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

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incorporating amendments 1 to 4

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

PREAMBLE

1 The Code has been developed to provide an international standard for the safe carriage by sea in bulk of liquefied gases and certain other substances listed in Chapter XIX, by prescribing the design and constructional features of ships involved in such carriage and the equipment they should carry so as to minimize the risk to the ship, its crew and to the environment having regard to the nature of the products involved.

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 due to the products being transported under cryogenic or pressure conditions.

3 Throughout the development of the Code it was recognized that it must be based upon sound naval architectural and engineering principles and the best understanding available as to the hazards of the various products covered; furthermore that gas ship design technology is not only a complex technology but is rapidly evolving and that the Code should not remain static but be continually re-evaluated and revised. To this end the Organization will periodically review the Code taking into account both experience and future development.

4 In the preparation of the Code it was recognized that severe collisions or standings could lead to cargo tank damage and result in uncontrolled release of the product. Such release could result in evaporation and dispersion of the product and, in some cases, cause bristle fracture of a 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.

5 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, have been considered by the Organization and reference, is made, to the, following publications prepared by the Organization which are of particular relevance:

> The International Conference on Training and Certification of Seafarers, 1978
>
> Recommendation on the Safe Transport, Handling and Storage of Dangerous Substances In Port Areas.

6 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 IV, V and VI.

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

8 Chapter XVIII of the Code dealing with the operation of liquefied gas tankers highlights the regulation in other chapters that are operational in nature and mentions those other important safety features that are peculiar to gas ship operation.

9 This Code is applicable to new ships as provided for in paragraph 1.2. Existing ships are dealt with by the Code for Existing Ships Carrying Liquefied Gases in Bulk (resolution A.329(IX)).

10 The Maritime Safety Committee at its forty-eighth session adopted with resolution MSC.5(48) the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk. It is intended that that Code becomes mandatory under the 1983 amendments to the International Convention for the Safety of Life at Sea, 1974, on 1 July 1986. Gas carriers built on or after that date shall comply with the International Gas Carrier Code. Ships built before 1 July 1986 should at !east comply with this Code but may be certificated under the IGC Code as set out in resolution MSC.7(48).

CHAPTER I - GENERAL.

1.1 Purpose

The purpose of this Code, in the following referred to as the Code, is to recommend suitable design criteria, construction standards and other safety measures for ships transporting liquefied gases and certain other substances in bulk so as to minimize the risk to the ship, its crew and to the environment.

1.2 Application

1.2.1 The Code applies to products which are liquefied gases having a vapour pressure exceeding 2.8 kp/cm^2 absolute at a temperature of 37.8°C, and certain other substances as shown in Chapter XIX, when carried in bulk on board ships, regardless of their size.

1.2.2 Subject to 1,2.1, the Code applies in its entirety to ships:

(i) for which the building contract is placed after 31 October 1976; or

(ii) in the absence of a building contract, the keel of which is laid or which is at a similar stage of construction after 31 December 1976, or

(iii) the delivery of which is after 30 June 1980; or

(iv) which have undergone a major conversion:

(1) for which the contract is placed after 31 October 1976; or

(2) in the absence of a contract the conversion of which is begun after 31 December 1976; or

(3) which is completed after 30 June 1980.

1.2.3 Any ship which fully complies with the provisions of this Code may be regarded as a ship as referred to in 1.2.2.

1.2.4 Except as provided in 1.2.5(a), when it is intended to carry products covered by this Code and products covered by the Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk, resolution A.212(VII) as amended (Bulk Chemical Code), the ship should comply with the requirements of both Codes appropriate to the products carried. [2]

1.2.5[2] a) The requirements of this Code should take precedence when a ship designed and constructed for the carriage of the following Products

(i) those listed exclusively in Chapter XIX of this Code; and

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

(b) When a ship is intended exclusively to carry one or more of the products noted in 1.2.5(a)(ii) the requirements of the Bulk Chemical Code as amended should apply.

1.2.6 Compliance of the ship with 1.2.2 or 1.2.3 as appropriate, should be shown on the Certificate of Fitness provided for in 1.6.[2]

1.3 Hazards

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

1.4 Definitions

Except where expressly provided otherwise, the following definitions apply to the Code. Additional definitions are given in 4.2.

1.4.1 *Cargoes* are products listed in Chapter XIX carried in bulk by ships subject to the Code.

1.4.2 *Vapour pressure* is the absolute equilibrium pressure of the saturated vapour above the liquid expressed in kp/cm^2 at a specified temperature.

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

1.4.4 *Flammable range* is the range between the minimum and maximum concentrations of vapour in air which flammable mixtures.

1.4.5 *Vapour density* is the relative weight of the vapour compared with the weight of an equal volume of dry air at standard conditions of temperature and pressure.

1.4.6 *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.

1.4.7 *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.

1.4.8 *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 and/or secondary barriers.

1.4.9 *Primary barrier* is the inner element designed to contain the cargo when the cargo containment system induces two boundaries.

1.4.10 *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 IV.

1.4.11 *Hold space* is the space, enclosed by the ship's structure in which a cargo containment system is situated.

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

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

1.4.14 *Void space* is the enclosed space in the cargo area external to a cargo containment system, not being a hold or ballast space, fuel oil tank, cargo pump or compressor room, or any space in normal use by personnel.

1.4.15 *Cofferdam* is the isolating space between two steel bulkheads or decks. This space may be a void space or ballast space.

1.4.16 *Gas-dangerous spaces or zones* are:

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

(b) an enclosed space outside the cargo area through which any piping, which may contain 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;

(c) a cargo containment system and cargo piping;

(d) (i) a hold space where cargo is carried in a cargo containment system requiring a secondary barrier,

(ii) a hold space where cargo is carried in a cargo containment system not requiring a secondary barrier;

(e) a space separated from a hold space described in sub-paragraph(d)(i) of this paragraph by a single gas-tight steel boundary;

(f) a cargo pump room and cargo compressor room;

(g) 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, cargo valve or of entrances and ventilation openings to cargo pump rooms and compressor rooms;

(h) 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;

(i) a zone within 2.4 m of the outer surface of a cargo containment system where such surface is exposed to the weather;

(j) 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 XVI are not considered gas-dangerous spaces in this context;

(k) a compartment for cargo hoses; and

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

1.4.17 *Gas-safe space* is a space not being a gas-dangerous space.

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

1.4.19 *Tank dome* is the upward extension of a portion of the cargo tank. For below deck cargo containment systems the tank dome protrudes through the weather deck of through a tank cover.

1.4.20 *Accommodation spaces* are those used for public spaces, corridors, lavatories, cabins, offices, hospitals, cinemas, games and hobbies rooms, pantries containing no cooking appliances and similar spaces. Public spaces are those portions of the accommodation which are used as halls, dining rooms, lounges and similar permanently enclosed spaces.

1.4.21 *Service spaces* are spaces outside the cargo area used for galleys, pantries containing cooking appliances lockers and store-rooms, workshops other than those forming part of the machinery spaces and similar spaces and trunks to such spaces.

1.4.22 *Cargo service spaces* are spaces within the cargo area used for workshops, lockers and store-rooms of more than 2 m^2 in area.

1.4.23 *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.

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

1.4.25 *Length (L)* means ninety-six per cent of the total length on a waterline at eighty-five per cent of the least moulded depth measured from the top the keel, or the length from the foreside of the stem to the axis of the rudder stock on that water-line, if that be greater. In ships designed with a rake of keel, the water-line on which this length is measured should be parallel to the designed water-line. The length (L) should be measured in metres.

1.4.26 *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.

1.4.27 *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.

1.4.28 *1974 Safety Convention* means the International Convention on Safety of Life at Sea, 1974.

1.4.29 *"A" Class divisions* means divisions as defined in Regulation 3 of Chapter II-2 of the 1974 Safety Convention.

1.4.30 *MARVS* means the maximum allowable relief valve setting

1.4.31 (a) *Administration* means the Government of the country in which the ship is registered,

(b) *port Administration* means the appropriate authority of the country in the port of which the ship is loading or unloading [1]]

1.4.32 *Organization* means the International Maritime Organization (IMO).

1.4.33 For the purposes of Chapters IV, V and VI of the Code, *Recognized Standards* are standards laid down and maintained by a classification society recognized by the Administration

1.4.34 *Flammable products* are identified by an "I" in column "f" of Chapter XIX.

1.4.35 *Toxic products* are identified by a "T" in column "f" of Chapter XIX.

7.4.36[4] *Machinery spaces of category A* are those spares and trunks to such spaces which contain:

(a) internal combustion machinery used for main propulsion; or

(b) 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

(c) any oil-fired boiler or oil fuel unit.

1.4.37[4] *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 kp/cm^2.

1.5 Equivalents

1.5.1 Where the Code requires that a particular fitting, material, appliance, apparatus, item of equipment or type thereof should be fitted or carried in a ship, or that any particular provision should be made, or any procedure or arrangement should 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. This authority of the Administration should not extend to substitution of operational methods or procedures for a particular fitting, material, appliance, apparatus, item of equipment, or type thereof which are prescribed by the Code.

1.5.2 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 them.

1.6[4] Survey requirements

1.6.1 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 Safety Radiotelegraphy Certificate or Cargo Ship Safety Radiotelephony Certificate are issued) of a gas carrier should be subjected to the following surveys:

(a) An initial survey before the ship is put in service or before the 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.

(b) 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.

(c) A minimum of one intermediate survey during the period of validity of the 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 arid are in good working order, Such surveys should be endorsed on the Certificate of Fitness for the Carriage of Liquefied Gases in Bulk,

(d) An annual survey within three months before or after the anniversary date of the 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 Certificate of Fitness for the Carriage of Liquefied Gases in Bulk.

(e) An additional survey, either general or partial according to thee circumstances, should be made when required after an investigation prescribed in 1.6.2(c), 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.

1.6.2 Maintenance of conditions after survey

(a) 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,

(b) After any survey of the ship under 1.6 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.

(c) 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 1.6.1(e), is necessary.

1.6.3 Issue of a Certificate of Fitness

(a) A certificate called a 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.

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

(c) When a ship is designed and constructed under the provisions of 1.2.4, Certificates of Fitness should be issued in accordance with the requirements of this section and with the requirements of section 1.6 of the Bulk Chemical Code.

1.6.4 Issue or endorsement of certificate by another Government

A 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.

1.6.5 Duration and validity of the certificate

(a) A 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.

(b) No extension of the five year period of the certificate should be permitted.

(c) The certificate should cease to be valid:

(i) if the surveys are not carried out within the period specified by 1.6:

(ii) upon transfer of the ship to the flag of another Government. A new certificate should only he issued when the Government issuing the new certificate is fully satisfied that the ship is in compliance with the requirements of 1.6.2(a) and 1.6.2(b). Where a transfer occurs to the flag of another Government, the Government of the State whose flag the ship was formerly entitled to fly may, 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.

1.7 Review of the Code

1.7.1 The Code will be reviewed by the Organization at intervals preferably not exceeding twelve months to consider revision of existing requirements and the formulation of requirements for new products and new developments in design and technology.

1.7.2 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 XIX, the Administrations involved in such carriage should establish suitable conditions of carriage based on the principles of the Code and notify the Organization of such conditions. During the periodical review of the Code these submissions will be considered for inclusion.

1.7.3 Where a new development in design and technology has been found acceptable to an Administration, that Administration may submit particulars of such development to the Organization for consideration for incorporation into the Code during the periodical review.

CHAPTER II - SHIP SURVIVAL CAPABILITY AND CARGO TANK LOCATION

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 shell plating. Both the damage to be assumed and the proximity of the cargo tanks to the ship's shell should be dependent upon the degree of hazard considered to be presented by the product to be carried.

2.1.2 Ships subject to the Code should be designed to one of the following standards. Type IG for the transportation of products considered to present the greatest overall hazard and Types IIG/IIPG and MG for products of progressively lesser hazards. Accordingly, a Type IG ship should survive the greatest extent of hull damage and its cargo tanks should be located at the greatest distance inboard from the shell plating.

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

2.1.4 [2] When it is intended to carry more than one product covered by this Code the requirements for ship survival capability should be those appropriate to the product having the most stringent ship type requirement. The requirements for the location of cargo tanks, however, will be those related to the respective products.

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, 1966. The additional requirements in 2.5 and 2.6, taking into account any empty or partially filled tank as well as the weight and volume of products to be carried, should, however, govern the operating draught for any actual condition of loading

2.2.2 The stability of the ship in all seagoing conditions and during the process of loading and unloading cargo should be positive and to a standard which is acceptable to the Administration,

2.2.3 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 and unloading and ballasting perations and a summary of the ship's survival capabilities and provisions for evaluating other conditions of loading, In addition, the booklet should contain sufficient information regarding the ship and its cargo to enable the master to load and operate the ship in a safe and seaworthy manner.

2.3 Damage and flooding assumptions

2.31 The following permeability factors should be applied to spaces assumed to be flooded

spaces	permeability
appropriated to stores	0.60
occupied by accommodation	0.95
occupied by machinery	0.85
voids	0.95
intended for consumable liquids	0 or 0.95*
intended for other liquids	0 to 0.95**

* Whichever results in the more severe requirements.
** The permeability of partially filled compartments should be consistent with the amount of liquid carried.

Wherever damage penetrates a cargo tank it should be assumed that the cargo is completely lost from that compartment and replaced by salt water up to the level of the final plane of equilibrium.
2.3.2 Assumed maximum extent of damage:

(a) Side damage:

(i) Longitudinal extent:	1/3 $L^{2/3}$ or 14.5 m whichever is less.
(ii) Transverse extent: (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.
(iii) Vertical extent:	from the base line upwards without limit.

(b) Bottom damage:

	For 0.3L from the forward of the ship	Any other part of the ship perpendicular
(i) Longitudinal extent:	1/3 $L^{2/3}$ or 14.5 m whichever is less,	L/10 or 5 m whichever is less.
(iii) Transverse extent:	B/6 or 10.0 m whichever is less.	B/6 or 5 m whichever is less.
(iii) Vertical extent:	B/15 or 2 m whichever is less, measured from the moulded line of the shell I at the centre line.	B/15 or 2 m whichever is less, measured from the moulded line of the shell at the centre line.

(c) If any damage of a lesser extent than the maximum specified would result in a more severe condition, such damage should be considered.

2.4 Survival requirements

2.4.1 Ships subject to the Code should be capable of surviving the damage assumed in 2.3 to the extent provided in 2.5 in a condition of stable equilibrium and should satisfy the following criteria.

(a) In any stage of flooding:

(i) The water-line taking into account sinkage, heel and trim should be below the lower edge of any opening through which progressive or down flooding 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, Credit -ray

be given to any portion of the structure which remains watertight above or below the freeboard deck.
(ii) Where damage produces an angle of heel, the maximum angle at any stage, of flooding should not exceed 30°

(iii) The Administration should be satisfied that the residual stability is sufficient.

(b) In the final stage of flooding:

(i) The righting lever curve has a minimum range of 20° beyond the position of equilibrium in association with a maximum righting lever of at least 100 mm within this range. Unprotected openings should not be immersed within the minimum range of residual stability required unless the space concerned is included in damage stability calculations as a floodable space. Within this range the immersion of all openings listed in 2.4.1(a)(i) and others capable of being closed weathertight may be permitted.

(ii) The life-saving devices should be capable of operating at the final angle of heel from the lower side of the vessel.

(iii) The emergency power supply should be capable of operating at the final angle of heel.

2.4.2 Under local damage conditions in the cargo area, extending in 760 mm measured normal to the hull shell and which for a Type IG ship and a Type IIG/IIPG ship in accordance with 2.5.1 or 2.5.2(a) and (b) respectively, may occur on a transverse watertight bulkhead, the maximum angle of heel should in no case exceed that applicable under 2.4.1(a)(ii), and should not reach that angle which would prohibit the restoration of propulsion and steering engine power at reduced speed and the use of the ballast system.

2.4.3 The ship design should ensure that the possibility of hull damage causing asymmetrical flooding is kept to the minimum consistent with efficient arrangements, 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 stability to meet the requirements of 2.4.1 and 2.4.2 and, if used, sufficient residual stability should be maintained during all stages of equalization, S: which are linked by ducts of large cross-sectional area may be considered to be common.

2.4.4 If pipes, ducts, trunks or tunnels are situated within the assumed extent of damage penetration, as defined in 2,3.2, arrangements should be such that progressive flooding cannot thereby extend to compartments other than those assumed to be flooded for each case of damage.

2.5 Standard of damage to be applied

Ships subject to this Code should be designed and constructed so as to be capable of sustaining the damage indicated in 2.3 in the manner stated in 2,4 to the following standards:

2.5.1 All Type IG ships should be capable of sustaining damage anywhere In their lengths,

2.5.2 (a) A Type I IG ship of more than 150 m in length should be capable of sustaining damage anywhere in her length.

(b) A Type I IG ship of 150 m or less in length should be capable of sustaining damage anywhere in her length except involving either of the bulkheads bounding a machinery space located aft, alternatively a Type IIG ship of 150 m or less in length with independent tanks type C design for a MARVS of at least 7 kp/cm^2 and where the design temperature of the cargo containment system is not below -55°C, need only be capable of sustaining damage anywhere in her length except involving transverse bulkheads spaced further apart than the longitudinal extent of damage as specified in 2.3.2(a)(i). Such a ship should be designated a Type IIPG ship and so indicated on the Certificate of Fitness provided for in 1.6.

2.5.3 (a) A Type IIIG ship of 125 m in length and over should be capable of sustaining damage anywhere in her length except involving transverse bulkheads spaced further apart than the longitudinal extent of damage specified in 2.3.2(a)(i).

(b) A Type IIIG ship below 125m in length should be capable of sustaining damage anywhere in her length except involving transverse bulkheads spaced further apart than the longitudinal extent of damage specified in 2.3.2(a)(i) and except involving damage to the machinery space. However, the ability to survive flooding of the machinery space should be considered by the Administration.

2.5.4 Where the damage between adjacent transverse watertight bulkheads is envisaged as specified in 2.5.2(b) and 2.5.3, a main transverse bulkhead or a transverse bulkhead bounding side tanks or double bottom tanks should be assumed damaged if there is a step or a recess in a transverse bulkhead of more than 3.05m 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.

2.6 Location of cargo tanks

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

(a) Type IG ships: from the side shell plating not less than the transverse extent of damage specified in 2.3.2(a)(ii) and from the moulded line of the bottom shell plating at centre line not less than the vertical extent of damage specified in 2.3.2(b)(iii) and nowhere less than 760 mm from the shell plating.

(b) Types IIG/IIPG and IIIG ships: from the, moulded line of the bottom shell plating at centre line not less than the vertical extent of damage specified in 2.3.2(b) (iii) and nowhere less than 760 mm from the shell plating.

E-NA 2.6.2 [2] For the purpose of tank location, the vertical extent of 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 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 IG ships suction wells installed in cargo tanks may protrude into the area of bottom damage provided that such wells are as small as practicable and the penetration does not exceed 25 per cent of double bottom height or 350 mm whichever is less.

2.6.4 Solid ballast should not normally be used in double bottom spaces in the cargo areas. Where, however, because of stability considerations the fitting of solid ballast in such spaces becomes unavoidable, then the quantity and its disposition should be governed by the need to ensure that the impact loads resulting from bottom damage are not directly transmitted on to the cargo tank structure.

2.7 Special consideration for small ships

2.7.1 In the case of small ships intended for the carriage of products requiring Type IIG/IIPG ships and Type IIIG ships which do not comply in all respects with the appropriate requirements of 2.5.2 and 2.5.3, special dispensations may only be considered by the Administration where alternate measures can be taken which maintain the same degree of safety.

2.7.2 In the approval of the design of a ship for which a dispensation has been granted, the nature of the alternate measures prescribed should be clearly stated and be available to the Administration in the countries the ship will visit and any such dispensation should be duly noted on the Certificate of Fitness referred to in 1.6.

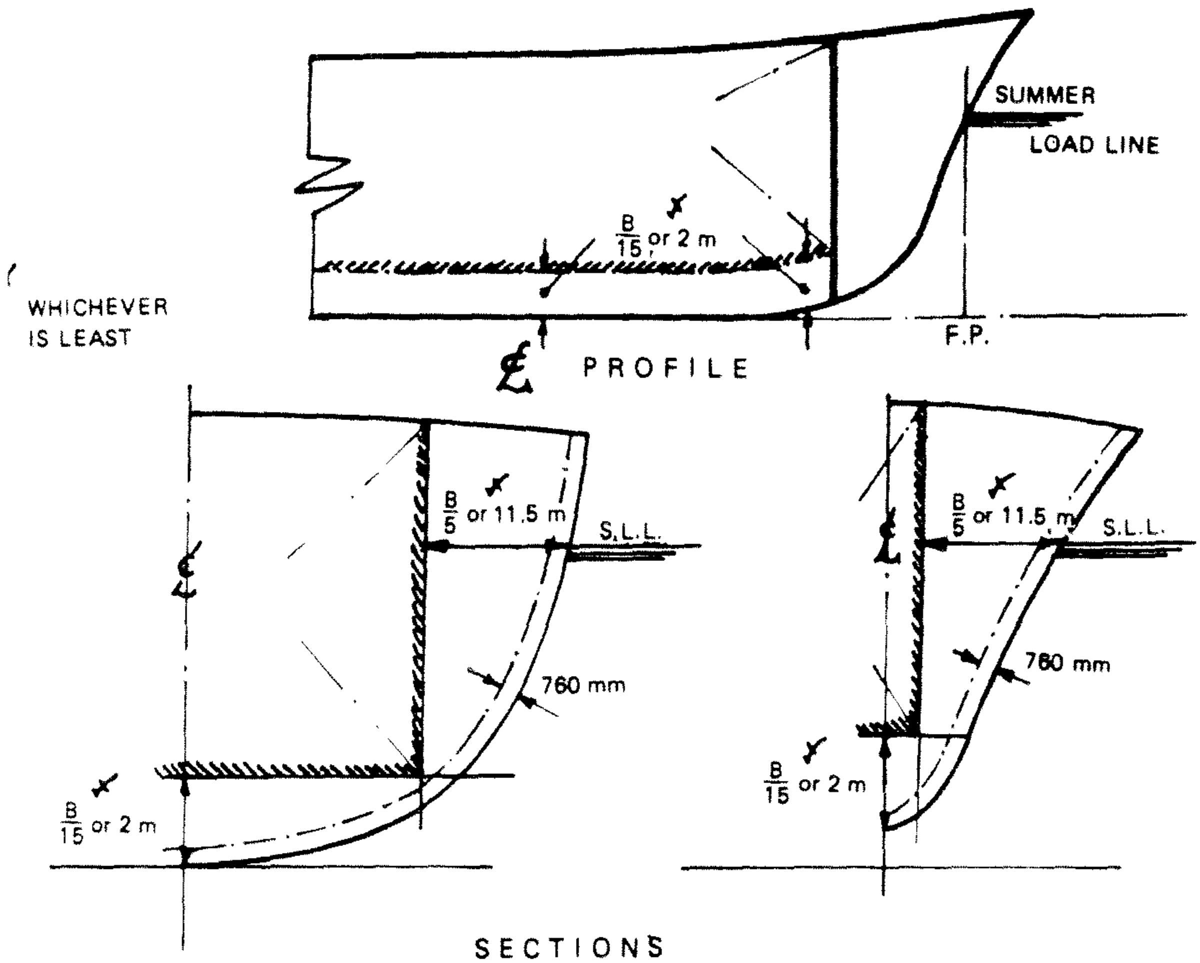

Figure 2.1 – Tank location requirements as set out in 2.6

CHAPTER III - SHIP ARRANGEMENTS

3.1 Segregation of the cargo area

3.1.1 Hold spaces should be segregated from machinery and boiler spaces, accommodation, service and control station spaces, 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. [4]

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 gas-tight 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:

(a) at temperatures below -10°C, hold spaces should be segregated from the sea by a double bottom; and

(b) at temperatures below -55°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:

(a) be segregated from other piping systems, except where interconnections 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-connections;

(b) except as provided in Chapter XVI, not pass through any accommodation, service or control station space or through a machinery space other than a cargo pump room or cargo compressor space. Emergency cargo dumping arrangements may be led aft externally to accommodation, service or control station spaces or machinery spaces, but should not pass through them;

(c) 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;

(d) except for bow or stern loading provisions in accordance with 3.8, and except in accordance with Chapter XVI, be located in the cargo area above the open deck; and

(e) except for thwartship shore connection piping not subject to internal pressure at sea or emergency cargo dumping arrangements, be located inboard of the transverse tank location requirement of 2.6.1.

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 control station spaces

3.2.1 No accommodation, service or control station space should be located within the cargo area. The bulkhead of accommodation, service or control station spaces which face the cargo area should be located so 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, machinery spaces, service and control station spaces in relation to cargo piping, cargo vent systems and machinery space exhausts from gas burning arrangements. [1]

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 far 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, service and control station spaces should not face the cargo area. They should be located on the end bulkhead not facing the cargo area and/or on the outboard side of the house at a distance of at least L/25 but not less 3.05 m from the end of the house facing the cargo area. This distance, however, need not exceed 5m. 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 wheelhouse doors may be located within the above limits so long as they are so designed that a rapid and efficient gas and vapour tightening of the wheelhouse can be ensured. For ships dedicated to cargoes which have neither flammable nor toxic hazards, the Administration may approve relaxations from the, above requirements. [4]

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, service and control station spaces 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 (a) 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. [4] *

E-NA

* This paragraph applies to ships built on or after 1 September 1984 (see Regulation II-2/1.1 and 1.2 of the 1981 SOLAS amendments).

(b) 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 1.4.6 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 the foregoing. [4]

E-NA

(c) 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, 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. [4]

E-NA

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 Cargo control rooms

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, service or control station spaces provided the following conditions are complied with:

(a) the cargo control room is a gas-safe space; and [1]

(b) (i) if the entrance complies with 3.2.4, the control room may have access to the spaces described above, [4]

(ii) 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" standard. [4]

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

E-NA 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 and/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. [2]

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:

(a) Access should be provided:

(i) to cargo tanks direct from the open deck;

(ii) 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

(iii) 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.

(b) The dimensions referred to in sub-paragraphs (a)(ii) and (a)(iii) of this paragraph 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.

(c) The requirements of sub-paragraphs (a) and (b) of this paragraph do not apply to spaces described in 1.4.16(e). Such spaces should be provided only with direct or indirect access from the open weather deck, not including an enclosed gas-safe space. [1]]

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 !east 1.5 m but not more than 2.5 m apart. [1]]

E-NA

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. [1]]

E-NA 3.6.4 In ships carrying flammable products electrical equipment which is not of the certified safe type in spaces protected by air-locks should be de-energized upon loss of over-pressure in the space (see also 10.2.9). [1]] Electrical equipment which is not of the certified safe type 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. [4]]

E-NA

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, 1966, the door sill should not be less than 300 mm in height.

3.7 Bilge, ballast and fuel oil arrangements [1]]

3.7.1 (a) 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.

(b) 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 interbarrier 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.

E-NA 3.7.3 In case of internal insulation tanks, means of detecting leakage and drainage arrangements are not required for interbarrier 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(b). [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 connections are led directly to the pumps and the discharge from the pumps led 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. [1] [2]

3.8 Bow or stern loading and discharge arrangements

3.8.1 Subject to the approval of the Administration, cargo pipes may be arranged to permit bow or stern loading or discharge subject to the requirements of this section, and of 17.7.

3.8.2 Cargo pipes and related piping and equipment forward or aft of the cargo area should have only welded connections in way of the house and should he led externally past accommodation service and control station spaces and machinery spaces and, except for thwartships shore connection piping, be at least 760 mm inboard. Such pipes should be clearly identified and segregated by at least two valves situated in the cargo area, which can be locked closed under the control of the master, or by one valve and other means together providing an equivalent standard of segregation. Means should be provided between the two valves if fitted, or in an equivalent position with, other arrangements, to enable the efficiency of the segregation to be checked.

3.8.3 Arrangements should be made to allow such pipes to be purged after use and maintained gas-safe when not in use. The vent pipes connected with the purge should be located in the cargo area.

3.8.4 Entrances, air inlets and openings to accommodation, service and control stations should not face the bow or stern loading or discharge arrangements. They should be located on the outboard side of the houses at a distance of at least L/25 but not less than 3.05 m from the end of the house facing the bow or stern loading or discharge arrangements (reference is also made to 3.2.4). This distance, however, need not exceed 5m. Port lights facing these loading and discharging arrangements and on the sides of the house 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 discharge arrangements, all doors, ports and other openings on the corresponding house side should be kept closed.

3.8.5 Fire fighting arrangements for the bow or stern loading and discharge areas should be in accordance with 11.4.7.

CHAPTER IV - CARGO CONTAINMENT

4.1 General

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

* Reference is made to the published Rules of members and associate members of the International Association of Clarification Societies and in particular to IACS Unified Requirements Nos. G1 and G2. [4]]

4.2 Definitions

In addition to those in 1.4, the following definitions apply throughout the Code.

4.2.1 ***Integral tanks***

(a) 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.

(b) The "design vapour pressure" P_o as defined in 4.2.5 should not normally exceed 0.25 kp/cm^2. If, however, the hull scantlings are increased accordingly, P_o may be increased to a higher value but less than 0.7 kp/cm2.

(c) Integral tanks may be used for the products provided that the lowest temperature in any part of the hull structure under no circumstances will fall below -10°C. A lower temperature may be accepted by the Administration subject to special consideration.

4.2.2 ***Membrane tanks***

(a) 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.

(b) The design vapour pressure P_o should not normally exceed 0.25 kp/cm^2. 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 kp/cm^2.

(c) 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. [2]]

E-NA

4.2.3 ***Semi-membrane tanks***

(a) 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,

(b) The design vapour pressure P_0 should not normally exceed 0.25 kp/cm^2. If, however, the hull scantlings are increased accordingly, and consideration is given, where appropriate, to the strength of the supporting insulation, P_0 may be increased to a higher value but less than 0.7 kp/cm^2.

4.2.4 ***Independent tanks***

Independent tanks are self-supporting; they do not form part of the ship's hull and are not essential to the hull strength. The three categories of independent tanks are:

(a) Independent tanks type A which are designed primarily using Recognized Standards of classical ship-structural analysis procedures. Where such tanks are primarily constructed of plane surfaces (gravity tanks), the design vapour pressure P_0 should be less then 0.7 kp/cm^2.

(b) Independent tanks type B 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_0 should be less than 0.7 kp/cm^2.

(c) Independent tanks type C (also referred to as pressure vessels) are tanks meeting pressure vessel criteria and having a design vapour pressure not less than:

$$P_0 = 2 + AC(\rho)^{3/2}\ [\text{kp/cm}^2]$$

where

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

with

$ó_m$ = design primary membrane stress

$\Delta\sigma_A$ = allowable dynamic membrane stress (double amplitude at probability level Q = 10^{-8})
5.5 kp/mm^2 for ferritic/martensitic steel
2.5 kp/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 0.45 ℓ

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 = the relative density of the cargo (p = 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*** [2]

E-NA (a) 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.

(b) The two categories of internal insulation tanks are:

(i) Type 1 tanks 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.

(ii) Type 2 tanks 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.

In (b)(i) and (b)(ii) the term "liner" means a thin, non-self-supporting, metallic, non-metallic 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 alone is not intended to function as a liquid barrier.

(c) 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.

(d) The design vapour pressure P_0 should not normally exceed 0.25 kp/cm^2. If, however, the cargo containment system is designed for a higher vapour pressure, P_0 may be increased to such higher value, but not exceeding 0.7 kp/cm^2 if the internal insulation tanks are supported by the inner hull structure. However, a design vapour pressure of more than 0.7 kp/cm^2 may be accepted by the Administration provided the internal insulation tanks are supported by suitable independent tank structures.

4.2.6 Design vapour pressure P_0 is the maximum gauge pressure at the top of the tank which has been used in the design of the tank.

(a) For cargo tanks where there is no temperature control and where the pressure of the cargo is dictated only by the ambient temperature, P_0 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.

(b) In all cases, including sub-paragraph (a) of this paragraph, P_0 should not be less than MARVS.

(c) Subject to special consideration by the Administration and to the limitations given in 4.2.1 to 4.2.4 for the various tank types, a vapour pressure higher than P_0 may be accepted in harbour conditions, where dynamic loads are reduced.

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

4.3 Design loads

4.3.1 (a) Tanks together with their supports and other fixtures should be designed taking into account proper combinations of the various loads listed hereafter:

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 of this section.

(b) Account should be taken of the loads corresponding to the pressure test referred to in 4.10.

(c) Account should be taken of an increase of vapour pressure in harbour conditions referred to in 4.2.6(c).

(d) The tanks should be designed for the most unfavourable static heel angle within the range 0° to 30° without exceeding allowable stresses given in 4.5.

4.3.2 ***Internal pressure***

(a) Internal pressure head (h_{eq}) in metres of fresh water resulting from the design vapour pressure (P_0) and the liquid pressure (h_{gd}) defined in sub-paragraph (b) of this paragraph, but not including effects of liquid sloshing, should be calculated as follows:

$$h_{eq} = 10\ P_0 + (h_{gd})_{max}$$

Equivalent calculation procedures may be applied.

(b) 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. The value of internal pressure head (h_{gd}) in metres of fresh water resulting from combined effects of gravity and dynamic accelerations should be calculated as follows:

$$h_{gd} = a_\beta Z_{\beta\gamma}$$

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. [1]]

γ = maximum specific weight of the cargo (t/m3) 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***

(a) 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 her 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.

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

(c) 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 108 wave encounters). If simplified dynamic loading spectra are used for the estimation of the fatigue life, those should be specially considered by the Administration.

(d) In order to practically apply 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.

(e) Ships for restricted service may be given special consideration.

(f) 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***

(a) 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(f) should be considered.

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

4.3.6 ***Thermal loads***

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

(b) 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 analysis

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***

(a) 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.

(b) Before approval is given, a model of both the primary and secondary barriers, including corners and joints, should normally he 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.

(c) For the purpose of the test referred to in sub-paragraph (b) of this paragraph, 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.

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

(e) 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 ***Independent tanks type A***

(a) 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(a).

(b) For parts, such as structure in ways 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 ***Independent tanks type B***

(a) 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.

(b) 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. [1]

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

(d) A buckling analysis should consider the maximum construction tolerances.

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

(f)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 Wohler (S-N) curve

N_j = number of cycles to fracture for the fatigue loads due to loading and unloading

Cw 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 Wohler (S-N) curve.

4.4.6 ***Independent tanks type C***

(a) Scantlings based on internal pressure

(i) 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.

(ii) The design liquid pressure defined in 4.3.2 should be taken into account when calculations are made according to 4.4.6(a)(i).

(iii) The welded joint efficiency factor to be used in the calculation according to 4.4.6(a)(i) should be 0.95 when the inspection and the non-destructive testing referred to in 4.10.7 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 4.10.7(b)(ii) 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.

(b) ***Buckling criteria***

(i) 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.

(ii) ***Design external pressure***

The design external pressure (P_e) used for verifying the buckling of the pressure vessels should not be less than that given by:

$$P_e = P_1 + P_2 + P_3 + P_4 \ (kp/cm^2)$$ [1]

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 kp/cm^2.

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 and/or internal pressure 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 $P_4 = 0$.

(c) ***Stress analysis in respect of static and dynamic loads***

(i) Pressure vessel scantlings should be determined in accordance with sub paragraphs (a) and (b) of this paragraph.

(ii) 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.

(iii) If required by the Administration, secondary stresses and thermal stresses should be specially considered.

(d) ***Plate tolerance***

For pressure vessels, the thickness calculated according to 4.4.6(a) or the thickness required by 4.4.6(b) plus the corrosion allowance, if any, should be considered as a minimum without any negative tolerance.

(e) ***Minimum thickness of shell and heads***

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.

E-NA 4.4.7 ***Internal insulation tanks*** [2]

(a) 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.

(b) (i) 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.

(ii) 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.

(iii) 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.

(c) 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.

(d) (i) 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.

(ii) 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).

(iii) 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 tank material properties, workmanship and quality control.

(iv) 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.

(e) The effects of fatigue loading should be determined in accordance with 4.4.5(f) or by an equivalent method.

(f) 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 allowance

4.5.1 ***Allowable stresses***

(a) For integral tanks, allowable stresses should normally be those given for hull structure in Recognized Standards.

(b) For membrane tanks, reference is made to the requirements of 4.4.2(e).

(c) For independent tanks type A 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 $ó_B/2.66$ or $ó_Y/1.33$ for carbon-manganese steels and aluminium alloys where $ó_B$ and $ó_Y$ are defined in sub-paragraph (f) of this paragraph, However, if detailed calculations are carried out for the primary members, the equivalent stress, $ó_C$, as defined in sub-paragraph (f) 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.

(d) (i) For independent tanks type B, primarily constructed of bodies of revolution, the allowable stresses should not exceed:

$ó_m \le f$
$ó_L \le 1.5f$
$ó_b \le 1.5F$
$ó_L + ó_b \le 1.5F$
$ó_m + ó_b \le 1.5F$

where

$ó_m$ = equivalent primary general membrane stress

ó$_{L}$ = equivalent primary local membrane stress

ó$_{b}$ = equivalent primary bending stress

f = the lesser of $\frac{\text{ó}_b}{A}$ or $\frac{\text{ó}_Y}{B}$

F = the lesser of $\frac{\text{ó}_b}{C}$ or $\frac{\text{ó}_Y}{D}$

with ó$_{m}$, ó$_{L}$, ó$_{b}$ as defined in 4.13 and the equivalent stress, ó$_{B}$ and ó$_{Y}$ as defined in sub-paragraph (f) of this paragraph. The values of A, B, C and D should be shown on the Certificate of Fitness provided for in 1.6, 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

(ii) For independent tanks type B, primarily constructed of plane surfaces, the Administration may require compliance with additional or other stress criteria.

(e) For independent tanks type C the maximum allowable equivalent membrane stress to be used in calculation according to 4.4.6(a)(i) should be the lower of:

$$\frac{\text{ó}_b}{A} \text{ or } \frac{\text{ó}_Y}{B}$$

where ó$_{B}$ and ó$_{Y}$ are as defined in sub-paragraph (f) of this paragraph. The values of A and B should be shown on the Certificate of Fitness provided for in 1.6, and should have at least the minimum values indicated in the table of 4.5.1(d)(i).

(f) For the purpose of sub-paragraphs (c), (d) and (e) of this paragraph the following apply:

(i) ó$_{Y}$ = specified minimum yield stress at room temperature. If the stress-strain curve does not show a defined yield stress, the 0,2 per cent proof stress applies. [1]]

ó$_{B}$ = specified minimum tensile strength at room temperature. For welded connections in aluminium alloys the respective values of ó$_{Y}$ or ó$_{B}$ in annealed conditions should be used.

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 proper-ties are based should be shown on the Certificate of Fitness provided for in 1.6. [1]]

(ii) The equivalent stress (ó$_{C}$) (von Mises, Huber) should be determined by:

$$\text{ó}_C = \sqrt{\text{ó}_x^2 + \text{ó}_y^2 - \text{ó}_x\text{ó}_y + 3\tau_{xy}^2}$$

where

$\acute{o}_x$ = total normal stress in x-direction

$\acute{o}_y$ = total normal stress in y-direction

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

(iii) 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:

$$\acute{o}_x = \acute{o}_{x.st} \pm \sqrt{\Sigma(\acute{o}_{x\cdot dyn})^2}$$

$$\acute{o}_y = \acute{o}_{y.st} \pm \sqrt{\Sigma(\acute{o}_{y\cdot dyn})^2}$$

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

where

$\acute{o}_{x.st}$, $\acute{o}_{y.st}$ and $\tau_{xy.st}$ are static stresses and

$\acute{o}_{x\cdot dyn}$, $\acute{o}_{y\cdot dyn}$ and $\tau_{xy\cdot dyn}$ are dynamic stresses

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

E-NA (g) For internal insulation tanks, reference is made to the requirement of 4.4.7(b).21

(h) (i) Allowable stresses for materials other than those covered by Chapter VI should be subject to approval by the Administration in each case.

(ii) Stresses may be further limited by fatigue analysis, crack propagation analysis and buckling criteria.

4.5.2 ***Corrosion allowance***

(a) 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.

(b) 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(b).

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. [1]

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, provisions 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 Secondary barrier

4.7.1 Where the cargo temperature at atmospheric pressures is below -10°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°C, the hull structure may act as a secondary barrier. In such a case:

(a) the hull material should be suitable for the cargo temperature at atmospheric pressure as required by 4.9.2; and

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

E-NA 4.7.321 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 I Type 2		 Complete secondary barrier 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 4.2.1.

[2] In the case of semi-membrane tanks which comply in all respects with the requirements applicable to independent tanks type B, 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 designed so that:

(a) 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(d);

(b) 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

(c) 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 fulfill its functions at a static angle of heel of 30°.

4.7.6 (a) 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(d) after the initial detection of a primary barrier leak. Due account may be taken of liquid evaporation, rate of leakage, reliable pumping capacity and other relevant factors. In all cases, however, the inner bottom in way of cargo tanks should be protected against liquid cargo.

(b) 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°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 for the concerned grade of steel in Chapter VI as detailed in 4.9 [1] when the cargo tanks are at their design temperature and the ambient temperatures at 5°C for air and 0°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 Certificate of Fitness as provided for in 1.6.

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 for the concerned grade of steel in Chapter VI as detailed in 4.9 [1] 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:

(a) 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;

(b) the heating system should be arranged so 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;

(c) the heating system should be considered as an essential auxiliary; and

(d) 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°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°C and 5°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. [1]

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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. [2]

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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, welds, 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 and/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.

E-NA 4.9.7 [2] (a) Materials used for thermal insulation should be tested for the following properties as applicable, to ensure that they are adequate for the intended service:

compatibility with the cargo solubility in the cargo

absorption of the cargo shrinkage

ageing

closed cell content

density

mechanical properties

thermal expansion

abrasion

cohesion
thermal conductivity

resistance to vibrations

resistance to fire and flame spread.

(b) In addition to the above requirements insulation materials which contribute as cargo containment as defined in 4.2.5(a) should be tested for the following properties after simulation of ageing and thermal cycling to ensure that they are adequate for the intended service:

bonding (adhesive and cohesive strength)

resistance to cargo pressure

fatigue and crack propagation properties

compatibility with cargo constituencies and any other agent expected to be in contact with the insulation in normal service

where applicable the influence of presence of water and water pressure on the insulation properties should be taken into account

gas de-absorbing.

(c) The above properties, where applicable, should 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.

4.9.8 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 (a) All welded joints of the shells of independent tanks should be of the butt weld, full penetration type. For dome to shell connections, 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.

(b) Welding joint details for independent tanks type C should be as follows:

(i) 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.

(ii) 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 independent tanks type C 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 (a) 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.

(b) A quality control specification including maximum 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. [1]

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4.10.6 Integral tanks should be hydrostatically or hydropneumatically tested to the satisfaction of the Administration. The test in general should be performed so that the stresses approximate, as far as practicable, the design stresses and so 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.

E-NA 4.10.8 [2] (a) In ships fitted with internal insulation tanks where the inner hull is the supporting structure, all inner hull structure should be hydrostatically or hydropneumatically tested in accordance with Recognized Standards, taking into account the MARVS.

(b) 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(a).

(c) 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.

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

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

(a) ***Manufacture and workmanship*** -The tolerances relating to manufacture and workmanship such as out-of-roundness local deviations from the true form, welded joints alignment and tapering of plates having different thicknesses, should comply with standards acceptable to the Administration. The tolerances should also be related to the buckling analysis referred to in 4.4.6(b).

(b) ***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:

(i) Total non-destructive testing referred to in 4.4.6(a)(iii):

Radiography:
butt welds 100 percent 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 replacement of the radiographic testing, if specially allowed by the Administration. In addition, the Administration may require total ultrasonic testing an welding of reinforcement rings around holes, nozzles, etc.

(ii) Partial non-destructive testing referred to in 4.4.6(a)(iii):

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 maybe required by the Administration in each instance.

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

(a) For independent tanks type A, this test should be performed so that the stresses approximate, as far as practicable, the design stresses and so 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.

(b) For independent tanks type B, the test should be performed as required in sub-paragraph (a) of this paragraph for independent tanks type A. 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.

(c) Independent tanks type C should be tested as follows:

(i) 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 4.2.5. 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 except simple cylindrical and spherical pressure vessels.

(ii) 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.

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

(iv) 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 sub-paragraphs (i), (ii) and (iii) of this sub-paragraph.

(v) 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 (i) of this sub-paragraph should be fully complied with.

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

(vii) 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 and/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 independent tanks type B, 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 independent tanks type C 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 under taken on the internal insulation tanks. [2]

E-NA

4.10.18 For independent tanks type C, 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 independent tanks type C

(a) For independent tanks type C of carbon and carbon-manganese steel, post-weld heat treatment should 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 should be to the satisfaction of the Administration. The soaking temperature and holding time should be to the satisfaction of the Administration.

(b) 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:

(i) Complicated welded pressure vessel o arts 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.

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

(iii) 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.

(iv) 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 motions in the case of ships with a length greater than 50m. These formulae correspond to a probability level of 10^{-8} in the North Atlantic.

(a) Vertical acceleration as defined in 4.3.4(f)

$$a_z = \pm a_0 \sqrt{1 + \left(5.3 - \frac{45}{L_0}\right)^2 \left(\frac{x}{L_0} + 0.05\right)^2 \left(\frac{0.6}{C_B}\right)^{3/2}}$$

(b) Transverse acceleration as defined in 4.3.4(f)

$$a_y = \pm a_0 \sqrt{0.6 + 2.5\left(\frac{x}{L_0} + 0.05\right)^2 + K\left(1 + 0.06K\frac{x}{B}\right)^2}$$

(c) Longitudinal acceleration as defined in 4.3.4(f)

$$a_x = \pm a_0 \sqrt{0.06 + A^2 - 0.25A}$$

in which $A = \left(0.7 - \frac{L_0}{1200} + 5\frac{z}{L_0}\right)\left(\frac{0.6}{C_B}\right)$

(d) In the formulae given in this paragraph:

(i) L_0 = length of ship for determination of scantlings as defined in Recognized Standards (m)

C_B = block coefficient

B = greatest moulded breadth (m)

x = longitudinal distance (m) from amidships to the centre of gravity of the tank with content. x is positive forward of amidships, negative aft of amidships

z = vertical distance (m) from the ship's actual water-line to the centre of gravity of tank with content, z is positive above and negative below the water-line

$$a_0 = 0.2\frac{V}{\sqrt{L_0}} + \frac{34 - \frac{600}{L_0}}{L_0}$$ where V = service speed in knots

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

$K = \frac{13GM}{B}$, where K> 1.0 and GM=metacentric height (m)

(ii) a_x, a_y, and a_z are the 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. [1]

4.13 Stress categories

For the purpose of stress evaluation referred to in 4.51 (d), stress categories are defined in this section,

4.13.1 ***Normal stress***: the component of stress normal to the plane of reference.

4.13.2 ***Membrane stress***: 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***: the variable stress across the thickness of the section under consideration, after the subtraction of the membrane stress.

4.13.4 ***Shear stress***: the component of the stress acting in the plane of reference.

4.13.5 ***Primary stress***: 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***: 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***: cases arise where a membrane stress produced by pressure or other mechanical loading and associated with a primary and/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 focal membrane stress although it has some characteristics of a secondary stress. A stress region may be considered as local if:

$S_1 \leq 0.5 \sqrt{R_t}$ and

$S2 \geq 2.5 \sqrt{R_t}$

where;

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

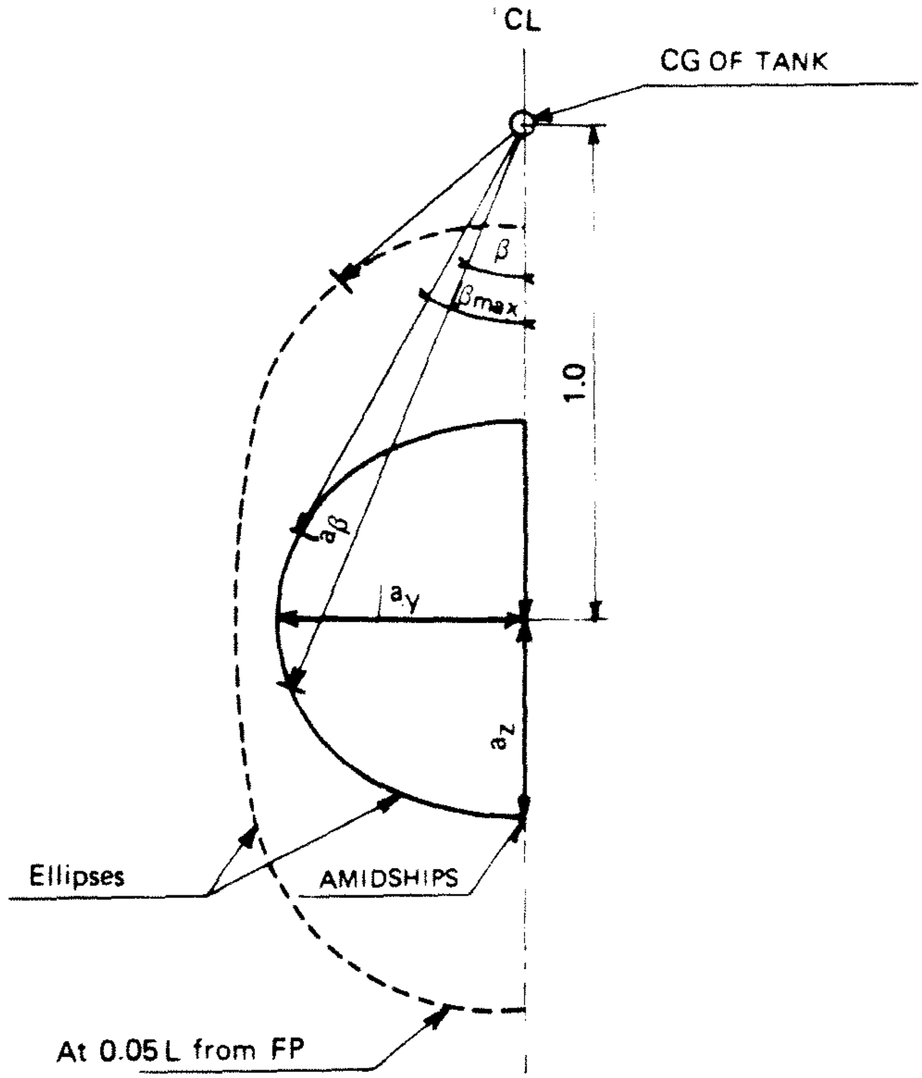
S2 = distance n the meridional direction to another region where the limits for primary general membrane stress are exceeded

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***: 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

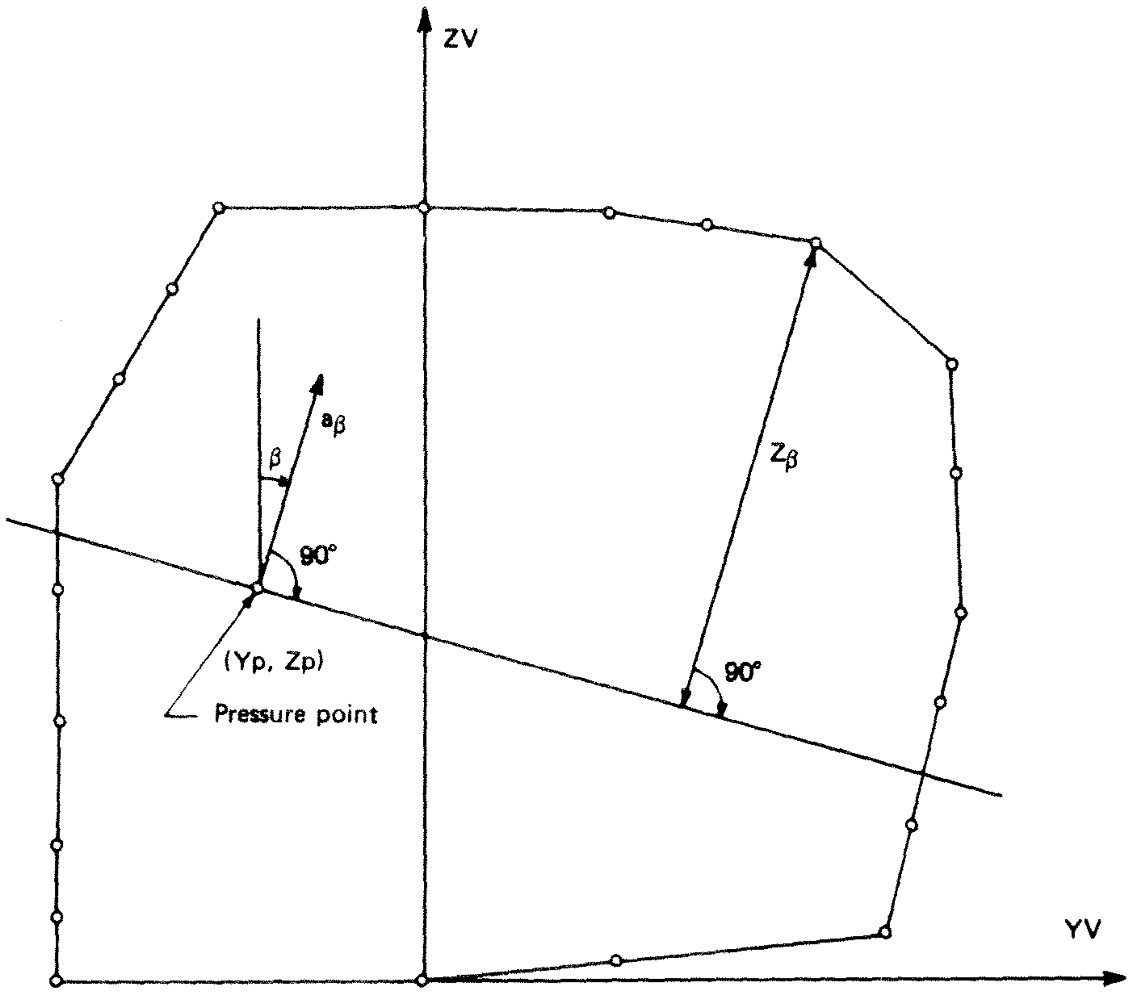
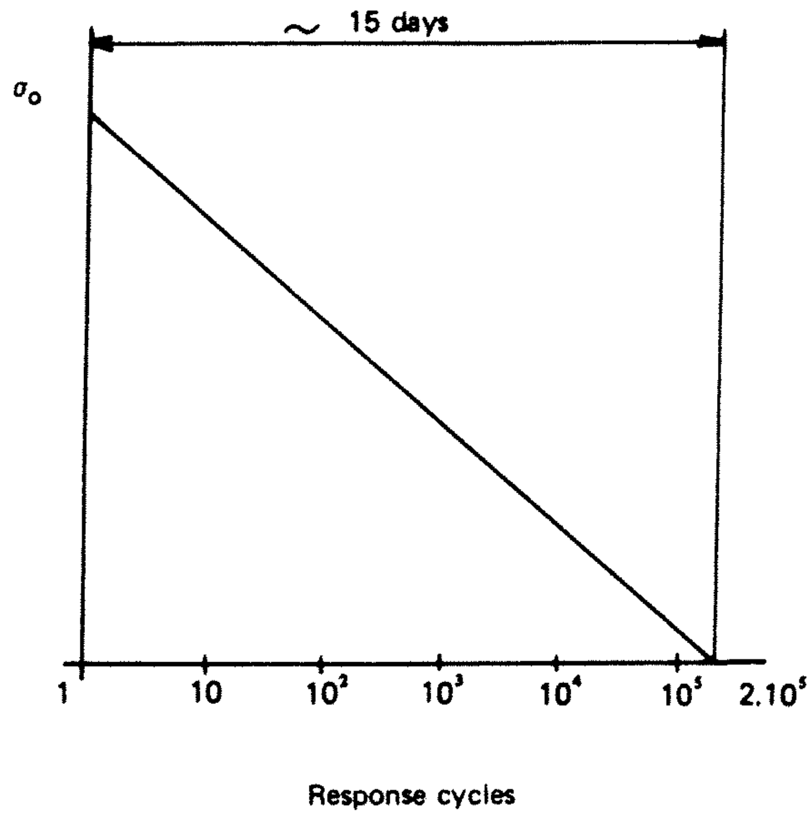


Figure 4.2 -- Determination of internal pressure heads



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 V - 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.*

* Reference is made to the published Rules of members and associate members of the International Association n of Classification Societies and in particular to IACS Unified Requirement No. G3. [4]

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

5.2 Cargo and process piping

5.2.1 (a) The requirements in 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.

(b) 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 the 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.

5.2.2 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 connections and at pump seals, protection for the hull beneath should be provided.

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

5.2.4 Suitable means should be provided to relieve the pressure and remove liquid contents from cargo loading and discharging crossover headers and/or cargo hoses to the cargo tanks or other suitable location, prior to disconnecting the cargo hoses.

5.2.5 (a) All pipelines or components which may be isolated in a liquid full condition should be provided with relief valves. [1]

(b) 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 be discharged to the pump suction. [1]

5.2.6 Scantlings based on internal pressure

(a) ***General***

Subject to the conditions stated in sub-paragraph (d) of this paragraph, the wall thickness of pipes should not be less than:

$$t = \frac{t_o + b + c}{1 - \frac{a}{100}}$$

where:

t = minimum thickness (mm)

t_o = theoretical thickness (mm)

$t_o = PD/(200\ K_e + P)$ with

P = design pressure (kp/cm^2) referred to in sub-paragraph (b) of this paragraph

D = outside diameter (mm)

K = allowable stress (kp/mm^2) referred to in sub-paragraph (c) of this paragraph

e = efficiency factor where e is 1.0 for seamless pipes and for longitudinally or spirally welded pipes, delivered by manufacturers approved for making welded pipes, which are considered equivalent to seamless pipes when non-destructive testing on welds is carried out in accordance with Recognized Standards. In other cases an efficiency factor 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:

$$b = \frac{D\ t_o}{2.5r}$$

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 (%).

E-NA (b) ***Design pressure 1]***

(ii) The design pressure P In the formula for t_o in sub-paragraph (a) of this paragraph is the maximum pressure to which the system may be subjected in service.

(ii) 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 4.2.5(a)); or

(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 4.2.5(a)), 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.

(iii) The design pressure should not be less than 10 kp/cm^2 except for open ended lines where it should be not less than 5 kp/cm^2.

(c) ***Allowable stress***

For pipes, the permissible stress to be considered in the formula for t in sub-paragraph (a) of this paragraph is the lower of the following values:

$$\frac{ó_B}{A} \text{ or } \frac{ó_Y}{B}$$

where:

$ó_B$ = specified minimum tensile strength at room temperature (kp/mm^2)

$ó_Y$ = specified lower minimum yield stress or 0.2 per cent proof stress at room temperature (kp/mm^2).

The values of A and B should be shown on the Certificate of Fitness as provided for in 1.6 and have values of at least A = 2.7 and B = 1.8.

(d) ***Minimum wall thickness***

(i) The minimum thickness should be in accordance with Recognized Standards.

(ii) 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 sub-paragraph (a) of this paragraph, or, if this is impracticable or would cause excessive local stresses, these loads should be reduced, protected against or eliminated by other design methods.

(e) ***Flanges, valves and other fittings***

(i) Flanges, valves and other fittings should be to a standard acceptable to the Administration, taking into account the design pressure defined in sub-paragraph (b) of this paragraph. For bellows expansion joints used in vapour service, a lower minimum design pressure may be accepted by the Administration. 1]

E-NA

(ii) For flanges not complying with a standard, the dimensions of flanges and relative bolts should be to the satisfaction of the Administration, 5.2.7 ***Stress analysis***

When the design temperature is -110°C or lower, a complete stress analysis, taking into account all the stresses due to weight of pipes, including acceleration loads if significant, internal pressure, thermal contraction and loads induced by hog and sag of the ship for each branch of the piping system should be submitted to the Administration. For temperatures of 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 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.

5.2.8 ***Materials***

(a) The choice and testing of materials used in piping systems should comply with the requirements of Chapter VI taking into account the minimum design temperature. However, some relaxation may be permitted in the quality of the material of open ended vent piping, provided the temperature of the cargo at the pressure relief valve setting is -55°C or greater and provided no 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 of membrane and semi-membrane tanks. [1]

(b) Materials having a melting point below 925°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.

5.2.9 ***Type tests on piping components***

Each type of piping component should be subjected to type tests as follows:

(a) ***Valves*** - Each size and type intended to be used at a working temperature below -55°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.

(b) ***Expansion*** - 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:

(i) 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.

(ii) 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.

(iii) 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.

(iv) 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.

(v) 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 kp/cm^2 this documentation is to include sufficient test data to substantiate the design method used, with particular reference to correlation between calculation and test results.

5.2.10 ***Piping fabrication and joining details***

(a) The requirements of this paragraph 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.

(b) The following direct connection of pipe lengths, without flanges, may be considered :

(i) Butt welded joints with complete penetration at the root may be used in all applications. For design temperatures below -10°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 or inert gas back-up on the first pass. For design pressures in excess of 10 kp/cm^2 and design temperatures of -10°C or lower, backing rings should be removed.

(ii) 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°C.

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

(c) ***Flange connections***

(i) Flanges should be of the welding neck, clip-on or socket welding type.

(ii) 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°C, only welding neck flanges should be used.

(2) For design temperatures lower than -10°C, slip-on flanges should not be used in nominal sizes above 100 mm and socket welding flanges should not be used in nominal sizes above 50 mm.

(d) Piping connections, other than those mentioned in sub-paragraphs (b) and (c) of this paragraph, may be accepted by the Administration in each case.

(e) ***Bellows and expansion joints***

(i) If necessary, bellows should be protected against icing.

(ii) Slip joints should not be used except within the cargo tanks.

(f) ***Welding, post-weld heat treatments and non-destructive testing***

(i) Welding should be carried out in accordance with 6.3.

(ii) 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 concerned piping system.

(iii) 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:

(1) 100 per cent radiographic inspection of butt welded joints for piping systems with service temperatures lower than -10° C and with inside diameters of more than 75 mm or wall thicknesses greater than 10 mm. [1]

(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.

5.2.11 ***Tests***

(a) The requirements of this paragraph 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.

(b) ***Pressure tests (strength and leak tests)***

(i) 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.

(ii) 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.

(c) ***Functional tests***

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.

5.3 Cargo system valving requirements

5.3.1 Every cargo piping system and cargo tank should be provided with the following valves, as applicable:

(a) For cargo tanks with a MARVS not exceeding 0.7 kp/cm^2, all liquid and vapour connections, 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 [1] valves 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 5.3.3 and should comply with the requirements of 5.3.4.

(b) For cargo tanks with a MARVS exceeding 0.7 kp/cm^2, all liquid and vapour connections, 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 [1] 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 [1] valve. A single valve may be substituted for the two separate valves provided the valve complies with the requirements of 5.3.4, is capable of local manual operation and provides full closure of the line.

(c) Cargo pumps and compressors should be arranged to shut-down automatically if the emergency shut-down [1] valves required by sub-paragraphs (a) and (b) of this paragraph are closed by the emergency shut-down system required by 5.3.4.

5.3.2 Cargo tank connections for gauging or measuring devices need not be equipped with excess flow or emergency shut-down [1] valves provided that the devices are constructed so that the outward flow of tank contents cannot exceed that passed by a 1.4 mm diameter circular hole.

5.3.3 One remote operated, emergency shut-down 1] valve should be provided at each cargo hose connection in use. Connections not used in transfer operations may be blinded with blank flanges in lieu of valves.

5.3.4 (a) 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 cargo loading station 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.

(b) Emergency shut-down valves in liquid piping should fully close under all service conditions within 30s of actuation. Information about the closing time of the valves and their operating characteristics should be available on board and the closing time should be verifiable and reproducible. Such valves should close smoothly. [1]

5.3.5 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 equalization of pressure, after an operating shut-down.

5.4 Ship's cargo hoses

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

5.4.2 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.

5.4.3 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 and/or minimum service temperature. The specified maximum working pressure should not be less than 10.5 kp/cm^2.

5.5 Cargo transfer methods

5.5.1 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.

5.5.2 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.

CHAPTER VI - 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.*

* Reference is made to the published Rules of members and associate members of the International Association of Classification Societies and in particular to ACS Unified Requirement No. W1. [4]

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 publication.

6.1.4 (a) Acceptance tests should include Charpy V-notch toughness tests. 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 smaller than 5.0 mm size specimens should be in accordance with Recognized Standards. Minimum average values for subsized specimens and the minimum value for a single specimen should be:

Charpy V-notch specimen size	Minimum energy average of 3 specimens	Minimum energy single specimen
10 x 10 mm	E	2/3 E
10 x 7.5 mm	5/6 E	5/9 E
10 x 5.0 mm	2/3 E	4/9 E

where E=the values of energy (kp.m) specified in tables 6.1 - 6.4.

E-NA (b) 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 fig. 6.1) [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. This new average of six specimens should not be less than the specified minimum average. At the discretion of the Administration other types of toughness tests, such as a drop weight test, may be used. These may be either 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. [4]

E-NA

6.2 Material requirements

The requirements for materials of construction in the tables are 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 and process piping for design temperatures below 0°C and down to -165°C.

Table 6.5: Plates and sections far hull structures required by 4.9.1 and 4.9.4.

E-NA TABLE 6.1 [4]

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 41 kp/mm^2 [3/]
CHARPY V-NOTCH TEST	
PLATES	Transverse test pieces. Minimum average energy value (E) 2.8 kp.m
SECTIONS AND FORGINGS	Longitudinal test pieces. Minimum average energy value (E) 4.2 kp.m
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 41 kp/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.

E-NA TABLE 6.2 [4]]

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: 0.16% max. [3/] — Mn: 0.70-1.60% — Si: 0.10-0.50% — S: 0.035% max. — P: 0.035% max. Optional additions: Alloys and grain refining elements may be generally in accordance with the following: Ni: 0.80% max. — Cr: 0.25% max. — Mo: 0.08% max. — Cu: 0.35% max. — Nb: 0.05% max. — V: 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) 2.8 kp.m SECTIONS AND FORGINGS [1/]: Longitudinal test pieces. Minimum average energy value (E) 4.2 kp.m

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 25mm, 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.

E-NA TABLE 6.3 [4]

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 25 mm [3/]		
Minimum design temperature (°C)	Chemical composition [4/] and heat treatment	Impact test temperature (°C)
- 60	1.5% Nickel steel - normalized	- 65
- 66	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 a 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	
SECT IONS AND FORGINGS	Batch test	
CHARPY V-NOTCH TEST		
PLATES	Transverse test nieces, Minimum average energy value (E) 2.8 kp. m	
SECTIONS AND FORGINGS	Longitudinal test pieces. Minimum average energy value (E) 4.2 kp.m	

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)
$25 < t \leq 30$	10° below design temperature
$30 < t \leq 35$	15° below design temperature
$35 < t \leq 40$	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 5% nickel steel, 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.

E-NA TABLE 6.4 [4]

PIPES (SEAMLESS AND WELDED), [1/] FORGINGS [2/] AND CASTINGS [2/]
FOR CARGO AND PROCESS PIPING FOR DESIGN TEMPERATURES
BELOW 0°C AND DOWN TO -165°C [3/]

Maximum thickness 25 mm

Minimum design temperature (°C)	Chemical composition [5/] and heat treatment	Impact test	
		Test temperature (°C)	Minimum average energy (E) (kp.m)
- 55	Carbon-manganese steel. Fully killed fine grain. Normalized or as agreed [6/]	[4/]	2.8
- 65	2.25% Nickel steel. Normalized or normalized and tempered [6/]	- 70	3.5
- 90	3.5% Nickel steel. Normalized or normalized and tempered [6/]	- 95	3.5
- 165	9% Nickel steel [7/] Double normalized and tempered or quenched and tempered	- 196	4.2
	Austenitic steels, such as types 304, 304L, 316, 316L, 321 and 347. Solution treated [8/]	- 196	4.2
	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.

E-NA TABLE 6.5 [4]

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						
-5 and above 0 [1/]	15	25	30	50	25	45	50
-10 and below -5	X	20	25	50	20	40	50
-20 and below -10	X	X	20	50	X	30	50
-30 and below -20	X	X	X	40	X	20	40
Below -30	In accordance with table 6.2 except that the thickness limitation of the table and of footnote [2/] do 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 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 far cargo tanks and process pressure vessels***

(a) Procedure tests 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.

(b) The following tests should be required from each test assembly:

(i) Cross-weld tests.

(ii) Transverse bend tests: These bend tests 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.

(iii) One set of three Charpy V-notch impacts should be made 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.

(iv) Macrosection, microsection and hardness survey may also be required by the Administration.

6.3.4 ***Test requirements***

(a) ***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.

(b) ***Bend tests:*** No fracture is acceptable after a 180° bend over a former of a diameter four times the thickness of the test pieces, unless otherwise specially required by or agreed with the Administration.

(c) ***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 2.8 kp.m. 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 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***

(a) For all cargo tanks and process pressure vessels except integral and membrane tanks, production tests should generally be performed for approximately each 50m 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 sub-paragraphs (b), (c) and (d) of this paragraph, may be required for cargo tanks or secondary barriers at the discretion of the Administration.

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

(i) 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.

(ii) 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.

(c) In addition to those tests listed in sub-paragraph(b)(i) of this paragraph for independent tank type G 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.

(d) Production tests for integral and membrane tanks should be in accordance with Recognized Standards.

3.7 ***Non-destructive testing***

(a) [1] (i) For independent tanks type A and semi-membrane tanks where the design temperature is -20°C or less, and for independent tanks type B regardless of temperature, all full penetration butt welds of the shell plating of cargo tanks should be subjected to 100 percent radiographic inspection.

(ii) Where the design temperature is higher than -20°C, all full penetration butt welds in way of intersections and at least 10 per cent of the remaining full penetration welds of tank structures should be subjected to radiographic inspection.

(iii) 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.

(iv) All testing procedures and acceptance standards should be in accordance with Recognized Standards. The Administration may accept an approved ultrasonic testing 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. [1]

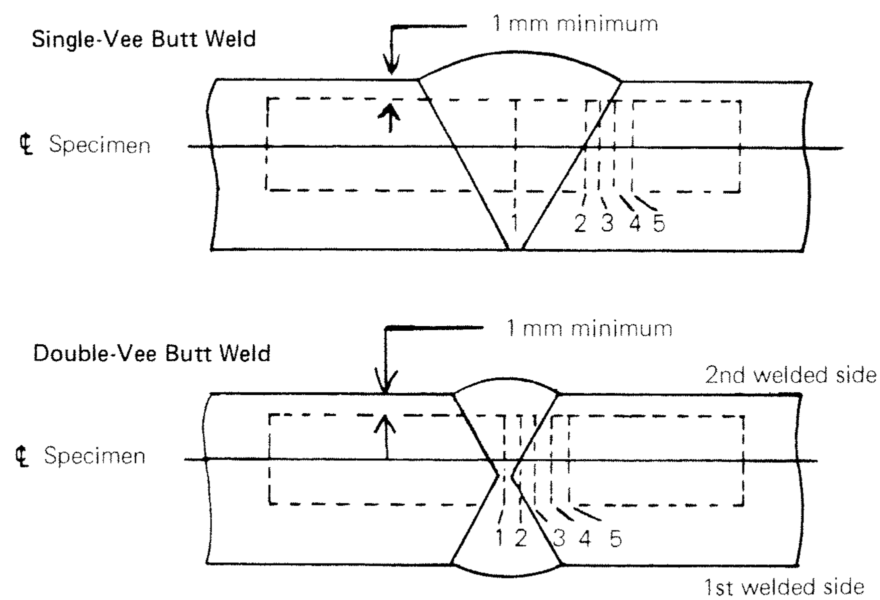
(b) Inspection of independent tanks type C and process pressure vessels should be carried out in accordance with Chapter IV.

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

(d) 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 as given in 4.4.7. The schedule for inspection and non-destructive testing should be to the satisfaction of the Administration. [2]

(e) Inspection of piping should be carried out in accordance with the requirements of Chapter V.

(f) 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

The largest size Charpy specimens possible for the material thickness are to be machined with the centre of the specimens located as near as practicable to a point midway between the surface and the centre of the thickness. In all cases, the distance from the surface of the material to the edge of the specimen should be approximately one mm or greater. In addition for double-vee butt welds, specimens are to be machined closer to the surface of the second welded side.

E-NA Figure 6.1 – Orientation of weld test specimen[1]

CHAPTER VII - 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.

(a) A system which regulates the pressure in the cargo tanks by the use of mechanical refrigeration.

(b) A system whereby the boil-off vapours are utilized as fuel for shipboard use and/or waste heat system subject to the provisions of Chapter XVI. 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.

(c) A system allowing the product to warm up and increase in pressure. The insulation and/or cargo tank design pressure 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.

(d) Other systems acceptable to the Administration.

(e) 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. [1]]

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 temperatures 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 XVII, 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 boil-off gas.

7.2 Refrigeration systems

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 (a) 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.

(b) 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(s) 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:

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

(b) an indirect system where cargo or evaporated cargo is cooled or condensed by refrigerant without being compressed;

(c) 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 XVII 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 may 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 VIII - CARGO 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, interbarrier spaces and cargo piping which may be subject to pressures beyond their design capabilities should also be provided with a suitable safety relief system. The pressure safety relief system should be connected to a vent piping system designed so as to minimize the possibility of cargo vapour accumulating about the decks, or entering accommodation service and control station spaces, and machinery spaces, or other spaces where it may create a dangerous condition. Pressure control systems specified by Chapter VII should be independent of the safety 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 Interbarrier 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 maximum pressure for which the cargo tank is designed.

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 working temperature below 0°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 kp/cm^2, ±6% for 1.5 to 3.0 kp/cm^2, ±3% for 3.0 kp/cm^2 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:

(a) 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

(b) 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:

(a) suitable arrangements to prevent more than one pressure relief valve being out of service at the same time;

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

(c) pressure relief valve capacities are such that if one valve is out of service the remaining valves should 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 arranged so 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, service and control station spaces, 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 10m from the nearest air intake or opening to accommodation, service and control station spaces, 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 0.015L trim, where L is as defined in 1.4.25.

8.3 Additional pressure relieving system

8.3.1 Where required by 15.1.4(b), an additional pressure relieving system of sufficient capacity to prevent the tank from becoming liquid full at any time during relief under the fire conditions referred to in 8.5 should be fitted to each tank. This pressure relieving system should consist of:

(a) a relief valve(s) set at a pressure corresponding to the gauge vapour pressure of the cargo at the reference temperature defined in 15.1.4(b); and

(b) an over-ride arrangement whenever necessary [4] 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 the relief valve specified in sub-paragraph (a) of this paragraph to become operable. Locations for the fusible elements should include the vicinity of the relief valve. 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 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.

8.3.3 Compliance with sub-paragraph 8.3.1 (a) 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. [4]

8.3.4 Relief valves mentioned under 8.3.1(a) above may be the same pressure relief valves mentioned in 8.2, provided the setting pressure and the relieving capacity are in compliance with the requirements of this paragraph. [4]

8.4 Vacuum protection systems

8.4.1 Cargo tanks designed to withstand a maximum external pressure differential exceeding 0.25 kp/cm^2 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 kp/cm^2, 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:

(a) 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

(b) 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

(c) other vacuum relief systems acceptable to the Administration.

8.4.3 Subject to the requirements of Chapter XVI I, 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 Size of valves

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:

(a) 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

(b) vapours generated under fire exposure computed using the following formula:

$$Q = FGA^{0.82}$$

where:

Q = minimum required rate of discharge in cubic metres (cubic feet) per minute of air at standard conditions of 0°C and 1.03 kp/cm2 (60°F and 14.7 psia)

F = fire exposure factor for different cargo tank types:

F = 1 .0 tanks without insulation located on deck;

F = 0.5 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 uninsulated independent tanks installed in holds;

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

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

F = 0.1 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:

(i) metric units

$$G = \frac{177}{LC}\sqrt{\frac{ZT}{M}}$$

(ii) British units

$$G = \frac{633,000}{LC}\sqrt{\frac{ZT}{M}}$$

with:

L = latent heat of the material being vapourized at relieving conditions, in Kcal/kg (Btu per pound);

C = constant based on relation of specific heats k, shown in table 8.1; if k is not known C = 0.606(315) should be used;

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

T = temperaturein degrees K = (273 + degrees C) (R = (460 + degrees F)) at the relieving conditions, i.e. 120 per cent of the pressure at which the pressure relief valve is set;

M = molecular weight of the product.

A = external surface area of the tank in m2 (sq ft) 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:

(i) insulation on the ship's structure:
A = external surface area of the hold less its projected bottom area;

(ii) 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 8.1 CONSTANT C

k	C		k	C	
	Metric	British		Metric	British
1.00	0.606	315	1.52	0.704	366
1.02	0.611	318	1.54	0.707	368
1.04	0.615	320	1.56	0.710	369
1.06	0.620	322	1.58	0.713	371
1.08	0.624	324	1.60	0.716	372
1.10	0.628	327	1.62	0.719	374
1.12	0.633	329	1.64	0.722	376
1.14	0.637	331	1.66	0.725	377
1.16	0.641	333	1.68	0.728	379
1.18	0.645	335	1.70	0.731	380
1.20	0.649	337	1.72	0.734	382
1.22	0.652	339	1.74	0.736	383
1.24	0.656	341	1.76	0.739	384
1.26	0.660	343	1.78	0.742	386
1.28	0.664	345	1.80	0.745	387
1.30	0.667	347	1.82	0.747	388
1.32	0.671	349	1.84	0.750	390
1.34	0.674	351	1.86	0.752	391
1.36	0.677	352	1.88	0.755	392
1.38	0.681	354	1.90	0.758	394
1.40	0.685	356	1.92	0.760	395
1.42	0.688	358	1.94	0.763	397
1.44	0.691	359	1.96	0.765	398
1.46	0.695	361	1.98	0.767	399
1.48	0.698	363	2.00	0.770	400
1.50	0.701	364	2.02	0.772	401
			2.20	0.792	412

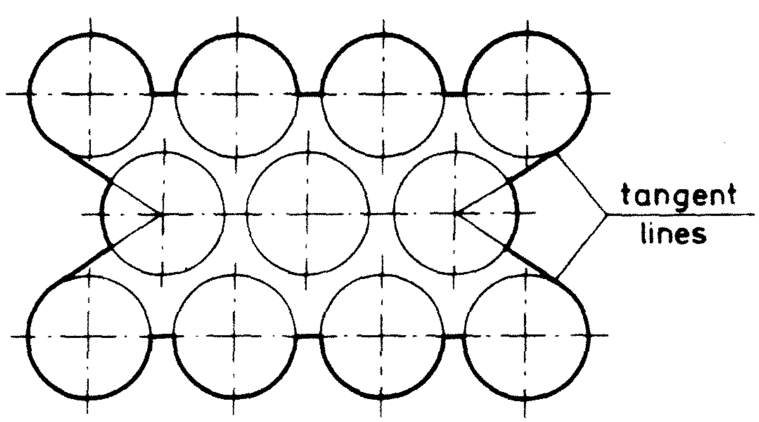


Figure 8.1

CHAPTER IX - ENVIRONMENTAL CONTROL FOR CARGO CONTAINMENT SYSTEMS

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 connections 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 furnished from ashore or from the ship.

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

9.2.1 Interbarrier 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 maintained 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 (a) Interbarrier and hold spaces associated with cargo containment systems for flammable gases requiring partial secondary barriers should be inerted with suitable, dry inert gas and maintained 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

(b) Except as limited by Chapter XVII, the Administration may allow the spaces referred to in sub-paragraph (a) of this paragraph 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 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 should be provided.

9.2.3 For non-flammable gases, the spaces referred to in 9.21 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 interbarrier spaces and spaces between the secondary barrier and the inner hull or independent tank structures completely filled with insulation material complying with 4.9.7(b). [2]]

E-NA

9.3 Environmental control of spaces surrounding independent tanks type C

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 manufactured 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 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 XVI I. 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 XVII. 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 return of cargo gas should be provided.

9.5.3 Spaces containing inert gas generating plants should have no direct access to accommodation, service or control station spaces, 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, service or control station spaces.

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.

CHAPTER X - ELECTRICAL ARRANGEMENTS

10.1 General

10.1.1 The provisions of this chapter are applicable to ships carrying flammable products and should be applied in conjunction with Part C of Chapter II of the 1974 Safety Convention.

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

10.1.3 Administrations should take appropriate steps to ensure uniformity in the implementation and application of the provisions of this chapter in respect of electrical installations.*

* Reference is made to the Recommendations published by the International Electrotechnical Commission and in particular to Publication 92-5, Chapter XX, Tankers.

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

10.1.5 Where electrical equipment is installed in gas-dangerous spaces or zones as provided in 10.1.4, it should be to the satisfaction of the Administration and approved by the relevant authorities recognized by the Administration for operation in the flammable atmosphere concerned.

10.2 Types of equipment

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

10.2.1 Intrinsically safe electrical equipment and wiring may be fitted in all gas-dangerous spaces and zones as defined in 1.4.16.

10.2.2 Cargo containment systems:

Submerged cargo pump motors and their supply cables. Arrangements should be made to automatically shut dawn 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 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 where cargo is carried in a cargo containment system requiring a secondary barrier:

Supply cables for submerged cargo pump motors.

10.2.4 Hold spaces where cargo is carried in a cargo containment system not requiring a secondary barrier; spaces separated from the hold spaces described in 1.4.16(d)(i) by a single gas-tight steel boundary:

(a) Through runs of cables.

(b) Lighting fittings with pressurized enclosures or of the flameproof 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.

(c) Flame-proof motors for valve operation for cargo or ballast systems may be installed in spaces described in 1.4.16(e).

(d) Electrical depth sounding or log devices and impressed current cathodic protection system anodes or electrodes. These devices should be housed in gas-tight enclosures.

(e) Flame-proof general alarm audible indicators may be installed in spaces described in 1.4.16(e).

10.2.5 Cargo pump rooms and cargo compressor rooms:

(a) Lighting fittings with pressurized enclosures or of the flameproof 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.

(b) Electric 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 XI I.

(c) Where operational or structural requirements are such as to make it impossible to comply with the method described in subparagraph (b) of this paragraph, motors of the following certified safe types may be installed in cargo pump rooms or cargo compressor rooms, provided they are of:

(i) increased safety type with flame-proof enclosure, or

(ii) pressurized type.

(d) Flame-proof general alarm audible indicator.

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

(a) Certified safe type equipment.

(b) Through runs of cables.

10.2.7 Enclosed or semi-enclosed spaces in which pipes containing cargo products are located and compartments for cargo hoses:

(a) Lighting fittings with pressurized enclosures or of the flameproof 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.

(b) Through runs of cables.

10.2.8 Enclosed or semi-enclosed spaces having a direct opening into any gas-dangerous space or zone should have electrical installations complying with the requirements for the space or zone to which the opening leads.

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

CHAPTER XI - FIRE PROTECTION AND FIRE EXTINGUISHING

11.1 Fire safety requirements

E-NA 11.1.1 [4] * 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:

* This paragraph applies to ships built on or after 1 September 1984 (see Regulation II-2/1.1 and 1.2 of the 1981 SOLAS amendments).

(a) Regulation 56.4 does not apply;

(b) 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;

(c) 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 III
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 X and XVI.

11.1.3 The provisions of this section apply in conjunction with Chapter III. [4]

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 the forward end of the forwardmost hold space should be included in the cargo area. [4] *

E-NA

* This paragraph applies to ships built on or after 1 September 1984 (see Regulation II-2/1.1 and 1.2 of the 1981 SOLAS amendments).

11.2 Firewater main equipment

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 kp/cm^2 [4] *

E-NA

* This paragraph applies to ships built on or after 1 September 1984 (see Regulation II-2/1.1 and 1.2 of the 1981 SOLAS amendments).

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. [4] *

E-NA

* This paragraph applies to ships built on or after 1 September 1984 (see Regulation II-2/1.1 and 1.2 of the 1981 SOLAS amendments).

11.2.3 Stop valves should be fitted in any cross-over provided and in the fire main(s) 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 example by galvanized pipe, 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 bridge or other control station outside the cargo area.

11.3 Water spray system

11.3.1 On ships carrying flammable or toxic products, a water spray system for cooling, fire prevention and crew protection should be installed to cover:

(a) exposed cargo tank domes and any exposed parts of cargo tanks;

(b) exposed on-deck storage vessels for flammable or toxic products;

(c) 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 at the drip trays provided; and

(d) 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. [3]

E-NA 11.3.2 [1] 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 not clearly defined horizontal or vertical surfaces, the capacity of the water spray system should be determined by the greater of the following:

(a) projected horizontal surface multiplied by 10 l/m^2 per minute; or

(b) 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, aft of the cargo area. A section protecting any area included in 11.3.1 (a) and (b) 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 simultaneously supply water to any one section and the surfaces specified in 11.3.1 (c) and (d). Alternatively, the main fire pumps may be used for this service provided that their total capacity is increased by the amount needed for the spray system. In either case, a connection, through a stop valve, 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 example by galvanized pipe, and to the effect of fire.

11.4 Dry chemical powder fire extinguishing systems

11.4.1 Ships intending to carry flammable products should be fitted with a fixed dry chemical powder type extinguishing system(s) 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 a combination monitor/hand hose line(s) 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 fines. 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. [3] All hand hose lines and monitors should be capable of actuation at the hose storage reel or monitor. At least one hand hose fine 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/sec. 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/sec. The maximum discharge rate should be such as to allow operation by one man. The length of a hand hose line should not exceed 33m, 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:

Fixed monitors capacity (kg/sec) 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 elevated above the monitor or hand hose reel locations. [1]

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. [1]

E-NA

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 [4]

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 ^{m3}	5

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

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 XII - MECHANICAL VENTILATION IN CARGO AREA*

* After 1 September 1984 for the requirements of this Chapter Substitute Regulation II-2/59.3 of the 1981 SOLAS amendments. [4]

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 or both upper and lower parts of the spaces dependent 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 10m in the horizontal direction from ventilation intakes and openings to accommodation, service and control station spaces 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 engine rooms, accommodation, service or control station spaces, except as allowed in Chapter XVI.

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:

(a) impellers and/or housing of non-metallic construction, due regard being paid to the elimination of static electricity;

(b) impellers and housing of non-ferrous materials;

(c) impellers and housing of austenitic (stainless) steel;

(d) 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.

12.1.1 1 Protection screens of not more than 13 mm square mesh should be fitted in outside openings of ventilation ducts

12.2 Spaces not normally entered

Hold spaces, interbarrier 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 interbarrier 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 XIII - 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 system as detailed in this chapter.

13.1.2 Where a secondary barrier is required, permanently installed 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 be 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. [2]]

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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. Testing 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 arranged so 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" of Chapter XIX :

(a) indirect devices, which determine the amount of cargo by means such as weighing or pipe flow meters;

(b) closed devices, which do not penetrate the cargo tank, such as devices using radioisotopes or ultrasonic devices;

(c) 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 shutoff valve located as close as possible to the tank;

(d) 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 kp/cm^2. [3]

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 XVII.

13.3 Liquid level alarms

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. This liquid level alarm or another independent sensor should also 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 5.3 may be used for this purpose. If another valve is used for this purpose, the same information as referred to in 5.3.4 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. [4]

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

(a) a pressure tank with a volume of not more than 200 m^3; or

(b) 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.

13.4 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 cargo control position. In addition, a high pressure alarm and, if vacuum protection is required, a low pressure alarm, should be provided on the bridge. Maximum and minimum allowable pressures should be marked on the indicators.

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 connections to the shore.

13.4.4 Hold spaces and interbarrier spaces without open connection 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 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:

(a) A sufficient number of devices to establish that an unsatisfactory temperature gradient does not occur.

(b) On one tank a number of devices in excess of those required in sub-paragraph (a) of this paragraph 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 Gas detection requirements

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" of Chapter XIX.

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 through gas-safe spaces except as permitted by 13.6.5.

13.6.4 Audible and visual alarms from the gas detection equipment, if required by this section, should be located on the bridge, in the cargo control position, and at the gas detector readout location.

13.6.5 Gas detection equipment may be located in the cargo control station, on the bridge or at other suitable locations. When located in a gas-safe space the following conditions should be met:

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

(b) 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 connections 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:

(a) cargo pump rooms;

(b) cargo compressor rooms;

(c) motor rooms for cargo handling machinery;

(d) cargo control rooms unless designated as gas-safe;

(e) other enclosed spaces in the cargo area where vapour may accumulate including hold spaces and interbarrier spaces for independent tanks other than type C;

(f) ventilation hoods and gas ducts where required by Chapter XVI; and

(g) 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(f) 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 toxic and flammable, the Administration may authorize the use of portable equipment, except when column "h" of Chapter XIX refers to 17.11, for toxic detection as an alternative to a permanently installed system, if used before entry of the spaces listed in 13.6.7 by personnel and thereafter at 30 minute intervals whilst occupied by them.

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 tower flammable limit.

13.6.11 In the case of flammable products, where cargo containment systems other than independent tanks are used, hold spaces and/or interbarrier spaces should be provided with a permanently installed system of gas detection capable of measuring gas concentrations of 0 to 100 percent 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/or interbarrier 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 whilst 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 XIV - PERSONNEL PROTECTION

14.1 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 Protective equipment should be kept in easily accessible places and in special lockers.

14.3 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. [1]

14.4 One complete set of safety equipment should consist of:

(a) one self-contained air-breathing apparatus not using stored oxygen, having a capacity of at least 1200 l of free air;

(b) protective clothing, boots, gloves and tight-fitting goggles;

(c) steel cored rescue line with belt; and (d) explosion-proof lamp.

14.5 [1] (a) An adequate supply of compressed air should be provided and should consist either of:

(i) one set of fully charged air-bottles for each breathing apparatus required by 14.3,

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 14.3; or

(ii) fully charged spare air-bottles with a total free air capacity of at least 6,000 l for each breathing apparatus required by 14.3.

(b) Alternatively, the Administration may accept a low pressure air line system with hose connections suitable for use with the breathing apparatus required by 14.3. 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.

14.6 Safety equipment as required in 14.3 should be kept in a suitable, clearly marked locker in a readily accessible place.

14.7 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.

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

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

CHAPTER XV - 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:

$$V_L = 0.98V \frac{d_R}{d_L}$$

where:

V_L = maximum volume to which the tank may be loaded

V = volume of the tank

d_R = density of cargo at the reference temperature

d_L = density of cargo at the loading temperature and pressure.

15.1.3 The Administration may allow a greater filling limit than 98 per cent 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 of 8.2.17 are maintained.

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

(a) 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 VII is provided.

(b) The temperature of the cargo upon termination of loading, during transport, or at unloading, whichever is the greater, when a cargo vapour pressure/temperature control as referred to in Chapter VII 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 system complying with 8.3 should be fitted.

15.2 Information to be provided to the master

The maximum allowable tank tilling 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 XVI - USE OF CARGO AS FUEL

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

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

(a) 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.

(b) 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 16.10. The exhaust fan for this duct should be arranged so that the gas fuel supply to the machinery space will be cut off if the required air flow is not established and maintained.

16.3 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.

16.4 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 16.5.

16.5 A ventilation hood or casing should be provided for the areas occupied by flanges, valves, etc., and for the gas fuel piping at the gas utilization unit, such as boiler, diesel engine, gas turbine, 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(b), 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 16.10. The exhaust fan should be arranged so 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.

16.6 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 series valves. These valves should be arranged so 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 series valves and 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.

16.7 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 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.

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

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

16.10 Gas detection systems provided in accordance with the requirements of 16.2 and 16.5 should alarm at 30 per cent of the lower flammable limit and shut down the gas fuel supply to the machinery space before the gas concentration reaches 60 per cent of the lower flammable limit.

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

16.12 The provisions of this chapter do not preclude the use of fuel for other services in other locations, such as cargo reliquefaction and inert gas generation, provided that such other services and locations should be subject to special consideration by the Administration.

CHAPTER XVII -SPECIAL REQUIREMENTS

17.1 General

Many of the products covered by the Code have individual characteristics which necessitate special requirements far their safe carriage. These are requirements additional to the general requirements of the Code.

The provisions of this chapter are applicable where reference is made in column "h" of Chapter XIX.

17.2 Personnel protection

17.2.1 [2] Respiratory and eye protection suitable for emergency escape purposes should be provided for every person on board subject to the following:

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

(ii) self-contained breathing apparatus normally having a duration service of at least 15 minutes;

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

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

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

17.2.3 In ships of a cargo capacity of 2,000 m3 and over two complete sets of safety equipment should be provided in addition to the equipment required by 11.6.1 and 14.3. At least three spare charged air-bottles should be provided for each self-contained air-breathing apparatus required in this paragraph. 1]

17.2.4 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.

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

17.3 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 far certain products as specified in column "h" of Chapter XIX.

17.3.1 Mercury, copper and copper bearing alloys, and zinc.

17.3.2 Copper, silver, mercury, magnesium and other acetylide-forming metals.

17.3.3 Aluminium and aluminium bearing alloys.

17.3.4 Copper, copper alloys, zinc or galvanized steel. [2]

17.3.5 Aluminium or copper or alloys of either. [2]

17.3.6 Copper and copper bearing alloys with greater than one per cent copper. [2]

17.4 Independent tanks

17.4.1 Products should be carried in independent tanks only.

17.4.2 Products should be carried in independent tanks type C and the provisions of 7.1.3 apply. The design pressure of the cargo tank should take into account any padding pressure and/or vapour discharge unloading pressure. [2]

17.5 Refrigeration systems

17.5.1 Only the indirect system described in 7.2.4{b) should be used.

17.5.2 For ships in service in products which readily form dangerous peroxides, recondensed cargo should not be allowed to form stagnant pockets of uninhibited liquid. This may be achieved either by:

(a) using the indirect system described in 7.2.4(b) with the condenser inside the cargo tank, or

(b) using the direct system or combined system described in 7.2.4(a) and (c) respectively or the indirect system described in 7.2.4(b) 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.

17.6 Deck cargo piping

One hundred per cent radiography of all butt welded joints in cargo piping exceeding 75 mm in diameter is required.

17.7 Bow or stern loading and discharge lines

Bow or stern loading and discharging lines should not be led past accommodation, service or control station spaces on Type IG ships. Bow and stern loading and discharging lines installed on Type IIG/IIPG ships should not be used for the transfer of toxic cargoes, unless specifically approved by the Administration.

17.8 Exclusion of air from vapour spaces

Air should be removed from the cargo tanks and associated piping before loading and then subsequently excluded by:

(a) 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

(b) control of cargo temperature such that a positive pressure is maintained at all times.

17.9 Moisture control

For gases which are non-flammable and may become corrosive or react dangerously with water, moisture control is required 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 dewpoint of -45°C or below at atmospheric pressure.

17.10 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:

(a) name and amount of inhibitor added;

(b) date inhibitor was added and the normally expected duration of its effectiveness;

(c) any temperature limitations affecting the inhibitor;

(d) the action to be taken should the length of the voyage exceed the effective lifetime of the inhibitors.

17.11 Permanently installed toxic gas detectors

17.11.1 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.

17.11.2 The alternative of using portable equipment in accordance with 13.6.9 should not be permitted.

17.12 Special requirements for individual gases

17.12.1 ***Ethylene Oxide*** [4]

(a) For the carriage of ethylene oxide the requirements of 17.12.8 apply analogously, with the additions and modification as given in this paragraph.

(b) Deck tanks should not be used for the carriage of ethylene oxide.

(c) Stainless steels types 416 and 442, as well as cast iron, should not be used in ethylene oxide cargo containment and piping systems.

(d) 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 tanks made of steel other than stainless steel.

(e) Ethylene oxide should be discharged only by deepwell pumps or inert gas displacement. The arrangement of pumps should comply with 17.12.8(f)(iii).

(f) Ethylene oxide should be carried refrigerated only and maintained at temperatures of less than +30°C.

(g) Pressure relief valves should be set at a pressure of not less than 5.5 kp/cm^2 gauge. The maximum set pressure should be specially approved by the Administration.

(h) The protective padding of nitrogen gas as required by 17.12.8(p) should be such that the nitrogen concentration in the vapour space of the cargo tank will at no time be less than 45% by volume.

(i) Before loading and at all times when a cargo tank contains ethylene oxide liquid or vapour, the cargo tank should be inerted with nitrogen.

(j) The water spray system required by paragraph 17.12.8(r) and that required by Section 11.3 should operate automatically in a fire involving the cargo containment system.

(k) A jettisoning arrangement should be provided to allow the emergency discharge of ethylene oxide in the event of uncontrollable self-reaction.

17.12.2 ***Methyl acetylene-propadiene mixture*** [3]]

(a) Methyl acetylene-propadiene mixtures should be suitably stabilized for transport. Additionally, upper limits of temperature and pressure during refrigeration should be specified for the mixtures.

(b) Examples of acceptable, stabilized composition limits are:

(i) 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 mole per cent;

(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

(4) maximum combined concentration of propylene and butadiene of 10 mole per cent.

(ii) Composition 2

(1) maximum methyl acetylene and propadiene combined concentration of 30 mole per cent;

(2) maximum methyl acetylene concentration of 20 mole per cent,

(3) maximum propadiene concentration of 20 mole per cent,

(4) maximum propylene concentration of 45 male per cent,

(5) maximum butadiene and butylenes combined concentration of 2 mole per cent,

(6) minimum saturated C4 hydrocarbon concentration of 4 mole per cent, and

(7) minimum propane concentration of 25 mole per cent,

(c) Other compositions may be accepted provided the stability of the mixture is demonstrated to the satisfaction of the Administration,

(d) A ship carrying methyl acetylene-propadiene mixtures should preferably have an indirect refrigeration system as specified in 7.2.4(b). 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 17.12.2(b), the following features should be provided:

(i) A vapour compressor that does not raise the temperature and pressure of the vapour above 60°C and 17.5 kg/cm^2 gauge during its operation, and that does not allow vapour to stagnate in the compressor while it continues to run.

(ii) Discharge piping from each compressor stage or each cylinder in the same stage of a reciprocating compressor should have:

(1) two temperature actuated shutdown switches set to operate at 60°C or less;

(2) a pressure actuated shutdown switch set to operate at 17.5 kg/cm^2 or less; and

(3) a safety relief valve set to relieve at 18.0 kg /cm^2 gauge or less.

(iii) The relief valve required by (d)(ii)(3) of this paragraph should vent to a mast meeting 8.2.9, 8.2.10, 8.2.13 and 8.2.14 and should not relieve into the compressor suction line.

(iv) An alarm that sounds in the cargo control station and in the navigating bridge when a high pressure switch, or a high temperature switch operates.

(e) 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 connections such as common inert gas supply lines.

17.12.3 ***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.

17.12.4 ***Ammonia***

Because high concentrations of ammonia in confined spaces can be flammable, the provisions of Chapter X 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°C (vapour pressure 1.9 kp/cm^2), 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°C may be affected unless it has been thermally stress relieved. [4]]

17.12.5 ***Chlorine*** [1]]

(a) Cargo containment

(i) 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.

(ii) The tank design vapour pressure should not be less than 13.5 kp/cm^2 (see also 7.1.3 and 17.4).

(iii) Parts of tanks protruding above the upper deck should be provided with protection against thermal radiation taking into account total engulfment by fire.

(iv) 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 kp/cm^2 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 kp/cm^2. 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. Provisions should be made to keep this space at or near the atmospheric pressure during normal operation.

(v) 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.

(vi) The Administration and the Port Administration may require that chlorine is carried in refrigerated state at a maximum pressure specified by these Administrations.

(b) Cargo piping systems

(i) 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 kp/cm^2. Cargo discharge compressors on board ships should not be accepted by the Administration.

(ii) The design pressure of the cargo piping system should be not less than 21 kp/cm^2. 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.

(iii) Relief valves of the cargo piping system should discharge to the absorption plant (see also 8.2.16).

(c) Materials

(i) The cargo tanks and cargo piping systems are to be made of steel suitable for the cargo and for a temperature of -40°C, even if a higher transport temperature is intended to be used.

(ii) The tanks should be thermally stress relieved. Mechanical stress relief should not be accepted as an equivalent.

(d) Instrumentation - safety devices

(i) The ship should be provided with a chlorine absorbing plant with connections 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.

(ii) During the gas-freeing of cargo tanks, vapours should not be discharged to the atmosphere.

(iii) A gas detecting system should be provided capable of monitoring chlorine concentrations of at least 1 ppm by volume. Suction points should be located:

- near the bottom of the cargo hold spaces;

- in the pipes from the safety relief valves;

- at the outlet from the gas absorbing plant;

- at the inlet to the ventilation systems for the accommodation, service, control and machinery spaces;

- on deck at the forward end, in the middle and at the aft end of the cargo area. [1] (Only required to be used during cargo handling and gas-freeing operations.) [4]

The gas detection system should be provided with audible and visual alarm with a set point of 5 ppm.

(iv) Each cargo tank should be fitted with a high pressure alarm giving audible alarm at a pressure equal to 10.5 kp/cm2.

(e) Personnel protection

In addition to the requirements given in 17.2 the following requirements should be met:

(i) The enclosed space required by 17.2.4 should be easily and quickly accessible from the open deck and accommodation and should be capable of being rapidly closed gas-tight. Access to this space from the deck and the remainder of the accommodation 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 17.2.2 should be located near the air-lock to the space.

(ii) A compressor and the necessary equipment for filling the air bottles should be provided.

(iii) One set of oxygen therapy equipment should be carried in the space referred to in sub-paragraph (i).

(f) Filling limits for cargo tanks

(i) The requirements of 15.1.4(b) do not apply when it is intended to carry chlorine.

(ii) 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,

17.12.6 ***Vinyl chloride***

In case polymerization of vinyl chloride is prevented by addition of an inhibitor, 17.10 is applicable. In case no or insufficient inhibitor has been added, any inert gas used for the purposes of 17.8 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.

17.12.7 ***Diethyl ether/vinyl ethyl ether*** [2]

(a) 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.

(b) Inert gas displacement may be used for discharging cargo from independent tanks type C provided the cargo system is designed for the expected pressure.

17.12.8 ***Propylene oxide and mixtures of ethylene oxide/propylene oxide with ethylene oxide content not more than 30 per cent by weight*** [4]

(a) Products transported under the provisions of this section should be acetylene free.

(b) For the purposes of this section the term "independent" means that a piping system or venting system, for example, is in no way connected to another system and that there are no means available for the potential connection to other systems.

(c) (i) 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:

- ammonia, anhydrous and ammonia solutions;

- amines and amine solutions;

- oxidizing substances (e.g. chlorine).

(ii) 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 tanks made of steel other than stainless steel.

(iii) 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.

(iv) Tanks should be entered and inspected prior to each initial loading of these products to ensure freedom from contamination, including heavy rust deposits and visible structural defects. When cargo tanks are in continuous service for these products, such inspections should be performed at intervals of not more than two years.

(v) Tanks for the carriage of these products should be of steel or stainless steel construction.

(vi) 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.

(d) (i) 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.

(ii) 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.

(iii) 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.

(iv) 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:

Neoprene or natural rubber if it contacts the products.

Asbestos or binders used with asbestos.

Materials containing oxides of magnesium, such as mineral wools.

(e) Filling and discharge piping should extend to within 100 mm of the bottom of the tank or any sump pit.

(f) (i) 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 from all other containment systems.

(ii) During discharging operations, the pressure in the cargo tank should be maintained above 0.07 kp/cm^2 gauge.

(iii) The cargo may 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.

(g) 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.

(h) Cargo hoses used for transfer of these products should be marked "FOR ALKYLENE OXIDE TRANSFER ONLY".

(i) Hold spaces should be monitored for these products. Hold spaces surrounding independent tanks type A and B 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.

(j) 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.

(k) Tanks should be designed for the maximum pressure expected to be encountered during loading, carriage or unloading of cargo.

(l) Tanks for the carriage of propylene oxide with a design vapour pressure of less than 0.6 kp/cm^2 gauge and tanks for the carriage of ethylene oxide/propylene oxide mixtures with a design vapour pressure of less than 1.2 kp/cm^2 gauge should have a cooling system to maintain the cargo below the reference temperature. For reference temperature see 15.1.4(a).

(m) Pressure relief valve settings should not be less than 0.2 kp/cm^2 gauge and for type C independent cargo tanks not greater than 7.0 kp/cm^2 gauge for the carriage of propylene oxide and not greater than 5.3 kp/cm^2 gauge for the carriage of ethylene oxide/ propylene oxide mixtures.

(n) (i) 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 subparagraph (b) the required piping separation must 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.

(ii) The product may 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 Certificate of Fitness should be endorsed to include reference to the approved cargo handling plans.

(iii) Before each initial loading of the product and before every subsequent return to such service, 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.

(o) The maximum allowable tank filling limits for each cargo tank should be indicated for each loading temperature which may be applied and `or 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.

(p) 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 kp/cm^2 gauge in the event of product temperature fall due to ambient conditions or maloperation of refrigeration systems. 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 v/v) 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.

(q) The cargo tank vapour space should be tested prior to and after loading to ensure that the oxygen content is 2 per cent (v/v) or less.

(r) 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 l/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.

17.13 ***Vapour return connections***
Connections for returning the expelled gases ashore during loading should be provided. [2]]

17.14 ***Toxic products***
Toxic products should have separate piping systems. [2]]

17.15 ***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. [2]

17.16 ***Maximum allowable quantity of cargo per tank***

When carrying cargo referenced to this section, the quantity of the cargo should not exceed 3,000 m^3 in any one tank. [2]

17.17 ***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. [4]

CHAPTER XVIII -OPERATING REQUIREMENTS

18.1 Information required to be carried

18.1.1 Information should be on board and available to all concerned, giving the necessary data for the safe carriage of the cargo. Such information should include for each product carried;

(a) a full description of the physical and chemical properties necessary for the safe containment of the cargo;

(b) action to be taken in the event of spills or leaks;

(c) counter measures against accidental personal contact

(d) fire-fighting procedures and fire-fighting media;

(e) procedures for cargo transfer, gas-freeing, ballasting, tank cleaning and changing cargoes;

(f) special equipment needed for the safe handling of the particular cargo;

(g) minimum inner hull steel temperatures, and

(h) emergency procedures.

18.1.2 Products required to be inhibited should be refused if the certificate required by 17.10 is not supplied.

18.2 Compatibility

18.2.1 The master should ascertain that the product to be loaded and its characteristics are included upon and are within the limits indicated on the Certificate of Fitness provided for in 1.6 and the loading and stability booklet provided for in 2.2.3.

18.2.2 Care should be taken to avoid dangerous chemical reactions if cargoes are mixed. This is of particular significance in respect of:

(a) tank cleaning procedures required between successive cargoes in the same tank; and

(b) 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 Personnel should not enter cargo tanks, hold spaces, void spaces, cargo handling spaces or other enclosed spaces where gas may accumulate unless:

(a) the gas content of the atmosphere in that space is determined by means of fixed or portable equipment to ensure oxygen sufficiency and the absence of toxic atmosphere; or

(b) 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,

E-NA 18.4.3 [2]] (a) For internal insulation tanks, special fire precautions should be taken in the event of hot work carried out in the vicinity of the tanks. The gas absorbing and de-absorbing characteristics of the insulation material should thereby be taken into account.

(b) For internal insulation tanks, repairs should be carried out in accordance with the procedures provided for in paragraph 4.4.7(f).

18.5 Carriage of cargo at low temperature

18.5.1 When carrying cargoes at low temperatures:

(a) if provided, the heating arrangements associated with cargo containment systems should be operated in such a manner as to avoid the temperature falling below that for which the material of the hull structure is designed;

(b) 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

(c) 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 clothing

Personnel should be made aware of the hazards associated with the cargo being handled and should be instructed to act with care and wear the appropriate protective clothing as mentioned in 141 during cargo handling.

18.7 Systems and controls

Cargo emergency shutdown and alarm systems involved in cargo transfer should be tested and/or checked before cargo handling operations begin. Essential cargo handling controls should also be tested and/or 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. [4]

18.8.2 The closing time of the valve referred to in 13.3.1 (i.e. time from shutdown signal initiation to complete valve closure} should not be greater than:

$$\frac{3600U}{LR} \ (s)$$

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 relevant. [4]

18.9 Additional operating requirements

Additional operating requirements will be found in the following paragraphs of the Code:
3.8.4, 7.1.1(e), 8.2.5, 8.2.7, 9.4.2, 12.1.1, 12.1.10, 13.1.3, 14.2, 14.6, 14,7, 14.8, 15.1, 15.2, 16.3, 17.2.5 [1], 17.7, 17.8, 17.9, 17.12.1(h), 17.12.4.

CHAPTER XIX - SUMMARY OF MINIMUM REQUIREMENTS

a	b	c	d	e	f	g	h
Product name	*United Nations number*	*Ship type*	*Independent tank type C required*	*Control of vapour space within cargo tanks*	*Vapour detection*	*Gauging*	*Special requirements*
Acetaldehyde	1089	IIG/IIPG	–	Inert	I + T	C	17.2.2, 17.2.3, 17.5.1, 17.7, 17.8
Ammonia, anhydrous	1005	IIG/IIPG	–	–	T	C	17.2.1, 17.2.2, 17.2.3, 17.3.1, 17.7, 17.12.4
Butadiene	1010	IIG/IIPG	–	Inert	I	R	17.3.2, 17.5.2, 17.8, 17.10
Butane	1011	IIG/IIPG	–	–	I	R	
Butane/propane mixtures	1011/1978	IIG/IIPG	–	–	I	R	
Butylenes	1012	IIG/IIPG	–	–	I	R	
Chlorine	1017	IG	Yes	Dry	T	I	17.2, 17.4.2,2) 17.5.1, 17.6, 17.7, 17.9, 17.11, 17.12.51)
Diethyl ether*	1155	IIG/IIPG	–	Inert	I + T	C	17.2.1, 17.2.2, 17.3.6, 17.4.1, 17.7, 17.8(a), 17.12.7, 17.13, 17.15, 17.16
Dimethylamine	1032	IIG/IIPG	–	–	I + T	C	17.2.1, 17.2.2, 17.2.3, 17.3.1, 17.7
Ethane	1961	IIG	–	–	I	R	
Ethyl chloride	1037	IIG/IIPG	–	–	I + T	R	17.7
Ethylene	1038	IIG	–	–	I	R	
Ethylene oxide	1040	IG	Yes	Inert	I + T	C	17.2.1, 17.2.2, 17.2.3, 17.2.5, 17.3.2, 17.4.2,2) 17.5.1, 17.6, 17.7, 17.8(a),4) 17.12.1
Ethylene oxide/propylene oxide mixture (max. 30% w/w4) ethylene oxide)	2983	IIG/IIPG	–	Inert	I + T	C	17.2.2, 17.4.1, 17.5.1, 17.7, 17.8(a), 17.12.8, 17.13, 17.15, 17.16
Isoprene*2)	1218	IIG/IIPG	–	–	I	R	17.2.2, 17.10, 17.13, 17.15, 17.174)
Isopropylamine*2)	1221	IIG/IIPG	–	–	I + T	C	17.2.1, 17.2.2, 17.3.4, 17.7, 17.13, 17.14, 17.15, 17.16, 17.174)
Methane (LNG)	19724)	IIG	–	–	I	C	
Methyl acetylene-propadiene mixture	1060	IIG/IIPG	–	–	I	R	17.12.2
Methyl bromide	1062	IG	Yes	–	I + T	C	17.2, 17.3.3, 17.4.2,2) 17.5.1, 17.6, 17.7, 17.11
Methyl chloride	1063	IIG/IIPG	–	–	I + T	C	17.3.3, 17.7
Monoethylamine*2)	1036	IIG/IIPG	–	–	I + T	C	17.2.1, 17.2.2, 17.2.3, 17.3.1, 17.4.1, 17.7, 17.13, 17.14, 17.15, 17.16, 17.174)
Nitrogen	2040	IIIG	–	–	O	C	17.12.3
Propane	1978	IIG/IIPG	–	–	I	R	
Propylene	1077	IIG/IIPG	–	–	I	R	
Propylene oxide*2)	1280	IIG/IIPG	–	Inert	I + T	C	17.2.2, 17.4.1, 17.5.1, 17.7, 17.8(a), 17.12.8, 17.13, 17.15, 17.16
Refrigerant gases (see notes)	–	IIIG	–	–	–	R	
Sulphur dioxide	1079	IG	Yes	Dry	T	C	17.2, 17.4.2,2) 17.5.1, 17.6, 17.7, 17.9, 17.11
Vinyl chloride	1086	IIG/IIPG	–	–	I + T	C	17.2.1, 17.2.2, 17.3.2, 17.3.3, 17.7, 17.8, 17.12.6
Vinyl ethyl ether*2)	1302	IIG/IIPG	–	Inert	I + T	C	17.2.1, 17.2.2, 17.3.2, 17.4.1, 17.7, 17.8(a), 17.10, 17.12.7, 17.13, 17.15, 17.16
Vinylidene chloride*2)	1303	IIG/IIPG	–	Inert	I + T	R	17.2.1, 17.2.2, 17.3.5, 17.7, 17.8(a),4) 17.10, 17.13, 17.15, 17.16

Explanatory Notes to the Summary of Minimum Requirements

Vapour detection required (column f)	I	- Flammable vapour detection
	T	- Toxic vapour detection
	0	- Oxygen analyser
	I +T	- Flammable and toxic vapour detection
Gauging - types permitted (column g)	I	- Indirect or closed, as described in 13.2.2(a) and (b)
	C	- Indirect or closed, as described in 13.2.2(a), (b) and (c)
	R	- Indirect, closed or restricted, as described in 13.2.2(a), (b), (c) and (d)
Refrigerant gases		Non-toxic and non-flammable gases such as:
		dichlorodifluoromethane (1028) dichloromonofluoromethane (1029) dichlorotetrafluoroethane (1958) monochforodifluoromethane (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. 3]

UN Numbers - The UN Numbers as listed in the tables of Chapter XIX are intended for information only. [3]]

* This cargo is covered also by the Bulk Chemical Code. [2]]

APPENDIX

MODEL FORM OF CERTIFICATE OF FITNESS FOR THE CARRIAGE OF LIQUEFIED GASES IN BULK

CERTIFICATE OF FITNESS FOR THE CARRIAGE OF LIQUEFIED GASES IN BULK

(Official seal)

Issued in pursuance of the
IMO CODE FOR THE CONSTRUCTION AND EQUIPMENT OF SHIPS CARRYING LIQUEFIED GASES IN BULK

Under the authority of the Government of

(full official designation of the 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 2.5 of the Code)[1/]

Date of building or major conversion contract

Date on which keel was laid or ship was at a similar stage of construction or on which major conversion was commenced

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. That the above-mentioned ship is

   *(i) a ship as defined in 1.2.2 of the Code;

   *(ii) a ship as defined in 1.2.3 of the Code.

2. (i) That the ship has been surveyed in accordance with the provisions of section 1.6 of the Code;

   (ii) 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.

3. That the following design criteria have been used:

   (a) ambient air temperature °C [2/]

   (b) ambient water temperature °C [2/]

   (c)

Tank type and number	Stress factors [3/]				Material [3/]	MARVS
	A	B	C	D		
Cargo piping						

N.B. Tank numbers referred to in this list are identified on the annexed, signed and dated tank plan numbered 2A.

(d) Mechanical properties of the cargo tank material were determined at ° C [4/]

4. 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, minimum temperature, maximum pressure, maximum density, tank loading conditions)

N. B. Continued on the annexed, signed and dated sheet(s) No, 1 A.

Tank numbers referred to in this list are identified on the annexed, signed and dated tank plan numbered 2A.

* Delete as appropriate.

5. That in accordance with sections 1.5/2.7* the provisions of the Code are modified in respect of the ship in the following manner:

This certificate is valid until the .... day of .... 19 ....

Issued at....................................... 19 .....
(place of issue of certificate)

The undersigned declares that he is duly authorized by the said Government to issue this Certificate.

(signature of official issuing the certificate
and/or seal of issuing authority)

(seal or stamp of the issuing authority,
as appropriate)

Notes on completion of certificate:

[1/] "Ship Type": Any entry under this column must relate to all relevant recommendations, e.g. an entry "Type IIG" should mean Type IIG in all respects prescribed by the Code.

[2/] Paragraph 3(a) and 3(b): The ambient temperatures accepted or required by the Administration for the purposes of 4.8.1 of the Code to be inserted.

[3/] Paragraph 3(c): Stress factors and materials as accepted or required by the Administration for the purposes of 4.5.1 (d) (i) and 4.5.1 (e) of the Code to be inserted.

[4/] Paragraph 3(d): Room temperature or other temperature accepted by the Administration for the purposes of 4.5.1 (f) to be inserted.

[5/] Paragraph 4: Only products listed in Chapter XIX of the Code, or which have been evaluated by the Administration in accordance with paragraph 1.7.3 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, any Special Requirements provisionally prescribed should be noted. [1]]

* Delete as appropriate.

ENDORSEMENT FOR ANNUAL AND INTERMEDIATE SURVEYS [4]

THIS IS TO CERTIFY that at an annual survey required by 1.6.1 (d) of the Code, the ship was found to comply with the relevant provisions of the Gas Carrier Code.

Annual Survey Signed:
(Signature of authorized official)

Place:

Date:

(Seal or stamp of the Authority, as appropriate)

Annual/Intermediate* Signed:
(Signature of authorized official)

Place:

Date:

(Seal or stamp of the Authority, as appropriate)

Annual/Intermediate* 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)

NOTE: An intermediate survey may take the place of an annual survey where the relevant provisions of 1.6.1 (c) and 1.6.1 (d) are complied with.

RESOLUTION A.328(IX)
adopted on 12 November 1975

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

The Assembly,

NOTING Article 16(i) of the IMO Convention concerning the functions of the Assembly,

RECOGNIZING that the rapid increase in sea transport of liquefied gases in bulk gives rise to the urgent need for international standards to ensure their safe carriage, with a view to avoiding or minimizing the risk to ships" crew, personnel of shore installations and to the environment,

RECALLING that when it adopted in resolution A.212(VII) the Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (Bulk Chemical Code), it requested the Maritime Safety Committee to draw up ***inter alia*** a code to cover the carriage of liquefied gases in bulk,

NOTING ALSO that the International Conference on Marine Pollution, 1973, adopted with resolution 16 the Recommendation concerning the prevention of pollution by liquefied gases carried in bulk,

HAVING CONSIDERED the Recommendation by the Maritime Safety Committee at its thirty-second session,

RECOGNIZING FURTHER that gas ship design technology is rapidly evolving, ADOPTS the Code for the Construction and Equipment of Ships carrying Liquefied Gases in Bulk (Gas Carrier Code), the text of which is set out at Annex to this resolution,

INVITES all governments concerned to take appropriate steps to give effect to the Code as soon as possible, and to inform the Organization on measures taken in this respect,

REQUESTS the Maritime Safety Committee to continue its study on this subject,

AUTHORIZES the Maritime Safety Committee to amend the Code as may be necessary.

RESOLUTION MSC.7(48)
adopted on 17 June 1983

RECOMMENDATION FOR CHEMICAL TANKERS AND GAS CARRIERS CONSTRUCTED BEFORE 1 JULY 1986

THE MARITIME SAFETY COMMITTEE,

RECALLING resolutions MSC.4(48) and MSC.5(48) by which it adopted the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code) and the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code),

NOTING that the IBC Code and the IGC Code shall apply to chemical tankers and gas carriers respectively, constructed on or after 1 July 1986,

1 RESOLVES that, in respect of chemical tankers and gas carriers constructed on or after 1 July 1986, the Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (Bulk Chemical Code) adopted by resolution A.212(VII) and the Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (Gas Carrier Code) adopted by resolution A.328(IX) will be superseded by the IBC Code and the IGC Code, respectively,

2 RECOMMENDS that chemical tankers and gas carriers constructed before 1 July 1986 should comply with the requirements of the Bulk Chemical Code (resolution A.212(VII)), the Gas Carrier Code (resolution A.328(IX)) and the Code for Existing Ships carrying Liquefied Gases in Bulk (resolution A.329(IX)) as amended, as applicable,

3 RECOMMENDS FURTHER that for chemical tankers and gas carriers constructed before 1 July 1986, the IBC Code and the IGC Code should be considered at least equivalent to the Bulk Chemical Code (resolution A.212(VI I)) and the Gas Carrier Code (resolution A.328(IX)) up to and including the tenth and fourth sets of amendments respectively,

4 INVITES all governments concerned to permit the application of the provisions of the IBC Code and the IGC Code to chemical tankers and gas carriers constructed before 1 July 1986 and, where the requirements of these codes have been fully complied with, to endorse the Certificates of Fitness issued in accordance with resolution A.212(VII) and resolution A.328(IX) accordingly. A model form of endorsement is attached at Annex.

MODEL FORM OF ENDORSEMENT TO BE INCLUDED IN THE CERTIFICATE OF FITNESS

Under the provisions of paragraph 4 of this resolution, the following text of endorsement should be inserted in paragraph 4 of the Certificate of Fitness issued under resolution A.212(VII) or paragraph 5 of the Certificate of Fitness issued under resolution A.328(IX):

> "As permitted by resolution MSC.7(48) the ship has been surveyed in accordance with the International Code for the Construction and Equipment of Ships [carrying Dangerous Chemicals]* [carrying Liquefied Gases]* in Bulk and found to comply fully with relevant provisions thereof."

* Delete as appropriate.

GUIDELINES FOR THE UNIFORM APPLICATION OF THE SURVIVAL REQUIREMENTS OF THE BULK CHEMICAL CODE AND THE GAS CARRIER CODE

(approved by the Maritime Safety Committee at its forty-second session, 1980)

Preamble

The following should be considered as guidelines for the purpose of uniform application of the survival requirements of the Bulk Chemical Code and the Gas Carrier Code. Alternative methods to the suggested specific programme of calculations and presentation, which demonstrate, to the Administration's satisfaction, compliance with the applicable survival criteria, may be accepted.

1 Alternative methods of calculation and presentation of ship survival capability

.1 The parcel tanker, will require a complete analysis of the limiting survival characteristics over the full range of intended loading conditions (as detailed in 2);

.2 The dedicated service tanker will require approval of calculations based on service conditions proposed by the builder or owner, in which case the Certificate of Fitness should be endorsed in respect of the conditions accepted;

.3 The inherently safe ship is one that will meet survival requirements with the ship assumed to be at a maximum draught and trim with all compartments within the extent of damage assumed to be empty with maximum vertical centre of gravity (adjusted for free liquids).

2 Minimum required metacentric height (GM) or maximum allowable height of the centre of gravity (KG) as a function of the draught of the parcel tanker

2.1 A systematic investigation of damage survival characteristics should be undertaken by making calculations to obtain the minimum required GM or maximum allowable KG at a sufficient number of draughts within the operating range to permit the construction of a series of curves of "required GM" or "allowable KG" in relation to draught and cargo tank content in way of the damage. The curves must be sufficiently comprehensive to cover operational trim requirements.

2.2 Each of the curves thus constructed relates to one position of assumed damage only and the calculations should be repeated for each damage and lesser extent of damage to be assumed at any part of the ship.

2.3 Where it can be determined by inspection that the effect of certain assumed damage will be less onerous than other assumed damage, for which calculations are provided and curves prepared, then the investigation of such damage cases may be dispensed with.

2.4 The damage calculations should take account of:

.1 tanks in way of the assumed damage filled with liquid at increments of about 25 per cent between empty and the maximum weight of liquid, or liquids, intended to be carried in the particular tanks under consideration;

.2 the distribution of liquids in the adjacent tanks concerned which will give the most severe result, taking into account trim;

.3 a number of draughts over the operating range, up to and including the tropical freeboard mark. The fresh water freeboards need not be considered;

.4 the effect of damage involving the machinery space and adjacent tanks containing liquids over a number of draughts as in 2.4.3;

.5 the ship in either the departure or the arrival condition, whichever will give the most severe result;

.6 the ship without trim and a sufficient number of trims covering the operating range, in order to permit interpolation.

3 Particulars concerning survival capability calculations

3.1 The calculations should be based on moulded lines and include large appendages such as shaft bosses, skegs and bow thrusters.

3.2 The metacentric heights (GM), stability levers (GZ) and centre of gravity positions (KG) for judging the final survival conditions should be calculated by the constant displacement (lost buoyancy) method.

3.3 The calculations should be done for the ship freely trimming.

3.4 Only computer calculations acceptable to the Administration should be used.

3.5 Where the assumed damage causes the ship to trim by the stern, the ship in the intact condition should be assumed to have the largest allowable trim by the stern, consistent with operational requirements.

3.6 Where the assumed damage causes the ship to trim by the bow the ship in the intact condition should be assumed to have the largest allowable trim by the bow, consistent with operational requirements.

3.7 Lesser extent of damage should be taken into account only where indicated by the presence of subdivision extending into the maximum extent of damage, e.g. double bottom tanks, side ballast tanks, side cargo tanks, fuel tanks and void spaces. However, the following should be given attention:

.1 "Lesser extent" means the reduction of any one of the three maximum dimensions of damage singly or in combination and also the assessment of the effect of damage affecting any combination of compartments within the maximum extent of damage.

.2 Where any damage involves the release of very heavy cargo liquid, then heel to the intact side of the ship may take place. In such cases the effect of lesser vertical extent of damage above the level of the tank top may result in the larger angle of heel, since otherwise the effect of cargo loss may be compensated by flood water entering the double bottom tanks on the damaged side.

3.8 The number of calculations required to show compliance with survival requirements should be that necessary to obtain sufficient data for the loading manual and should be such that all loading conditions indicated in 1 can be covered, i.e. no additional calculations should be necessary once the series of calculations has been executed.

3.9 Calculations to determine the displacement, trim and the vertical position of the centre of gravity should be performed for each operational loading condition. The vertical position of the centre of gravity should be corrected for free surface effects. One method would be to construct graphs showing the free surface moments at the criterion angle, for all filling levels at a specific gravity of one. The free surface moments for all tanks can then be taken from the graphs and be multiplied by the cargo specific gravity.

3.10 In calculating the effect of free surface of consumable liquids it is to be assumed that, for each type of liquid, at least one transverse pair or a single centreline tank has maximum free surface, and the tank or combination of tanks to be taken into account are to be those where the effect of free surfaces is the greatest; in each tank the centre of gravity of the contents is to be taken at the centre of volume of the tank. The remaining tanks are to be assumed either completely empty or completely filled, and the distribution of consumable liquids among these tanks is to be such as to obtain the greatest possible height above the keel for the centre of gravity.

3.11 To take account of the presence of structure within cargo compartments, a permeability of 95 should be assumed as stated in the Codes. Where, in particular cases such as the cargo tanks of gas carriers, this assumption would lead to a significant discrepancy in cargo tank volume, it is preferable to calculate the permeability taking into account actual tank structure; the volume of tank insulation should then be calculated separately and an appropriate permeability applied.

3.12 Attention should be paid to the possibility of progressive flooding through deck cargo pipes and common cargo tank ventilation pipes, if these are immersed at large angles of heel after damage. The possibility of progressive flooding through ballast piping passing through the assumed extent of damage, where positive action valves are not fitted to the ballast system at the open ends of the pipes in the tanks served, should be considered. Where remote control systems are fitted to ballast valves and these controls pass through the assumed extent of damage then the effect of damage to the system should be considered to ensure that the valves would remain closed in that event.

3.13 Where the ship is required to be capable of sustaining bottom damage anywhere in its length (L), the following method should be used when damage is assumed to occur in the vicinity of the 0.3 L position from the forward perpendicular:

> .1 When applying the longitudinal extent of bottom damage applicable to the foremost part of the ship, no part of the damage should be assumed to extend abaft the 0.3 L position from the forward perpendicular.
>
> .2 When applying the longitudinal extent of damage applicable to the rest of the ship's length the damage should be assumed to extend to a foremost limit including a point at 0.3 L minus 5.0 metres abaft the forward perpendicular.

3.14 In ships carrying liquefied gases, large cargo tanks may be subdivided into sections by centreline and transverse bulkheads which are liquid-tight but which have openings near the top of the tank. These openings would permit spillage of cargo from one section of the cargo tank to another when the ship is heeled where the tank is undamaged, or loss of cargo due to spillage from sections of a damaged cargo tank. The effect of this spillage should be taken into account in calculations and also in any calculation of GM or KG for loading conditions where a "required GM" or "allowable KG" curve is to be used.

3.15 In ships carrying liquefied gases, the ability of longitudinal bulkheads fitted within cargo tanks to withstand the unequal pressures due to flooding of one section of cargo tank should only be considered in the final stage of flooding.

3.16 Where lubricating oil drain tanks fitted below the main engine would be affected by the vertical extent of bottom damage then flooding of the engine-room by way of the drain tank and engine should be assumed to take place.

3.17 In ships with machinery spaces aft, the machinery space and steering gear compartment should be regarded as being common for damage purposes when any access is fitted in the after machinery space bulkhead, unless a remotely operated sliding watertight door is fitted, or the sill of the access openings fitted with hinged watertight doors which are to be kept closed at sea is at least 0.3 metres above the damage waterline and will not be submerged within the minimum range of residual stability.

3.18 Where dry cargoes are carried at the same time as bulk liquid cargoes which require compliance with the requirements of the Codes then the permeability of the space carrying the dry cargo is to be ascertained.

3.19 The harmonized regulations specify that no account should be taken of cross-flooding arrangements to attain stipulated limits of heel in the final state of equilibrium after damage. However, compartments an the opposite sides of a ship could be regarded as single compartments from the aspect of flooding if they were to be finked by openings or ducts of sufficiently large area. In such cases consideration should be given to the adequacy of tank air flaw and to the effect of free surface.

4 Stability information and Certificate of Fitness

4.1 With regard to loading conditions to be submitted to the Administration (exclusive of the loading condition contained in loading and stability manual) the principal objective, at the stage of design evaluation, is that the Administration can satisfy itself that the calculations presented will cover all conditions of full and partial loading, including variations of draught and trim. To achieve this objective the Administration may either:

.1 require a complete analysis of survival requirements over the full range of probable loading conditions; or

.2 undertake approval an the basis of service conditions proposed by the builder or owner, in which case the Certificate of Fitness should be endorsed for the conditions accepted.

4.2 Particular attention should be paid to the provision of adequate stability data to enable the master to take into account accurately the effect of liquid heeling moments of the contents of undamaged tanks. These heeling moments vary with the specific gravity of the liquid and the percentage filling of the tanks and may change significantly in magnitude from condition to condition, Adequate information would include curves showing the variation of liquid heeling moment with the contents of each individual tank,

4.3 In addition to the usual loading information required under intact stability requirements the master should be supplied with the following information pertaining to damage stability:

.1 data relative to loading and distribution of cargo and ballast necessary to ensure compliance with damage survival requirements;

.2 data relative to the ship's survival capabilities;

.3 a damage control drawing showing the position of important fittings and listing instructions for their control;

.4 data relating to the effect of free surface or liquid heeling moments of cargo tanks at all stages of filling;

.5 example calculations and standard blank forms to facilitate calculations.

4.4 The following should be stated on the Certificate of Fitness:

.1 the deepest draught or least freeboard permitted for those loading conditions which require greater freeboard than the International Load Line Certificate (1966);

.2 the range of specific gravities of cargoes which may be carried, this relates to all cargoes;

.3 the particular cargo tanks in which certain ranges of specific gravities of cargoes may be carried, if relevant;

.4 details of fittings, valves etc., the control of which is essential for survival, together with instructions for control, operation and logging; and

.5 identification of required loading and stability manual.

TESTING OF SHORE INSTALLATION CARGO HOSES (MSC/Circ. 220)

The Maritime Safety Committee, at its thirty-fifth session, noted that requirements for the testing of ship's cargo hoses, as reflected in section 5.4 of the Codes for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, resolution A.328 (IX), and Existing Ships Carrying Liquefied Gases in Bulk, approved by the MSC (MSC/Circ. 218), should also be applied to any other cargo hoses which may be supplied by shore installations for the loading or unloading of vessels.

The attention of Administrations is invited to this matter, and they are requested to inform the appropriate bodies to ensure that cargo hoses in loading and unloading ports also comply with the provisions of section 5.4.

The Maritime Safety Committee also agreed that hoses should be clearly marked to show the temperature, pressure and associated product compatibility with the hose materials used.