature. Flange connections in the piping shall only be permitted within the cargo area and at the shore connection.

5.10.2 *Turret compartment transfer systems*

The following requirements shall apply to liquid and vapour cargo piping where it is run outside the cargo area:

.1 cargo piping and related piping equipment outside the cargo area shall have only welded connections; and

.2 the piping shall be full penetration butt-welded, and subjected to full radiographic or ultrasonic inspection, regardless of pipe diameter and design temperature. Flange connections in the piping shall only be permitted within the cargo area and at connections to cargo hoses and the turret connection.

5.10.3 *Gas fuel piping*

Gas fuel piping, as far as practicable, shall have welded joints. Those parts of the gas fuel piping that are not enclosed in a ventilated pipe or duct according to 16.4.3, and are on the weather decks outside the cargo area, shall have full penetration butt-welded joints and shall be subjected to full radiographic or ultrasonic inspection.

5.11 Piping system component requirements

5.11.1 Piping scantlings. Piping systems shall be designed in accordance with recognized standards.

5.11.2.1 The following criteria shall be used for determining pipe wall thickness.

5.11.2.2 The wall thickness of pipes shall not be less than:

$$t = \frac{t_0 + b + c}{1 - \frac{a}{100}} \qquad \text{(mm)}$$

where:

t_o = theoretical thickness, determined by the following formula:

$$t_0 = \frac{P \cdot D}{2K \cdot e + P} \quad \text{(mm)}$$

with:

P = design pressure (MPa) referred to in 5.4;
D = outside diameter (mm);

K = allowable stress (N/mm²) referred to in 5.11.3;

e = efficiency factor equal to 1 for seamless pipes and for longitudinally or spirally welded pipes, delivered by approved manufacturers of welded pipes, that are considered equivalent to seamless pipes when non-destructive testing on welds is carried out in accordance with recognized standards. In other cases, an efficiency factor of less than 1, in accordance with recognized standards, may be required, depending on the manufacturing process;

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

$$b = \frac{D \cdot t_0}{2.5r} \quad \text{(mm)},$$

with:

r = mean radius of the bend (mm);

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

a = negative manufacturing tolerance for thickness (%).

5.11.2.3 The minimum wall thickness shall be in accordance with recognized standards.

5.11.2.4 Where necessary for mechanical strength to prevent damage, collapse, excessive sag or buckling of pipes due to superimposed loads, the wall thickness shall be increased over that required by 5.11.2.2 or, if this is impracticable or would cause excessive local stresses, these loads may be reduced, protected against or eliminated by other design methods. Such superimposed loads may be due to: supporting structures, ship deflections, liquid pressure surge during transfer operations, the weight of suspended valves, reaction to loading arm connections, or otherwise.

5.11.3 ***Allowable stress***

5.11.3.1 For pipes, the allowable stress K referred to in the formula in 5.11.2 is the lower of the following values:

$$\frac{R_m}{A} \text{ or } \frac{R_e}{B}$$

where:

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

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

The values of A and B shall be shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk required in 1.4.4, and have values of at least A = 2.7 and B = 1.8.

5.11.4 ***High-pressure gas fuel outer pipes or ducting scantlings***

In fuel gas piping systems of design pressure greater than the critical pressure, the tangential membrane stress of a straight section of pipe or ducting shall not exceed the tensile strength divided by 1.5 (R_m /1.5) when subjected to the design pressure specified in 5.4. The pressure ratings of all other piping components shall reflect the same level of strength as straight pipes.

5.11.5 ***Stress analysis***

When the design temperature is -110°C or lower, a complete stress analysis, taking into account all the stresses due to the 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 shall be submitted to the Administration. For temperatures above -110°C, a stress analysis may be required by the Administration in relation to such matters as the design or stiffness of the piping system and the choice of materials. In any case, consideration shall 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 Administration.

5.11.6 ***Flanges, valves and fittings***

5.11.6.1 Flanges, valves and other fittings shall comply with recognized standards, taking into account the material selected and the design pressure defined in 5.4. For bellows expansion joints used in vapour service, a lower minimum design pressure may be accepted.

5.11.6.2 For flanges not complying with a recognized standard, the dimensions of flanges and related bolts shall be to the satisfaction of the Administration or recognized organization acting on its behalf.

5.11.6.3 All emergency shutdown valves shall be of the "fire closed" type (see 5.13.1.1 and 18.10.2).

5.11.6.4 The design and installation of expansion bellows shall be in accordance with recognized standards and be fitted with means to prevent damage due to over-extension or compression.

5.11.7 ***Ship's cargo hoses***

5.11.7.1 Liquid and vapour hoses used for cargo transfer shall be compatible with the cargo and suitable for the cargo temperature.

5.11.7.2 Hoses subject to tank pressure, or the discharge pressure of pumps or vapour compressors, shall be designed for a bursting pressure not less than five times the maximum pressure the hose will be subjected to during cargo transfer.

5.11.7.3 Each new type of cargo hose, complete with end-fittings, shall 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 shall demonstrate a bursting pressure of at least 5 times its specified maximum working pressure at the upper and lower extreme service temperature. Hoses used for prototype testing shall not be used for cargo service. Thereafter, before being placed in service, each new length of cargo hose produced shall be hydrostatically tested at ambient temperature to a pressure not less than 1.5 times its specified maximum working pressure, but not more than two fifths of its bursting pressure. The hose shall be stencilled, or otherwise marked, with the date of testing, its specified maximum working pressure and, if used in services other than ambient temperature services, its maximum and minimum service temperature, as applicable. The specified maximum working pressure shall not be less than 1 MPa gauge.

5.12 Materials

5.12.1 The choice and testing of materials used in piping systems shall 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 that the temperature of the cargo at the pressure relief valve setting is not lower than 55°C, and that no liquid 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.

5.12.2 Materials having a melting point below 925°C shall not 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 shall be provided.

5.12.3 ***Cargo piping insulation system***

5.12.3.1 Cargo piping systems shall be provided with a thermal insulation system as required to minimize heat leak into the cargo during transfer operations and to protect personnel from direct contact with cold surfaces.

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

5.12.4 Where the cargo piping system is of a material susceptible to stress corrosion cracking in the presence of a salt-laden atmosphere, adequate measures to avoid this occurring shall be taken by considering material selection, protection of exposure to salty water and/or readiness for inspection.

5.13 Testing requirements

5.13.1 *Type testing of piping components*

5.13.1.1 Valves

Each type of valve intended to be used at a working temperature below -55ºC shall be subject to the following type tests:

.1 each size and type of valve shall be subjected to seat tightness testing over the full range of operating pressures for bi-directional flow and temperatures, at intervals, up to the rated design pressure of the valve. Allowable leakage rates shall be to the requirements of the Administration or recognized organization acting on its behalf. During the testing, satisfactory operation of the valve shall be verified;

.2 the flow or capacity shall be certified to a recognized standard for each size and type of valve;

.3 pressurized components shall be pressure tested to at least 1.5 times the rated pressure; and

.4 for emergency shutdown valves, with materials having melting temperatures lower than 925°C, the type testing shall include a fire test to a standard acceptable to the Administration.

5.13.1.2 Expansion bellows

The following type tests shall be performed on each type of expansion bellows intended for use on cargo piping outside the cargo tank and where required by the Administration or recognized organization acting on its behalf, on those installed within the cargo tanks:

.1 elements of the bellows, not pre-compressed, shall be pressure tested at not less than five times the design pressure without bursting. The duration of the test shall not be less than 5 min;

2 a pressure test shall be performed on a type expansion joint, complete with all the accessories such as flanges, stays and articulations, at the minimum design temperature and twice the design pressure at the extreme displacement conditions recommended by the manufacturer, without permanent deformation;

.3 a cyclic test (thermal movements) shall be performed on a complete expansion joint, which shall withstand at least as many cycles under the conditions of pressure, temperature, axial movement, rotational movement and transverse movement as it will encounter in actual service. Testing at ambient temperature is permitted when this testing is at least as severe as testing at the service temperature; and

.4 a cyclic fatigue test (ship deformation) shall be performed on a complete expansion joint, without internal pressure, by simulating the bellows movement corresponding to a compensated pipe length, for at least 2,000,000 cycles at a frequency not higher than 5 Hz. This test is only required when, due to the piping arrangement, ship deformation loads are actually experienced.

5.13.2 ***System testing requirements***

5.13.2.1 The requirements of this section shall apply to piping inside and outside the cargo tanks.

5.13.2.2 After assembly, all cargo and process piping shall be subjected to a strength test with a suitable fluid. The test pressure shall be at least 1.5 times the design pressure (1.25 times the design pressure where the test fluid is compressible) for liquid lines and 1.5 times the maximum system working pressure (1.25 times the maximum system working pressure where the test fluid is compressible) for vapour lines. When piping systems or parts of systems are completely manufactured and equipped with all fittings, the test may be conducted prior to installation on board the ship. Joints welded on board shall be tested to at least 1.5 times the design pressure.

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

5.13.2.4 In double wall gas-fuel piping systems, the outer pipe or duct shall also be pressure tested to show that it can withstand the expected maximum pressure at gas pipe rupture.

5.13.2.5 All piping systems, including valves, fittings and associated equipment for handling cargo or vapours, shall be tested under normal operating conditions not later than at the first loading operation, in accordance with recognized standards.

5.13.3 ***Emergency shutdown valves***

The closing characteristics of emergency shutdown valves used in liquid cargo piping systems shall be tested to demonstrate compliance with 18.10.2.1.3. This testing may be carried out on board after installation.

CHAPTER 6

MATERIALS OF CONSTRUCTION AND QUALITY CONTROL

Goal

To identify the required properties, testing standards and stability of metallic and non-metallic materials and fabrication processes used in the construction of cargo containment and piping systems to ensure they serve the functions for which they have been selected, as required in chapters 4 and 5.

6.1 Definitions

6.1.1 Where reference is made in this chapter to A, B, D, E, AH, DH, EH and FH hull structural steels, these steel grades are hull structural steels according to recognized standards.

6.1.2 *A piece* is the rolled product from a single slab or billet or from a single ingot, if this is rolled directly into plates, strips, sections or bars.

6.1.3 *A batch* is the number of items or pieces to be accepted or rejected together, on the basis of the tests to be carried out on a sampling basis. The size of a batch is given in the recognized standards.

6.1.4 *Controlled rolling (CR)* is a rolling procedure in which the final deformation is carried out in the normalizing temperature range, resulting in a material condition generally equivalent to that obtained by normalizing.

6.1.5 *Thermo-mechanical controlled processing (TMCP)* is a procedure that involves strict control of both the steel temperature and the rolling reduction. Unlike CR, the properties conferred by TMCP cannot be reproduced by subsequent normalizing or other heat treatment. The use of accelerated cooling on completion of TMCP may also be accepted, subject to approval by the Administration. The same applies for the use of tempering after completion of TMCP.

6.1.6 *Accelerated cooling (AcC)* is a process that aims to improve mechanical properties by controlled cooling with rates higher than air cooling, immediately after the final TMCP operation. Direct quenching is excluded from accelerated cooling. The material properties conferred by TMCP and AcC cannot be reproduced by subsequent normalizing or other heat treatment.

6.2 Scope and general requirements

6.2.1 This chapter gives the requirements for metallic and non-metallic materials used in the construction of the cargo system. This includes requirements for joining processes, production process, personnel qualification, NDT and inspection and testing including production testing. The requirements for rolled materials, forgings and castings are given in 6.4 and tables 6.1, to 6.5. The requirements for weldments are given in 6.5, and the guidance for non-metallic materials is given in appendix 4. A quality assurance/quality control programme shall be implemented to ensure that the requirements of 6.2 are complied with.

6.2.2 The manufacture, testing, inspection and documentation shall be in accordance with recognized standards and the specific requirements given in the Code.

6.2.3 Where post-weld heat treatment is specified or required, the properties of the base material shall be determined in the heat-treated condition, in accordance with the applicable table of this chapter, and the weld properties shall be determined in the heat treated condition in accordance with 6.5. In cases where a post-weld heat treatment is applied, the test requirements may be modified at the discretion of the Administration.

6.3 General test requirements and specifications

6.3.1 ***Tensile test***

6.3.1.1 Tensile testing shall be carried out in accordance with recognized standards.

6.3.1.2 Tensile strength, yield stress and elongation shall be to the satisfaction of the Administration. For carbon-manganese steel and other materials with definitive yield points, consideration shall be given to the limitation of the yield to tensile ratio.

6.3.2 ***Toughness test***

6.3.2.1 Acceptance tests for metallic materials shall include Charpy V-notch toughness tests, unless otherwise specified by the Administration. The specified Charpy V-notch requirements are minimum average energy values for three full size (10 mm × 10 mm) specimens and minimum single energy values for individual specimens. Dimensions and tolerances of Charpy V-notch specimens shall be in accordance with recognized standards. The testing and requirements for specimens smaller than 5 mm in size shall be in accordance with recognized standards. Minimum average values for subsized specimens shall be:

Charpy V-notch specimen size (mm)	Minimum average energy of three specimens
10 x 10	KV
10 x 7.5	5/6 KV
10 x 5	2/3 KV

where:

KV = the energy values (J) specified in tables 6.1 to 6.4.

Only one individual value may be below the specified average value, provided it is not less than 70% of that value.

6.3.2.2 For base metal, the largest size Charpy V-notch specimens possible for the material thickness shall be machined with the specimens located as near as practicable to a point midway between the surface and the centre of the thickness and the length of the notch perpendicular to the surface as shown in figure 6.1.

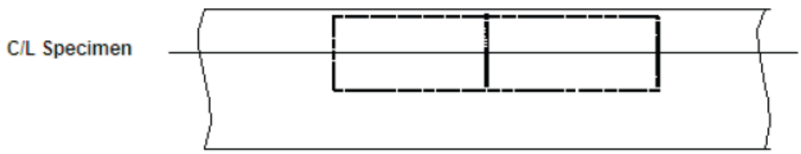


Figure 6.1 – Orientation of base metal test specimen

6.3.2.3 For a weld test specimen, the largest size Charpy V-notch specimens possible for the material thickness shall be machined, with the specimens located as near as practicable to a point midway between the surface and the centre of the thickness. In all cases, the distance from the surface of the material to the edge of the specimen shall be approximately 1 mm or greater. In addition, for double-V butt welds, specimens shall be machined closer to the surface of the second welded section. The specimens shall be taken generally at each of the following locations, as shown in figure 6.2, on the centreline of the welds, the fusion line and 1 mm, 3 mm and 5 mm from the fusion line.

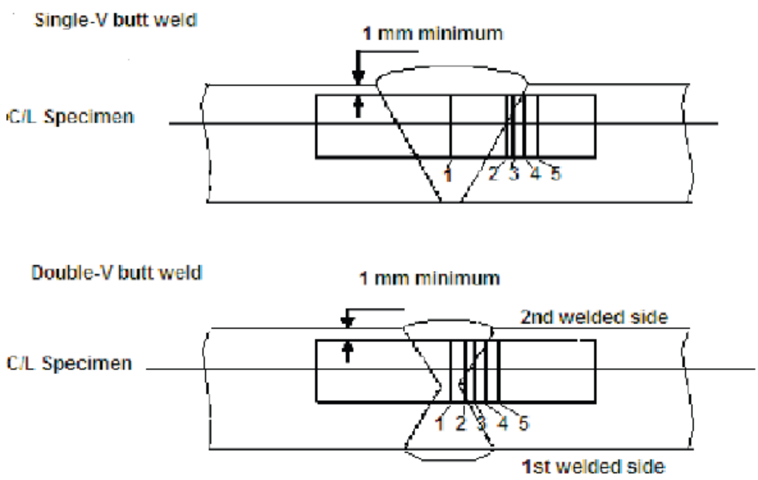


Figure 6.2 – Orientation of weld test specimen

Notch locations in figure 6.2:

.1 Centreline of the weld.

.2 Fusion line.

.3 In heat-affected zone (HAZ), 1 mm from the fusion line.

.4 In HAZ, 3 mm from the fusion line.

.5 In HAZ, 5 mm from the fusion line.

6.3.2.4 If the average value of the three initial Charpy V-notch specimens fails to meet the stated requirements, or the value for more than one specimen is below the required average value, or when the value for one specimen is below the minimum value permitted for a single specimen, three additional specimens from the same material may be tested and the results be combined with those previously obtained to form a new average. If this new average complies with the requirements and if no more than two individual results are lower than the required average and no more than one result is lower than the required value for a single specimen, the piece or batch may be accepted.

6.3.3 ***Bend test***

6.3.3.1 The bend test may be omitted as a material acceptance test, but is required for weld tests. Where a bend test is performed, this shall be done in accordance with recognized standards.
6.3.3.2 The bend tests shall be transverse bend tests, which may be face, root or side bends at the discretion of the Administration. However, longitudinal bend tests may be required in lieu of transverse bend tests in cases where the base material and weld metal have different strength levels.

6.3.4 ***Section observation and other testing***

Macrosection, microsection observations and hardness tests may also be required by the Administration, and they shall be carried out in accordance with recognized standards, where required.

6.4 Requirements for metallic materials

6.4.1 ***General requirements for metallic materials***

6.4.1.1 The requirements for materials of construction are shown in the tables as follows:

.1 Table 6.1: Plates, pipes (seamless and welded), sections and forgings for cargo tanks and process pressure vessels for design temperatures not lower than 0°C.

.2 Table 6.2: Plates, sections and forgings for cargo tanks, secondary barriers and process pressure vessels for design temperatures below 0°C and down to -55°C.

.3 Table 6.3: Plates, sections and forgings for cargo tanks, secondary barriers and process pressure vessels for design temperatures below -55°C and down to -165°C.

.4 Table 6.4: Pipes (seamless and welded), forgings and castings for cargo and process piping for design temperatures below 0°C and down to -165°C.

.5 Table 6.5: Plates and sections for hull structures required by 4.19.1.2 and 4.19.1.3.

Table 6.1

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

Notes

1 For seamless pipes and fittings normal practice applies. The use of longitudinally and spirally welded pipes shall be specially approved by the Administration or recognized organization acting on its behalf.

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

3 This table is generally applicable for material thicknesses up to 40 mm. Proposals for greater thicknesses shall be approved by the Administration or recognized organization acting on its behalf.

4 A controlled rolling procedure or TMCP may be used as an alternative.

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

Table 6.2

PLATES, SECTIONS AND FORGINGS [See note 1] **FOR CARGO TANKS, SECONDARY BARRIERS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES BELOW 0°C AND DOWN TO -55°C** **Maximum thickness 25 mm** [See note 2]
CHEMICAL COMPOSITION AND HEAT TREATMENT
◆ Carbon-manganese steel
◆ Fully killed, aluminium treated fine grain steel
◆ Chemical composition (ladle analysis)

C	Mn	Si	S	P
0.16%max [See note 3]	0.7-1.60%	0.1-0.50%	0.025% max	0.025% max

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

Ni	Cr	Mo	Cu	Nb	V
0.8% max	0.25% max	0.08% max	0.35% max	0.05% max	0.1% max

Al content total 0.02% min (Acid soluble 0.015% min)	
◆ Normalized, or quenched and tempered [See note 4]	
TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS	
Sampling frequency	
◆ Plates	Each "piece" to be tested
◆ Sections and forgings	Each "batch" to be tested
Mechanical properties	
◆ Tensile properties	Specified minimum yield stress not to exceed 410 N/mm^2 [See note 5]
Toughness (Charpy V-notch test)	
◆ Plates	Transverse test pieces. Minimum average energy value (KV) 27J
◆ Sections and forgings	Longitudinal test pieces. Minimum average energy (KV) 41J
◆ Test temperature	5°C below the design temperature or -20°C, whichever is lower

Notes

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

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

Material thickness (mm)	Test temperature (°C)
25 < t ≤ 30	10°C below design temperature or -20°C, whichever is lower
30 < t ≤ 35	15°C below design temperature or -20°C, whichever is lower
35 < t ≤ 40	20°C below design temperature
40 < t	Temperature approved by the Administration or recognized organization acting on its behalf

The impact energy value shall be in accordance with the table for the applicable type of test specimen.

Materials for tanks and parts of tanks which are completely thermally stress relieved after welding may be tested at a temperature 5°C below design temperature or -20°C, whichever is lower.

PLATES, SECTIONS AND FORGINGS See note1 FOR CARGO TANKS, SECONDARY BARRIERS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES BELOW 0°C AND DOWN TO -55°C Maximum thickness 25 mm See note 2
For thermally stress relieved reinforcements and other fittings, the test temperature shall be the same as that required for the adjacent tank-shell thickness. 3 By special agreement with the Administration, the carbon content may be increased to 0.18% maximum, provided the design temperature is not lower than -40°C. 4 A controlled rolling procedure or TMCP may be used as an alternative. 5 Materials with specified minimum yield stress exceeding 410 N/mm^2 may be approved by the Administration or recognized organization acting on its behalf. For these materials, particular attention shall be given to the hardness of the welded and heat affected zones. Guidance: For materials exceeding 25 mm in thickness for which the test temperature is -60°C or lower, the application of specially treated steels or steels in accordance with table 6.3 may be necessary.

Table 6.3

PLATES, SECTIONS AND FORGINGS See note 1 FOR CARGO TANKS, SECONDARY BARRIERS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES BELOW -55°C AND DOWN TO -165°C See note 2 Maximum thickness 25 mm See notes 3 and 4		
Minimum design temperature (°C)	Chemical composition See note 5 and heat treatment	Impact test temperature (°C)
-60	1.5% nickel steel – normalized or normalized and tempered or quenched and tempered or TMCP See note 6	-65
-65	2.25% nickel steel – normalized or normalized and tempered or quenched and tempered or TMCP See notes 6 and 7	-70
-90	3.5% nickel steel – normalized or normalized and tempered or quenched and tempered or TMCP See notes 6 and 7	-95
-105	5% nickel steel – normalized or normalized and tempered or quenched and tempered See notes 6, 7 and 8	-110
-165	9% nickel steel – double normalized and tempered or quenched and tempered See note 6	-196
-165	Austenitic steels, such as types 304, 304L, 316, 316L, 321 and 347 solution treated See note 9	-196
-165	Aluminium alloys; such as type 5083 annealed	Not required
-165	Austenitic Fe-Ni alloy (36% nickel). Heat treatment as agreed	Not required

TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS	
Sampling frequency	
◆ Plates	Each "piece" to be tested
◆ Sections and forgings	Each "batch" to be tested
Toughness (Charpy V-notch test)	
◆ Plates	Transverse test pieces. Minimum average energy value (KV) 27J
◆ Sections and forgings	Longitudinal test pieces. Minimum average energy (KV) 41J

Notes

1 The impact test required for forgings used in critical applications shall be subject to special consideration by the Administration.

2 The requirements for design temperatures below -165°C shall be specially agreed with the Administration.

3 For materials 1.5% Ni, 2.25% Ni, 3.5% Ni and 5% Ni, with thicknesses greater than 25 mm, the impact tests shall be conducted as follows:

Material thickness (mm)	Test temperature (°C)
$25 < t \leq 30$	10°C below design temperature
$30 < t \leq 35$	15°C below design temperature
$35 < t \leq 40$	20°C below design temperature

The energy value shall be in accordance with the table for the applicable type of test specimen. For material thickness of more than 40 mm, the Charpy V-notch values shall be specially considered.

PLATES, SECTIONS AND FORGINGS See note 1 FOR CARGO TANKS, SECONDARY BARRIERS AND PROCESS PRESSURE VESSELS FOR DESIGN TEMPERATURES BELOW -55°C AND DOWN TO -165°C See note 2 Maximum thickness 25 mm See notes 3 and 4	
4	For 9% Ni steels, austenitic stainless steels and aluminium alloys, thickness greater than 25 mm may be used.
5	The chemical composition limits shall be in accordance with recognized standards.
6	TMCP nickel steels will be subject to acceptance by the Administration.
7	A lower minimum design temperature for quenched and tempered steels may be specially agreed with the Administration.
8	A specially heat treated 5% nickel steel, for example triple heat treated 5% nickel steel, may be used down to -165°C, provided that the impact tests are carried out at -196°C.
9	The impact test may be omitted, subject to agreement with the Administration.

Table 6.4

PIPES (SEAMLESS AND WELDED) See note 1, FORGINGS See note 2 AND CASTINGS See note 2 FOR CARGO AND PROCESS PIPING FOR DESIGN TEMPERATURES BELOW 0°C AND DOWN TO -165°C See note 3 Maximum thickness 25 mm			
Minimum design temperature (°C)	Chemical composition See note 5 and heat treatment	Impact test	
		Test temp. (°C)	Minimum average energy (KV)
-55	Carbon-manganese steel. Fully killed fine grain. Normalized or as agreed See note 6	See note 4	27
-65	2.25% nickel steel. Normalized, normalized and tempered or quenched and tempered See note 6	-70	34
-90	3.5% nickel steel. Normalized, normalized and tempered or quenched and tempered See note 6	-95	34
-165	9% nickel steel See note 7. Double normalized and tempered or quenched and tempered	-196	41
	Austenitic steels, such as types 304. 304L, 316, 316L, 321 and 347. Solution treated See note 8	-196	41
	Aluminium alloys; such as type 5083 annealed		Not required
TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS			
Sampling frequency			
◆ Each "batch" to be tested.			
Toughness (Charpy V-notch test)			
◆ Impact test: Longitudinal test pieces			

Notes

1 The use of longitudinally or spirally welded pipes shall be specially approved by the Administration.

2 The requirements for forgings and castings may be subject to special consideration by the Administration.

3 The requirements for design temperatures below -165°C shall be specially agreed with the Administration.

4 The test temperature shall be 5°C below the design temperature or -20°C, whichever is lower.

5 The composition limits shall be in accordance with recognized standards.

6 A lower design temperature may be specially agreed with the Administration for quenched and tempered materials.

7 This chemical composition is not suitable for castings.

8 Impact tests may be omitted, subject to agreement with the Administration.

Table 6.5

PLATES AND SECTIONS FOR HULL STRUCTURES REQUIRED BY 4.19.1.2 AND 4.19.1.3								
Minimum design temperature of hull structure (°C)	Maximum thickness (mm) for steel grades							
	A	B	D	E	AH	DH	EH	FH
0 and above See note 1 -5 and above See note 2	Recognized standards							
down to -5	15	25	30	50	25	45	50	50
down to -10	x	20	25	50	20	40	50	50
down to -20	x	x	20	50	x	30	50	50
down to -30	x	x	x	40	x	20	40	50
Below -30	In accordance with table 6.2, except that the thickness limitation given in table 6.2 and in note 2 of that table does not apply.							

Notes

"x" means steel grade not to be used.

1 For the purpose of 4.19.1.3.

2 For the purpose of 4.19.1.2.

6.5 Welding of metallic materials and non-destructive testing

6.5.1 ***General***

6.5.1.1 This section shall apply to primary and secondary barriers only, including the inner hull where this forms the secondary barrier. Acceptance testing is specified for carbon, carbon-manganese, nickel alloy and stainless steels, but these tests may be adapted for other materials. At the discretion of the Administration, impact testing of stainless steel and aluminium alloy weldments may be omitted and other tests may be specially required for any material.

6.5.2 ***Welding consumables***

6.5.2.1 Consumables intended for welding of cargo tanks shall be in accordance with recognized standards. Deposited weld metal tests and butt weld tests shall be required for all consumables. The results obtained from tensile and Charpy V-notch impact tests shall be in accordance with recognized standards. The chemical composition of the deposited weld metal shall be recorded for information.

6.5.3 ***Welding procedure tests for cargo tanks and process pressure vessels***

6.5.3.1 Welding procedure tests for cargo tanks and process pressure vessels are required for all butt welds.

6.5.3.2 The test assemblies shall be representative of:

.1 each base material;

.2 each type of consumable and welding process; and

.3 each welding position.

6.5.3.3 For butt welds in plates, the test assemblies shall be so prepared that the rolling direction is parallel to the direction of welding. The range of thickness qualified by each welding procedure test shall be in accordance with recognized standards. Radiographic or ultrasonic testing may be performed at the option of the fabricator.

6.5.3.4 The following welding procedure tests for cargo tanks and process pressure vessels shall be carried out in accordance with 6.3, with specimens made from each test assembly:

.1 cross-weld tensile tests;

.2 longitudinal all-weld testing, where required by the recognized standards;

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

.4 one set of three Charpy V-notch impacts, generally at each of the following locations, as shown in figure 6.2:

.1 centreline of the weld;

.2 fusion line;

.3 1 mm from the fusion line;

.4 3 mm from the fusion line; and

.5 5 mm from the fusion line; and

.5 macrosection, microsection and hardness survey may also be required.

6.5.3.5 Each test shall satisfy the following requirements:

.1 tensile tests: cross-weld tensile strength shall not be less than the specified minimum tensile strength for the appropriate parent materials. For aluminium alloys, reference shall be made to 4.18.1.3 with regard to the requirements for weld metal strength of under-matched welds (where the weld metal has a lower tensile strength than the parent metal). In every case, the position of fracture shall be recorded for information;

.2 bend tests: no fracture is acceptable after a 180° bend over a former of a diameter four times the thickness of the test pieces; and

.3 Charpy V-notch impact tests: Charpy V-notch tests shall be conducted at the temperature prescribed for the base material being joined. The results of weld metal impact tests, minimum average energy (KV), shall be no less than 27 J. The weld metal requirements for subsize specimens and single energy values shall be in accordance with 6.3.2. The results of fusion line and heat-affected zone impact tests shall show a minimum average energy (KV) in accordance with the transverse or longitudinal requirements of the base material, whichever is applicable, and for subsize specimens, the minimum average energy (KV) shall be in accordance with 6.3.2. If the material thickness does not permit machining either full-size or standard subsize specimens, the testing procedure and acceptance standards shall be in accordance with recognized standards.

6.5.3.6 Procedure tests for fillet welding shall be in accordance with recognized standards. In such cases, consumables shall be so selected that exhibit satisfactory impact properties.

6.5.4 *Welding procedure tests for piping*

Welding procedure tests for piping shall be carried out and shall be similar to those detailed for cargo tanks in 6.5.3.

6.5.5 *Production weld tests*

6.5.5.1 For all cargo tanks and process pressure vessels, except integral and membrane tanks, production weld tests shall generally be performed for approximately each 50 m of butt-weld joints and shall be representative of each welding position. For secondary barriers, the same type production tests as required for primary tanks shall be performed, except that the number of tests may be reduced subject to agreement with the Administration. Tests, other than those specified in 6.5.5.2 to 6.5.5.5 may be required for cargo tanks or secondary barriers.

6.5.5.2 The production tests for type A and type B independent tanks and semi-membrane tanks shall include bend tests and, where required for procedure tests, one set of three Charpy V-notch tests. The tests shall be made for each 50 m of weld. The Charpy V-notch tests shall be made with specimens having the notch alternately located in the centre of the weld and in the heat-affected zone (most critical location based on procedure qualification results). For austenitic stainless steel, all notches shall be in the centre of the weld.

6.5.5.3 For type C independent tanks and process pressure vessels, transverse weld tensile tests are required in addition to the tests listed in 6.5.5.2. Tensile tests shall meet the requirements of 6.5.3.5.

6.5.5.4 The quality assurance/quality control programme shall ensure the continued conformity of the production welds as defined in the material manufacturers quality manual.

6.5.5.5 The test requirements for integral and membrane tanks are the same as the applicable test requirements listed in 6.5.3.

6.5.6 *Non-destructive testing*

6.5.6.1 All test procedures and acceptance standards shall be in accordance with recognized standards, unless the designer specifies a higher standard in order to meet design assumptions. Radiographic testing shall be used, in principle, to detect internal defects. However, an approved ultrasonic test procedure in lieu of radiographic testing may be conducted, but, in addition, supplementary radiographic testing at selected locations shall be carried out to verify the results. Radiographic and ultrasonic testing records shall be retained.

6.5.6.2 For type A independent tanks and semi-membrane tanks, where the design temperature is below -20°C, and for type B independent tanks, regardless of temperature, all full penetration butt welds of the shell plating of cargo tanks shall be subjected to non-destructive testing suitable to detect internal defects over their full length. Ultrasonic testing in lieu of radiographic testing may be carried out under the same conditions as described in 6.5.6.1.

6.5.6.3 Where the design temperature is higher than -20°C, all full penetration butt welds in way of intersections and at least 10% of the remaining full penetration welds of tank structures shall be subjected to radiographic testing or ultrasonic testing under the same conditions as described in 6.5.6.1.

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

6.5.6.5 For type C independent tanks, the extent of non-destructive testing shall be total or partial according to recognized standards, but the controls to be carried out shall not be less than the following:

.1 Total non-destructive testing referred to in 4.23.2.1.3:

Radiographic testing:

.1 all butt welds over their full length;

Non-destructive testing for surface crack detection:

.2 all welds over 10% of their length;

.3 reinforcement rings around holes, nozzles, etc., over their full length.

As an alternative, ultrasonic testing as described in 6.5.6.1 may be accepted as a partial substitute for the radiographic testing. In addition, the Administration may require total ultrasonic testing on welding of reinforcement rings around holes, nozzles, etc.

.2 Partial non-destructive testing referred to in 4.23.2.1.3:

Radiographic testing:

.1 all butt-welded crossing joints and at least 10% of the full length of butt welds at selected positions uniformly distributed;

Non-destructive testing for surface crack detection:

.2 reinforcement rings around holes, nozzles, etc., over their full length;

Ultrasonic testing:

.3 as may be required by the Administration or recognized organization acting on its behalf in each instance.

6.5.6.6 The quality assurance/quality control programme shall ensure the continued conformity of the non-destructive testing of welds, as defined in the material manufacturer's quality manual.

6.5.6.7 Inspection of piping shall be carried out in accordance with the requirements of chapter 5.

6.5.6.8 The secondary barrier shall be non-destructive tested for internal defects as considered necessary. Where the outer shell of the hull is part of the secondary barrier, all sheer strake butts and the intersections of all butts and seams in the side shell shall be tested by radiographic testing.

6.6 Other requirements for construction in metallic materials

6.6.1 *General*

6.6.1.1 Inspection and non-destructive testing of welds shall be in accordance with the requirements of 6.5.5 and 6.5.6. Where higher standards or tolerances are assumed in the design, they shall also be satisfied.

6.6.2 *Independent tank*

6.6.2.1 For type C tanks and type B tanks primarily constructed of bodies of revolution, the tolerances relating to manufacture, such as out-of-roundness, local deviations from the true form, welded joints alignment and tapering of plates having different thicknesses, shall comply with recognized standards. The tolerances shall also be related to the buckling analysis referred to in 4.22.3.2 and 4.23.3.2.

6.6.2.2 For type C tanks of carbon and carbon-manganese steel, post-weld heat treatment shall 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 shall be to recognized standards. The soaking temperature and holding time shall be to the recognized standards.

6.6.2.3 In the case of type C tanks and large cargo pressure vessels of carbon or carbon-manganese steel, for which it is difficult to perform the heat treatment, mechanical stress relieving by pressurizing may be carried out as an alternative to the heat treatment and subject to the following conditions:

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

.2 the mechanical stress relieving process shall preferably be carried out during the hydrostatic pressure test required by 4.23.6, by applying a higher pressure than the test pressure required by 4.23.6.1. The pressurizing medium shall be water;

.3 for the water temperature, 4.23.6.2 applies;

.4 stress relieving shall 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 shall 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 shall be the following:

  .1 equivalent general primary membrane stress: 0.9 R_e;

  .2 equivalent stress composed of primary bending stress plus membrane stress: 1.35 R_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 location of strain gauges shall be included in the mechanical stress relieving procedure to be submitted in accordance with 6.6.2.3;

.8 the test procedure shall 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 shall be checked for cracks by dye penetrant or magnetic particle inspection after mechanical stress relieving. Particular attention in this respect shall be paid to plates exceeding 30 mm in thickness;

.10 steels which have a ratio of yield stress to ultimate tensile strength greater than 0.8 shall generally not 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 the thickness of the shell and heads of the tank shall not exceed 40 mm. Higher thicknesses may be accepted for parts which are thermally stress relieved;

.13 local buckling shall be guarded against, particularly when tori-spherical heads are used for tanks and domes; and

.14 the procedure for mechanical stress relieving shall be to a recognized standard.

6.6.3 *Secondary barriers*

During construction, the requirements for testing and inspection of secondary barriers shall be approved or accepted by the Administration or recognized organization acting on its behalf (see 4.6.2.5 and 4.6.2.6).

6.6.4 *Semi-membrane tanks*

For semi-membrane tanks, the relevant requirements in section 6.6 for independent tanks or for membrane tanks shall be applied as appropriate.

6.6.5 *Membrane tanks*

The quality assurance/quality control programme shall ensure the continued conformity of the weld procedure qualification, design details, materials, construction, inspection and production testing of components. These standards and procedures shall be developed during the prototype testing programme.

6.7 Non-metallic materials

6.7.1 *General*

The information in the attached appendix 4 is given for guidance in the selection and use of these materials, based on the experience to date.

CHAPTER 7

CARGO PRESSURE/TEMPERATURE CONTROL

Goal

To maintain the cargo tank pressure and temperature within design limits of the containment system and/or carriage requirements of the cargo.

7.1 Methods of control

7.1.1 With the exception of tanks designed to withstand full gauge vapour pressure of the cargo under conditions of the upper ambient design temperatures, cargo tanks' pressure and temperature shall be maintained at all times within their design range by either one, or a combination of, the following methods:

.1 reliquefaction of cargo vapours;

.2 thermal oxidation of vapours;

.3 pressure accumulation; and

.4 liquid cargo cooling.

7.1.2 For certain cargoes, where required by chapter 17, the cargo containment system shall be capable of withstanding the full vapour pressure of the cargo under conditions of the upper ambient design temperatures, irrespective of any system provided for dealing with boil-off gas.

7.1.3 Venting of the cargo to maintain cargo tank pressure and temperature shall not be acceptable except in emergency situations. The Administration may permit certain cargoes to be controlled by venting cargo vapours to the atmosphere at sea. This may also be permitted in port with the authorization of the port Administration.

7.2 Design of systems

For normal service, the upper ambient design temperature shall be:

- sea: 32°C
- air: 45°C

For service in particularly hot or cold zones, these design temperatures shall be increased or decreased, to the satisfaction of the Administration. The overall capacity of the system shall be such that it can control the pressure within the design conditions without venting to atmosphere.

7.3 Reliquefaction of cargo vapours

7.3.1 ***General***

The reliquefaction system may be arranged in one of the following ways:

.1 a direct system, where evaporated cargo is compressed, condensed and returned to the cargo tanks;

.2 an indirect system, where cargo or evaporated cargo is cooled or condensed by refrigerant without being compressed;

.3 a combined system, where evaporated cargo is compressed and condensed in a cargo/refrigerant heat exchanger and returned to the cargo tanks; and

.4 if the reliquefaction system produces a waste stream containing methane during pressure control operations within the design conditions, these waste gases, as far as reasonably practicable, are disposed of without venting to atmosphere.

Note:

The requirements of chapters 17 and 19 may preclude the use of one or more of these systems or may specify the use of a particular system.

7.3.2 ***Compatibility***

Refrigerants used for reliquefaction shall be compatible with the cargo they may come into contact with. In addition, when several refrigerants are used and may come into contact, they shall be compatible with each other.

7.4 Thermal oxidation of vapours

7.4.1 ***General***

Maintaining the cargo tank pressure and temperature by means of thermal oxidation of cargo vapours, as defined in 1.2.52 and 16.2 shall be permitted only for LNG cargoes. In general:

.1 thermal oxidation systems shall exhibit no externally visible flame and shall maintain the uptake exhaust temperature below 535°C;

.2 arrangement of spaces where oxidation systems are located shall comply with 16.3 and supply systems shall comply with 16.4; and

.3 if waste gases coming from any other system are to be burnt, the oxidation system shall be designed to accommodate all anticipated feed gas compositions.

7.4.2 ***Thermal oxidation systems***

Thermal oxidation systems shall comply with the following:

.1 each thermal oxidation system shall have a separate uptake;

.2 each thermal oxidation system shall have a dedicated forced draught system; and

.3 combustion chambers and uptakes of thermal oxidation systems shall be designed to prevent any accumulation of gas.

7.4.3 ***Burners***

Burners shall be designed to maintain stable combustion under all design firing conditions.

7.4.4 ***Safety***

7.4.4.1 Suitable devices shall be installed and arranged to ensure that gas flow to the burner is cut off unless satisfactory ignition has been established and maintained.

7.4.4.2 Each oxidation system shall have provision to manually isolate its gas fuel supply from a safely accessible position.

7.4.4.3 Provision shall be made for automatic purging the gas supply piping to the burners by means of an inert gas, after the extinguishing of these burners.

7.4.4.4 In case of flame failure of all operating burners for gas or oil or for a combination thereof, the combustion chambers of the oxidation system shall be automatically purged before relighting.

7.4.4.5 Arrangements shall be made to enable the combustion chamber to be manually purged.

7.5 Pressure accumulation systems

The containment system insulation, design pressure or both shall be adequate to provide for a suitable margin for the operating time and temperatures involved. No additional pressure and temperature control system is required. Conditions for acceptance shall be recorded in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk required in 1.4.4.

7.6 Liquid cargo cooling

The bulk cargo liquid may be refrigerated by coolant circulated through coils fitted either inside the cargo tank or onto the external surface of the cargo tank.

7.7 Segregation

Where two or more cargoes that may react chemically in a dangerous manner are carried simultaneously, separate systems as defined in 1.2.47, each complying with availability criteria as specified in 7.8, shall be provided for each cargo. For simultaneous carriage of two or more cargoes that are not reactive to each other but where, due to properties of their vapour, separate systems are necessary, separation may be by means of isolation valves.

7.8 Availability

The availability of the system and its supporting auxiliary services shall be such that:

.1 in case of a single failure of a mechanical non-static component or a component of the control systems, the cargo tanks' pressure and temperature can be maintained within their design range without affecting other essential services;

.2 redundant piping systems are not required;

.3 heat exchangers that are solely necessary for maintaining the pressure and temperature of the cargo tanks within their design ranges shall have a standby heat exchanger, unless they have a capacity in excess of 25% of the largest required capacity for pressure control and they can be repaired on board without external resources. Where an additional and separate method of cargo tank pressure and temperature control is fitted that is not reliant on the sole heat exchanger, then a standby heat exchanger is not required; and

.4 for any cargo heating or cooling medium, provisions shall be made to detect the leakage of toxic or flammable vapours into an otherwise non-hazardous area or overboard in accordance with 13.6. Any vent outlet from this leak detection arrangement shall be to a non-hazardous area and be fitted with a flame screen.

CHAPTER 8

VENT SYSTEMS FOR CARGO CONTAINMENT

Goal

To protect cargo containment systems from harmful overpressure or underpressure at all times.

8.1 General

All cargo tanks shall be provided with a pressure relief system appropriate to the design of the cargo containment system and the cargo being carried. Hold spaces and interbarrier spaces, which may be subject to pressures beyond their design capabilities, shall also be provided with a suitable pressure relief system. Pressure control systems specified in chapter 7 shall be independent of the pressure relief systems.

8.2 Pressure relief systems

8.2.1 Cargo tanks, including deck tanks, shall be fitted with a minimum of two pressure relief valves (PRVs), each being of equal size within manufacturer's tolerances and suitably designed and constructed for the prescribed service.

8.2.2 Interbarrier spaces shall be provided with pressure relief devices. For membrane systems, the designer shall demonstrate adequate sizing of interbarrier space PRVs.

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

8.2.4 The following temperature requirements apply to PRVs fitted to pressure relief systems:

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

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

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

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

8.2.5 ***Valve testing***

8.2.5.1 PRVs shall be type-tested. Type tests shall include:

.1 verification of relieving capacity;

.2 cryogenic testing when operating at design temperatures colder than -55°C;

.3 seat tightness testing; and

.4 pressure containing parts are pressure tested to at least 1.5 times the design pressure.

PRVs shall be tested in accordance with recognized standards.

8.2.5.2 Each PRV shall be tested to ensure that:

.1 it opens at the prescribed pressure setting, with an allowance not exceeding ± 10% for 0 to 0.15 MPa, ± 6% for 0.15 to 0.3 MPa, ± 3% for 0.3 MPa and above;

.2 seat tightness is acceptable; and

.3 pressure containing parts will withstand at least 1.5 times the design pressure.

8.2.6 PRVs shall be set and sealed by the Administration or recognized organization acting on its behalf, and a record of this action, including the valves' set pressure, shall be retained on board the ship.

8.2.7 Cargo tanks may be permitted to have more than one relief valve set pressure in the following cases:

.1 installing two or more properly set and sealed PRVs and providing means, as necessary, for isolating the valves not in use from the cargo tank; or

.2 installing relief valves whose settings may be changed by the use of a previously approved device not requiring pressure testing to verify the new set pressure. All other valve adjustments shall be sealed.

8.2.8 Changing the set pressure under the provisions of 8.2.7 and the corresponding resetting of the alarms referred to in 13.4.2 shall be carried out under the supervision of the master in accordance with approved procedures and as specified in the ship's operating manual. Changes in set pressure shall be recorded in the ship's log and a sign shall be posted in the cargo control room, if provided, and at each relief valve, stating the set pressure.

8.2.9 In the event of a failure of a cargo tank-installed PRV, a safe means of emergency isolation shall be available:

.1 Procedures shall be provided and included in the cargo operations manual (see 18.2).

.2 The procedures shall allow only one of the cargo tank installed PRVs to be isolated.

.3 Isolation of the PRV shall be carried out under the supervision of the master. This action shall be recorded in the ship's log and a sign posted in the cargo control room, if provided, and at the PRV.

.4 The tank shall not be loaded until the full relieving capacity is restored.

8.2.10 Each PRV installed on a cargo tank shall be connected to a venting system, which shall be:

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

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

.3 arranged such that the height of vent exits shall not be less than B/3 or 6 m, whichever is the greater, above the weather deck; and

.4 6 m above working areas and walkways.

8.2.11.1 Cargo PRV vent exits shall be arranged at a distance at least equal to B or 25 m, whichever is less, from the nearest air intake, outlet or opening to accommodation spaces, service spaces and control stations, or other non-hazardous areas. For ships less than 90 m in length, smaller distances may be permitted.

8.2.11.2 All other vent outlets connected to the cargo containment system shall be arranged at a distance of at least 10 m from the nearest air intake, outlet or opening to accommodation spaces, service spaces and control stations, or other non-hazardous areas.

8.2.12 All other cargo vent outlets not dealt with in other chapters shall be arranged in accordance with 8.2.10, 8.2.11.1 and 8.2.11.2. Means shall be provided to prevent liquid overflow from vent mast outlets, due to hydrostatic pressure from spaces to which they are connected.

8.2.13 If cargoes that react in a dangerous manner with each other are carried simultaneously, a separate pressure relief system shall be fitted for each one.

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

8.2.15 Suitable protection screens of not more than 13 mm square mesh shall be fitted on vent outlets to prevent the ingress of extraneous objects without adversely affecting the flow. Other requirements for protection screens apply when carrying specific cargoes (see 17.9 and 17.21).

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

8.2.17 PRVs shall be connected to the highest part of the cargo tank above deck level. PRVs shall be positioned on the cargo tank so that they will remain in the vapour phase at the filling limit (*FL*) as defined in chapter 15, under conditions of 15° list and 0.015L trim, where L is defined in 1.2.31.

8.2.18 The adequacy of the vent system fitted on tanks loaded in accordance with 15.5.2 shall be demonstrated by the Administration, taking into account the recommendations developed by the Organization. A relevant certificate shall be permanently kept on board the ship. For the purposes of this paragraph, vent system means:

.1 the tank outlet and the piping to the PRV;

.2 the PRV; and

.3 the piping from the PRVs to the location of discharge to the atmosphere, including any interconnections and piping that joins other tanks.

8.3 Vacuum protection systems

8.3.1 Cargo tanks not designed to withstand a maximum external pressure differential 0.025 MPa, or tanks that cannot withstand the maximum external pressure differential that can be attained at maximum discharge rates with no vapour return into the cargo tanks, or by operation of a cargo refrigeration system, or by thermal oxidation, shall be fitted with:

.1 two independent pressure switches to sequentially alarm and subsequently stop all suction of cargo liquid or vapour from the cargo tank and refrigeration equipment, if fitted, by suitable means at a pressure sufficiently below the maximum external designed pressure differential of the cargo tank; or

.2 vacuum relief valves with a gas flow capacity at least equal to the maximum cargo discharge rate per cargo tank, set to open at a pressure sufficiently below the external design differential pressure of the cargo tank.

8.3.2 Subject to the requirements of chapter 17, the vacuum relief valves shall admit an inert gas, cargo vapour or air to the cargo tank and shall be arranged to minimize the possibility of the entrance of water or snow. If cargo vapour is admitted, it shall be from a source other than the cargo vapour lines.

8.3.3 The vacuum protection system shall be capable of being tested to ensure that it operates at the prescribed pressure.

8.4 Sizing of pressure relieving system

8.4.1 *Sizing of pressure relief valves*

PRVs shall 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:

8.4.1.1 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

8.4.1.2 Vapours generated under fire exposure computed using the following formula:

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

where:

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

F = fire exposure factor for different cargo types as follows:

- 1 for tanks without insulation located on deck;
- 0.5 for tanks above the deck, when insulation is approved by the Administration. Approval will be based on the use of a fireproofing material, the thermal conductance of insulation and its stability under fire exposure;
- 0.5 for uninsulated independent tanks installed in holds;
- 0.2 for insulated independent tanks in holds (or uninsulated independent tanks in insulated holds);

- 0.1 for insulated independent tanks in inerted holds (or uninsulated independent tanks in inerted, insulated holds);
- 0.1 for membrane and semi-membrane tanks. For independent tanks partly protruding through the weather decks, the fire exposure factor shall be determined on the basis of the surface areas above and below deck.

G = gas factor according to formula:

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

with:

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

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

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

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

where:

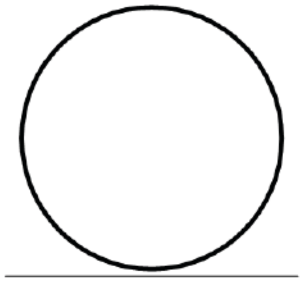
k = ratio of specific heats at relieving conditions, and the value of which is between 1 and 2.2. If *k* is not known, *D* = 0.606 shall be used;

Z = compressibility factor of the gas at relieving conditions. If not known, *Z* = 1 shall be used; and

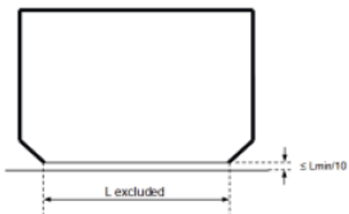
M = molecular mass of the product.

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

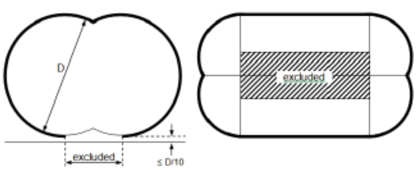
A = external surface area of the tank (m^2), as defined in 1.2.14, for different tank types, as shown in figure 8.1.



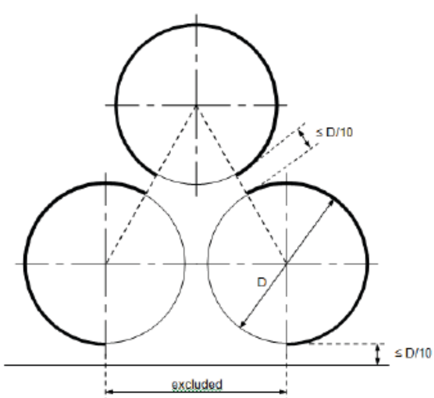
Cylindrical tanks with spherically dished,
hemispherical or semi-ellipsoidal heads
or spherical tanks



Prismatic tanks



Bilobe tanks



Horizontal cylindrical
tanks arrangement

Figure 8.1

8.4.1.3 The required mass flow of air at relieving conditions is given by the formula:

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

where:

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

8.4.2 ***Sizing of vent pipe system***

Pressure losses upstream and downstream of the PRVs shall be taken into account when determining their size to ensure the flow capacity required by 8.4.1.

8.4.3 ***Upstream pressure losses***

8.4.3.1 The pressure drop in the vent line from the tank to the PRV inlet shall not exceed 3% of the valve set pressure at the calculated flow rate, in accordance with 8.4.1.

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

8.4.3.3 Pressure losses in remotely sensed pilot lines shall be considered for flowing type pilots.

8.4.4 ***Downstream pressure losses***

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

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

.1 for unbalanced PRVs: 10% of MARVS;

.2 for balanced PRVs: 30% of MARVS; and

.3 for pilot operated PRVs: 50% of MARVS.

Alternative values provided by the PRV manufacturer may be accepted.

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

CHAPTER 9

CARGO CONTAINMENT SYSTEM ATMOSPHERE CONTROL

Goal

To enable monitoring of the integrity of the containment system and to ensure that the atmosphere within the system and hold spaces is maintained in a safe condition at all times that the ship is in service.

9.1 Atmosphere control within the cargo containment system

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

9.1.2 For flammable cargoes, the system shall be designed to eliminate the possibility of a flammable mixture existing in the cargo tank during any part of the atmosphere change operation by utilizing an inerting medium as an intermediate step.

9.1.3 Piping systems that may contain flammable cargoes shall comply with 9.1.1 and 9.1.2.

9.1.4 A sufficient number of gas sampling points shall be provided for each cargo tank and cargo piping system to adequately monitor the progress of atmosphere change. Gas sampling connections shall be fitted with a single valve above the main deck, sealed with a suitable cap or blank (see 5.6.5.5).

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

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

9.2.1 Interbarrier and hold spaces associated with cargo containment systems for flammable gases requiring full or partial secondary barriers shall be inerted with a suitable dry inert gas and kept inerted with make-up gas provided by a shipboard inert gas generation system, or by shipboard storage, which shall be sufficient for normal consumption for at least 30 days.

9.2.2 Alternatively, subject to the restrictions specified in chapter 17, the spaces referred to in 9.2.1 requiring only a partial secondary barrier may be filled with dry air provided that the ship maintains a stored charge of inert gas or is fitted with an inert gas generation system sufficient to inert the largest of these spaces, and provided that the configuration of the spaces and the relevant vapour detection systems, together with the capability of the inerting arrangements, ensures that any leakage from the cargo tanks will be rapidly detected and inerting effected before a dangerous condition can develop. Equipment for the provision of sufficient dry air of suitable quality to satisfy the expected demand shall be provided.

9.2.3 For non-flammable gases, the spaces referred to in 9.2.1 and 9.2.2 may be maintained with a suitable dry air or inert atmosphere.

9.3 Environmental control of spaces surrounding type C independent tanks

Spaces surrounding cargo tanks that do not have secondary barriers shall be filled with suitable dry inert gas or dry air and be maintained in this condition with make-up inert gas provided by a shipboard inert gas generation system, shipboard storage of inert gas, or with dry air provided by suitable air drying equipment. If the cargo is carried at ambient temperature, the requirement for dry air or inert gas is not applicable.

9.4 Inerting

9.4.1 Inerting refers to the process of providing a non-combustible environment. Inert gases shall be compatible chemically and operationally at all temperatures likely to occur within the spaces and the cargo. The dew points of the gases shall be taken into consideration.

9.4.2 Where inert gas is also stored for firefighting purposes, it shall be carried in separate containers and shall not 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 shall be designed so that the temperature of the ship's structure is not reduced below the limiting values imposed on it.

9.4.4 Arrangements to prevent the backflow of cargo vapour into the inert gas system that are suitable for the cargo carried, shall be provided. If such plants are located in machinery spaces or other spaces outside the cargo area, two non-return valves or equivalent devices and, in addition, a removable spool piece shall be fitted in the inert gas main in the cargo area. When not in use, the inert gas system shall be made separate from the cargo system in the cargo area except for connections to the hold spaces or interbarrier spaces.

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

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

9.5 Inert gas production on board

9.5.1 The equipment shall be capable of producing inert gas with an oxygen content at no time greater than 5% by volume, subject to the special requirements of chapter 17. A continuous-reading oxygen content meter shall be fitted to the inert gas supply from the equipment and shall be fitted with an alarm set at a maximum of 5% oxygen content by volume, subject to the requirements of chapter 17.

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

9.5.3 Spaces containing inert gas generation plants shall have no direct access to accommodation spaces, service spaces or control stations, but may be located in machinery spaces. Inert gas piping shall not pass through accommodation spaces, service spaces or control stations.

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

CHAPTER 10

ELECTRICAL INSTALLATIONS

Goal

To ensure that electrical installations are designed such as to minimize the risk of fire and explosion from flammable products, and that electrical generation and distribution systems relating to the safe carriage, handling and conditioning of cargo liquid and vapour are available.

10.1 Definitions

For the purpose of this chapter, unless expressly provided otherwise, the definitions below shall apply.

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

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

10.1.1.2 *Zone 1 hazardous area* is an area in which an explosive gas atmosphere is likely to occur in normal operation.

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

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

10.2 General requirements

10.2.1 Electrical installations shall be such as to minimize the risk of fire and explosion from flammable products.

10.2.2 Electrical installations shall be in accordance with recognized standards.

10.2.3 Electrical equipment or wiring shall not be installed in hazardous areas, unless essential for operational purposes or safety enhancement.

10.2.4 Where electrical equipment is installed in hazardous areas as provided in 10.2.3, it shall be selected, installed and maintained in accordance with standards not inferior to those acceptable to the Organization. Equipment for hazardous areas shall be evaluated and certified or listed by an accredited testing authority or notified body recognized by the Administration. Automatic isolation of non-certified equipment on detection of a flammable gas shall not be accepted as an alternative to the use of certified equipment.

10.2.5 To facilitate the selection of appropriate electrical apparatus and the design of suitable electrical installations, hazardous areas are divided into zones in accordance with recognized standards.

10.2.6 Electrical generation and distribution systems, and associated control systems shall be designed such that a single fault will not result in the loss of ability to maintain cargo tank pressures, as required by 7.8.1, and hull structure temperature, as required by 4.19.1.6, within normal operating limits. Failure modes and effects shall be analysed and documented to a standard not inferior to those acceptable to the Administration.

10.2.7 The lighting system in hazardous areas shall be divided between at least two branch circuits. All switches and protective devices shall interrupt all poles or phases and shall be located in a non-hazardous area.

10.2.8 Electrical depth sounding or log devices and impressed current cathodic protection system anodes or electrodes shall be housed in gastight enclosures.

10.2.9 Submerged cargo pump motors and their supply cables may be fitted in cargo containment systems. Arrangements shall be made to automatically shut down the motors in the event of low-liquid level. This may be accomplished by sensing low pump discharge pressure, low motor current or low liquid level. This shutdown shall be alarmed at the cargo control station. Cargo pump motors shall be capable of being isolated from their electrical supply during gas-freeing operations.

CHAPTER 11

FIRE PROTECTION AND EXTINCTION

Goal

To ensure that suitable systems are provided to protect the ship and crew from fire in the cargo area.

11.1 Fire safety requirements

11.1.1 The requirements for tankers in SOLAS chapter II-2 shall apply to ships covered by the Code, irrespective of tonnage including ships of less than 500 gross tonnage, except that:

.1 regulations 4.5.1.6 and 4.5.10 do not apply;

.2 regulations 10.4 and 10.5 shall apply as they would apply to tankers of 2,000 gross tonnage and over;

.3 regulation 10.5.6 shall apply to ships of 2,000 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 the Code as detailed below:

Regulation:	Replaced by:
10.10	11.6
4.5.1.1 and 4.5.1.2	Chapter 3
4.5.5	Relevant sections in the Code

10.8	11.3 and 11.4
10.9	11.5
10.2	11.2.1 to 11.2.4;

.5 regulations 13.3.4 and 13.4.3 shall apply to ships of 500 gross tonnage and over.

11.1.2 All sources of ignition shall 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 shall apply in conjunction with chapter 3.

11.1.4 For the purposes of firefighting, any weather 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 shall be included in the cargo area.

11.2 Fire mains and hydrants

11.2.1 Irrespective of size, ships carrying products that are subject to the Code shall comply with the requirements of regulation II-2/10.2 of the SOLAS Convention, as applicable to cargo ships, except that the required fire pump capacity and fire main and water service pipe diameter shall not be limited by the provisions of regulations II-2/10.2.2.4.1 and II-2/10.2.1.3, when a fire pump is used to supply the water-spray system, as permitted by 11.3.3 of the Code. The capacity of this fire pump shall be such that these areas can be protected when simultaneously supplying two jets of water from fire hoses with 19 mm nozzles at a pressure of at least 0.5 MPa.

11.2.2 The arrangements shall 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 that are above the deck. The necessary number of fire hydrants shall be located to satisfy the above arrangements and to comply with the requirements of regulations II-2/10.2.1.5.1 and II-2/10.2.3.3 of the SOLAS Convention, with hose lengths as specified in regulation II-2/10.2.3.1.1. In addition, the requirements of regulation II-2/10.2.1.6 shall be met at a pressure of at least 0.5 MPa gauge.

11.2.3 Stop valves shall be fitted in any crossover provided and in the fire main or mains in a protected location, before entering the cargo area and at intervals ensuring isolation of any damaged single section of the fire main, so that 11.2.2 can be complied with using not more than two lengths of hoses from the nearest fire hydrant. The water supply to the fire main serving the cargo area shall be a ring main supplied by the main fire pumps or a single main supplied by fire pumps positioned fore and aft of the cargo area, one of which shall be independently driven.

11.2.4 Nozzles shall be of an approved dual-purpose type (i.e. spray/jet type) incorporating a shutoff.

11.2.5 After installation, the pipes, valves, fittings and assembled system shall be subject to a tightness and function test.

11.3 Water-spray system

11.3.1 On ships carrying flammable and/or toxic products, a water-spray system, for cooling, fire prevention and crew protection shall be installed to cover:

.1 exposed cargo tank domes, any exposed parts of cargo tanks and any part of cargo tank covers that may be exposed to heat from fires in adjacent equipment containing cargo such as exposed booster pumps/heaters/re-gasification or re-liquefaction plants, hereafter addressed as gas process units, positioned on weather decks;

.2 exposed on-deck storage vessels for flammable or toxic products;

.3 gas process units positioned on deck;

.4 cargo liquid and vapour discharge and loading connections, including the presentation flange and the area where their control valves are situated, which shall be at least equal to the area of the drip trays provided;

.5 all exposed emergency shut-down (ESD) valves in the cargo liquid and vapour pipes, including the master valve for supply to gas consumers;

.6 exposed boundaries facing the cargo area, such as bulkheads of superstructures and deckhouses normally manned, cargo machinery spaces, store-rooms containing high fire-risk items and cargo control rooms. Exposed horizontal boundaries of these areas do not require protection unless detachable cargo piping connections are arranged above or below. Boundaries of unmanned forecastle structures not containing high fire-risk items or equipment do not require water-spray protection;

.7 exposed lifeboats, liferafts and muster stations facing the cargo area, regardless of distance to cargo area; and

.8 any semi-enclosed cargo machinery spaces and semi-enclosed cargo motor room.

Ships intended for operation as listed in 1.1.10 shall be subject to special consideration (see 11.3.3.2).

11.3.2.1 The system shall be capable of covering all areas mentioned in 11.3.1.1 to 11.3.1.8, with a uniformly distributed water application rate of at least 10 ℓ/m^2/min for the largest projected horizontal surfaces and 4 ℓ/m^2/min for vertical surfaces. For structures having no clearly defined horizontal or vertical surface, the capacity of the water-spray system shall not be less than the projected horizontal surface multiplied by 10 ℓ/m^2/min.

11.3.2.2 On vertical surfaces, spacing of nozzles protecting lower areas may take account of anticipated rundown from higher areas. Stop valves shall be fitted in the main supply line(s) in the water-spray system, at intervals not exceeding 40 m, for the purpose of isolating damaged sections. Alternatively, the system may be divided into two or more sections that may be operated independently, provided the necessary controls are located together in a readily accessible position outside the cargo area. A section protecting any area included in 11.3.1.1 and .2 shall cover at least the entire athwartship tank grouping in that area. Any gas process unit(s) included in 11.3.1.3 may be served by an independent section.

11.3.3 The capacity of the water-spray pumps shall be capable of simultaneous protection of the greater of the following:

.1 any two complete athwartship tank groupings, including any gas process units within these areas; or

.2 for ships intended for operation as listed in 1.1.10, necessary protection subject to special consideration under 11.3.1 of any added fire hazard and the adjacent athwartship tank grouping,

in addition to surfaces specified in 11.3.1.4 to 11.3.1.8. Alternatively, the main fire pumps may be used for this service, provided that their total capacity is increased by the amount needed for the water-spray system. In either case, a connection, through a stop valve, shall be made between the fire main and water-spray system main supply line outside the cargo area.

11.3.4 The boundaries of superstructures and deckhouses normally manned, and lifeboats, liferafts and muster areas facing the cargo area, shall also be capable of being served by one of the fire pumps or the emergency fire pump, if a fire in one compartment could disable both fire pumps.

11.3.5 Water pumps normally used for other services may be arranged to supply the water-spray system main supply line.

11.3.6 All pipes, valves, nozzles and other fittings in the water-spray system shall be resistant to corrosion by seawater. Piping, fittings and related components within the cargo area (except gaskets) shall be designed to withstand 925°C. The water-spray system shall be arranged with in-line filters to prevent blockage of pipes and nozzles. In addition, means shall be provided to back-flush the system with fresh water.

11.3.7 Remote starting of pumps supplying the water-spray system and remote operation of any normally closed valves in the system shall 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 protected areas.

11.3.8 After installation, the pipes, valves, fittings and assembled system shall be subject to a tightness and function test.

11.4 Dry chemical powder fire-extinguishing systems

11.4.1 Ships in which the carriage of flammable products is intended shall be fitted with fixed dry chemical powder fire-extinguishing systems, approved by the Administration based on the guidelines developed by the Organization, for the purpose of firefighting on the deck in the cargo area, including any cargo liquid and vapour discharge and loading connections on deck and bow or stern cargo handling areas, as applicable.

11.4.2 The system shall be capable of delivering powder from at least two hand hose lines, or a combination of monitor/hand hose lines, to any part of the exposed cargo liquid and vapour piping, load/unload connection and exposed gas process units.

11.4.3 The dry chemical powder fire-extinguishing system shall be designed with not less than two independent units. Any part required to be protected by 11.4.2 shall be capable of being reached from not less than two independent 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. A monitor shall be arranged to protect any load/unload connection area and be capable of actuation and discharge both 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. One hose line shall be provided at both port- and starboard side at the end of the cargo area facing the accommodation and readily available from the accommodation.

11.4.4 The capacity of a monitor shall be not less than 10 kg/s. Hand hose lines shall 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 shall allow operation by one man. The length of a hand hose line shall not exceed 33 m. Where fixed piping is provided between the powder container and a hand hose line or monitor, the length of piping shall not 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 shall be of weather-resistant construction or stored in weather resistant housing or covers and be readily accessible.

11.4.5 Hand hose lines shall be considered to have a maximum effective distance of coverage equal to the length of hose. Special consideration shall be given where areas to be protected are substantially higher than the monitor or hand hose reel locations.

11.4.6 Ships fitted with bow/stern load/unload connections shall be provided with independent dry powder unit protecting the cargo liquid and vapour piping, aft or forward of the cargo area, by hose lines and a monitor covering the bow/stern load/unload complying with the requirements of 11.4.1 to 11.4.5.

11.4.7 Ships intended for operation as listed in 1.1.10 shall be subject to special consideration.

11.4.8 After installation, the pipes, valves, fittings and assembled systems shall be subjected to a tightness test and functional testing of the remote and local release stations. The initial testing shall also include a discharge of sufficient amounts of dry chemical powder to verify that the system is in proper working order. All distribution piping shall be blown through with dry air to ensure that the piping is free of obstructions.

11.5 Enclosed spaces containing cargo handling equipment

11.5.1 Enclosed spaces meeting the criteria of cargo machinery spaces in 1.2.10, and the cargo motor room within the cargo area of any ship, shall be provided with a fixed fire-extinguishing system complying with the provisions of the FSS Code and taking into account the necessary concentrations/application rate required for extinguishing gas fires.

11.5.2 Enclosed spaces meeting the criteria of cargo machinery spaces in chapter 3.3, within the cargo area of ships that are dedicated to the carriage of a restricted number of cargoes, shall be protected by an appropriate fire-extinguishing system for the cargo carried.

11.5.3 Turret compartments of any ship shall be protected by internal water spray, with an application rate of not less than 10 ℓ/m^2/min of the largest projected horizontal surface. If the pressure of the gas flow through the turret exceeds 4 MPa, the application rate shall be increased to 20 ℓ/m^2/min. The system shall be designed to protect all internal surfaces.

11.6 Firefighter's outfits

11.6.1 Every ship carrying flammable products shall carry firefighter's outfits complying with the requirements of regulation II-2/10.10 of the SOLAS Convention, as follows:

Total cargo capacity	Number of outfits
5,000 m^3 and below	4
Above 5,000 m^3	5

11.6.2 Additional requirements for safety equipment are given in chapter 14.

11.6.3 Any breathing apparatus required as part of a firefighter's outfit shall be a self-contained compressed air-operated breathing apparatus having a capacity of at least 1,200 ℓ of free air.

CHAPTER 12

ARTIFICIAL VENTILATION IN THE CARGO AREA

Goal

To ensure that arrangements are provided for enclosed spaces in the cargo area to control the accumulation of flammable and/or toxic vapours.

Scope

The requirements of this chapter replace the requirements of SOLAS regulations II-2/4.5.2.6 and 4.5.4.1, as amended.

12.1 Spaces required to be entered during normal cargo handling operations

12.1.1 Electric motor rooms, cargo compressor and pump-rooms, spaces containing cargo handling equipment and other enclosed spaces where cargo vapours may accumulate shall be fitted with fixed artificial ventilation systems capable of being controlled from outside such spaces. The ventilation shall be run continuously to prevent the accumulation of toxic and/or flammable vapours, with a means of monitoring acceptable to the Administration to be provided. A warning notice requiring the use of such ventilation prior to entering shall be placed outside the compartment.

12.1.2 Artificial ventilation inlets and outlets shall be arranged to ensure sufficient air movement through the space to avoid accumulation of flammable, toxic or asphyxiant vapours, and to ensure a safe working environment.

12.1.3 The ventilation system shall have a capacity of not less than 30 changes of air per hour, based upon the total volume of the space. As an exception, non-hazardous cargo control rooms may have eight changes of air per hour.

12.1.4 Where a space has an opening into an adjacent more hazardous space or area, it shall be maintained at an overpressure. It may be made into a less hazardous space or non-hazardous space by overpressure protection in accordance with recognized standards.

12.1.5 Ventilation ducts, air intakes and exhaust outlets serving artificial ventilation systems shall be positioned in accordance with recognized standards.

12.1.6 Ventilation ducts serving hazardous areas shall not be led through accommodation, service and machinery spaces or control stations, except as allowed in chapter 16.

12.1.7 Electric motors' driving fans shall be placed outside the ventilation ducts that may contain flammable vapours. Ventilation fans shall not produce a source of ignition in either the ventilated space or the ventilation system associated with the space. For hazardous areas, ventilation fans and ducts, adjacent to the fans, shall be of non-sparking construction, as defined below:

.1 impellers or housing of non-metallic construction, with due regard being paid to the elimination of static electricity;

.2 impellers and housing of non-ferrous materials;

.3 impellers and housing of austenitic stainless steel; and

.4 ferrous impellers and housing with design tip clearance of not less than 13 mm.

Any combination of an aluminium or magnesium alloy fixed or rotating component and a ferrous fixed or rotating component, regardless of tip clearance, is considered a sparking hazard and shall not be used in these places.

12.1.8 Where fans are required by this chapter, full required ventilation capacity for each space shall be available after failure of any single fan, or spare parts shall be provided comprising a motor, starter spares and complete rotating element, including bearings of each type.

12.1.9 Protection screens of not more than 13 mm square mesh shall be fitted to outside openings of ventilation ducts.

12.1.10 Where spaces are protected by pressurization, the ventilation shall be designed and installed in accordance with recognized standards.

12.2 Spaces not normally entered

12.2.1 Enclosed spaces where cargo vapours may accumulate shall be capable of being ventilated to ensure a safe environment when entry into them is necessary. This shall be capable of being achieved without the need for prior entry.

12.2.2 For permanent installations, the capacity of 8 air changes per hour shall be provided and for portable systems, the capacity of 16 air changes per hour.

12.2.3 Fans or blowers shall be clear of personnel access openings, and shall comply with 12.1.7.

CHAPTER 13

INSTRUMENTATION AND AUTOMATION SYSTEMS

Goal

To ensure that the instrumentation and automation systems provides for the safe carriage, handling and conditioning of cargo liquid and vapour.

13.1 General

13.1.1 Each cargo tank shall be provided with a means for indicating level, pressure and temperature of the cargo. Pressure gauges and temperature indicating devices shall be installed in the liquid and vapour piping systems, in cargo refrigeration installations.

13.1.2 If 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 shall be concentrated in one control position.

13.1.3 Instruments shall be tested to ensure reliability under the working conditions, and recalibrated at regular intervals. Test procedures for instruments and the intervals between recalibration shall be in accordance with manufacturer's recommendations.

13.2 Level indicators for cargo tanks

13.2.1 Each cargo tank shall be fitted with liquid level gauging device(s), arranged to ensure that a level reading is always obtainable whenever the cargo tank is operational. The device(s) shall be designed to operate throughout the design pressure range of the cargo tank and at temperatures within the cargo operating temperature range.

13.2.2 Where only one liquid level gauge is fitted, it shall be arranged so that it can be maintained in an operational condition without the need to empty or gas-free the tank.

13.2.3 Cargo tank liquid level gauges may be of the following types, subject to special requirements for particular cargoes shown in column "g" in the table of chapter 19:

.1 indirect devices, which determine the amount of cargo by means such as weighing or in-line flow metering;

.2 closed devices which do not penetrate the cargo tank, such as devices using radio-isotopes 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 closed gauging device is not mounted directly onto the tank, it shall be provided with a shutoff valve located as close as possible to the tank; and

.4 restricted devices which penetrate the tank and, when in use, permit a small quantity of cargo vapour or liquid to escape to the atmosphere, such as fixed tube and slip tube gauges. When not in use, the devices shall be kept completely closed. The design and installation shall ensure that no dangerous escape of cargo can take place when opening the device. Such gauging devices shall 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.

13.3 Overflow control

13.3.1 Except as provided in 13.3.4, each cargo tank shall be fitted with a high liquid level alarm operating independently of other liquid level indicators and giving an audible and visual warning when activated.

13.3.2 An additional sensor operating independently of the high liquid level alarm shall automatically actuate a shutoff valve in a manner that will both avoid excessive liquid pressure in the loading line and prevent the tank from becoming liquid full.

13.3.3 The emergency shutdown valve referred to in 5.5 and 18.10 may be used for this purpose. If another valve is used for this purpose, the same information as referred to in 18.10.2.1.3 shall be available on board. During loading, whenever the use of these valves may possibly create a potential excess pressure surge in the loading system, alternative arrangements such as limiting the loading rate shall be used.

13.3.4 A high liquid level alarm and automatic shut-off of cargo tank filling need not be required, when the cargo tank:

.1 is a pressure tank with a volume not more than 200 m^3; or

.2 is designed to withstand the maximum possible pressure during the loading operation, and such pressure is below that of the set pressure of the cargo tank relief valve.

13.3.5 The position of the sensors in the tank shall be capable of being verified before commissioning. At the first occasion of full loading after delivery and after each dry-docking, testing of high-level alarms shall be conducted by raising the cargo liquid level in the cargo tank to the alarm point.

13.3.6 All elements of the level alarms, including the electrical circuit and the sensor(s), of the high, and overfill alarms, shall be capable of being functionally tested. Systems shall be tested prior to cargo operation in accordance with 18.6.2.

13.3.7 Where arrangements are provided for overriding the overflow control system, they shall be such that inadvertent operation is prevented. When this override is operated, continuous visual indication shall be given at the relevant control station(s) and the navigation bridge.

13.4 Pressure monitoring

13.4.1 The vapour space of each cargo tank shall be provided with a direct reading gauge. Additionally, an indirect indication shall be provided at the control position required by 13.1.2. Maximum and minimum allowable pressures shall be clearly indicated.

13.4.2 A high-pressure alarm and, if vacuum protection is required, a low-pressure alarm shall be provided on the navigation bridge and at the control position required by 13.1.2. Alarms shall be activated before the set pressures are reached.

13.4.3 For cargo tanks fitted with PRVs which can be set at more than one set pressure in accordance with 8.2.7, high-pressure alarms shall be provided for each set pressure.

13.4.4 Each cargo-pump discharge line and each liquid and vapour cargo manifold shall be provided with at least one pressure indicator.

13.4.5 Local-reading manifold pressure indication shall be provided to indicate the pressure between ship's manifold valves and hose connections to the shore.

13.4.6 Hold spaces and interbarrier spaces without open connection to the atmosphere shall be provided with pressure indication.

13.4.7 All pressure indications provided shall be capable of indicating throughout the operating pressure range.

13.5 Temperature indicating devices

13.5.1 Each cargo tank shall be provided with at least two devices for indicating cargo temperatures, one placed at the bottom of the cargo tank and the second near the top of the tank, below the highest allowable liquid level. The lowest temperature for which the cargo tank has been designed, as shown on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk required by 1.4.4, shall be clearly indicated by means of a sign on or near the temperature indicating devices.

13.5.2 The temperature indicating devices shall be capable of providing temperature indication across the expected cargo operating temperature range of the cargo tanks.

13.5.3 Where thermowells are fitted, they shall be designed to minimize failure due to fatigue in normal service.

13.6 Gas detection

13.6.1 Gas detection equipment shall be installed to monitor the integrity of the cargo containment, cargo handling and ancillary systems, in accordance with this section.

13.6.2 A permanently installed system of gas detection and audible and visual alarms shall be fitted in:

.1 all enclosed cargo and cargo machinery spaces (including turrets compartments) containing gas piping, gas equipment or gas consumers;

.2 other enclosed or semi-enclosed spaces where cargo vapours may accumulate, including interbarrier spaces and hold spaces for independent tanks other than type C tanks;

.3 airlocks;

.4 spaces in gas-fired internal combustion engines, referred to in 16.7.3.3;

.5 ventilation hoods and gas ducts required by chapter 16;

.6 cooling/heating circuits, as required by 7.8.4;

.7 inert gas generator supply headers; and

.8 motor rooms for cargo handling machinery.

13.6.3 Gas detection equipment shall be designed, installed and tested in accordance with recognized standards and shall be suitable for the cargoes to be carried in accordance with column "*f*" in table of chapter 19.

13.6.4 Where indicated in column "*f*" in the table of chapter 19 ships certified for carriage of non-flammable products, oxygen deficiency monitoring shall be fitted in cargo machinery spaces and cargo tank hold spaces. Furthermore, oxygen deficiency monitoring equipment shall be installed in enclosed or semi-enclosed spaces containing equipment that may cause an oxygen-deficient environment such as nitrogen generators, inert gas generators or nitrogen cycle refrigerant systems.

13.6.5 In the case of toxic products or both toxic and flammable products, except when column "*i*" in the table of chapter 19 refers to 17.5.3, portable equipment can be used for the detection of toxic products as an alternative to a permanently installed system. This equipment shall be used prior to personnel entering the spaces listed in 13.6.2 and at 30-minute intervals while they remain in the space.

13.6.6 In the case of gases classified as toxic products, hold spaces and interbarrier spaces shall be provided with a permanently installed piping system for obtaining gas samples from the spaces. Gas from these spaces shall be sampled and analysed from each sampling head location.

13.6.7 Permanently installed gas detection shall be of the continuous detection type, capable of immediate response. Where not used to activate safety shutdown functions required by 13.6.9 and chapter 16, sampling type detection may be accepted.

13.6.8 When sampling type gas detection equipment is used, the following requirements shall be met:

.1 the gas detection equipment shall be capable of sampling and analysing for each sampling head location sequentially at intervals not exceeding 30 min;

.2 individual sampling lines from sampling heads to the detection equipment shall be fitted; and

.3 pipe runs from sampling heads shall not be led through non-hazardous spaces except as permitted by 13.6.9.

13.6.9 The gas detection equipment may be located in a non-hazardous space, provided that the detection equipment such as sample piping, sample pumps, solenoids and analysing units are located in a fully enclosed steel cabinet with the door sealed by a gasket. The atmosphere within the enclosure shall be continuously monitored. At gas concentrations above 30% lower flammable limit (LFL) inside the enclosure, the gas detection equipment shall be automatically shut down.

13.6.10 Where the enclosure cannot be arranged directly on the forward bulkhead, sample pipes shall be of steel or equivalent material and be routed on their shortest way. Detachable connections, except for the connection points for isolating valves required in 13.6.11 and analysing units, are not permitted.

13.6.11 When gas sampling equipment is located in a non-hazardous space, a flame arrester and a manual isolating valve shall be fitted in each of the gas sampling lines. The isolating valve shall be fitted on the non-hazardous side. Bulkhead penetrations of sample pipes between hazardous and non-hazardous areas shall maintain the integrity of the division penetrated. The exhaust gas shall be discharged to the open air in a non-hazardous area.

13.6.12 In every installation, the number and the positions of detection heads shall be determined with due regard to the size and layout of the compartment, the compositions and densities of the products intended to be carried and the dilution from compartment purging or ventilation and stagnant areas.

13.6.13 Any alarms status within a gas detection system required by this section shall initiate an audible and visible alarm:

.1 on the navigation bridge;

.2 at the relevant control station(s) where continuous monitoring of the gas levels is recorded; and

.3 at the gas detector readout location.

13.6.14 In the case of flammable products, the gas detection equipment provided for hold spaces and interbarrier spaces that are required to be inerted shall be capable of measuring gas concentrations of 0% to 100% by volume.

13.6.15 Alarms shall be activated when the vapour concentration by volume reaches the equivalent of 30% LFL in air.

13.6.16 For membrane containment systems, the primary and secondary insulation spaces shall be able to be inerted and their gas content analysed individually. The alarm in the secondary insulation space shall be set in accordance with 13.6.15, that in the primary space is set at a value approved by the Administration or recognized organization acting on its behalf.

13.6.17 For other spaces described by 13.6.2, alarms shall be activated when the vapour concentration reaches 30% LFL and safety functions required by chapter 16 shall be activated before the vapour concentration reaches 60% LFL. The crankcases of internal combustion engines that can run on gas shall be arranged to alarm before 100% LFL.

13.6.18 Gas detection equipment shall be so designed that it may readily be tested. Testing and calibration shall be carried out at regular intervals. Suitable equipment for this purpose shall be carried on board and be used in accordance with the manufacturer's recommendations. Permanent connections for such test equipment shall be fitted.

13.6.19 Every ship shall be provided with at least two sets of portable gas detection equipment that meet the requirement of 13.6.3 or an acceptable national or international standard.

13.6.20 A suitable instrument for the measurement of oxygen levels in inert atmospheres shall be provided.

13.7 Additional requirements for containment systems requiring a secondary barrier

13.7.1 *Integrity of barriers*

Where a secondary barrier is required, permanently installed instrumentation shall be provided to detect when the primary barrier fails to be liquid-tight at any location or when liquid cargo is in contact with the secondary barrier at any location. This instrumentation shall consist of appropriate gas detecting devices according to 13.6. However, the instrumentation need not be capable of locating the area where liquid cargo leaks through the primary barrier or where liquid cargo is in contact with the secondary barrier.

13.7.2 *Temperature indication devices*

13.7.2.1 The number and position of temperature-indicating devices shall be appropriate to the design of the containment system and cargo operation requirements.

13.7.2.2 When cargo is carried in a cargo containment system with a secondary barrier, at a temperature lower than -55°C, temperature-indicating devices shall be provided within the insulation or on the hull structure adjacent to cargo containment systems. The devices shall give readings at regular intervals and, where applicable, alarm of temperatures approaching the lowest for which the hull steel is suitable.

13.7.2.3 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, shall be fitted with a sufficient number of temperature-indicating devices to verify that unsatisfactory temperature gradients do not occur.

13.7.2.4 For the purposes of design verification and determining the effectiveness of the initial cooldown procedure on a single or series of similar ships, one tank shall be fitted with devices in excess of those required in 13.7.2.1. These devices may be temporary or permanent and only need to be fitted to the first ship, when a series of similar ships is built.

13.8 Automation systems

13.8.1 The requirements of this section shall apply where automation systems are used to provide instrumented control, monitoring/alarm or safety functions required by this Code.

13.8.2 Automation systems shall be designed, installed and tested in accordance with recognized standards.

13.8.3 Hardware shall be capable of being demonstrated to be suitable for use in the marine environment by type approval or other means.

13.8.4 Software shall be designed and documented for ease of use, including testing, operation and maintenance.

13.8.5 The user interface shall be designed such that the equipment under control can be operated in a safe and effective manner at all times.

13.8.6 Automation systems shall be arranged such that a hardware failure or an error by the operator does not lead to an unsafe condition. Adequate safeguards against incorrect operation shall be provided.

13.8.7 Appropriate segregation shall be maintained between control, monitoring/alarm and safety functions to limit the effect of single failures. This shall be taken to include all parts of the automation systems that are required to provide specified functions, including connected devices and power supplies.

13.8.8 Automation systems shall be arranged such that the software configuration and parameters are protected against unauthorized or unintended change.

13.8.9 A management of change process shall be applied to safeguard against unexpected consequences of modification. Records of configuration changes and approvals shall be maintained on board.

13.8.10 Processes for the development and maintenance of integrated systems shall be in accordance with recognized standards. These processes shall include appropriate risk identification and management.

13.9 System integration

13.9.1 Essential safety functions shall be designed such that risks of harm to personnel or damage to the installation or the environment are reduced to a level acceptable to the Administration, both in normal operation and under fault conditions. Functions shall be designed to fail-safe. Roles and responsibilities for integration of systems shall be clearly defined and agreed by relevant parties.

13.9.2 Functional requirements of each component subsystem shall be clearly defined to ensure that the integrated system meets the functional and specified safety requirements and takes account of any limitations of the equipment under control.

13.9.3 Key hazards of the integrated system shall be identified using appropriate risk-based techniques.

13.9.4 The integrated system shall have a suitable means of reversionary control.

13.9.5 Failure of one part of the integrated system shall not affect the functionality of other parts, except for those functions directly dependent on the defective part.

13.9.6 Operation with an integrated system shall be at least as effective as it would be with individual stand-alone equipment or systems.

13.9.7 The integrity of essential machinery or systems, during normal operation and fault conditions, shall be demonstrated.

CHAPTER 14

PERSONNEL PROTECTION

Goal

To ensure that protective equipment is provided for ship staff, considering both routine operations or emergency situations and possible short- or long-term effects of the product being handled.

14.1 Protective equipment

14.1.1 Suitable protective equipment, including eye protection to a recognized national or international standard, shall be provided for protection of crew members engaged in normal cargo operations, taking into account the characteristics of the products being carried.

14.1.2 Personal protective and safety equipment required in this chapter shall be kept in suitable, clearly marked lockers located in readily accessible places.

14.1.3 The compressed air equipment shall be inspected at least once a month by a responsible officer and the inspection logged in the ship's records. This equipment shall also be inspected and tested by a competent person at least once a year.

14.2 First-aid equipment

14.2.1 A stretcher that is suitable for hoisting an injured person from spaces below deck shall be kept in a readily accessible location.

14.2.2 The ship shall have onboard medical first-aid equipment, including oxygen resuscitation equipment, based on the requirements of the Medical First Aid Guide (MFAG) for the cargoes listed on the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk shown in appendix 2.

14.3 Safety equipment

14.3.1 Sufficient, but not less than three complete sets of safety equipment shall be provided in addition to the firefighter's outfits required by 11.6.1. Each set shall provide adequate personal protection to permit entry and work in a gas-filled space. This equipment shall take into account the nature of the cargoes, listed on the International Certificate of Fitness for the Carriage of Liquified Gases in Bulk shown in appendix 2.

14.3.2 Each complete set of safety equipment shall consist of:

.1 one self-contained positive pressure air-breathing apparatus incorporating full face mask, not using stored oxygen and having a capacity of at least 1,200 ℓ of free air. Each set shall be compatible with that required by 11.6.1;

.2 protective clothing, boots and gloves to a recognized standard;

.3 steel-cored rescue line with belt; and

.4 explosion-proof lamp.

14.3.3 An adequate supply of compressed air shall be provided and shall consist of:

.1 at least one fully charged spare air bottle for each breathing apparatus required by 14.3.1;

.2 an air compressor of adequate capacity capable of continuous operation, suitable for the supply of high-pressure air of breathable quality; and

.3 a charging manifold capable of dealing with sufficient spare breathing apparatus air bottles for the breathing apparatus required by 14.3.1.

14.4 Personal protection requirements for individual products

14.4.1 Requirements of this section shall apply to ships carrying products for which those paragraphs are listed in column "*i*" in the table of chapter 19.

14.4.2 Suitable respiratory and eye protection for emergency escape purposes shall be provided for every person on board, subject to the following:

.1 filter-type respiratory protection is unacceptable;

.2 self-contained breathing apparatus shall have at least a duration of service of 15 min; and

.3 emergency escape respiratory protection shall not be used for firefighting or cargo-handling purposes and shall be marked to that effect.

14.4.3 One or more suitably marked decontamination showers and eyewash stations shall be available on deck, taking into account the size and layout of the ship. The showers and eyewashes shall be operable in all ambient conditions.

14.4.4 The protective clothing required under 14.3.2.2 shall be gastight.

CHAPTER 15

FILLING LIMITS FOR CARGO TANKS

Goal

To determine the maximum quantity of cargo that can be loaded.

15.1 Definitions

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

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

15.1.3 *Reference temperature* means (for the purposes of this chapter only):

.1 when no cargo vapour pressure/temperature control, as referred to in chapter 7, is provided, the temperature corresponding to the vapour pressure of the cargo at the set pressure of the PRVs; and

.2 when a cargo vapour pressure/temperature control, as referred to in chapter 7, is provided, the temperature of the cargo upon termination of loading, during transport or at unloading, whichever is the greatest.

15.1.4 *Ambient design temperature for unrestricted service* means sea temperature of 32°C and air temperature of 45°C. However, lesser values of these temperatures may be accepted by the Administration 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 these temperatures may be required for ships permanently operating in areas of high-ambient temperature.

15.2 General requirements

The maximum filling limit of cargo tanks shall be so determined that the vapour space has a minimum volume at reference temperature allowing for:

.1 tolerance of instrumentation such as level and temperature gauges;

.2 volumetric expansion of the cargo between the PRV set pressure and the maximum allowable rise stated in 8.4; and

.3 an operational margin to account for liquid drained back to cargo tanks after completion of loading, operator reaction time and closing time of valves, see 5.5 and 18.10.2.1.4.

15.3 Default filling limit

The default value for the filling limit (*FL*) of cargo tanks is 98% at the reference temperature. Exceptions to this value shall meet the requirements of 15.4.

15.4 Determination of increased filling limit

15.4.1 A filling limit greater than the limit of 98% specified in 15.3 may be permitted under the trim and list conditions specified in 8.2.17, providing:

.1 no isolated vapour pockets are created within the cargo tank;

.2 the PRV inlet arrangement shall remain in the vapour space; and

.3 allowances need to be provided for:

  .1 volumetric expansion of the liquid cargo due to the pressure increase from the MARVS to full flow relieving pressure in accordance with 8.4.1;

  .2 an operational margin of minimum 0.1% of tank volume; and

  .3 tolerances of instrumentation such as level and temperature gauges.

15.4.2 In no case shall a filling limit exceeding 99.5% at reference temperature be permitted.

15.5 Maximum loading limit

15.5.1 The maximum loading limit (LL) to which a cargo tank may be loaded shall be determined by the following formula:

$$LL = FL \frac{\rho_R}{\rho_L}$$

where:

LL = loading limit as defined in 15.1.2, expressed in percentage;

FL = filling limit as specified in 15.3 or 15.4 expressed in percentage;

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

ρ_L = relative density of cargo at the loading temperature.

15.5.2 The Administration may allow type C tanks to be loaded according to the formula in 15.5.1 with the relative density ρ_R as defined below, provided that the tank vent system has been approved in accordance with 8.2.18:

ρ_R = relative density of cargo at the highest temperature that the cargo may reach upon termination of loading, during transport, or at unloading, under the ambient design temperature conditions described in 15.1.4.

This paragraph does not apply to products requiring a type 1G ship.

15.6 Information to be provided to the master

15.6.1 A document shall be provided to the ship, specifying the maximum allowable loading limits for each cargo tank and product, at each applicable loading temperature and maximum reference temperature. The information in this document shall be approved by the Administration or recognized organization acting on its behalf.

15.6.2 Pressures at which the PRVs have been set shall also be stated in the document.

15.6.3 A copy of the above document shall be permanently kept on board by the master.

CHAPTER 16

USE OF CARGO AS FUEL

Goal

To ensure the safe use of cargo as fuel.

16.1 General

Except as provided for in 16.9, methane (LNG) is the only cargo whose vapour or boil-off gas may be utilized in machinery spaces of category A, and, in these spaces, it may be utilized only in systems such as boilers, inert gas generators, internal combustion engines, gas combustion unit and gas turbines.

16.2 Use of cargo vapour as fuel

This section addresses the use of cargo vapour as fuel in systems such as boilers, inert gas generators, internal combustion engines, gas combustion units and gas turbines.

16.2.1 For vaporized LNG, the fuel supply system shall comply with the requirements of 16.4.1, 16.4.2 and 16.4.3.

16.2.2 For vaporized LNG, gas consumers shall exhibit no visible flame and shall maintain the uptake exhaust temperature below 535°C.

16.3 Arrangement of spaces containing gas consumers

16.3.1 Spaces in which gas consumers are located shall be fitted with a mechanical ventilation system that is arranged to avoid areas where gas may accumulate, taking into account the density of the vapour and potential ignition sources. The ventilation system shall be separated from those serving other spaces.

16.3.2 Gas detectors shall be fitted in these spaces, particularly where air circulation is reduced. The gas detection system shall comply with the requirements of chapter 13.

16.3.3 Electrical equipment located in the double wall pipe or duct specified in 16.4.3 shall comply with the requirements of chapter 10.

16.3.4 All vents and bleed lines that may contain or be contaminated by gas fuel shall be routed to a safe location external to the machinery space and be fitted with a flame screen.

16.4 Gas fuel supply

16.4.1 *General*

16.4.1.1 The requirements of this section shall apply to gas fuel supply piping outside of the cargo area. Fuel piping shall not pass through accommodation spaces, service spaces, electrical equipment rooms or control stations. The routeing of the pipeline shall take into account potential hazards, due to mechanical damage, in areas such as stores or machinery handling areas.

16.4.1.2 Provision shall be made for inerting and gas-freeing that portion of the gas fuel piping systems located in the machinery space.

16.4.2 *Leak detection*

Continuous monitoring and alarms shall be provided to indicate a leak in the piping system in enclosed spaces and shut down the relevant gas fuel supply.

16.4.3 *Routeing of fuel supply pipes*

Fuel piping may pass through or extend into enclosed spaces other than those mentioned in 16.4.1, provided it fulfils one of the following conditions:

.1 it is of a double-wall design with the space between the concentric pipes pressurized with inert gas at a pressure greater than the gas fuel pressure. The master gas fuel valve, as required by 16.4.6, closes automatically upon loss of inert gas pressure; or

.2 it is installed in a pipe or duct equipped with mechanical exhaust ventilation having a capacity of at least 30 air changes per hour and is arranged to maintain a pressure less than the atmospheric pressure. The mechanical ventilation is in accordance with chapter 12, as applicable. The ventilation is always in operation when there is fuel in the piping and the master gas fuel valve, as required by 16.4.6, closes automatically if the required air flow is not established and maintained by the exhaust ventilation system. The inlet or the duct may be from a non-hazardous machinery space, and the ventilation outlet is in a safe location.

16.4.4 ***Requirements for gas fuel with pressure greater than 1 MPa***

16.4.4.1 Fuel delivery lines between the high-pressure fuel pumps/compressors and consumers shall be protected with a double-walled piping system capable of containing a high pressure line failure, taking into account the effects of both pressure and low temperature. A single-walled pipe in the cargo area up to the isolating valve(s) required by 16.4.6 is acceptable.

16.4.4.2 The arrangement in 16.4.3.2 may also be acceptable providing the pipe or trunk is capable of containing a high pressure line failure, according to the requirements of 16.4.7 and taking into account the effects of both pressure and possible low temperature and providing both inlet and exhaust of the outer pipe or trunk are in the cargo area.

16.4.5 ***Gas consumer isolation***

The supply piping of each gas consumer unit shall be provided with gas fuel isolation by automatic double block and bleed, vented to a safe location, under both normal and emergency operation. The automatic valves shall be arranged to fail to the closed position on loss of actuating power. In a space containing multiple consumers, the shutdown of one shall not affect the gas supply to the others.

16.4.6 ***Spaces containing gas consumers***

16.4.6.1 It shall be possible to isolate the gas fuel supply to each individual space containing a gas consumer(s) or through which fuel gas supply piping is run, with an individual master valve, which is located within the cargo area. The isolation of gas fuel supply to a space shall not affect the gas supply to other spaces containing gas consumers if they are located in two or more spaces, and it shall not cause loss of propulsion or electrical power.

16.4.6.2 If the double barrier around the gas supply system is not continuous due to air inlets or other openings, or if there is any point where single failure will cause leakage into the space, the individual master valve for the space shall operate under the following circumstances:

.1 automatically by:

.1 gas detection within the space;

.2 leak detection in the annular space of a double-walled pipe;

.3 leak detection in other compartments inside the space, containing single-walled gas piping;

.4 loss of ventilation in the annular space of a double-walled pipe; and

.5 loss of ventilation in other compartments inside the space, containing single-walled gas piping; and

.2 manually from within the space, and at least one remote location.

16.4.6.3 If the double barrier around the gas supply system is continuous, an individual master valve located in the cargo area may be provided for each gas consumer inside the space. The individual master valve shall operate under the following circumstances:

.1 automatically by:

.1 leak detection in the annular space of a double-walled pipe served by that individual master valve;

.2 leak detection in other compartments containing single-walled gas piping that is part of the supply system served by the individual master valve; and

.3 loss of ventilation or loss of pressure in the annular space of a double-walled pipe; and

.2 manually from within the space, and at least one remote location.

16.4.7 *Piping and ducting construction*

Gas fuel piping in machinery spaces shall comply with 5.1 to 5.9, as applicable. The piping shall, as far as practicable, have welded joints. Those parts of the gas fuel piping that are not enclosed in a ventilated pipe or duct according to 16.4.3, and are on the weather decks outside the cargo area, shall have full penetration butt-welded joints and shall be fully radiographed.

16.4.8 *Gas detection*

Gas detection systems provided in accordance with the requirements of this chapter shall activate the alarm at 30% LFL and shut down the master gas fuel valve required by 16.4.6 at not more than 60% LFL (see 13.6.17).

16.5 Gas fuel plant and related storage tanks

16.5.1 *Provision of gas fuel*

All equipment (heaters, compressors, vaporizers, filters, etc.) for conditioning the cargo and/or cargo boil off vapour for its use as fuel, and any related storage tanks, shall be located in the cargo area. If the equipment is in an enclosed space, the space shall be ventilated according to 12.1 and be equipped with a fixed fire-extinguishing system, according to 11.5, and with a gas detection system according to 13.6, as applicable.

16.5.2 *Remote stops*

16.5.2.1 All rotating equipment utilized for conditioning the cargo for its use as fuel shall be arranged for manual remote stop from the engine-room. Additional remote stops shall be located in areas that are always easily accessible, typically cargo control room, navigation bridge and fire control station.

16.5.2.2 The fuel supply equipment shall be automatically stopped in the case of low suction pressure or fire detection. Unless expressly provided otherwise, the requirements of 18.10 need not apply to gas fuel compressors or pumps when used to supply gas consumers.

16.5.3 ***Heating and cooling mediums***

If the heating or cooling medium for the gas fuel conditioning system is returned to spaces outside the cargo area, provisions shall be made to detect and alarm the presence of cargo/cargo vapour in the medium. Any vent outlet shall be in a safe position and fitted with an effective flame screen of an approved type.

16.5.4 ***Piping and pressure vessels***

Piping or pressure vessels fitted in the gas fuel supply system shall comply with chapter 5.

16.6 Special requirements for main boilers

16.6.1 ***Arrangements***

16.6.1.1 Each boiler shall have a separate exhaust uptake.

16.6.1.2 Each boiler shall have a dedicated forced draught system. A crossover between boiler force draught systems may be fitted for emergency use providing that any relevant safety functions are maintained.

16.6.1.3 Combustion chambers and uptakes of boilers shall be designed to prevent any accumulation of gaseous fuel.

16.6.2 ***Combustion equipment***

16.6.2.1 The burner systems shall be of dual type, suitable to burn either: oil fuel or gas fuel alone, or oil and gas fuel simultaneously.

16.6.2.2 Burners shall be designed to maintain stable combustion under all firing conditions.

16.6.2.3 An automatic system shall be fitted to change over from gas fuel operation to oil fuel operation without interruption of the boiler firing, in the event of loss of gas fuel supply.

16.6.2.4 Gas nozzles and the burner control system shall be configured such that gas fuel can only be ignited by an established oil fuel flame, unless the boiler and combustion equipment is designed and approved by recognized organization to light on gas fuel.

16.6.3 ***Safety***

16.6.3.1 There shall be arrangements to ensure that gas fuel flow to the burner is automatically cut-off, unless satisfactory ignition has been established and maintained.

16.6.3.2 On the pipe of each gas-burner, a manually operated shut-off valve shall be fitted.

16.6.3.3 Provisions shall be made for automatically purging the gas supply piping to the burners, by means of an inert gas, after the extinguishing of these burners.

16.6.3.4 The automatic fuel changeover system required by 16.6.2.3 shall be monitored with alarms to ensure continuous availability.

16.6.3.5 Arrangements shall be made that, in case of flame failure of all operating burners, the combustion chambers of the boilers are automatically purged before relighting.

16.6.3.6 Arrangements shall be made to enable the boilers to be manually purged.

16.7 Special requirements for gas-fired internal combustion engines

Dual fuel engines are those that employ gas fuel (with pilot oil) and oil fuel. Oil fuels may include distillate and residual fuels. Gas only engines are those that employ gas fuel only.

16.7.1 *Arrangements*

16.7.1.1 When gas is supplied in a mixture with air through a common manifold, flame arrestors shall be installed before each cylinder head.

16.7.1.2 Each engine shall have its own separate exhaust.

16.7.1.3 The exhausts shall be configured to prevent any accumulation of unburnt gaseous fuel.

16.7.1.4 Unless designed with the strength to withstand the worst case overpressure due to ignited gas leaks, air inlet manifolds, scavenge spaces, exhaust system and crank cases shall be fitted with suitable pressure relief systems. Pressure relief systems shall lead to a safe location, away from personnel.

16.7.1.5 Each engine shall be fitted with vent systems independent of other engines for crankcases, sumps and cooling systems.

16.7.2 *Combustion equipment*

16.7.2.1 Prior to admission of gas fuel, correct operation of the pilot oil injection system on each unit shall be verified.

16.7.2.2 For a spark ignition engine, if ignition has not been detected by the engine monitoring system within an engine specific time after opening of the gas supply valve, this shall be automatically shut off and the starting sequence terminated. It shall be ensured that any unburnt gas mixture is purged from the exhaust system.

16.7.2.3 For dual-fuel engines fitted with a pilot oil injection system, an automatic system shall be fitted to change over from gas fuel operation to oil fuel operation with minimum fluctuation of the engine power.

16.7.2.4 In the case of unstable operation on engines with the arrangement in 16.7.2.3 when gas firing, the engine shall automatically change to oil fuel mode.

16.7.3 *Safety*

16.7.3.1 During stopping of the engine, the gas fuel shall be automatically shut off before the ignition source.

16.7.3.2 Arrangements shall be provided to ensure that there is no unburnt gas fuel in the exhaust gas system prior to ignition.

16.7.3.3 Crankcases, sumps, scavenge spaces and cooling system vents shall be provided with gas detection (see 13.6.17).

16.7.3.4 Provision shall be made within the design of the engine to permit continuous monitoring of possible sources of ignition within the crank case. Instrumentation fitted inside the crankcase shall be in accordance with the requirements of chapter 10.

16.7.3.5 A means shall be provided to monitor and detect poor combustion or misfiring that may lead to unburnt gas fuel in the exhaust system during operation. In the event that it is detected, the gas fuel supply shall be shut down. Instrumentation fitted inside the exhaust system shall be in accordance with the requirements of chapter 10.

16.8 Special requirements for gas turbine

16.8.1 *Arrangements*

16.8.1.1 Each turbine shall have its own separate exhaust.

16.8.1.2 The exhausts shall be appropriately configured to prevent any accumulation of unburnt gas fuel.

16.8.1.3 Unless designed with the strength to withstand the worst case overpressure due to ignited gas leaks, pressure relief systems shall be suitably designed and fitted to the exhaust system, taking into consideration explosions due to gas leaks. Pressure relief systems within the exhaust uptakes shall be lead to a non-hazardous location, away from personnel.

16.8.2 *Combustion equipment*

An automatic system shall be fitted to change over easily and quickly from gas fuel operation to oil fuel operation with minimum fluctuation of the engine power.

16.8.3 *Safety*

16.8.3.1 Means shall be provided to monitor and detect poor combustion that may lead to unburnt gas fuel in the exhaust system during operation. In the event that it is detected, the gas fuel supply shall be shut down.

16.8.3.2 Each turbine shall be fitted with an automatic shutdown device for high exhaust temperatures.

16.9 Alternative fuels and technologies

16.9.1 If acceptable to the Administration, other cargo gases may be used as fuel, providing that the same level of safety as natural gas in this Code is ensured.

16.9.2 The use of cargoes identified as toxic products shall not be permitted.

16.9.3 For cargoes other than LNG, the fuel supply system shall comply with the requirements of 16.4.1, 16.4.2, 16.4.3 and 16.5, as applicable, and shall include means for preventing condensation of vapour in the system.

16.9.4 Liquefied gas fuel supply systems shall comply with 16.4.5.

16.9.5 In addition to the requirements of 16.4.3.2, both ventilation inlet and outlet shall be in a non-hazardous area external to the machinery space.

CHAPTER 17

SPECIAL REQUIREMENTS

Goal

To set out the additional requirements in respect of specific cargoes.

17.1 General

The requirements of this chapter are applicable where reference thereto is made in column "*i*" in the table of chapter 19. These requirements are additional to the general requirements of the Code.

17.2 Materials of construction

Materials that may be exposed to cargo during normal operations shall be resistant to the corrosive action of the gases. In addition, the following materials of construction for cargo tanks and associated pipelines, valves, fittings and other items of equipment normally in direct contact with the cargo liquid or vapour shall not be used for certain products as specified in column "*i*" in the table of chapter 19:

.1 mercury, copper and copper-bearing alloys, and zinc;

.2 copper, silver, mercury, magnesium and other acetylide-forming metals;

.3 aluminium and aluminium-bearing alloys;

.4 copper, copper alloys, zinc and galvanized steel;

.5 aluminium, copper and alloys of either; and

.6 copper and copper-bearing alloys with greater than 1% copper.

17.3 Independent tanks

17.3.1 Products shall be carried in independent tanks only.

17.3.2 Products shall be carried in type C independent tanks, and the requirements of 7.1.2 shall apply. The design pressure of the cargo tank shall take into account any padding pressure or vapour discharge unloading pressure.

17.4 Refrigeration systems

17.4.1 Only the indirect system described in 7.3.1.2 shall be used.

17.4.2 For a ship engaged in the carriage of products that readily form dangerous peroxides, recondensed cargo shall not be allowed to form stagnant pockets of uninhibited liquid. This may be achieved either by:

.1 using the indirect system described in 7.3.1.2, with the condenser inside the cargo tank; or

.2 using the direct system or combined system described in 7.3.1.1 and .3 respectively, or the indirect system described in 7.3.1.2 with the condenser outside the cargo tank, and designing the condensate system to avoid any places in which liquid could collect and be retained. Where this is impossible, inhibited liquid shall be added upstream of such a place.

17.4.3 If the ship is to consecutively carry products as specified in 17.4.2 with a ballast passage between, all uninhibited liquid shall be removed prior to the ballast voyage. If a second cargo is to be carried between such consecutive cargoes, the reliquefaction system shall be thoroughly drained and purged before loading the second cargo. Purging shall be carried out using either inert gas or vapour from the second cargo, if compatible. Practical steps shall be taken to ensure that polymers or peroxides do not accumulate in the cargo system.

17.5 Cargoes requiring type 1G ship

17.5.1 All butt-welded joints in cargo piping exceeding 75 mm in diameter shall be subject to 100% radiography.

17.5.2 Gas sampling lines shall not be led into or through non-hazardous areas. Alarms referred to in 13.6.2 shall be activated when the vapour concentration reaches the threshold limiting value.

17.5.3 The alternative of using portable gas detection equipment in accordance with 13.6.5 shall not be permitted.

17.5.4 Cargo control rooms shall be located in a non-hazardous area and, additionally, all instrumentation shall be of the indirect type.

17.5.5 Personnel shall be protected against the effects of a major cargo release by the provision of a space within the accommodation area that is designed and equipped to the satisfaction of the Administration.

17.5.6 Notwithstanding the requirements in 3.2.4.3, access to forecastle spaces shall not be permitted through a door facing the cargo area, unless airlock in accordance with 3.6 is provided.

17.5.7 Notwithstanding the requirements in 3.2.7, access to control rooms and machinery spaces of turret systems shall not be permitted through doors facing the cargo area.

17.6 Exclusion of air from vapour spaces

Air shall be removed from cargo tanks and associated piping before loading and, then, subsequently excluded by:

.1 introducing inert gas to maintain a positive pressure. Storage or production capacity of the inert gas shall be sufficient to meet normal operating requirements and relief valve leakage. The oxygen content of inert gas shall, at no time, be greater than 0.2% by volume; or

.2 control of cargo temperatures such that a positive pressure is maintained at all times.

17.7 Moisture control

For gases that are non-flammable and may become corrosive or react dangerously with water, moisture control shall be provided to ensure that cargo tanks are dry before loading and that, during discharge, dry air or cargo vapour is introduced to prevent negative pressures. For the purposes of this paragraph, dry air is air that has a dew point of -45°C or below at atmospheric pressure.

17.8 Inhibition

Care shall be taken to ensure that the cargo is sufficiently inhibited to prevent self-reaction (e.g. polymerization or dimerization) at all times during the voyage. Ships shall be provided with a certificate from the manufacturer stating:

.1 name and amount of inhibitor added;

.2 date inhibitor was added and the normally expected duration of its effectiveness;

.3 any temperature limitations affecting the inhibitor; and

.4 the action to be taken should the length of the voyage exceed the effective lifetime of the inhibitors.

17.9 Flame screens on vent outlets

When carrying a cargo referenced to this section, cargo tank vent outlets shall be provided with readily renewable and effective flame screens or safety heads of an approved type. Due attention shall be paid in the design of flame screens and vent heads, to the possibility of the blockage of these devices by the freezing of cargo vapour or by icing up in adverse weather conditions. Flame screens shall be removed and replaced by protection screens, in accordance with 8.2.15, when carrying cargoes not referenced to this section.

17.10 Maximum allowable quantity of cargo per tank

When carrying a cargo referenced to this section, the quantity of the cargo shall not exceed 3,000 m^3 in any one tank.

17.11 Cargo pumps and discharge arrangements

17.11.1 The vapour space of cargo tanks equipped with submerged electric motor pumps shall be inerted to a positive pressure prior to loading, during carriage and during unloading of flammable liquids.

17.11.2 The cargo shall be discharged only by deepwell pumps or by hydraulically operated submerged pumps. These pumps shall be of a type designed to avoid liquid pressure against the shaft gland.

17.11.3 Inert gas displacement may be used for discharging cargo from type C independent tanks, provided the cargo system is designed for the expected pressure.

17.12 Ammonia

17.12.1 Anhydrous ammonia may cause stress corrosion cracking in containment and process systems made of carbon-manganese steel or nickel steel. To minimize the risk of this occurring, measures detailed in 17.12.2 to 17.12.8 shall be taken, as appropriate.

17.12.2 Where carbon-manganese steel is used, cargo tanks, process pressure vessels and cargo piping shall be made of fine-grained steel with a specified minimum yield strength not exceeding 355 N/mm^2, and with an actual yield strength not exceeding 440 N/mm^2. One of the following constructional or operational measures shall also be taken:

.1 lower strength material with a specified minimum tensile strength not exceeding 410 N/mm^2 shall be used; or

.2 cargo tanks, etc., shall be post-weld stress relief heat treated; or

.3 carriage temperature shall be maintained, preferably at a temperature close to the product's boiling point of -33°C, but in no case at a temperature above -20°C; or

.4 the ammonia shall contain not less than 0.1% w/w water, and the master shall be provided with documentation confirming this.

17.12.3 If carbon-manganese steels with higher yield properties are used other than those specified in 17.12.2, the completed cargo tanks, piping, etc., shall be given a post-weld stress relief heat treatment.

17.12.4 Process pressure vessels and piping of the condensate part of the refrigeration system shall be given a post-weld stress relief heat treatment when made of materials mentioned in 17.12.1.

17.12.5 The tensile and yield properties of the welding consumables shall exceed those of the tank or piping material by the smallest practical amount.

17.12.6 Nickel steel containing more than 5% nickel and carbon-manganese steel, not complying with the requirements of 17.12.2 and 17.12.3, are particularly susceptible to ammonia stress corrosion cracking and shall not be used in containment and piping systems for the carriage of this product.

17.12.7 Nickel steel containing not more than 5% nickel may be used, provided the carriage temperature complies with the requirements specified in 17.12.2.3.

17.12.8 To minimize the risk of ammonia stress corrosion cracking, it is advisable to keep the dissolved oxygen content below 2.5 ppm w/w. This can best be achieved by reducing the average oxygen content in the tanks prior to the introduction of liquid ammonia to less than the values given as a function of the carriage temperature *T* in the table below:

T (°C)	**O_2 (% v/v)**
-30 and below	0.9
-20	0.5
-10	0.28
0	0.16
10	0.1
20	0.05
30	0.03

Oxygen percentages for intermediate temperatures may be obtained by direct interpolation.

17.13 Chlorine

17.13.1 *Cargo containment system*

17.13.1.1 The capacity of each tank shall not exceed 600 m^3 and the total capacity of all cargo tanks shall not exceed 1,200 m^3.

17.13.1.2 The tank design vapour pressure shall not be less than 1.35 MPa (see 7.1.2 and 17.3.2).

17.13.1.3 Parts of tanks protruding above the upper deck shall be provided with protection against thermal radiation, taking into account total engulfment by fire.

17.13.1.4 Each tank shall be provided with two PRVs. A bursting disc of appropriate material shall be installed between the tank and the PRVs. The rupture pressure of the bursting disc shall be 0.1 MPa lower than the opening pressure of the pressure relief valve, which shall be set at the design vapour pressure of the tank but not less than 1.35 MPa gauge. The space between the bursting disc and the relief valve shall be connected through an excess flow valve to a pressure gauge and a gas detection system. Provisions shall be made to keep this space at or near the atmospheric pressure during normal operation.

17.13.1.5 Outlets from PRVs shall be arranged in such a way as to minimize the hazards on board the ship as well as to the environment. Leakage from the relief valves shall be led through the absorption plant to reduce the gas concentration as far as possible. The relief valve exhaust line shall be arranged at the forward end of the ship to discharge outboard at deck level with an arrangement to select either port or starboard side, with a mechanical interlock to ensure that one line is always open.

17.13.1.6 The Administration and the port Administration may require that chlorine is carried in a refrigerated state at a specified maximum pressure.

17.13.2 ***Cargo piping systems***

17.13.2.1 Cargo discharge shall be performed by means of compressed chlorine vapour from shore, dry air or another acceptable gas, or fully submerged pumps. Cargo discharge compressors on board ships shall not be used for this. The pressure in the vapour space of the tank during discharging shall not exceed 1.05 MPa gauge.

17.13.2.2 The design pressure of the cargo piping system shall be not less than 2.1 MPa gauge. The internal diameter of the cargo pipes shall not exceed 100 mm. Only pipe bends shall be accepted for compensation of pipeline thermal movement. The use of flanged joints shall be restricted to a minimum and, when used, the flanges shall be of the welding neck type with tongue and groove.

17.13.2.3 Relief valves of the cargo piping system shall discharge to the absorption plant, and the flow restriction created by this unit shall be taken into account when designing the relief valve system (see 8.4.3 and 8.4.4).

17.13.3 ***Materials***

17.13.3.1 The cargo tanks and cargo piping systems shall be made of steel suitable for the cargo and for a temperature of -40ºC, even if a higher transport temperature is intended to be used.

17.13.3.2 The tanks shall be thermally stress relieved. Mechanical stress relief shall not be accepted as an equivalent.

17.13.4 ***Instrumentation: safety devices***

17.13.4.1 The ship shall be provided with a chlorine absorbing plant with a connection to the cargo piping system and the cargo tanks. The absorbing plant shall be capable of neutralizing at least 2% of the total cargo capacity at a reasonable absorption rate.

17.13.4.2 During the gas-freeing of cargo tanks, vapours shall not be discharged to the atmosphere.

17.13.4.3 A gas detecting system shall be provided that is capable of monitoring chlorine concentrations of at least 1 ppm by volume. Sample points shall be located:

.1 near the bottom of the hold spaces;

.2 in the pipes from the safety relief valves;

.3 at the outlet from the gas absorbing plant;

.4 at the inlet to the ventilation systems for the accommodation, service and machinery spaces and control stations; and

.5 on deck – at the forward end, midships and the after end of the cargo area. This is only required to be used during cargo handling and gas-freeing operations.

The gas detection system shall be provided with an audible and visual alarm with a set point of 5 ppm.

17.13.4.4 Each cargo tank shall be fitted with a high-pressure alarm giving an audible alarm at a pressure equal to 1.05 MPa gauge.

17.13.5 ***Personnel protection***

The enclosed space required by 17.5.5 shall meet the following requirements:

.1 the space shall be easily and quickly accessible from the weather decks and from accommodation spaces by means of air locks, and shall be capable of being rapidly closed gastight;

.2 one of the decontamination showers required by 14.4.3 shall be located near the weather deck airlock to the space;

.3 the space shall be designed to accommodate the entire crew of the ship and be provided with a source of uncontaminated air for a period of not less than 4 h; and

.4 one set of oxygen therapy equipment shall be carried in the space.

17.13.6 ***Filling limits for cargo tanks***

17.13.6.1 The requirements of 15.1.3.2 do not apply when it is intended to carry chlorine.

17.13.6.2 The chlorine content of the gas in the vapour space of the cargo tank after loading shall be greater than 80% by volume.

17.14 Ethylene oxide

17.14.1 For the carriage of ethylene oxide, the requirements of 17.18 shall apply, with the additions and modifications as given in this section.

17.14.2 Deck tanks shall not be used for the carriage of ethylene oxide.

17.14.3 Stainless steels types 416 and 442, as well as cast iron, shall not be used in ethylene oxide cargo containment and piping systems.

17.14.4 Before loading, tanks shall be thoroughly and effectively cleaned to remove all traces of previous cargoes from tanks and associated pipework, except where the immediate prior cargo has been ethylene oxide, propylene oxide or mixtures of these products. Particular care shall be taken in the case of ammonia in tanks made of steel other than stainless steel.

17.14.5 Ethylene oxide shall be discharged only by deepwell pumps or inert gas displacement. The arrangement of pumps shall comply with 17.18.15.

17.14.6 Ethylene oxide shall be carried refrigerated only and maintained at temperatures of less than 30°C.

17.14.7 PRVs shall be set at a pressure of not less than 0.55 MPa gauge. The maximum set pressure shall be specially approved by the Administration.

17.14.8 The protective padding of nitrogen gas, as required by 17.18.27, shall be such that the nitrogen concentration in the vapour space of the cargo tank will, at no time, be less than 45% by volume.

17.14.9 Before loading, and at all times when the cargo tank contains ethylene oxide liquid or vapour, the cargo tank shall be inerted with nitrogen.

17.14.10 The water-spray system required by 17.18.29 and that required by 11.3 shall operate automatically in a fire involving the cargo containment system.

17.14.11 A jettisoning arrangement shall be provided to allow the emergency discharge of ethylene oxide in the event of uncontrollable self-reaction.

17.15 Separate piping systems

Separate piping systems, as defined in 1.2.47, shall be provided.

17.16 Methyl acetylene-propadiene mixtures

17.16.1 Methyl acetylene-propadiene mixtures shall be suitably stabilized for transport. Additionally, upper limits of temperatures and pressure during the refrigeration shall be specified for the mixtures.

17.16.2 Examples of acceptable stabilized compositions are:

- .1 Composition 1:
  - .1 maximum methyl acetylene to propadiene molar ratio of 3 to 1;
  - .2 maximum combined concentration of methyl acetylene and propadiene of 65 mol%;
  - .3 minimum combined concentration of propane, butane, and isobutane of 24 mol%, of which at least one third (on a molar basis) shall be butanes and one third propane;
  - .4 maximum combined concentration of propylene and butadiene of 10 mol%;
- .2 Composition 2:
  - .1 maximum methyl acetylene and propadiene combined concentration of 30 mol%;
  - .2 maximum methyl acetylene concentration of 20 mol%;
  - .3 maximum propadiene concentration of 20 mol%;

.4 maximum propylene concentration of 45 mol%;

.5 maximum butadiene and butylenes combined concentration of 2 mol%;

.6 minimum saturated C4 hydrocarbon concentration of 4 mol%; and

.7 minimum propane concentration of 25 mol%.

17.16.3 Other compositions may be accepted, provided the stability of the mixture is demonstrated to the satisfaction of the Administration.

17.16.4 If a ship has a direct vapour compression refrigeration system, this shall comply with the following requirements, subject to pressure and temperature limitations depending on the composition. For the example compositions given in 17.16.2, the following features shall be provided:

.1 a vapour compressor that does not raise the temperature and pressure of the vapour above 60ºC and 1.75 MPa gauge during its operation, and that does not allow vapour to stagnate in the compressor while it continues to run;

.2 discharge piping from each compressor stage or each cylinder in the same stage of a reciprocating compressor shall have:

  .1 two temperature-actuated shutdown switches set to operate at 60ºC or less;

  .2 a pressure-actuated shutdown switch set to operate at 1.75 MPa gauge or less; and

  .3 a safety relief valve set to relieve at 1.8 MPa gauge or less;

.3 the relief valve required by .2.3 shall vent to a mast meeting the requirements of 8.2.10, 8.2.11 and 8.2.15 and shall not relieve into the compressor suction line; and

.4 an alarm that sounds in the cargo control position and in the navigation bridge when a high-pressure switch, or a high-temperature switch, operates.

17.16.5 The piping system, including the cargo refrigeration system, for tanks to be loaded with methyl acetylene-propadiene mixtures shall be either independent (as defined in 1.2.28) or separate (as defined in 1.2.47) from piping and refrigeration systems for other tanks. This segregation shall apply to all liquid and vapour vent lines and any other possible connections, such as common inert gas supply lines.

17.17 Nitrogen

Materials of construction and ancillary equipment such as insulation shall be resistant to the effects of high oxygen concentrations caused by condensation and enrichment at the low temperatures attained in parts of the cargo system. Due consideration shall be given to ventilation in areas where condensation might occur, to avoid the stratification of oxygen-enriched atmosphere.

17.18 Propylene oxide and mixtures of ethylene oxide-propylene oxide with ethylene oxide content of not more than 30% by weight

17.18.1 Products transported under the provisions of this section shall be acetylene-free.

17.18.2 Unless cargo tanks are properly cleaned, these products shall not be carried in tanks that have contained as one of the three previous cargoes any product known to catalyse polymerization, such as:

.1 anhydrous ammonia and ammonia solutions;

.2 amines and amine solutions; and

.3 oxidizing substances (e.g. chlorine).

17.18.3 Before loading, tanks shall be thoroughly and effectively cleaned to remove all traces of previous cargoes from tanks and associated pipework, except where the immediate prior cargo has been propylene oxide or ethylene oxide-propylene oxide mixtures. Particular care shall be taken in the case of ammonia in tanks made of steel other than stainless steel.

17.18.4 In all cases, the effectiveness of cleaning procedures for tanks and associated pipework shall be checked, by suitable testing or inspection, to ascertain that no traces of acidic or alkaline materials remain that might create a hazardous situation in the presence of these products.

17.18.5 Tanks shall be entered and inspected prior to each initial loading of these products to ensure freedom from contamination, heavy rust deposits and any visible structural defects. When cargo tanks are in continuous service for these products, such inspections shall be performed at intervals of not more than two years.

17.18.6 Tanks for the carriage of these products shall be of steel or stainless steel construction.

17.18.7 Tanks that have contained these products may be used for other cargoes after thorough cleaning of tanks and associated pipework systems by washing or purging.

17.18.8 All valves, flanges, fittings and accessory equipment shall be of a type suitable for use with these products and shall be constructed of steel or stainless steel in accordance with recognized standards. Disc or disc faces, seats and other wearing parts of valves shall be made of stainless steel containing not less than 11% chromium.

17.18.9 Gaskets shall be constructed of materials which do not react with, dissolve in, or lower the auto-ignition temperature of, these products and which are fire-resistant and possess adequate mechanical behaviour. The surface presented to the cargo shall be polytetrafluoroethylene (PTFE) or materials giving a similar degree of safety by their inertness. Spirally-wound stainless steel with a filler of PTFE or similar fluorinated polymer may be accepted, if approved by the Administration or recognized organization acting on its behalf.

17.18.10 Insulation and packing, if used, shall be of a material which does not react with, dissolve in, or lower the auto-ignition temperature of, these products.

17.18.11 The following materials are generally found unsatisfactory for use in gaskets, packing and similar uses in containment systems for these products and would require testing before being approved:

.1 neoprene or natural rubber, if it comes into contact with the products;

.2 asbestos or binders used with asbestos; and

.3 materials containing oxides of magnesium, such as mineral wools.

17.18.12 Filling and discharge piping shall extend to within 100 mm of the bottom of the tank or any sump.

17.18.13 The products shall be loaded and discharged in such a manner that venting of the tanks to atmosphere does not occur. If vapour return to shore is used during tank loading, the vapour return system connected to a containment system for the product shall be independent of all other containment systems.

17.18.14 During discharging operations, the pressure in the cargo tank shall be maintained above 0.007 MPa gauge.

17.18.15 The cargo shall be discharged only by deepwell pumps, hydraulically operated submerged pumps or inert gas displacement. Each cargo pump shall be arranged to ensure that the product does not heat significantly if the discharge line from the pump is shut off or otherwise blocked.

17.18.16 Tanks carrying these products shall be vented independently of tanks carrying other products. Facilities shall be provided for sampling the tank contents without opening the tank to atmosphere.

17.18.17 Cargo hoses used for transfer of these products shall be marked "FOR ALKYLENE OXIDE TRANSFER ONLY".

17.18.18 Hold spaces shall be monitored for these products. Hold spaces surrounding type A and type B independent tanks shall also be inerted and monitored for oxygen. The oxygen content of these spaces shall be maintained below 2% by volume. Portable sampling equipment is satisfactory.

17.18.19 Prior to disconnecting shore lines, the pressure in liquid and vapour lines shall be relieved through suitable valves installed at the loading header. Liquid and vapour from these lines shall not be discharged to atmosphere.

17.18.20 Tanks shall be designed for the maximum pressure expected to be encountered during loading, carriage or unloading of cargo.

17.18.21 Tanks for the carriage of propylene oxide with a design vapour pressure of less than 0.06 MPa, and tanks for the carriage of ethylene oxide-propylene oxide mixtures with a design vapour pressure of less than 0.12 MPa, shall have a cooling system to maintain the cargo below the reference temperature. The reference temperatures are referred to in 15.1.3.

17.18.22 Pressure relief valve settings shall not be less than 0.02 MPa gauge; and for type C independent tanks not greater than 0.7 MPa gauge for the carriage of propylene oxide and not greater than 0.53 MPa gauge for the carriage of ethylene oxide-propylene oxide mixtures.

17.18.23 The piping system for tanks to be loaded with these products shall be completely separate from piping systems for all other tanks, including empty tanks, and from all cargo compressors. If the piping system for the tanks to be loaded with these products is not independent, as defined in 1.2.28, the required piping separation shall be accomplished by the removal of spool pieces, valves, or other pipe sections and the installation of blank flanges at these locations. The required separation applies to all liquid and vapour piping, liquid and vapour vent lines and any other possible connections such as common inert gas supply lines.

17.18.24 The products shall be transported only in accordance with cargo handling plans approved by the Administration. Each intended loading arrangement shall be shown on a separate cargo handling plan. Cargo handling plans shall show the entire cargo piping system and the locations for installation of the blank flanges needed to meet the above piping separation requirements. A copy of each approved cargo handling plan shall be kept on board the ship. The International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk shall be endorsed to include references to the approved cargo handling plans.

17.18.25 Before each initial loading of these products, and before every subsequent return to such service, certification verifying that the required piping separation has been achieved shall be obtained from a responsible person acceptable to the port Administration and carried on board the ship. Each connection between a blank flange and pipeline flange shall be fitted with a wire and seal by the responsible person to ensure that inadvertent removal of the blank flange is impossible.

17.18.26 The maximum allowable loading limits for each tank shall be indicated for each loading temperature that may be applied, in accordance with 15.5.

17.18.27 The cargo shall be carried under a suitable protective padding of nitrogen gas. An automatic nitrogen make-up system shall be installed to prevent the tank pressure falling below 0.007 MPa gauge in the event of product temperature fall due to ambient conditions or malfunctioning of refrigeration system. Sufficient nitrogen shall be available on board to satisfy the demand of the automatic pressure control. Nitrogen of commercially pure quality (99.9% by volume) shall be used for padding. A battery of nitrogen bottles, connected to the cargo tanks through a pressure reduction valve, satisfies the intention of the expression "automatic" in this context.

17.18.28 The cargo tank vapour space shall be tested prior to and after loading to ensure that the oxygen content is 2% by volume or less.

17.18.29 A water-spray system of sufficient capacity shall be provided to blanket effectively the area surrounding the loading manifold, the exposed deck piping associated with product handling and the tank domes. The arrangement of piping and nozzles shall be such as to give a uniform distribution rate of $10 l/m^2$/min. The arrangement shall ensure that any spilled cargo is washed away.

17.18.30 The water-spray system shall be capable of local and remote manual operation in case of a fire involving the cargo containment system. Remote manual operation shall be arranged such that the remote starting of pumps supplying the water-spray system and remote operation of any normally closed valves in the system can be carried out from a suitable location outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the areas protected.

17.18.31 When ambient temperatures permit, a pressurized water hose ready for immediate use shall be available during loading and unloading operations, in addition to the above water-spray requirements.

17.19 Vinyl chloride

In cases where polymerization of vinyl chloride is prevented by addition of an inhibitor, 17.8 is applicable. In cases where no inhibitor has been added, or the inhibitor concentration is insufficient, any inert gas used for the purposes of 17.6 shall contain no more oxygen than 0.1% by volume. Before loading is started, inert gas samples from the tanks and piping shall be analysed. When vinyl chloride is carried, a positive pressure shall always be maintained in the tanks and during ballast voyages between successive carriages.

17.20 Mixed C4 cargoes

17.20.1 Cargoes that may be carried individually under the requirements of this Code, notably butane, butylenes and butadiene, may be carried as mixtures subject to the provisions of this section. These cargoes may variously be referred to as "Crude C4", "Crude butadiene", "Crude steam-cracked C4", "Spent steam-cracked C4", "C4 stream", "C4 raffinate", or may be shipped under a different description. In all cases, the material safety data sheets (MSDS) shall be consulted as the butadiene content of the mixture is of prime concern as it is potentially toxic and reactive. While it is recognized that butadiene has a relatively low vapour pressure, if such mixtures contain butadiene they shall be regarded as toxic and the appropriate precautions applied.

17.20.2 If the mixed C4 cargo shipped under the terms of this section contains more than 50% (mole) of butadiene, the inhibitor precautions in 17.8 shall apply.

17.20.3 Unless specific data on liquid expansion coefficients is given for the specific mixture loaded, the filling limit restrictions of chapter 15 shall be calculated as if the cargo contained 100% concentration of the component with the highest expansion ratio.

17.21 Carbon dioxide: high purity

17.21.1 Uncontrolled pressure loss from the cargo can cause "sublimation" and the cargo will change from the liquid to the solid state. The precise "triple point" temperature of a particular carbon dioxide cargo shall be supplied before loading the cargo, and will depend on the purity of that cargo, and this shall be taken into account when cargo instrumentation is adjusted. The set pressure for the alarms and automatic actions described in this section shall be set to at least 0.05 MPa above the triple point for the specific cargo being carried. The "triple point" for pure carbon dioxide occurs at 0.5 MPa gauge and -54.4°C.

17.21.2 There is a potential for the cargo to solidify in the event that a cargo tank relief valve, fitted in accordance with 8.2, fails in the open position. To avoid this, a means of isolating the cargo tank safety valves shall be provided and the requirements of 8.2.9.2 do not apply when carrying this carbon dioxide. Discharge piping from safety relief valves shall be designed so they remain free from obstructions that could cause clogging. Protective screens shall not be fitted to the outlets of relief valve discharge piping, so the requirements of 8.2.15 do not apply.

17.21.3 Discharge piping from safety relief valves are not required to comply with 8.2.10, but shall be designed so they remain free from obstructions that could cause clogging. Protective screens shall not be fitted to the outlets of relief valve discharge piping, so the requirements of 8.2.15 do not apply.

17.21.4 Cargo tanks shall be continuously monitored for low pressure when a carbon dioxide cargo is carried. An audible and visual alarm shall be given at the cargo control position and on the bridge. If the cargo tank pressure continues to fall to within 0.05 MPa of the "triple point" for the particular cargo, the monitoring system shall automatically close all cargo manifold liquid and vapour valves and stop all cargo compressors and cargo pumps. The emergency shutdown system required by 18.10 may be used for this purpose.

17.21.5 All materials used in cargo tanks and cargo piping system shall be suitable for the lowest temperature that may occur in service, which is defined as the saturation temperature of the carbon dioxide cargo at the set pressure of the automatic safety system described in 17.21.1.

17.21.6 Cargo hold spaces, cargo compressor rooms and other enclosed spaces where carbon dioxide could accumulate shall be fitted with continuous monitoring for carbon dioxide build-up. This fixed gas detection system replaces the requirements of 13.6, and hold spaces shall be monitored permanently even if the ship has type C cargo containment.

17.22 Carbon dioxide: reclaimed quality

17.22.1 The requirements of 17.21 also apply to this cargo. In addition, the materials of construction used in the cargo system shall also take account of the possibility of corrosion, in case the reclaimed quality carbon dioxide cargo contains impurities such as water, sulphur dioxide, etc., which can cause acidic corrosion or other problems.

CHAPTER 18

OPERATING REQUIREMENTS

Goal

To ensure that all ship staff involved in cargo operations have sufficient information about cargo properties and operating the cargo system so they can conduct cargo operations safely.

18.1 General

18.1.1 Those involved in liquefied gas carrier operations shall be made aware of the special requirements associated with, and precautions necessary for, their safe operation.

18.1.2 A copy of the Code, or national regulations incorporating the provisions of the Code, shall be on board every ship covered by the Code.

18.2 Cargo operations manuals

18.2.1 The ship shall be provided with copies of suitably detailed cargo system operation manuals approved by the Administration such that trained personnel can safely operate the ship with due regard to the hazards and properties of the cargoes that are permitted to be carried.

18.2.2 The content of the manuals shall include, but not be limited to:

.1 overall operation of the ship from dry-dock to dry-dock, including procedures for cargo tank cooldown and warm-up, transfer (including ship-to-ship transfer), cargo sampling, gas-freeing, ballasting, tank cleaning and changing cargoes;

.2 cargo temperature and pressure control systems;

.3 cargo system limitations, including minimum temperatures (cargo system and inner hull), maximum pressures, transfer rates, filling limits and sloshing limitations;

.4 nitrogen and inert gas systems;

.5 firefighting procedures: operation and maintenance of firefighting systems and use of extinguishing agents;

.6 special equipment needed for the safe handling of the particular cargo;

.7 fixed and portable gas detection;

.8 control, alarm and safety systems;

.9 emergency shutdown systems;

.10 procedures to change cargo tank pressure relief valve set pressures in accordance with 8.2.8 and 4.13.2.3; and

.11 emergency procedures, including cargo tank relief valve isolation, single tank gas-freeing and entry and emergency ship-to-ship transfer operations.

18.3 Cargo information

18.3.1 Information shall be on board and available to all concerned in the form of a cargo information data sheet(s) giving the necessary data for the safe carriage of cargo. Such information shall include, for each product carried:

.1 a full description of the physical and chemical properties necessary for the safe carriage and containment of the cargo;

.2 reactivity with other cargoes that are capable of being carried on board in accordance with the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk;

.3 the actions to be taken in the event of cargo spills or leaks;

.4 countermeasures against accidental personal contact;

.5 firefighting procedures and firefighting media;

.6 special equipment needed for the safe handling of the particular cargo; and

.7 emergency procedures.

18.3.2 The physical data supplied to the master, in accordance with 18.3.1.1, shall include information regarding the relative cargo density at various temperatures to enable the calculation of cargo tank filling limits in accordance with the requirements of chapter 15.

18.3.3 Contingency plans in accordance with 18.3.1.3, for spillage of cargo carried at ambient temperature, shall take account of potential local temperature reduction such as when the escaped cargo has reduced to atmospheric pressure and the potential effect of this cooling on hull steel.

18.4 Suitability for carriage

18.4.1 The master shall ascertain that the quantity and characteristics of each product to be loaded are within the limits indicated in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk required by 1.4, and in the Loading and Stability Information booklet required by 2.2.5, and that products are listed in the International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk as required under section 4 of the certificate.

18.4.2 Care shall be taken to avoid dangerous chemical reactions if cargoes are mixed. This is of particular significance in respect of:

.1 tank cleaning procedures required between successive cargoes in the same tank; and

.2 simultaneous carriage of cargoes that react when mixed. This shall be permitted only if the complete cargo systems including, but not limited to, cargo pipework, tanks, vent systems and refrigeration systems are separated as defined in 1.2.47.

18.4.3 Where products are required to be inhibited, the certificate required by 17.8 shall be supplied before departure, otherwise the cargo shall not be transported.

18.5 Carriage of cargo at low temperature

When carrying cargoes at low temperatures:

.1 the cooldown procedure laid down for that particular tank, piping and ancillary equipment shall be followed closely;

.2 loading shall be carried out in such a manner as to ensure that design temperature gradients are not exceeded in any cargo tank, piping or other ancillary equipment; and

.3 if provided, the heating arrangements associated with the cargo containment systems shall be operated in such a manner as to ensure that the temperature of the hull structure does not fall below that for which the material is designed.

18.6 Cargo transfer operations

18.6.1 A pre-cargo operations meeting shall take place between ship personnel and the persons responsible at the transfer facility. Information exchanged shall include the details of the intended cargo transfer operations and emergency procedures. A recognized industry checklist shall be completed for the intended cargo transfer and effective communications shall be maintained throughout the operation.

18.6.2 Essential cargo handling controls and alarms shall be checked and tested prior to cargo transfer operations.

18.7 Personnel training

18.7.1 Personnel shall be adequately trained in the operational and safety aspects of liquefied gas carriers as required by the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978, as amended, the International Safety Management Code and the Medical First Aid Guide (MFAG). As a minimum:

.1 all personnel shall be adequately trained in the use of protective equipment provided on board and have basic training in the procedures, appropriate to their duties, necessary under emergency conditions; and

.2 officers shall be trained in emergency procedures to deal with conditions of leakage, spillage or fire involving the cargo and a sufficient number of them shall be instructed and trained in essential first aid for the cargoes carried.

18.8 Entry into enclosed spaces

18.8.1 Under normal operational circumstances, personnel shall not enter cargo tanks, hold spaces, void spaces or other enclosed spaces where gas may accumulate, unless the gas content of the atmosphere in such space is determined by means of fixed or portable equipment to ensure oxygen sufficiency and the absence of toxic atmosphere.

18.8.2 If it is necessary to gas-free and aerate a hold space surrounding a type A cargo tank for routine inspection, and flammable cargo is carried in the cargo tank, the inspection shall be conducted when the tank contains only the minimum amount of cargo "heel" to keep the cargo tank cold. The hold shall be re-inerted as soon as the inspection is completed.

18.8.3 Personnel entering any space designated as a hazardous area on a ship carrying flammable products shall not introduce any potential source of ignition into the space, unless it has been certified gas-free and is maintained in that condition.

18.9 Cargo sampling

18.9.1 Any cargo sampling shall be conducted under the supervision of an officer who shall ensure that protective clothing appropriate to the hazards of the cargo is used by everyone involved in the operation.

18.9.2 When taking liquid cargo samples, the officer shall ensure that the sampling equipment is suitable for the temperatures and pressures involved, including cargo pump discharge pressure, if relevant.

18.9.3 The officer shall ensure that any cargo sample equipment used is connected properly to avoid any cargo leakage.

18.9.4 If the cargo to be sampled is a toxic product, the officer shall ensure that a "closed loop" sampling system as defined in 1.2.15 is used to minimize any cargo release to atmosphere.

18.9.5 After sampling operations are completed, the officer shall ensure that any sample valves used are closed properly and the connections used are correctly blanked.

18.10 Cargo emergency shutdown (ESD) system

18.10.1 *General*

18.10.1.1 A cargo emergency shutdown system shall be fitted to stop cargo flow in the event of an emergency, either internally within the ship, or during cargo transfer to ship or shore. The design of the ESD system shall avoid the potential generation of surge pressures within cargo transfer pipe work (see 18.10.2.1.4).

18.10.1.2 Auxiliary systems for conditioning the cargo that use toxic or flammable liquids or vapours shall be treated as cargo systems for the purposes of ESD. Indirect refrigeration systems using an inert medium, such as nitrogen, need not be included in the ESD function.

18.10.1.3 The ESD system shall be activated by the manual and automatic initiations listed in table 18.1. Any additional initiations shall only be included in the ESD system if it can be shown that their inclusion does not reduce the integrity and reliability of the system overall.

18.10.1.4 Ship's ESD systems shall incorporate a ship-shore link in accordance with recognized standards.

18.10.1.5 A functional flow chart of the ESD system and related systems shall be provided in the cargo control station and on the navigation bridge.

18.10.2 ***ESD valve requirements***

18.10.2.1 General

18.10.2.1.1 The term *ESD valve* means any valve operated by the ESD system.

18.10.2.1.2 ESD valves shall be remotely operated, be of the fail-closed type (closed on loss of actuating power), be capable of local manual closure and have positive indication of the actual valve position. As an alternative to the local manual closing of the ESD valve, a manually operated shut-off valve in series with the ESD valve shall be permitted. The manual valve shall be located adjacent to the ESD valve. Provisions shall be made to handle trapped liquid should the ESD valve close while the manual valve is also closed.

18.10.2.1.3 ESD valves in liquid piping systems shall close fully and smoothly within 30 s of actuation. Information about the closure time of the valves and their operating characteristics shall be available on board, and the closing time shall be verifiable and repeatable.

18.10.2.1.4 The closing time of the valve referred to in 13.3.1 to 13.3.3 (i.e. time from shutdown signal initiation to complete valve closure) shall not be greater than:

$$\frac{3600U}{LR} \qquad \text{(second)}$$

where:

U = ullage volume at operating signal level (m^3);

LR = maximum loading rate agreed between ship and shore facility (m^3/h).

The loading rate shall be adjusted to limit surge pressure on valve closure to an acceptable level, taking into account the loading hose or arm, the ship and the shore piping systems, where relevant.

18.10.2.2 Ship-shore and ship-ship manifold connections

One ESD valve shall be provided at each manifold connection. Cargo manifold connections not being used for transfer operations shall be blanked with blank flanges rated for the design pressure of the pipeline system.

18.10.2.3 Cargo system valves

If cargo system valves as defined in section 5.5 are also ESD valves within the meaning of 18.10, then the requirements of 18.10 shall apply.

18.10.3 ***ESD system controls***

18.10.3.1 As a minimum, the ESD system shall be capable of manual operation by a single control on the bridge and either in the control position required by 13.1.2 or the cargo control room, if installed, and no less than two locations in the cargo area.

18.10.3.2 The ESD system shall be automatically activated on detection of a fire on the weather decks of the cargo area and/or cargo machinery spaces. As a minimum, the method of detection used on the weather decks shall cover the liquid and vapour domes of the cargo tanks, the cargo manifolds and areas where liquid piping is dismantled regularly. Detection may be by means of fusible elements designed to melt at temperatures between 98°C and 104°C, or by area fire detection methods.

18.10.3.3 Cargo machinery that is running shall be stopped by activation of the ESD system in accordance with the cause and effect matrix in table 18.1.

18.10.3.4 The ESD control system shall be configured so as to enable the high-level testing required in 13.3.5 to be carried out in a safe and controlled manner. For the purpose of the testing, cargo pumps may be operated while the overflow control system is overridden. Procedures for level alarm testing and re-setting of the ESD system after completion of the high-level alarm testing shall be included in the operation manual required by 18.2.1.

Table 18.1 – ESD functional arrangements

	Pumps		**Compressor systems**				**Valves**	**Link**
Shutdown action → **Initiation ↓**	Cargo pumps/ cargo booster pumps	Spray/ stripping pumps	Vapour return compressors	Fuel gas compressors	Reliquefaction plant***, including condensate return pumps, if fitted	Gas combustion unit	ESD valves	Signal to ship/ shore link****
Emergency push buttons (see 18.10.3.1)	✓	✓	✓	Note 2	✓	✓	✓	✓
Fire detection on deck or in compressor house* (see 18.10.3.2)	✓	✓	✓	✓	✓	✓	✓	✓
High level in cargo tank (see 13.3.2 and 13.3.3)	✓	✓	✓	Note 1 Note 2	Note1 Note 3	Note 1	Note 6	✓
Signal from ship/shore link (see 18.10.1.4)	✓	✓	✓	Note 2	Note 3	n/a	✓	n/a
Loss of motive power to ESD valves**	✓	✓	✓	Note 2	Note 3	n/a	✓	✓
Main electric power failure ("blackout")	Note 7	Note 7	Note 7	Note 7	Note 7	Note 7	✓	✓
Level alarm override (see 13.3.7)	Note 4	Note 4 Note 5	✓	Note 1	Note1	Note 1	✓	✓

Note 1: These items of equipment can be omitted from these specific automatic shutdown initiators, provided the equipment inlets are protected against cargo liquid ingress.

Note 2: If the fuel gas compressor is used to return cargo vapour to shore, it shall be included in the ESD system when operating in this mode.

Note 3: If the reliquefaction plant compressors are used for vapour return/shore line clearing, they shall be included in the ESD system when operating in that mode.

Note 4: The override system permitted by 13.3.7 may be used at sea to prevent false alarms or shutdowns. When level alarms are overridden, operation of cargo pumps and the opening of manifold ESD valves shall be inhibited except when high-level alarm testing is carried out in accordance with 13.3.5 (see 18.10.3.4).

Note 5: Cargo spray or stripping pumps used to supply forcing vaporizer may be excluded from the ESD system only when operating in that mode.

Note 6: The sensors referred to in 13.3.2 may be used to close automatically the tank filling valve for the individual tank where the sensors are installed, as an alternative to closing the ESD valve referred to in 18.10.2.2. If this option is adopted, activation of the full ESD system shall be initiated when the high-level sensors in all the tanks to be loaded have been activated.

Note 7: These items of equipment shall be designed not to restart upon recovery of main electric power and without confirmation of safe conditions.

* Fusible plugs, electronic point temperature monitoring or area fire detection may be used for this purpose on deck.

** Failure of hydraulic, electric or pneumatic power for remotely operated ESD valve actuators.

*** Indirect refrigeration systems which form part of the reliquefaction plant do not need to be included in the ESD function if they employ an inert medium such as nitrogen in the refrigeration cycle.

**** Signal need not indicate the event initiating ESD.

✓ Functional requirement.

N/A Not applicable.

18.10.4 ***Additional shutdowns***

18.10.4.1 The requirements of 8.3.1.1 to protect the cargo tank from external differential pressure may be fulfilled by using an independent low pressure trip to activate the ESD system, or, as minimum, to stop any cargo pumps or compressors.

18.10.4.2 An input to the ESD system from the overflow control system required by 13.3 may be provided to stop any cargo pumps or compressors' running at the time a high level is detected, as this alarm may be due to inadvertent internal transfer of cargo from tank to tank.

18.10.5 ***Pre-operations testing***

Cargo emergency shutdown and alarm systems involved in cargo transfer shall be checked and tested before cargo handling operations begin.

18.11 Hot work on or near cargo containment systems

18.11.1 Special fire precautions shall be taken in the vicinity of cargo tanks and, particularly, insulation systems that may be flammable or contaminated with hydrocarbons or that may give off toxic fumes as a product of combustion.

18.12 Additional operating requirements

Additional operating requirements will be found in the following paragraphs of the Code: 2.2.2, 2.2.5, 2.2.8, 3.8.4, 3.8.5, 5.3.2, 5.3.3.3, 5.7.3, 7.1, 8.2.7, 8.2.8, 8.2.9, 9.2, 9.3, 9.4.4, 12.1.1, 13.1.3, 13.3.6, 13.6.18, 14.3.3, 15.3, 15.6, 16.6.3, 17.4.2, 17.6, 17.7, 17.9, 17.10, 17.11, 17.12, 17.13, 17.14, 17.16, 17.18, 17.19, 17.21, 17.22.

CHAPTER 19

SUMMARY OF MINIMUM REQUIREMENTS

Explanatory notes to the summary of minimum requirements

Product name *(column a)*	The product name shall be used in the shipping document for any cargo offered for bulk shipments. Any additional name may be included in brackets after the product name. In some cases, the product names are not identical with the names given in previous issues of the Code.
(column b)	*Deleted*
Ship type *(column c)*	1: Ship type 1G (2.1.2.1) 2: Ship type 2G (2.1.2.2) 3: Ship type 2PG (2.1.2.3) 4: Ship type 3G (2.1.2.4)
Independent tank type C required *(column d)*	Type C independent tank (4.23)
Tank environmental control *(column e)*	Inert: Inerting (9.4) Dry: Drying (17.7) - : No special requirements under the Code
Vapour detection *(column f)*	F: Flammable vapour detection T: Toxic vapour detection F+T: Flammable and toxic vapour detection A: Asphixiant
Gauging *(column g)*	I: Indirect or closed (13.2.3.1 and .2) R: Indirect, closed or restricted (13.2.3.1, .2, .3 and .4) C: Indirect or closed (13.2.3.1, .2 and .3)
(column h)	*Deleted*
Special requirements *(column i)*	When specific reference is made to chapters 14 and/or 17, these requirements shall be additional to the requirements in any other column.
Refrigerant gases	Non-toxic and non-flammable gases

Unless otherwise specified, gas mixtures containing less than 5% total acetylenes may be transported with no further requirements than those provided for the major components.

a	b	c	d	e	f	g	h	i
Product name		***Ship type***	***Independent tank type C required***	***Control of vapour space within cargo tanks***	***Vapour detection***	***Gauging***		***Special requirements***
Acetaldehyde		2G/2PG	-	Inert	F + T	C		14.4.2, 14.3.3.1, 17.4.1, 17.6.1
Ammonia, anhydrous		2G/2PG	-	-	T	C		14.4, 17.2.1, 17.12
Butadiene (all isomers)		2G/2PG	-	-	F + T	C		14.4, 17.2.2, 17.4.2, 17.4.3, 17.6, 17.8
Butane (all isomers)		2G/2PG	-	-	F	R		
Butane-propane mixture		2G/2PG	-	-	F	R		
Butylenes (all isomers)		2G/2PG	-	-	F	R		
Carbon Dioxide (high purity)		3G	-	-	A	R		17.21
Carbon Dioxide (Reclaimed quality)		3G	-	-	A	R		17.22
Chlorine		1G	Yes	Dry	T	I		14.4, 17.3.2, 17.4.1, 17.5, 17.7, 17.9, 17.13
Diethyl ether*		2G/2PG	-	Inert	F + T	C		14.4.1, 14.4.2, 17.2.6, 17.3.1, 17.6.1, 17.9, 17.10, 17.11.2, 17.11.3
Dimethylamine		2G/2PG	-	-	F + T	C		14.4, 17.2.1
Dimethyl Ether		2G/2PG			F + T	C		
Ethane		2G	-	-	F	R		
Ethyl Chloride		2G/2PG	-	-	F +T	C		
Ethylene		2G	-	-	F	R		
Ethylene oxide		1G	Yes	Inert	F +T	C		14.4, 17.2.2, 17.3.2, 17.4.1, 17.5, 17.6.1, 17.14
Ethylene oxide-propylene oxide mixtures with		2G/2PG	-	Inert	F +T	C		14.4.2, 17.3.1, 17.4.1, 17.6.1, 17.9, 17.10, 17.18

a **Product name**	b	c ***Ship type***	d ***Independent tank type C required***	e ***Control of vapour space within cargo tanks***	f ***Vapour detection***	g ***Gauging***	h	i ***Special requirements***
ethylene oxide content of not more than 30% by weight*								
Isoprene* (all isomers)		2G/2PG	-	-	F	R		14.4.2, 17.8, 17.9, 17.11.1
Isoprene (part refined)*		2G/2PG	-	-	F	R		14.4.2, 17.8, 17.9, 17.11.1
Isopropylamine*		2G/2PG	-	-	F +T	C		14.4.1, 14.4.2, 17.2.4, 17.9, 17.10, 17.11.1, 17.15
Methane (LNG)		2G	-	-	F	C		
Methyl acetylene-propadiene mixtures		2G/2PG	-	-	F	R		17.16
Methyl bromide		1G	Yes	-	F + T	C		14.4, 17.2.3, 17.3.2, 17.4.1, 17.5
Methyl chloride		2G/ 2PG	-	-	F + T	C		17.2.3
Mixed C4 Cargoes		2G/2PG	-	-	F + T	C		14.4, 17.2.2, 17.4.2, 17.4.3, 17.6, 17.20
Monoethylamine*		2G/2PG	-	-	F + T	C		14.4, 17.2.1, 17.3.1, 17.9, 17.10, 17.11.1, 17.15
Nitrogen		3G	-	-	A	C		17.17
Pentane (all isomers)*		2G/2PG	-	-	F	R		17.9, 17.11
Pentene (all isomers)*		2G/2PG	-	-	F	R		17.9, 17.11
Propane		2G/2PG	-	-	F	R		
Propylene		2G/2PG	-	-	F	R		
Propylene oxide*		2G/2PG	-	Inert	F + T	C		14.4.2, 17.3.1, 17.4.1, 17.6.1, 17.9, 17.10, 17.18

a Product name	*b*	*c* Ship type	*d* Independent tank type C required	*e* Control of vapour space within cargo tanks	*f* Vapour detection	*g* Gauging	*h*	*i* Special requirements
Refrigerant gases		3G	-	-	-	R		
Sulphur dioxide		1G	Yes	Dry	T	C		14.4, 17.3.2, 17.4.1, 17.5, 17.7
Vinyl chloride		2G/2PG	-	-	F + T	C		14.4.1, 14.4.2, 17.2.2, 17.2.3, 17.3.1, 17.6, 17.19
Vinyl ethyl ether*		2G/2PG	-	Inert	F + T	C		14.4.1, 14.4.2, 17.2.2, 17.3.1, 17.6.1, 17.8, 17.9, 17.10, 17.11.2, 17.11.3
Vinylidene chloride*		2G/2PG	-	Inert	F + T	C		14.4.1, 14.4.2, 17.2.5, 17.6.1, 17.8, 17.9, 17.10

* This cargo is also covered by the IBC Code.

APPENDIX 1

IGC CODE PRODUCT DATA REPORTING FORM

Characteristics of products proposed for transport on the IGC Code ships

1 PRODUCT IDENTITY

Product name

The product name should be used in the shipping document for any cargo offered for bulk shipments. Any additional name may be included in brackets after the product name.

1.1 Other names and identification numbers

Main trade name : ____________________
Main chemical name : ____________________
Chemical formula : ____________________
C.A.S number : ____________________
EHS number : ____________________
BMR number : ____________________
RTECS number : ____________________

1.2 Associated synonyms

Structure

Synonym name	Type

1.3 Composition

Component name	%	Type

2 Physical properties

Property	Units	Qual	Lower value	Upper value	Reference/ comments
Molecular weight					
Density at 20°C	(kg/m^3)				
Flash point (c.c.)	(°C)				
Boiling point	(°C)				
Water solubility at 20°C	(mg/l)				
Vapour pressure at 20°C	(Pa)				
Auto-ignition temperature	(°C)				
Explosion limits	(% v/v)				
MESG	(mm)				

3 Relevant chemical properties

Water reactivity (0 - 2) [ ]

0 = No reactivity
1 = Reactive
2 = Highly

Details [ ]

Does the product react with air to cause a potentially hazardous situation (Y/N) [ ]

If so, provide details [ ]

Reference [ ]

Is an inhibitor or stabilizer needed to prevent a hazardous reaction? (Y/N) [ ]

If so, provide details [ ]

Reference [ ]

4 Mammalian toxicity

4.1 Acute toxicity

		Qual	Lower value	Upper value	Species	Reference/ comments
Oral (mg/kg)	LD_{50}					
Dermal (mg/kg)	LD_{50}					
Inhalation (mg/l/4h)	LD_{50}					

4.2 Corrosivity and irritation

	Units	Qual.	Lower Value	Upper Value	Reference/ Comments
Skin corrosion time	(hours)				

	Resultant observation	Species	Reference/ Comments
Skin irritation (4-hour exposure)			
Eye irritation			

Not irritating, slightly irritating, mildly irritating, moderately irritating, severely irritating or corrosive

4.3 Sensitization

			Reference/Comments
Respiratory sensitizer (in humans)	(Y/N)		
Skin sensitization	(Y/N)		

4.4 Other specific long-term effects

Reference/Comments

Carcinogen	(Y/N)		
Mutagen	(Y/N)		
Toxic to reproduction	(Y/N)		
Other long term	(Y/N)		

4.5 Other relevant mammalian toxicity

5 Proposed carriage requirements

Column in the IGC Code	Property	Value
c	Ship type	
d	Type C independent tank required	
e	Control of vapour space within cargo tank	
f	Vapour detection	
g	Gauging	
i	Special requirements	

APPENDIX 2

MODEL FORM OF INTERNATIONAL CERTIFICATE OF FITNESS FOR THE CARRIAGE OF LIQUEFIED GASES IN BULK

INTERNATIONAL CERTIFICATE OF FITNESS FOR
THE CARRIAGE OF LIQUEFIED GASES IN BULK

(Official seal)

Issued under the provisions of the

INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT
OF SHIPS CARRYING LIQUEFIED GASES IN BULK

under the authority of the Government of

....

(full official designation of country)

by...

(full designation of the competent person or organization recognized by the Administration)

Particulars of ship[1]

Name of ship	....
Distinctive number or letters	....
IMO number[2]	....
Port of registry	....
Cargo capacity (m^3)	....
Ship type[3] (Code paragraph 2.1.2)	....
Date on which keel was laid or on which the ship was at a similar stage of construction or, in the case of a converted ship, date on which conversion to a gas carrier was commenced	....

The ship also complies fully with the following amendments to the Code:

....

....

The ship is exempted from compliance with the following provisions of the Code:

....

....

THIS IS TO CERTIFY:

1 That the ship has been surveyed in accordance with the provisions of section 1.4 of the Code.

2 That the survey showed that the construction and equipment of the ship and the condition thereof are in all respects satisfactory and that the ship complies with the relevant provisions of the Code.

3 That the following design criteria have been used:

.1 ambient air temperature ....°C[4]

.2 ambient water temperature..°C[4]

.3

Tank type and number	Stress factors[5]				Materials[5]	MARVS[6]
	A	B	C	D		
Cargo piping						

Note: Tank numbers referred to in this list are identified on attachment 2, signed and dated tank plan.

.4 Mechanical properties of the cargo tank materials were determined at ....°C[7].

4 That the ship is suitable for the carriage in bulk of the following products provided that all the relevant operational provisions of the Code are observed[8].

Products	**Conditions of carriage (tank numbers, etc.)**	**Minimum temperature**
Continued on attachment 1, additional signed and dated sheets. Tank numbers referred to in this list are identified on attachment 2, signed and dated tank plan.		

5 That, in accordance with 1.4/2.6.2*, the provisions of the Code are modified in respect of the ship in the following manner:

....

6 That the ship shall be loaded:

.1* only in accordance with loading conditions verified compliant with intact and damage stability requirements using the approved stability instrument fitted in accordance with paragraph 2.2.6 of the Code;

.2* where a dispensation permitted by paragraph 2.2.7 of the Code applies and the approved stability instrument required by paragraph 2.2.6 of the Code is not fitted, loading shall be made in accordance with one or more of the following approved methods:

.i * in accordance with the loading conditions provided in the approved loading manual, stamped and dated .... and signed by a responsible officer of the Administration, or of an organization recognized by the Administration; or

.ii * in accordance with loading conditions verified remotely using an approved means…………………; or

.iii * in accordance with a loading condition which lies within an approved range of conditions defined in the approved loading manual referred to in i above; or

.iv * in accordance with a loading condition verified using approved critical KG/GM data defined in the approved loading manual referred to in i above;

.3* in accordance with the loading limitations appended to this Certificate.

Where it is required to load the ship other than in accordance with the above instruction, then the necessary calculations to justify the proposed loading conditions shall be communicated to the certifying Administration who may authorize in writing the adoption of the proposed loading condition.**

This Certificate is valid until ………………………..…………………………….………………….
subject to surveys in accordance with 1.4 of the Code.

Completion date of the survey on which this certificate is based: ....
(dd/mm/yyyy)

Issued at …………………………………………………….
(Place of issue of certificate)

………………
(Date of issue)

………………………………………
(Signature of authorized official issuing the certificate)

(Seal or stamp of the authority, as appropriate)

* Delete as appropriate.

** Instead of being incorporated in the Certificate, this text may be appended to the Certificate, if duly signed and stamped.

Notes on completion of certificate:

1. Alternatively, the particulars of the ship may be placed horizontally in boxes.

2. In accordance with *IMO ship identification number scheme*, adopted by the Organization by resolution A.1078(28).

3. Any entry shall be related to all relevant recommendations, e.g. an entry "type 2G" shall mean type 2G in all respects prescribed by the Code.

4. The ambient temperature required for the purposes of 4.19.1.1 is to be inserted.

5. The stress factors and materials acceptable under 4.22.3.1 and 4.23.3.1 of the Code are to be inserted.

6. All relief valve settings assigned in accordance with 4.13.2 are to be inserted.

7. Temperatures accepted by the Administration or recognized organization acting on its behalf for the purposes of 4.18.1.3 are to be inserted.

8. Only products listed in chapter 19 of the Code or products that have been evaluated by the Administration in accordance with paragraph 1.1.6.1, or their compatible mixtures having physical proportions within the limitations of tank design, shall be listed. In respect of the latter "new products", any special requirements provisionally agreed under the tripartite agreement shall be indicated in an addendum to the certificate.

ENDORSEMENT FOR ANNUAL AND INTERMEDIATE SURVEYS

THIS IS TO CERTIFY that at a survey required by 1.4.2 of the Code the ship was found to comply with the relevant provisions of the Code.

Annual survey: Signed: ……………………………………………
(Signature of duly authorized official)

Place: …………………………………...................

Date *(dd/mm/yyyy)*: ……………………………...

(Seal or stamp of the Authority, as appropriate)

Annual/Intermediate* survey: Signed: ……………………………………………
(Signature of duly authorized official)

Place: ………………………………………………

Date *(dd/mm/yyyy)*: ………………………………

(Seal or stamp of the Authority, as appropriate)

Annual/Intermediate* survey: Signed: ……………………………………………
(Signature of duly authorized official)

Place: ……………………………………………..

Date *(dd/mm/yyyy)*: ……………………………...

(Seal or stamp of the Authority, as appropriate)

Annual survey: Signed: ……………………………………………
(Signature of duly authorized official)

Place: ………………………………………………

Date *(dd/mm/yyyy)*: ……………………………….

(Seal or stamp of the Authority, as appropriate)

* Delete as appropriate.

ANNUAL/INTERMEDIATE SURVEY IN ACCORDANCE WITH PARAGRAPH 1.4.6.8.3

THIS IS TO CERTIFY that, at an annual/intermediate* survey in accordance with paragraph 1.4.6.8.3 of the Code, the ship was found to comply with the relevant provisions of the Code:

Signed: ……………………………….
(Signature of duly authorized official)

Place: ………………………………..

Date *(dd/mm/yyyy)*: ………………….

(Seal or stamp of the Authority, as appropriate)

ENDORSEMENT TO EXTEND THE CERTIFICATE IF VALID FOR LESS THAN 5 YEARS WHERE PARAGRAPH 1.4.6.3 APPLIES

The ship complies with the relevant provisions of the Code, and this Certificate shall, in accordance with paragraph 1.4.6.3 of the Code, be accepted as valid until..............................

Signed: ……………………………….
(Signature of duly authorized official)

Place: ………………………………....

Date *(dd/mm/yyyy)*: …………………....

(Seal or stamp of the Authority, as appropriate)

ENDORSEMENT WHERE THE RENEWAL SURVEY HAS BEEN COMPLETED AND PARAGRAPH 1.4.6.4 APPLIES

The ship complies with the relevant provisions of the Code, and this Certificate shall, in accordance with paragraph 1.4.6.4 of the Code, be accepted as valid until..............................

Annual survey:

Signed: ……………………………….
(Signature of duly authorized official)

Place: ……………………………….

Date *(dd/mm/yyyy)*: ………………….

(Seal or stamp of the Authority, as appropriate)

* Delete as appropriate.

ENDORSEMENT TO EXTEND THE VALIDITY OF THE CERTIFICATE UNTIL REACHING THE PORT OF SURVEY OR FOR A PERIOD OF GRACE WHERE PARAGRAPH 1.4.6.5 OR 1.4.6.6 APPLIES

This Certificate shall, in accordance with paragraph 1.4.6.5/1.4.6.6* of the Code, be accepted as valid until ………………………

Signed: …………………………………
(Signature of duly authorized official)

Place: …………………………………

Date *(dd/mm/yyyy)*: …………………

(Seal or stamp of the Authority, as appropriate)

ENDORSEMENT FOR ADVANCEMENT OF ANNIVERSARY DATE WHERE PARAGRAPH 1.4.6.8 APPLIES

In accordance with paragraph 1.4.6.8 of the Code, the new anniversary date is ……………

Signed: …………………………………
(Signature of duly authorized official)

Place: …………………………………

Date *(dd/mm/yyyy)*: …………………

(Seal or stamp of the Authority, as appropriate)

In accordance with paragraph 1.4.6.8, the new anniversary date is ……………………………

Signed: …………………………………
(Signature of duly authorized official)

Place: …………………………………

Date *(dd/mm/yyyy)*: …………………

(Seal or stamp of the Authority, as appropriate)

* Delete as appropriate.

ATTACHMENT 1
TO THE INTERNATIONAL CERTIFICATE OF FITNESS FOR
THE CARRIAGE OF LIQUEFIED GASES IN BULK

Continued list of products to those specified in paragraph 4 of the certificate, and their conditions of carriage.

Products	Conditions of carriage (tank numbers, etc.)	Minimum temperature

Date: ……………………
(as for Certificate)

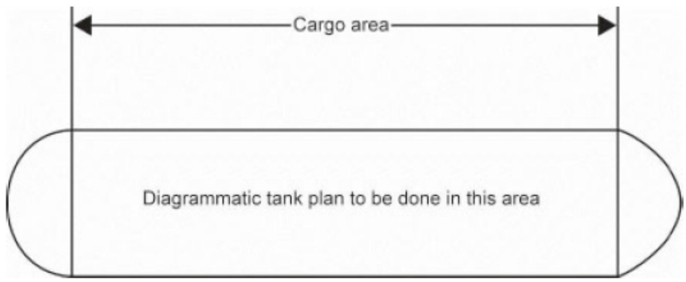
……………………………………………….
(Signature of official issuing the Certificate and/or seal of issuing authority)

ATTACHMENT 2
TO THE INTERNATIONAL CERTIFICATE OF FITNESS FOR THE CARRIAGE OF LIQUEFIED GASES IN BULK

TANK PLAN (specimen)

Name of ship:

Distinctive number or letters:



Date: ………………………
(dd/mm/yyyy)
(as for Certificate)

……………………………………………………
(Signature of official issuing the Certificate and/or seal of issuing authority)

APPENDIX 3

EXAMPLE OF AN ADDENDUM TO THE INTERNATIONAL CERTIFICATE OF FITNESS FOR THE CARRIAGE OF LIQUEFIED GASES IN BULK

<table>
<tr><td colspan="3">Addendum to Certificate No.:</td><td colspan="3">Issued at: dd/mm/yyyy</td></tr>
<tr><td colspan="6">Issued in pursuance of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, as amended, under the authority of the Government of:

……………………………………….……..</td></tr>
<tr><td>Name of ship</td><td>Distinctive number or letters</td><td>IMO number</td><td>Port of registry</td><td>Cargo capacity (m^3)</td><td>Ship type</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

THIS IS TO CERTIFY:

That the ship meets the requirements for the carriage in bulk of the following product(s), provided that all relevant operational provisions of the Code are observed:

Product	Conditions of carriage (tank numbers, etc.)	Minimum temperature	MARVS

The transportation of this product is permitted between the following countries:

The issuance of this Addendum is based on document: ………………………………………..

The Tripartite Agreement for this product is valid until: (dd/mm/yyyy)……...……………………

This Addendum will remain in force until: (dd/mm/yyyy)…………………………………………

Place and date of issue: (dd/mm/yyyy)…………………………………..……………………

Signed: ………………..……………………
(signature of authorized official)

APPENDIX 4

NON-METALLIC MATERIALS

1 General

1.1 The guidance given in this appendix is in addition to the requirements of 4.19, where applicable to non-metallic materials.

1.2 The manufacture, testing, inspection and documentation of non-metallic materials should in general comply with recognized standards, and with the specific requirements of this Code, as applicable.

1.3 When selecting a non-metallic material, the designer should ensure that it has properties appropriate to the analysis and specification of the system requirements. A material can be selected to fulfil one or more requirements.

1.4 A wide range of non-metallic materials may be considered. Therefore, the section below on material selection criteria cannot cover every eventuality and should be considered as guidance.

2 Material selection criteria

2.1 Non-metallic materials may be selected for use in various parts of liquefied gas carrier cargo systems based on consideration of the following basic properties:

.1 insulation – the ability to limit heat flow;

.2 load bearing – the ability to contribute to the strength of the containment system;

.3 tightness – the ability to provide liquid and vapour tight barriers;

.4 joining – the ability to be joined (for example by bonding, welding or fastening).

2.2 Additional considerations may apply depending on the specific system design.

3 Properties of materials

3.1 Flexibility of insulating material is the ability of an insulating material to be bent or shaped easily without damage or breakage.

3.2 Loose fill material is a homogeneous solid generally in the form of fine particles, such as a powder or beads, normally used to fill the voids in an inaccessible space to provide an effective insulation.

3.3 Nanomaterial is a material with properties derived from its specific microscopic structure.

3.4 Cellular material is a material type containing cells that are either open, closed or both and which are dispersed throughout its mass.

3.5 Adhesive material is a product that joins or bonds two adjacent surfaces together by an adhesive process.

3.6 Other materials are materials that are not characterized in this section of the Code and should be identified and listed. The relevant tests used to evaluate the suitability of material for use in the cargo system should be identified and documented.

4 Material selection and testing requirements

4.1 *Material specification*

4.1.1 When the initial selection of a material has been made, tests should be conducted to validate the suitability of this material for the use intended.

4.1.2 The material used should clearly be identified and the relevant tests should be fully documented.

4.1.3 Materials should be selected according to their intended use. They should:

.1 be compatible with all the products that may be carried;

.2 not be contaminated by any cargo nor react with it;

.3 not have any characteristics or properties affected by the cargo; and

.4 be capable to withstand thermal shocks within the operating temperature range.

4.2 *Material testing*

The tests required for a particular material depend on the design analysis, specification and intended duty. The list of tests below is for illustration. Any additional tests required, for example in respect of sliding, damping and galvanic insulation, should be identified clearly and documented. Materials selected according to 4.1 of this appendix should be tested further according to the following table:

Function	Insulation	Load bearing structural	Tightness	Joining
Mechanical tests		X		X
Tightness tests			X	
Thermal tests	X			

Thermal shock testing should submit the material and/or assembly to the most extreme thermal gradient it will experience when in service.

4.2.1 Inherent properties of materials

4.2.1.1 Tests should be carried out to ensure that the inherent properties of the material selected will not have any negative impact in respect of the use intended.

4.2.1.2 For all selected materials, the following properties should be evaluated:

.1 density; example standard ISO 845; and

.2 linear coefficient of thermal expansion (LCTE); example standard ISO 11359 across the widest specified operating temperature range. However, for loose fill material the volumetric coefficient of thermal expansion (VCTE) should be evaluated, as this is more relevant.

4.2.1.3 Irrespective of its inherent properties and intended duty, all materials selected should be tested for the design service temperature range down to 5°C below the minimum design temperature, but not lower than -196°C.

4.2.1.4 Each property evaluation test should be performed in accordance with recognized standards. Where there are no such standards, the test procedure proposed should be fully detailed and submitted to the Administration for acceptance. Sampling should be sufficient to ensure a true representation of the properties of the material selected.

4.2.2 Mechanical tests

4.2.2.1 The mechanical tests should be performed in accordance with the following table.

Mechanical tests	Load bearing structural
Tensile	ISO 527 ISO 1421 ISO 3346 ISO 1926
Shearing	ISO 4587 ISO 3347 ISO 1922 ISO 6237
Compressive	ISO 604 ISO 844 ISO 3132
Bending	ISO 3133 ISO 14679
Creep	ISO 7850

4.2.2.2 If the chosen function for a material relies on particular properties such as tensile, compressive and shear strength, yield stress, modulus or elongation, these properties should be tested to a recognized standard. If the properties required are assessed by numerical simulation according to a high order behaviour law, the testing should be performed to the satisfaction of the Administration.

4.2.2.3 Creep may be caused by sustained loads, for example cargo pressure or structural loads. Creep testing should be conducted based on the loads expected to be encountered during the design life of the containment system.

4.2.3 Tightness tests

4.2.3.1 The tightness requirement for the material should relate to its operational functionality.

4.2.3.2 Tightness tests should be conducted to give a measurement of the material's permeability in the configuration corresponding to the application envisaged (e.g. thickness and stress conditions) using the fluid to be retained (e.g. cargo, water vapour or trace gas).

4.2.3.3 The tightness tests should be based on the tests indicated as examples in the following table.

Tightness tests	**Tightness**
Porosity/Permeability	ISO 15106 ISO 2528 ISO 2782

4.2.4 Thermal conductivity tests

4.2.4.1 Thermal conductivity tests should be representative of the lifecycle of the insulation material so its properties over the design life of the cargo system can be assessed. If these properties are likely to deteriorate over time, the material should be aged as best possible in an environment corresponding to its lifecycle, for example operating temperature, light, vapour and installation (e.g. packaging, bags, boxes, etc.).

4.2.4.2 Requirements for the absolute value and acceptable range of thermal conductivity and heat capacity should be chosen taking into account the effect on the operational efficiency of the cargo containment system. Particular attention should also be paid to the sizing of the associated cargo handling system and components such as safety relief valves plus vapour return and handling equipment.

4.2.4.3 Thermal tests should be based on the tests indicated as examples in the following table or their equivalents:

Thermal tests	Insulating
Thermal conductivity	ISO 8301 ISO 8302
Heat capacity	x

4.2.5 Physical tests

4.2.5.1 In addition to the requirements of 4.19.2.3 and 4.19.3.2, the following table provides guidance and information on some of the additional physical tests that may be considered.

Physical tests	Flexible insulating	Loose fill	Nano-material	Cellular	Adhesive
Particle size		x			
Closed cells content				ISO 4590	
Absorption/Desorption	ISO 12571	x	x	ISO 2896	
Viscosity					ISO 2555 ISO 2431
Open time					ISO 10364
Thixotropic properties					x
Hardness					ISO 868

4.2.5.2 Requirements for loose fill material segregation should be chosen considering its potential adverse effect on the material properties (density, thermal conductivity) when subjected to environmental variations such as thermal cycling and vibration.

4.2.5.3 Requirements for a material with closed cell structures should be based on its eventual impact on gas flow and buffering capacity during transient thermal phases.

4.2.5.4 Similarly, adsorption and absorption requirements should take into account the potential adverse effect an uncontrolled buffering of liquid or gas may have on the system.

5 Quality assurance and quality control (QA/QC)

5.1 *General*

5.1.1 Once a material has been selected, after testing as outlined in section 4 of this appendix, a detailed quality assurance/quality control (QA/QC) programme should be applied to ensure the continued conformity of the material during installation and service. This programme should consider the material starting from the manufacturer's quality manual (QM) and then follow it throughout the construction of the cargo system.

5.1.2 The QA/QC programme should include the procedure for fabrication, storage, handling and preventive actions to guard against exposure of a material to harmful effects. These may include, for example, the effect of sunlight on some insulation materials or the contamination of material surfaces by contact with personal products such as hand creams. The sampling methods and the frequency of testing in the QA/QC programme should be specified to ensure the continued conformity of the material selected throughout its production and installation.

5.1.3 Where powder or granulated insulation is produced, arrangements should be made to prevent compacting of the material due to vibrations.

5.2 *QA/QC during component manufacture*

The QA/QC programme in respect of component manufacture should include, as a minimum but not limited to, the following items.

5.2.1 Component identification

5.2.1.1 For each material, the manufacturer should implement a marking system to clearly identify the production batch. The marking system should not interfere, in any way, with the properties of the product.

5.2.1.2 The marking system should ensure complete traceability of the component and should include:

.1 date of production and potential expiry date;

.2 manufacturer's references;

.3 reference specification;

.4 reference order; and

.5 when necessary, any potential environmental parameters to be maintained during transportation and storage.

5.2.2 Production sampling and audit method

5.2.2.1 Regular sampling is required during production to ensure the quality level and continued conformity of a selected material.

5.2.2.2 The frequency, the method and the tests to be performed should be defined in QA/QC programme; for example, these tests will usually cover, inter alia, raw materials, process parameters and component checks.

5.2.2.3 Process parameters and results of the production QC tests should be in strict accordance with those detailed in the QM for the material selected.

5.2.2.4 The objective of the audit method as described in the QM is to control the repeatability of the process and the efficacy of the QA/QC programme.

5.2.2.5 During auditing, auditors should be provided with free access to all production and QC areas. Audit results should be in accordance with the values and tolerances as stated in the relevant QM.

6 Bonding and joining process requirement and testing

6.1 *Bonding procedure qualification*

6.1.1 The bonding procedure specification and qualification test should be defined in accordance with recognized standards.

6.1.2 The bonding procedures should be fully documented before work commences to ensure the properties of the bond are acceptable.

6.1.3 The following parameters should be considered when developing a bonding procedure specification:

.1 surface preparation;

.2 materials storage and handling prior to installation;

.3 covering-time;

.4 open-time;

.5 mixing ratio, deposited quantity;

.6 environmental parameters (temperature, humidity); and

.7 curing pressure, temperature and time.

6.1.4 Additional requirements may be included as necessary to ensure acceptable results.

6.1.5 The bonding procedures specification should be validated by an appropriate procedure qualification testing programme.

6.2 ***Personnel qualifications***

6.2.1 Personnel involved in bonding processes should be trained and qualified to recognized standards.

6.2.2 Regular tests should be made to ensure the continued performance of people carrying out bonding operations to ensure a consistent quality of bonding.

7 Production bonding tests and controls

7.1 ***Destructive testing***

During production, representative samples should be taken and tested to check that they correspond to the required level of strength as required for the design.

7.2 ***Non-destructive testing***

7.2.1 During production, tests which are not detrimental to bond integrity should be performed using an appropriate technique such as:

.1 visual examination;

.2 internal defects detection (for example acoustic, ultrasonic or shear test); and

.3 local tightness testing.

7.2.2 If the bonds have to provide tightness as part of their design function, a global tightness test of the cargo containment system should be completed after the end of the erection in accordance with the designer's and QA/QC programme.

7.2.3 The QA/QC standards should include acceptance standards for the tightness of the bonded components when built and during the lifecycle of the containment system.

APPENDIX 5

STANDARD FOR THE USE OF LIMIT STATE METHODOLOGIES IN THE DESIGN OF CARGO CONTAINMENT SYSTEMS OF NOVEL CONFIGURATION

1 General

1.1 The purpose of this standard is to provide procedures and relevant design parameters of limit state design of cargo containment systems of a novel configuration in accordance with section 4.27 of this Code.

1.2 Limit state design is a systematic approach where each structural element is evaluated with respect to possible failure modes related to the design conditions identified in section 4.3.4 of this Code. A limit state can be defined as a condition beyond which the structure, or part of a structure, no longer satisfies the requirements.

1.3 The limit states are divided into the three following categories:

.1 Ultimate Limit States (ULS), which correspond to the maximum load-carrying capacity or, in some cases, to the maximum applicable strain, deformation or instability in structure resulting from buckling and plastic collapse; under intact (undamaged) conditions;

.2 Fatigue Limit States (FLS), which correspond to degradation due to the effect of cyclic loading; and

.3 Accident Limit States (ALS), which concern the ability of the structure to resist accident situations.

1.4 Part A through part D of chapter 4 of this Code shall be complied with as applicable depending on the cargo containment system concept.

2 Design format

2.1 The design format in this standard is based on a Load and Resistance Factor Design format. The fundamental principle of the Load and Resistance Factor Design format is to verify that design load effects, L_d, do not exceed design resistances, R_d, for any of the considered failure modes in any scenario:

$$L_d \leq R_d$$

A design load F_{dk} is obtained by multiplying the characteristic load by a load factor relevant for the given load category:

$$F_{dk} = \gamma_f \cdot F_k$$

where:

γ_f is load factor; and

F_k is the characteristic load as specified in part B and part C of chapter 4 of this Code.

A design load effect L_d (e.g. stresses, strains, displacements and vibrations) is the most unfavourable combined load effect derived from the design loads, and may be expressed by:

$$L_d = q(F_{d1}, F_{d2}, \ldots, F_{dN})$$

where q denotes the functional relationship between load and load effect determined by structural analyses.

The design resistance R_d is determined as follows:

$$R_d = \frac{R_k}{\gamma_R \cdot \gamma_C}$$

where:

R_k is the characteristic resistance. In case of materials covered by chapter 6 of this Code, it may be, but not limited to, specified minimum yield stress, specified minimum tensile strength, plastic resistance of cross sections, and ultimate buckling strength;

γ_R is the resistance factor, defined as $\gamma_R = \gamma_m \cdot \gamma_s$;

γ_m is the partial resistance factor to take account of the probabilistic distribution of the material properties (material factor);

γ_s is the partial resistance factor to take account of the uncertainties on the capacity of the structure, such as the quality of the construction, method considered for determination of the capacity including accuracy of analysis; and

γ_C is the consequence class factor, which accounts for the potential results of failure with regard to release of cargo and possible human injury.

2.2 Cargo containment design shall take into account potential failure consequences. Consequence classes are defined in table 1, to specify the consequences of failure when the mode of failure is related to the Ultimate Limit State, the Fatigue Limit State, or the Accident Limit State.

Table 1: Consequence classes

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

3 Required analyses

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

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

3.3 Fatigue and crack propagation analysis shall be carried out in accordance with paragraph 5.1 of this standard.

4 Ultimate Limit States

4.1 Structural resistance may be established by testing or by complete analysis taking account of both elastic and plastic material properties. Safety margins for ultimate strength shall be introduced by partial factors of safety taking account of the contribution of stochastic nature of loads and resistance (dynamic loads, pressure loads, gravity loads, material strength, and buckling capacities).

4.2 Appropriate combinations of permanent loads, functional loads and environmental loads including sloshing loads shall be considered in the analysis. At least two load combinations with partial load factors as given in table 2 shall be used for the assessment of the ultimate limit states.

Table 2: Partial load factors

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

The load factors for permanent and functional loads in load combination '*a*' are relevant for the normally well-controlled and/or specified loads applicable to cargo containment systems such as vapour pressure, cargo weight, system self-weight, etc. Higher load factors may be relevant for permanent and functional loads where the inherent variability and/or uncertainties in the prediction models are higher.

4.3 For sloshing loads, depending on the reliability of the estimation method, a larger load factor may be required by the Administration or recognized organization acting on its behalf.

4.4 In cases where structural failure of the cargo containment system are considered to imply high potential for human injury and significant release of cargo, the consequence class factor shall be taken as $\gamma_C = 1.2$. This value may be reduced if it is justified through risk analysis and subject to the approval by the Administration or recognized organization acting on its behalf. The risk analysis shall take account of factors including, but not limited to, provision of full or partial secondary barrier to protect hull structure from the leakage and less hazards associated with intended cargo. Conversely, higher values may be fixed by the Administration or recognized organization acting on its behalf, for example, for ships carrying more hazardous or higher pressure cargo. The consequence class factor shall in any case not be less than 1.0.

4.5 The load factors and the resistance factors used shall be such that the level of safety is equivalent to that of the cargo containment systems as described in sections 4.21 to 4.26 of this Code. This may be carried out by calibrating the factors against known successful designs.

4.6 The material factor γ_m shall in general reflect the statistical distribution of the mechanical properties of the material, and needs to be interpreted in combination with the specified characteristic mechanical properties. For the materials defined in chapter 6 of this Code, the material factor γ_m may be taken as:

1.1 when the characteristic mechanical properties specified by the recognized organization typically represents the lower 2.5% quantile in the statistical distribution of the mechanical properties; or

1.0 when the characteristic mechanical properties specified by the recognized organization represents a sufficiently small quantile such that the probability of lower mechanical properties than specified is extremely low and can be neglected.

4.7 The partial resistance factors γ_{si} shall in general be established based on the uncertainties in the capacity of the structure considering construction tolerances, quality of construction, the accuracy of the analysis method applied, etc.

4.7.1 For design against excessive plastic deformation using the limit state criteria given in paragraph 4.8 of this standard, the partial resistance factors γ_{si} shall be taken as follows:

$$\gamma_{s1} = 0.76 \cdot \frac{B}{\kappa_1}$$

$$\gamma_{s2} = 0.76 \cdot \frac{D}{\kappa_2}$$

$$\kappa_1 = Min\left(\frac{R_m}{R_e} \cdot \frac{B}{A};1.0\right)$$

$$\kappa_2 = Min\left(\frac{R_m}{R_e} \cdot \frac{D}{C};1.0\right)$$

Factors A, B, C and D are defined in section 4.22.3.1 of this Code. R_m and R_e are defined in section 4.18.1.3 of this Code.

The partial resistance factors given above are the results of calibration to conventional type B independent tanks.

4.8 ***Design against excessive plastic deformation***

4.8.1 Stress acceptance criteria given below refer to elastic stress analyses.

4.8.2 Parts of cargo containment systems where loads are primarily carried by membrane response in the structure shall satisfy the following limit state criteria:

$$\sigma_m \leq f$$
$$\sigma_L \leq 1.5f$$
$$\sigma_b \leq 1.5F$$
$$\sigma_L + \sigma_b \leq 1.5F$$
$$\sigma_m + \sigma_b \leq 1.5F$$
$$\sigma_m + \sigma_b + \sigma_g \leq 3.0F$$

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

where:

σ_m = equivalent primary general membrane stress
σ_L = equivalent primary local membrane stress
σ_b = equivalent primary bending stress
σ_g = equivalent secondary stress

$$f = \frac{R_e}{\gamma_{s1} \cdot \gamma_m \cdot \gamma_C}$$
$$F = \frac{R_e}{\gamma_{s2} \cdot \gamma_m \cdot \gamma_C}$$

With regard to the stresses σ_m, σ_L, σ_b and σ_g, see also the definition of stress categories in section 4.28.3 of this Code.

Guidance Note:

The stress summation described above shall be carried out by summing up each stress component ($\sigma_x, \sigma_y, \tau_{xy}$), and subsequently the equivalent stress shall be calculated based on the resulting stress components as shown in the example below.

$$\sigma_L + \sigma_b = \sqrt{(\sigma_{Lx} + \sigma_{bx})^2 - (\sigma_{Lx} + \sigma_{bx})(\sigma_{Ly} + \sigma_{by}) + (\sigma_{Ly} + \sigma_{by})^2 + 3(\tau_{Lxy} + \tau_{bxy})^2}$$

4.8.3 Parts of cargo containment systems where loads are primarily carried by bending of girders, stiffeners and plates, shall satisfy the following limit state criteria:

$\sigma_{ms} + \sigma_{bp} \le 1.25F$ (See notes 1, 2)
$\sigma_{ms} + \sigma_{bp} + \sigma_{bs} \le 1.25F$ (See note 2)
$\sigma_{ms} + \sigma_{bp} + \sigma_{bs} + \sigma_{bt} + \sigma_g \le 3.0F$

Note 1: The sum of equivalent section membrane stress and equivalent membrane stress in primary structure ($\sigma_{ms} + \sigma_{bp}$) will normally be directly available from three-dimensional finite element analyses.

Note 2: The coefficient, 1.25, may be modified by the Administration or recognized organization acting on its behalf considering the design concept, configuration of the structure, and the methodology used for calculation of stresses.

where:

σ_{ms} = equivalent section membrane stress in primary structure

σ_{bp} = equivalent membrane stress in primary structure and stress in secondary and tertiary structure caused by bending of primary structure

σ_{bs} = section bending stress in secondary structure and stress in tertiary structure caused by bending of secondary structure

σ_{bt} = section bending stress in tertiary structure

σ_{g} = equivalent secondary stress

$$f = \frac{R_e}{\gamma_{s1} \cdot \gamma_m \cdot \gamma_C}$$

$$F = \frac{R_e}{\gamma_{s2} \cdot \gamma_m \cdot \gamma_C}$$

The stresses σ_{ms}, σ_{bp}, σ_{bs}, and σ_{bt} are defined in 4.8.4. For a definition of σ_{g}, see section 4.28.3 of this Code.

> **Guidance Note:**
>
> The stress summation described above shall be carried out by summing up each stress component ($\sigma_x, \sigma_y, \tau_{xy}$), and subsequently the equivalent stress shall be calculated based on the resulting stress components.

Skin plates shall be designed in accordance with the requirements of the Administration or recognized organization acting on its behalf. When membrane stress is significant, the effect of the membrane stress on the plate bending capacity shall be appropriately considered in addition.

4.8.4 Section stress categories

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

Equivalent section membrane stress is the component of the normal stress that is uniformly distributed and equal to the average value of the stress across the cross section of the structure under consideration. If this is a simple shell section, the section membrane stress is identical to the membrane stress defined in paragraph 4.8.2 of this standard.

Section bending stress is the component of the normal stress that is linearly distributed over a structural section exposed to bending action, as illustrated in figure 1.

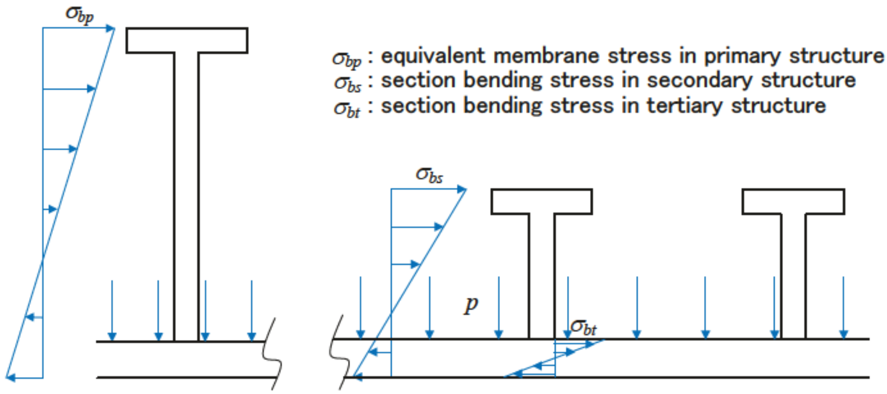


Figure 1: Definition of the three categories of section stress
(Stresses σ_{bp} and σ_{bs} are normal to the cross section shown.)

4.9 The same factors γ_C, γ_m, γ_{si} shall be used for design against buckling unless otherwise stated in the applied recognized buckling standard. In any case the overall level of safety shall not be less than given by these factors.

5 Fatigue Limit States

5.1 Fatigue design condition as described in section 4.18.2 of this Code shall be complied with as applicable depending on the cargo containment system concept. Fatigue analysis is required for the cargo containment system designed under section 4.27 of this Code and this standard.

5.2 The load factors for FLS shall be taken as 1.0 for all load categories.

5.3 Consequence class factor γ_C and resistance factor γ_R shall be taken as 1.0.

5.4 Fatigue damage shall be calculated as described in sections 4.18.2.2 to 4.18.2.5 of this Code. The calculated cumulative fatigue damage ratio for the cargo containment systems shall be less than or equal to the values given in table 3.

Table 3: Maximum allowable cumulative fatigue damage ratio

	Consequence class		
C_W	Low	Medium	High
	1.0	0.5	0.5*

Note*: Lower value shall be used in accordance with sections 4.18.2.7 to 4.18.2.9 of this Code, depending on the detectability of defect or crack, etc.

5.5 Lower values may be fixed by the Administration or recognized organization acting on its behalf, for example for tank structures where effective detection of defect or crack cannot be assured, and for ships carrying more hazardous cargo.

5.6 Crack propagation analyses are required in accordance with sections 4.18.2.6 to 4.18.2.9 of this Code. The analysis shall be carried out in accordance with methods laid down in a standard recognized by the Administration or recognized organization acting on its behalf.

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MARITIME SAFETY COMMITTEE
93rd session
Agenda item 22

MSC 93/22/Add.1/Corr.3
5 November 2015
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REPORT OF THE MARITIME SAFETY COMMITTEE ON ITS NINETY-THIRD SESSION

Corrigendum

ANNEX 6

RESOLUTION MSC.370(93)
(adopted on 22 May 2014)

AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK (IGC CODE)

1 In paragraph 5.12.1, the words "not lower than 55°C" are replaced with the words "not lower than -55°C".

2 In the last sentence of paragraph 7.8.4, the words "non-hazardous area" are replaced with the words "safe location".

3 In paragraph 8.2.18, the words "by the Administration" are deleted.

4 At the end of paragraph 11.2.1, the word "gauge" is added after "MPa".

5 In the last sentence of paragraph 13.6.11, the words "non-hazardous area" are replaced with the words "safe location".

6 Paragraph 16.9.5 is replaced with the following:

> "16.9.5 In addition to the requirements of 16.4.3.2, both ventilation inlet and outlet shall be located outside the machinery space. The inlet shall be in a non-hazardous area and the outlet shall be in a safe location."

7 In chapter 19 – Summary of minimum requirements, in column 'i' of the table containing the summary of minimum requirements, all occurrences of referenced paragraph number "14.4.1" are replaced with "14.4.2" and all occurrences of referenced paragraph number "14.4.2" are replaced with "14.4.3".

8 In APPENDIX 2 – MODEL FORM OF INTERNATIONAL CERTIFICATE OF FITNESS FOR THE CARRIAG OF LIQUEFIED GASES IN BULK, the second note on completion of certificate is replaced with the following:

> "2. In accordance with *IMO ship identification number scheme*, adopted by the Organization by resolution A.1078(28)"

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ANNEX 6

RESOLUTION MSC.370(93)
(adopted on 22 May 2014)

AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK (IGC CODE)

1 In paragraph 5.9.3.1, the words "or with inside diameters" are replaced with the words "and with inside diameters".

2 In paragraph 5.11.6.3, the words "fire closed" are replaced with the words "fail-closed".

3 In paragraph 13.6.4:

.1 the words "where indicated in column "f" in the table of chapter 19" are replaced with the words "where indicated by an "A" in column "f" in the table of chapter 19"; and

.2 the words "cargo tank hold spaces" are replaced with the words "hold spaces for independent tanks other than type C tanks".

4 In paragraph 5 of APPENDIX 2 – MODEL FORM OF INTERNATIONAL CERTIFICATE OF FITNESS FOR THE CARRIAGE OF LIQUEFIED GASES IN BULK, the reference to "1.4/2.6.2" is replaced with "1.3/2.6.2".

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Title	RESOLUTIONs / MSC Resolutions / 97th Session / Res.MSC.411 (97)

RESOLUTION MSC.411(97)

(adopted on 25 November 2016)

AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK (IGC CODE)

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the functions of the Committee,

NOTING resolution MSC.5(48), by which it adopted the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk ("the IGC Code"), which has become mandatory under chapter VII of the International Convention for the Safety of Life at Sea, 1974 ("the Convention"),

NOTING ALSO Article VIII(b) and regulation VII/11.1 of the Convention concerning the procedure for amending the IGC Code,

HAVING CONSIDERED, at its ninety-seventh session, amendments to the IGC Code proposed and circulated in accordance with Article VIII(b)(i) of the Convention,

1 ADOPTS, in accordance with Article VIII(b)(iv) of the Convention, amendments to the IGC Code, the text of which is set out in the annex to the present resolution;

2 DETERMINES, in accordance with Article VIII(b)(vi)(2)(bb) of the Convention, that the amendments shall be deemed to have been accepted on 1 July 2019 unless, prior to that date, more than one third of the Contracting Governments to the Convention or Contracting Governments the combined merchant fleets of which constitute not less than 50% of the gross tonnage of the world's merchant fleet, have notified their objections to the amendments;

3 INVITES Contracting Governments to note that, in accordance with Article VIII(b)(vii)(2) of the Convention, the amendments shall enter into force on 1 January 2020 upon their acceptance in accordance with paragraph 2 above;

4 REQUESTS the Secretary-General, for the purpose of Article VIII(b)(v) of the Convention, to transmit certified copies of the present resolution and the text of the amendments contained in the annex to all Contracting Governments to the Convention;

5 REQUESTS ALSO the Secretary-General to transmit copies of this resolution and its annex to Members of the Organization which are not Contracting Governments to the Convention.

ANNEX

AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING

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LIQUEFIED GASES IN BULK (IGC CODE)

CHAPTER 3
SHIP ARRANGEMENTS

3.2 Accommodation, service and machinery spaces and control stations

Existing paragraph 3.2.5 is replaced with the following:

"3.2.5 Windows and sidescuttles facing the cargo area and on the sides of the superstructures and deckhouses within the limits specified in 3.2.4, except wheelhouse windows, shall be constructed to "A-60" class. Sidescuttles in the shell below the uppermost continuous deck and in the first tier of the superstructure or deckhouse shall be of fixed (non-opening) type."

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RESOLUTION MSC.441(99)

(adopted on 24 May 2018)

AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK (IGC CODE)

THE MARITIME SAFETY COMMITTEE,

RECALLING Article 28(b) of the Convention on the International Maritime Organization concerning the functions of the Committee,

NOTING resolution MSC.5(48), by which it adopted the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk ("the IGC Code"), which has become mandatory under chapter VII of the International Convention for the Safety of Life at Sea (SOLAS), 1974 ("the Convention"),

NOTING ALSO article VIII(b) and regulation VII/11.1 of the Convention concerning the procedure for amending the IGC Code,

HAVING CONSIDERED, at its ninety-ninth session, amendments to the IGC Code, proposed and circulated in accordance with article VIII(b)(i) of the Convention,

1 ADOPTS, in accordance with article VIII(b)(iv) of the Convention, amendments to the IGC Code, the text of which is set out in the annex to the present resolution;

2 DETERMINES, in accordance with article VIII(b)(vi)(2)(bb) of the Convention, that said amendments shall be deemed to have been accepted on 1 July 2019, unless, prior to that date, more than one third of the Contracting Governments to the Convention or Contracting Governments, the combined merchant fleets of which constitute not less than 50% of the gross tonnage of the world's merchant fleet, have notified the Secretary-General of their objections to the amendments;

3 INVITES Contracting Governments to note that, in accordance with article VIII(b)(vii)(2) of the Convention, the amendments shall enter into force on 1 January 2020 upon its acceptance in accordance with paragraph 2 above;

4 REQUESTS the Secretary-General, for the purpose of article VIII(b)(v) of the Convention, to transmit certified copies of the present resolution and the text of the amendments contained in the annex to all Contracting Governments to the Convention;

5 REQUESTS ALSO the Secretary-General to transmit copies of this resolution and its annex to Members of the Organization, which are not Contracting Governments to the Convention.

ANNEX

AMENDMENTS TO THE INTERNATIONAL CODE FOR THE CONSTRUCTION

AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK (IGC CODE)

In appendix 2, the existing paragraph 6 of the model form of International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk is replaced with the following:

"6 That the loading and stability information booklet required by paragraph 2.2.5 of the Code has been supplied to the ship in an approved form.

7 That the ship shall be loaded:

.1* only in accordance with loading conditions verified compliant with intact and damage stability requirements using the approved stability instrument fitted in accordance with paragraph 2.2.6 of the Code;

* Delete as appropriate.

.2* where a dispensation permitted by paragraph 2.2.7 of the Code is granted and the approved stability instrument required by paragraph 2.2.6 of the Code is not fitted, loading shall be made in accordance with one or more of the following approved methods:

.i* in accordance with the loading conditions provided in the approved loading and stability information booklet referred to in 6 above; or

.ii* in accordance with loading conditions verified remotely using an approved means………………; or

.iii* in accordance with a loading condition which lies within an approved range of conditions defined in the approved loading and stability information booklet referred to in 6 above; or

.iv* in accordance with a loading condition verified using approved critical KG/GM data defined in the approved loading and stability information booklet referred to in 6 above; and

.3* in accordance with the loading limitations appended to this Certificate.

Where it is required to load the ship other than in accordance with the above instruction, then the necessary calculations to justify the proposed loading conditions shall be communicated to the certifying Administration who may authorize in writing the adoption of the proposed loading condition.**

** Instead of being incorporated in the Certificate, this text may be appended to the Certificate, if duly signed and stamped."

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