INTLREG
INTERNATIONAL REGISTER OF SHIPPING

RULES AND REGULATIONS FOR CLASSIFICATION OF STEEL VESSELS

2021

Part 7
Special Ship Types

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PART 7B Special Ship Types

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CHANGES HISTORY

Refer Changes history in Part 1

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CHAPTER 1 SHIPS FOR ICE NAVIGATION

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SECTION 1 GENERAL REQUIREMENTS

Contents

1.1 Classification

1.1.1 Application

The rules in this chapter apply to vessels primarily or occasionally intended for navigation in waters with ice conditions. The requirements shall be considered as supplementary to those given for the assignment of main class.

1.1.2 Class Notation

1.1.2.1. Vessels complying with relevant additional requirements of this chapter will be assigned one of the following class notations:

Table 1.1.1 Class Notations

Notations	Reference
ICE-C ICE-E	(Refer Sec 2)
ICE-IA*F ICE-1A* ICE-1A ICE-1B ICE-1C	(Refer Sec 3)
(for maximum draft x.x m)	(Refer Sec 1)
ICE-05 (or -10 or -15) POLAR-10 (or -20 or -30) ICEBREAKER	(Refer Sec 4)
WINTERISED BASIC (t_d) (ENHANCED) WINTERISED COLD (t_d) (ENHANCED) WINTERISED POLAR (t_d)	(Refer Sec 6)
SEALER	(Refer Sec 5)
DAT (-X^o C)	(Refer Sec 7)
PC-1 PC-2 PC-3 PC-4 PC-5 PC-6 PC-7 ICEBREAKER	(Refer Sec 8)

1.2 Definitions

1.2.1 Symbols

L = Rule length (m)
B = Rule breadth (m)
D = Rule depth (m)
T = Rule draft (m)
Δ = Rule displacement (t)
C_b = Block coefficient (-)
Δ_f = displacement (t) in fresh water (density 1.0 t/m^3) at ice class draught
P_s = maximum continuous output (kW) of propulsion machinery
s = stiffener spacing (m) measured along the plating between ordinary and/or intermediate stiffeners
l = stiffener span (m) measured along the top flange of the member. (For definition of span point, refer Pt 3, Ch3, Sec 3)
S = girder span (m) (For definition of span point, refer Pt 3, Ch3, Sec 3)
σ_F = minimum upper yield stress of material (N/mm^2)
g_0 = standard acceleration of gravity (m/sec^2)

1.2.2 Upper and Lower Ice waterlines (UIWL & LIWL)

1.1.2.2. Upper Ice Waterlines (UIWL)
The envelope of the highest points of the waterline at which the ship is intended to operate in ice irrespective of water salinity. The line may be a broken line.

1.1.2.3. Lower Ice Waterlines (LIWL)
The envelope of the lowest points of the waterline at which the ship is intended to operate in ice irrespective of water salinity. The line may be a broken line.

All design loading conditions in ice, including trim, shall be within the draught envelope limited by the UIWL and LIWL. The lower ice waterline should further be determined with due regard to the vessel's ice going capability in the ballast loading conditions (e.g. propeller submergence). Refer Section 3.B. (IACS UR I 1.3)

1.3 Documentation

1.3.1 General

1.3.1.1 Details related to the additional classes regarding design, arrangement and strength are in general to be included in the plans specified for the main class.

1.3.1.2 Additional documentation not covered by the main class are specified in appropriate sections of this chapter.

1.4 Markings and Onboard Documentations

1.4.1 General

1.1.2.4. The maximum and minimum ice class draughts (extreme draughts) at the fore, amidships and aft shall be indicated in the “Appendix to the Classification Certificate”.

1.1.2.5. If the “Summer Load Line” in fresh water is anywhere located at a higher level than the UIWL, the maximum amidships draft shall be explicitly indicated in the class notation with the qualifier (**for max draught x.x m**).

1.1.2.6. For such ships, the ship sides shall be provided with a warning triangle and with ice class draught marks at the maximum permissible amidships draught, Refer Fig. 1.

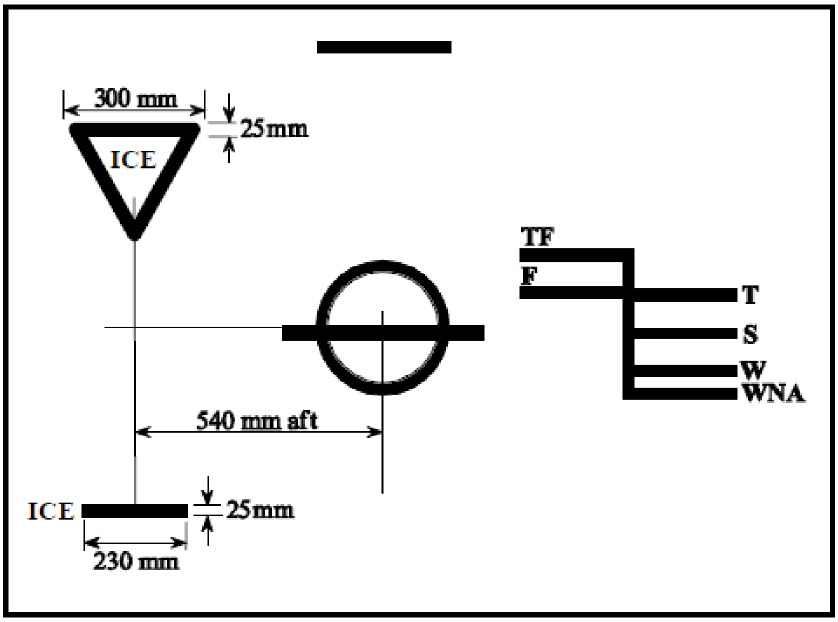


Fig. 1: Ice Class Draft Marking

Marking Requirements

1. The marking "ICE" in the ice class draught shall indicate the maximum ice class draught.

2. The sides of the triangle shall be 300 mm in length. The upper edge of the warning triangle shall be located vertically above the "ICE" mark, at the height 1000 mm above Summer Fresh Water Load Line, but not higher than the deck line.

3. The ice class draught mark shall be located 540 mm abaft the center of the load line ring or 540 mm abaft the vertical line of the timber load line mark, if applicable.

4. The marks and letters shall be painted in a red or yellow reflecting color in order to make the marks and Figures plainly visible even in ice conditions. The ice marks and letters shall be cut out of 5 to 8 mm thick plate and then welded to the ship's side or marking shall be indicated by weld seam directly on the ship side.

5. The dimensions of all letters shall be the same as those used in the load line mark.

6. For vessels not having load line markings, the warning triangle and ice draught mark shall be vertically aligned with the draught mark. The warning triangle shall be placed 1000 mm above the draught mark, but in no case above the deck line.

1.5 Materials

1.5.1 Minimum material grade for ice strengthening ships, shall comply with Pt 3, Ch 2, Sec 2, Table 2.2.6 and Pt 3, Ch 2, Sec 2, Table 2.2.7. Shell strakes in way f ice strengthening area for plates shall be minimum grade B/AH.

1.5.2 Use of any materials other than those specified in Pt 3, Ch 2 shall be approved by Class.

SECTION 2 BASIC ICE STRENGTHENING

Contents

2.1 General

2.1.1 Classification

2.1.1.1 The requirements in this section apply to vessels intended for service in waters with light ice conditions. The requirements in [2.4] for class notation **ICE-E** are intended for light localized drift ice in mouths of rivers and coastal areas.

2.1.1.2 Those vessels built in compliance with the requirements in Sec [2.4] shall be given the class notation **ICE-E**

2.1.1.3 Those vessels built in compliance with the following requirements may be given the class notation **ICE-C**.

2.2 Structural Requirements for the Class Notation ICE-C

2.2.1 General

2.2.1.1 The requirements for the bow ice belt region, as defined in Sec 3 Fig. 2, for sub-section elements [2.2.2] to [2.2.7], shall be in accordance with Sec 3 as follows:

- In Table 3.2.5, the value of h_0 and h, as given for **ICE-1C**

- The ice pressure shall be determined in accordance with Sec [3.2.2], where the factor c_1, as given in Table 3.2.7, is taken as being equal to 0.55.

- Vertical extension of the ice belt plating and framing shall be:

Plating: 0.40 m above UIWL ad 0.50 m below LIWL
Framing: 0.62 m above UIWL and 1.0 m below LIWL

2.2.2 Plating

2.2.2.1 In the bow ice belt region as defined in [2.2.1.1] the shell plate thickness shall be as given in Sec [3.3].

2.2.3 Framing

2.2.3.1 In the bow ice belt region as defined in Sec [2.2.1.1] the frame shall be as given in Sec [3.4.1] to Sec [3.4.3].

The following to be complied with, in addition:

1. Frames shall be effectively attached to all supporting structures. Transverse and longitudinal frames crossing support structures shall be connected to these with lugs. Alternatively, top stiffener in combination with lug may be used. The upper end of intermediate frames may be sniped at a stringer or deck provided the ice belt covers not more than 1/3 of the span.

2. Frames where the angle between the web and the shell is less than 75 degrees shall be supported against tripping by brackets, intercostal, stringers or similar at a distance preferably not exceeding 2.5 m. Transverse frames perpendicular to shell which are of unsymmetrical profiles shall have tripping preventions if the span is exceeding 4.0 m.

3. The web thickness of the frames shall be at least one half of the thickness of the shell plating. Where there is a deck, tank top, bulkhead, web frame or stringer in lieu of a frame, at least one half of the thickness of shell plating shall be kept to a depth of not less than 0.0025 L, minimum 0.2 m.

2.2.4 Stringers and Web Frames

2.2.4.1 Stringers situated inside and outside the ice belt shall be as given in Sec [3.5.1] to Sec [3.5.2]. Web frames shall be as given in Sec [3.6].

2.2.5 Welded Connections

2.2.5.1 Weld connections to shell in fore peak shall be double continuous.

2.2.6 Rudder and Steering Arrangement

2.2.6.1 The rudder and steering arrangement shall comply with Sec [3.9.2], given that the maximum service speed of the vessel is not taken less thn 14 knots.

2.2.7 Stem

2.2.7.1 The plate thickness of a shaped plate stem and any part of the bow which forms an angle of 60 degrees or more to the centerline in a horizontal plane shall comply with Sec [3.8.1.2] up to 600 mm above UIWL.

2.3 Machinery

2.3.1 Propulsion Machinery Output

2.3.1.1 The maximum continuous output (kW) is generally not to be less than:

$P_s = L\ B / 1.37$

For ships with a bow specially designed for navigation in ice, a reduced output may be accepted. In any case, the output (kW) shall not be less than:

$P_s = L\ B / 1.70$

2.3.1.2 If the ship is fitted with a controllable pitch propeller, the output may be reduced by 25%.

2.3.2 Propeller and Propeller Shaft Design

2.3.2.1 The scantlings are based on the following loads:

T_0 = mean torque (N.m.)of propulsion engine at maximum continuous rating. (For plants with multiple engines, T_0 is the mean torque in an actual branch or after the common point. T_0 is referred to engine rpm)

Th_0 = mean propeller thrust (N) at maximum continuous speed
R = Propeller radius (m) as provided in Sec [2.3.2.2].
T_{ice} = Ice torque (N.m.) at propeller RPM
= $35200\ R^2$ (for open propeller)
= $(0.90- 0.0622/\sqrt{R})\ 35200\ R^2$ (for ducted propellers)

Due to the risk of blade bending in skewed propellers at outer radii if f_{sk} exceeds 1.15 .Refer Sec [2.3.2.4], these shall be specially considered.

2.3.2.2 The particulars governing the requirements for propeller scantlings are:

R = Propeller Radius (m)
H_r = Pitch (m) at radius in question
Θ = Rake (deg.) at blade tip (backward rake positive)
Z = Number of blades
t = Blade thickness (mm) at cylindrical section considered.

$t_{0.25}$ = t at 0.25 R
$t_{0.35}$ = t at 0.35 R
$t_{0.60}$ = t at 0.60 R
C_T = Blade width (m) at cylindrical section considered
$C_{0.25}$ = C_T at 0.25 R
$C_{0.35}$ = C_T at 0.35 R
$C_{0.60}$ = C_T at 0.60 R
e = Distance between skew line and generatrix (m) at cylindrical section considered, positive when skew line is forward of generatrix.
$e_{0.60}$ = e at 0.60 R
$e_{1.00}$ = e at 1.00 R
u = gear ratio (1, if the shafting system is directly coupled to the engine)
n_0 = propeller speed at maximum continuous output, for which the machinery shall be approved, in revolutions per minute.

2.3.2.3 Propellers and propeller parts Pt 5A,Ch 5shall be of steel or bronze as specified in Part 2. Nodular cast iron of suitable grad e may be used for relevant parts in CP mechanism. Other type of nodular cast iron with elongation ≥ 12% may be accepted upon special consideration for same purposes.

2.3.2.4 The blade thickness of the cylindrical sections at 0.25 R (fixed pitch propellers only) and at 0.35 R shall not be less than:

$t = C_1 \sqrt{(A_{11}/A_{22})}$ (mm)

where
$A_{11} = 2RK_1 (U_2C_4 + 0.2) + K_4$
$A_{22} = Z\ C_r\ (K_{mat}\ U_1 – U_2\ S_r)$

The thickness at 0.60R shall not be less than:
$t = t_{0.35} \sqrt{(A_{33}/A_{44})}$
where
$A_{33} = 0.45\ C_{0.35}\ f_{sk}$
$A_{44} = C_{0.6}$
$f_{sk} = 1 + \{(e_{0.6} - e_{1.0})/R\}^2$
U_1, U_2 = Material constants to be taken as given in Pt 5A,Ch 5
$S_r = (0.02\ R\ n_0)^2\ (C_2\ \theta + C_3)$
$K_1 = 0.85\ A_1\ d\ T\ h_0 + (0.75\ A_2\ u\ T_0 / R)$; For fixed blade propellers
$K_1 = 1.25\ A_1\ d\ T\ h_0 + (A_2\ u\ T_0 / R)$; For controllable pitch propellers
$K_4 = k_i\ Z\ T_{ice}\ Sin\alpha$
C_1, C_2, C_3, C_4 as given in Table 2.3.1.
$A = q_0 + q_1\ d + q_2\ d^2 + q_3\ d^3$
q_0, q_1, q_2, q_3 as given in Table 2.3.2
$d = 2\pi\ R / H_r$; For fixed blade propellers
$d = 2\pi\ R / (0.70\ H_r)$; For controllable pitch propellers
k_i = 96 at 0.25 R
= 92 at 0.35 R
K_{Mat} = 1.0 for stainless steel propellers
= 0.8 for other materials
$Sin\alpha = 4 / \sqrt{d^2 + 16}$ at 0.25 R
$= 2 \cdot 86 / \sqrt{d^2 + 8 \cdot 1}8$ at 0.35 R

K_1 as given above is only valid for population by diesel engines (by about zero speed, it is assumed 85% thrust and 75% torques for fixed pitch propellers and 125% thrust and 100% torque for controllable pitch propellers).

For diesel- electric, turbine or similar propulsion machinery K_1 will be specially considered on a case by case basis.
K1 may be calculated for other than diesel driven propellers by replacing the constants 0.85 by 1.1 and 0.75 by 1.0 for FP provided that maximum torque of

the driving engine is limited to 100% of the nominal torque. If driving torque exceeds 100%, the torque constant 1.0 shall be multiplied by the ratio Tmax/To and corresponding thrust value (Tho times constant) calculated based on the actual maximum torque.

Table 2.3.1: Value C_1, C_2, C_3, C_4			
r	**0.25 R**	**0.35 R**	**0.6 R**
C_1	0.278	0.258	0.15
C_2	0.026	0.025	0.02
C_3	0.055	0.049	0.034
C_4	1.38	1.48	1.69

Table 2.3.2: Value q_0, q_1, q_2, q_3					
R		q_0	q_1	q_2	q_3
0.25 R	A1	8.3	0.37	-0.34	0.03
	A2	63.8	-4.50	-0.64	0.0845
0.35 R	A1	9.55	-0.015	-0.339	0.0322
	A2	57.3	-7.47	-0.069	0.0472
0.60 R	A1	14.6	-1.72	-0.103	0.0203
	A2	52.90	-10.30	0.667	0.0

2.3.2.5 Minor deviations from the dimensions given in Sec 2.3.2.4 may be approved upon special consideration if found necessary by the torsional vibration calculations.

2.3.2.6 Section modulus of the blade bolt connection referred to an axis tangentially to the bolt pitch diameter, shall be greater than the following:

W_b = 0.10 $C_{0.35}$ $t_{0.35}^2 \left(\sigma_b / \sigma_y\right)$ (cm^3)

Where

σ_b = Tensile strength of propeller blade material (N/mm^2)

σ_y = Yield strength of propeller bolt material (N/mm^2)

The propeller blade foot shall have a strength (including stress concentration) not less than that of the bolts.

2.3.2.7 Fitting of the propeller to the shaft is given in Pt 5A,Ch5 as below:

- Flange connection in Pt 5A,Ch 5
- Keyless cone connection ~~in~~ Pt 5A,Ch 5
- Keyed cone connection in Pt 5A,Ch 5

(Considering 0^0 C sea water temperature)

The bolt connection shall have at least the same bending strength as the propeller shaft if the propeller is bolted to the propeller shaft.

The strength of the propeller shaft flange (including stress concentration) shall be at least the same as the strength of the bolts.

2.3.2.8 The propeller shaft diameter need not exceed 1.05 times the rule diameter given for main class, irrespective of the dimension required below.

The diameter of the propeller shaft at the aft bearing shall not be less than:

d_p = 11.5 $\{(\sigma_b\, c_{0.35}\, t_{0.35}{}^{2})/ \sigma_y\}^{(1/3)}$ (mm)

σ_b = tensile strength of propeller blade material (N/mm2)
σ_y = yield strength of propeller shaft material (N/mm2)
$c_{0.35}$ = as defined in Sec 2.3.2.2
$t_{0.35}$ = as defined in Sec 2.3.2.2
Between the aft and second aft bearing, the shaft may be evenly tapered to 1.22 times the diameter of the intermediate shaft, as required for the main class.

Forward of the after peak bulkhead, the shaft may be evenly tapered down to 1.05 times the rule diameter of intermediate shaft, but not less than the actual diameter of the intermediate shaft.

2.3.3 **Sea Suctions and Discharges**

2.3.3.1 The sea cooling water inlet and discharge for main and auxiliary engines shall be so arranged so that blockage of strums and strainers by ice is prevented. In addition to requirements in Pt 5A,Ch 4 and Ch 5 the requirements in Pt 5A,Ch 5 Sect [3.6]shall be complied with.

2.3.3.2 One of the sea water cooling inlet sea chests shall be situated near the centre line of the ship and well aft. At least one of the sea chests shall be sufficiently high to allow ice to accumulate above the pump suctions.

2.3.3.3 A full capacity discharge branched off from the cooling water overboard discharge line shall be connected to at least one of the sea inlet chests. At least one of the fire pumps shall be connected to this sea chest or to another sea chest with de-icing arrangements.

Note: Heating coils may be installed in the upper part of the sea chest(s). Arrangement using ballast water for cooling purposes is recommended but will not be accepted as a substitute for sea inlet chest arrangement as described above.

2.4 Requirements for the Class Notation ICE-E

2.4.1 **General**

2.4.1.1 The requirements for the bow ice belt region, as defined in Sec 3 Fig 2, shall, for sub-section elements [2.4.2] to [2.4.4], be in accordance with Sec 3 as follows:

- In Table 3.2.5, the value of ho and h shall be as given for ICE-1C.

- The ice pressure shall be determined in accordance with Sec [3.2.2] where:
- For determination of k, the machinery output, Ps need not be taken >750 kW.
- The factor C_1, as given in Table 3.2.7, shall be taken as equal to 0.30

2.4.2 **Plating**

2.4.2.1 In the bow ice belt region, as defined in Sec [2.4.1.1], the shell plate thickness shall be as provided in Sec [3.3].

2.4.2.2 The vertical extension of the ice strengthening, as given in Sec [3.3.1], shall be as given for notation ICE-C.

2.4.3 **Framing**

2.4.3.1 In the bow ice belt region as defined in 101, the frames shall be as given in Sec [3.4.1] to [3.4.3].

2.4.3.2 The framing shall extend vertically not less than 0.62 m above the UIWL and 1.0 m below the LIWL.

2.4.3.3 For the bow ice belt region tripping brackets shall be fitted.

2.4.4 Stem

2.4.4.1 The plate thickness of a shaped plate stem and any part of the bow which forms an angle of 60 degrees or more to the centreline in a horizontal plane shall comply with Sec [3.8.1.2], up to 600 mm above UIWL.

SECTION 3 ICE STRENGTHENING FOR THE NORTHERN BALTIC

Contents

3.1 General

3.1.1 Classification

3.1.1.1 The requirements in this section apply to vessels for service in the northern Baltic in winter or areas with similar ice conditions.

3.1.1.2 Vessels built in compliance with the following requirements may be given one of the class notations **ICE-1A*, ICE-1A, ICE-1B** or **ICE-1C** whichever is relevant.

3.1.1.3 INTLREG Ice Class Notation and equivalent Finnish- Swedish Ice Class are provided in the table below:

INTLREG ICE CLASS NOTATION	FINNISH – SWEDISH ICE CLASS
ICE-1A*	1A Super
ICE-1A	1A
ICE-1B	1B
ICE-1C	1C

3.1.1.4 Vessels built in compliance with the requirements for Class **ICE-1A*** and with the additional requirements given below may acquire the class notation **ICE-1A*F.**

*Note: The additional ice class ICE-1A*F is recommended applied to vessels with relatively high engine power designed for regular traffic in the northern Baltic and other relevant areas, normally operating according to rather fixed timetables irrespective of ice conditions and to a certain degree independent of ice breaker assistance.*

3.1.2 Assumptions

3.1.2.1 The method for determining the hull scantlings, engine output and other properties are based on certain assumptions concerning the nature of the ice load on the structure and operation of the ship as described in the Finnish-Swedish Ice Class Rules. The assumptions rest on full scale observations made in the Northern Baltic

TABLE 3.1.1 : Operation of the Ship	
ICE-1A*	Vessels normally capable of navigating in difficult ice conditions without the assistance of icebreakers
ICE-1A	Vessels capable of navigating in difficult ice conditions, with the assistance of icebreakers when necessary
ICE-1B	Vessels capable of navigating in moderate ice conditions, with the assistance of icebreakers when necessary
ICE-1C	Vessels capable of navigating in light ice conditions, with the assistance of icebreakers when necessary

Note: For background documentation of Sec. 3 "Ice Strengthening for the Northern Baltic", reference is made to Finnish Transport Safety Agency (TraFi) homepage:
http://www.trafi.fi/en/maritime/ice_classes_of_ships :
"Finnish-Swedish Ice Class Rules"
"Guidelines for the application of the Finnish-Swedish ice class rules" (hereafter called "TraFi Guidelines")

3.1.2.2 Assistance from icebreakers is normally assumed when navigating in ice bound waters.

3.1.2.3 The formulations provided for plating, stiffeners and girders are based on special investigations as to the distribution of ice loads from plating to stiffeners and girders as well as redistribution of loads on stiffeners and girders. Special values have been given for distribution factors and certain assumptions have been made regarding boundary conditions.

3.1.2.4 For the formulae and values given in this section for the determination of the hull scantlings more sophisticated methods may be substituted subject to special approval. However, direct analysis is not to be utilized as an alternative to the analytical procedures prescribed by explicit requirements in Section [3.3], [3.4] and [3.5] (Plates, Frames and Stringers), unless these are invalid or inapplicable for a given structural arrangement or detail.

3.1.2.5 Direct analyses are to be carried out using the load patch defined in Section [3.2] (p, h and l_a). The pressure to be used is 1.8·p where p is determined according to Section [3.3.3]. The load patch is to be applied at locations where the capacity of the structure under the combined effects of bending and shear are minimized. In particular, the structure is to be checked with load centred at the UIWL, $0.5 \cdot h_o$ below the LIWL, and positioned several vertical locations in between. Several horizontal locations shall also be checked, especially the locations centred at the mid-span or -spacing. Further, if the load length l_a cannot be determined directly from the arrangement of the structure, several values of l_a shall be checked using corresponding values for c_a.

Acceptance criteria for designs are that the combined stresses from bending and shear, using the Von Mises yield criterion, are lower than the yield point σy. If the structure is analysed by the use of beam models, the allowable bending and shear stress is not to be larger than 0.9·σy and 0.9·τy respectively where τy = σy/√3.

3.1.2.6 If scantlings derived from these regulations are less than those required for a non ice-strengthened ship, the latter shall be used.

3.1.2.7 The frame spacing and spans defined in the following text are in general to be as given in Pt 3, Ch 3, and normally assumed to be measured along the plate and perpendicular to the axis of the stiffener for plates, along the flange for members with a flange, and along the free edge for flat bar stiffeners. For curved members the span (or spacing) is defined as the chord length between span (or spacing) points. The span points are defined by the intersection between the flange or upper edge of the member and the supporting structural element (Stringer, Web frame, Deck or Bulkhead). Fig. 1 illustrates the determination of span and spacing for curved members.

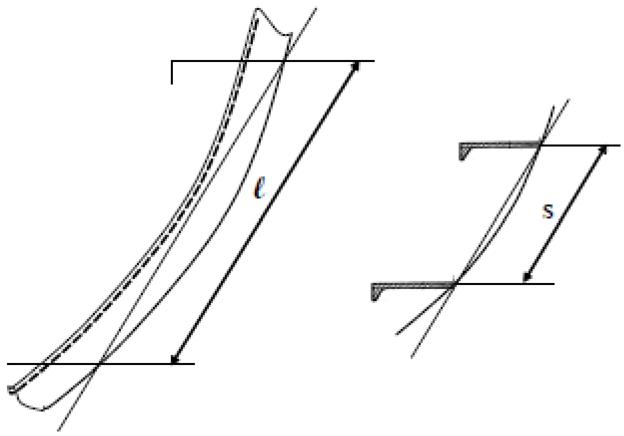


Fig. 1 Definition of the frame span and frame spacing for curved members

3.1.2.8 The effective breadth of the attached plate to be used for calculating the combined section modulus of the stiffener, stringer and web frame and attached plate is to be taken as given in Pt 3, Ch 3.

3.1.2.9 The requirements for the section modulus and shear area of the frames, stringers and web frames in D. E. and F. with respect to the effective member cross section, where the member is not normal to the plating, the section properties are to be calculated in accordance with Pt 3, Ch 3.

3.1.3 **Definitions**

3.1.3.1 Extend of Ice Strengthening

The extent of the ice strengthening of the hull is determined from the Upper Ice Water Line (UIWL) to the Lower Ice Water Line (LIWL), which defines the extreme draughts. For operation in Baltic, the upper ice waterline (UIWL) is in general the same as the Fresh Water Summer Load Line. Refer also Section 1.1.2.2.

3.1.3.2 Transit in Ballast Condition

Forward draft in any condition shall be minimum: $(2 + 0.00025\ \Delta_f)\ h_0$ (m); but not to exceed 4 h_0;

Where
Δ_f = Displacement of the ship (t) at the maximum ice class draught according to 301
h_0 = Ice thickness according to Table 3.2.5.

3.1.3.3 Ice belt Regions

The ice belt is divided into regions as follows (Refer also Fig. 2):

Bow region:
From the stem to a line parallel to and 0.04 L aft of the forward borderline of the part of the hull where the waterlines run parallel to the centre line. For ice classes ICE-1A*F, ICE-1A* and ICE-1A the overlap of the borderline need not exceed 6 m, for ice classes ICE-1B, ICE-1C and ICE-C this overlap need not exceed 5 m. For the case of ICE-E, 0.02 L aft of the forward borderline, the overlap need not to exceed 2 m.

Mid body region:
From the aft boundary of the Bow region to a line parallel to and 0.04 L aft of the aft borderline of the part of the hull where the waterlines run parallel to the centre line. For ice classes **ICE 1A*F, ICE-1A*** and **ICE-1A** the overlap of the borderline need not exceed 6 m, for ice classes ICE-1B and **ICE-1C** this overlap need not exceed 5 m.

Stern region:
From the aft boundary of the Midbody region to the stern.

3.1.4 **Documentation Requirements**

3.1.4.1 Document requirements are shown in Table 3.1.2. For a full definition of the documentation types, Refer Part 1 Classification Regulations.

TABLE 3.1.2: Document Requirements			
Object	**Documentation Type**	**Additional Description**	**(A) / (I)**
Ship Hull	Shell expansion drawing	UIWL and LIWL details to be provided together with the lines separating the Bow, Mid body and Stern regions of the ice belt. Refer 3.1.4.2	(A)
Ship Hull/ machinery	Calculation Report	Supporting documentations of minimum required propulsion power, P_{min} according to 3.2.1, hull particulars defined in 3.2.1.3.	(I)
Ship	Specification	Vessel's displacement, machinery type, propulsion power.	(I)
Propulsion line	Analysis report	Applicable if a first blade order torsional resonance is within operational speed range +/- 20%. Torsional vibration analysis of ice torque response.	(A)
Propeller blades	Analysis report	Blade stresses due to ice loads based on finite element analysis.	(A)
Propulsion System	Analysis report	Applicable for alternative designs, not applying loads defined in the rules. Comprehensive design analysis of entire system.	(A)
Note: (A): For Approval; (I) : For Information			

3.1.4.2 The shell expansion plan to indicate details of UIWL and LIWL together with the lines separating then Bow, Midbody and Stern regions of the ice belt. The machinery, displacement, Δf, the output of propulsion machinery, Ps Refer Sec [3.2.1.1], and the minimum required engine output, Pmin .Refer Sec [3.2.14], shall be stated on the shell expansion and/or the framing plan.

For a comprehensive definition of the documentation types, Refer Pt 1.

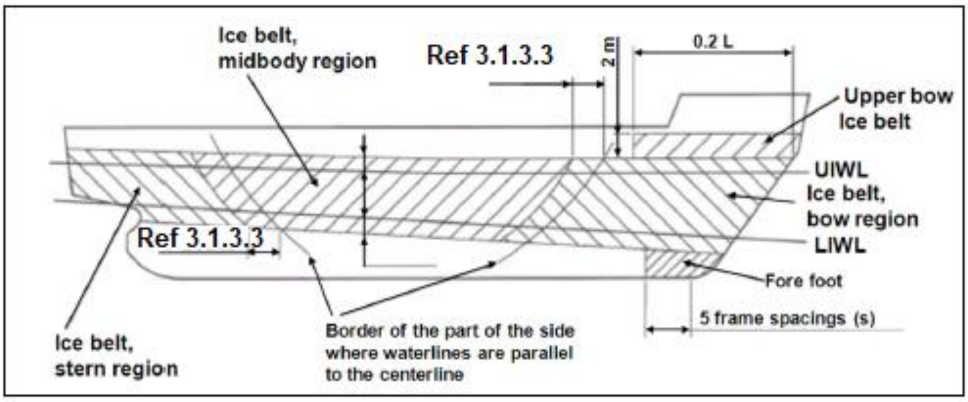


Fig. 2 Ice Belt Regions

3.2 Design Loads

3.2.1 **Engine Output**

3.2.1.1 Definition
The maximum output the propulsion machinery can continuously deliver to the propeller(s) defines the engine output (Ps). If this is restricted by technical mean or by any regulations applicable to the ship, Ps shall be taken as the restricted output.

3.2.1.2 Documentation on board

The minimum engine output corresponding to the ice class shall be indicated in the Classification Certificate.

3.2.1.3 Required engine output for ice class:

Definitions:

L = Length of ship between perpendiculars (m)
L_{BOW} = Length of the bow (m), Fig.. 3
L_{PAR} = Length of parallel mid body (m), Fig.. 3
B = Maximum breadth of ship (m)
T = Actual ice class draughts of the ship (m), Refer Sec [2.1.3.1]
A_{wf} = Area of the waterline of the bow (m^2), Fig. 3
α = Angle of waterline at B/4 (^{0}), Fig. 3
φ_1 = Rake of the stem at centreline (^{0}), Fig. 3
φ_2 = Rake of the bow at B/4 (^{0}), Fig. 3
ψ = Flare angle (°) calculated as $\psi = \arctan(\tan\phi / \sin\alpha)$ using angles α and ϕ at each location.

For Sec [3.10], flare angle is calculated using $\phi = \phi_2$
D_p = Diameter of the propeller or outer diameter of nozzle for the nozzle propeller, maximum 1.2 times the propeller diameter (m)
H_M = Thickness of brash ice in mid channel (m)
H_F = Thickness of brash ice layer displaced by the bow (m)
R_{CH} = Resistance (N) of the ship in a channel with brash ice and a consolidated layer .Refer formula in Sec [3.2.1.4]
K_e = Factor depending on number of propellers, CPP (or similar), fixed pitch type (Refer Table 3.2.2.)
P_{min} = Minimum required engine output (kW)
C = Coefficients
f = Factor 1
g = Factor 2

Range of validity:

The range of validity of the formulae for powering requirements in Sec [3.2.1.4] is provided in Table 3.2.1. When calculating the parameter DP/T, T shall be measured at UIWL.

Table 3.2.1 Parameter Validity Range

PARAMETER	MINIMUM	MAXIMUM
α (deg.)	15.00	55.00
Φ_1 (deg.)	25.00	90.00
Φ_2 (deg.)	10.00	90.00
L (m)	65.00	250.00
B (m)	11.00	40.00
T (m)	4.00	15.00
L_{BOW}/L	0.15	0.40
L_{PAR}/L	0.25	0.75
D_p/T	0.45	0.75
$A_{wf}/(L \times B)$	0.09	0.27

If the ship's parameter values are beyond the ranges defined in Table 3.2.1, other methods for determining RCH may alternative be used as defined in Sec 3.2.1.5.

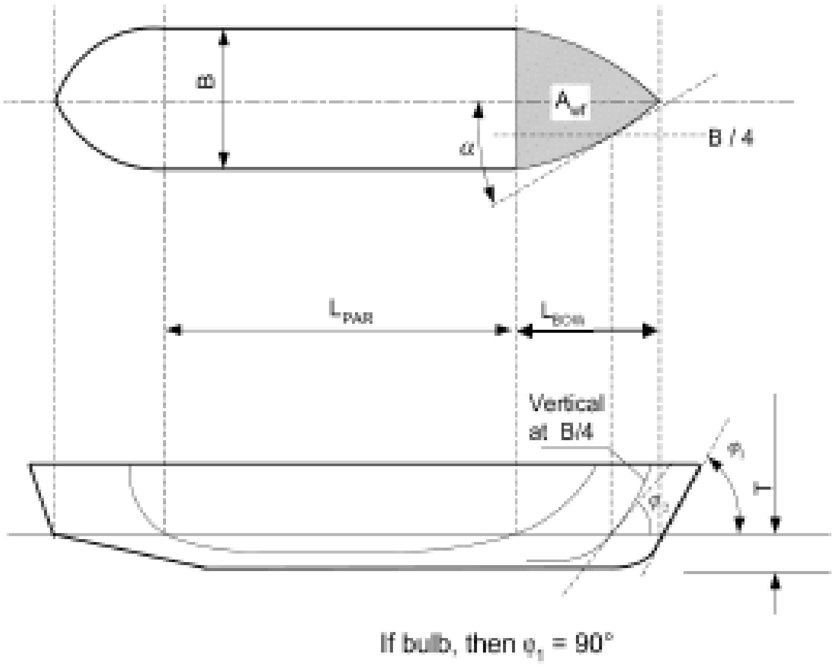


Fig.. 3 Definitions

3.2.1.4 The engine output requirement shall be calculated for the Upper Ice Waterline (UIWL) and Lower Ice Waterline (LIWL) as defined in Sec [1.2]

In the calculations the ships parameters which depend on the draught shall be determined at the appropriate draught, but L and B shall be determined only at the UIWL. The engine output shall not be less than the greater of these two outputs.

The engine output P_{min} shall not be less than that determined by the formulae and in no case less than that given in Sect [3.10] Table 3.10.3

$P_{min} = K_e R_{CH}' / D_P$ (kW)

Where,
$R_{CH}' = (0.001 R_{CH})^{1.5}$

Table 3.2.2 K_e VALUE FOR CONVENTIONAL PROPULSION SYSTEM (*)		
	Propeller Type or Machinery	
No of Propellers	**CPP(**) or Electric or Hydraulic Propulsion Machinery**	**Fixed Pitch Propeller**
1 Propeller	2.03	2.26
2 Propeller	1.44	1.60
3 Propeller	1.18	1.31
(*) For advanced system Refer 3.2.1.5 (**) CPP Controllable Pitch Propeller		

Table 3.2.3 MINIMUM ENGINE OUTPUT P_{min}	
Class Notations	P_{min}
ICE-1A, ICE-1B, ICE-1C	1000 kW
ICE-1A*	2800 kW

R_{CH} is the resistance in Newton of the ship in a channel with brash ice and a consolidated layer:

$R_{CH} = C_1 + C_2 + C_3 C_\mu (H_F + H_M)^2 (B + H_F C_\psi) + C_4 L_{PAR} H_F^2 + C_5 (LT/B^2)^3 (A_{wf} / L)$ (N)

Where,

C_μ = 0.15 Cosφ_2 + Sinψ Sinα (also $C_\mu \geq 0.45$ as minimum value)

$C\psi$ = 0.047 ψ – 2.115 and 0 if $\psi \leq 45^0$

H_F = $0.26 + (H_M B)^{0.50}$

H_M = 1.00 for **ICE-1A** and **ICE-1A***
= 0.80 for **ICE-1B**
= 0.60 for **ICE-1C**

C_1 and C_2 take into account a consolidated upper layer of the brash ice and can be taken as zero for ice class **ICE-1A, ICE-1B, ICE-1C.**

For ice class **ICE-1A***;

C_1 = $(1 + 0.021 \varphi_1) (f_2 B + f_3 L_{BOW} + f_4 B L_{bow}) + f_1 (B L_{PAR} / [2T/B + 1])$

C_2 = $(1 + 0.063 \varphi_1) (g_1 + g_2 B) + g_3 (1 + [1.2T/B]) (B^2/L^{0.50})$

For a ship with bulbous bow, φ_1 shall be taken as 90^0.

C_3 = 845 kg/(m^{2}s^2)

C_4 = 42 kg/(m^{2}s^2)

C_5 = 825 kg/(s^2)

f_1= 23.00 N/m^2

f_2= 45.80 N/m

f_3= 14.70 N/m

f_4= 29.00 N/m^2

g_1 = 1530 N

g_2 = 170 N/m

g_3 = 400 N/m$^{1.5}$

ψ = arctan (tanφ_2 / Sinα)

$(LT/B^2)^3$ shall not be taken less than 5 and not more than 20.

3.2.1.5 Alternate Methods for Determining K_e or R_{CH}

For a ship, in lieu of the K_e or R_{ch} values defined in Table 3.2.2 and Sec [3.2.1.4], the use of K_e or R_{ch} values based on more exact calculations or values based on model test may be approved. Such approval will be given on the understanding that it can be revoked if experience of the ships performance in practice substantiates this.

Notes: For ships intended for trading in Finnish waters and having the propulsion power determined by model tests or by means other than the rule formula, additional approval by Finnish and Swedish authorities is necessary.

The design requirement for ice classes shall be a minimum speed of 5 knots in the following brash ice channels. -Refer Table 3.2.4

Table 3.2.4 VALUES OF HM

ICE CLASS	HM
ICE-1A*	1.00 m and a 0.10 m thick consolidated ice layer
ICE-1A	1.00 m
ICE-1B	0.80 m
ICE-1C	0.60 m

3.2.2 **Height of the Ice Load Area**

3.2.2.1 An ice strengthened ship is assumed to operate in open sea conditions corresponding to a level ice thickness not exceeding h_o. The design ice height (h) of the area actually under ice pressure at any particular point of time is, however, assumed to be only a fraction of the ice thickness. The values for h_o and h are given in the following table.

Table 3.2.5 VALUES OF h_0 & h		
ICE CLASS	**h_0 (m)**	**h (m)**
ICE-1A*	1.0	0.35
ICE-1A	0.8	0.30
ICE-1B	0.6	0.25
ICE-1C	0.4	0.22

3.2.3 Ice Pressure

3.2.3.1 The design ice pressure (based on a nominal pressure of 5600 kN/m2) is determined by the following:

$p = 5,600\ c_d\ c_1\ c_a\ (kN/m^2)$

Where,

cd = Factor which takes into account the influence of the size and engine output of the ship. This factor is taken as maximum $c_d = 1$.

It is calculated by the formula:
$c_d = 0.001\ (ak + b)$

Where,
$K = 0.001\ (P_{min}\ \Delta_f)^{0.50}$

The values of a and b are provided in Table 3.2.6.

Table 3.2.6 Values of a and b				
	Region			
	Bow		**Midbody & Stern**	
	k ≤ 12	k > 12	k ≤ 12	k > 12
a	30	6	8	2
b	230	518	214	286

Δ_f = Displacement (t) as defined in Sec [3.1.3.2].
P_{min} = Machinery output (kW) as defined in Sec [3.2.1.4].
c_1 = a factor which takes account of the probability that the design ice pressure occurs in a certain region of the hull for the ice class in question.
The value of c_1 is provided in Table 3.2.7

Table 3.2.7 VALUES OF c_1			
	Region		
Ice Class	**Bow**	**Midbody**	**Stern**
ICE-1A*	1.00	1.00	0.75
ICE-1A	1.00	0.85	0.65
ICE-1B	1.00	0.70	0.45
ICE-1C	1.00	0.50	0.25

For ice class **ICE-1A*F** an additional lower Bow ice belt Refer Sec [3.3.1.2] is defined with a factor c_1= 0.20.

C_a = A factor which takes into account the probability that the full length of the area under consideration will be under pressure at the same time.
= $(\ell_0 / \ell_a)^{0.5}$, with maximum 1.0 and minimum 0.35, ℓ_0 = 0.60 m

ℓ_a = Refer Table 3.2.8.

Table 3.2.8 Values of l_a		
Structure	**Framing Type**	l_a
Shell	Transverse	Frames spacing
	Longitudinal	1.7 x Frame spacing
Frames	Transverse	Frame spacing
	Longitudinal	Span of frame
Ice Stringer		Span of stringer
Web Frame		2 x Web frame spacing

3.3 Shell Plating

3.3.1 Vertical extension of ice strengthening for plating

3.3.1.1 The vertical extension of the ice belt (Refer Fig. 2) shall not be less than given in Table 3.3.1 below.

Table 3.3.1 Vertical Extension of Ice Belt			
Ice Class	**Region**	**Above UIWL (m)**	**Below LIWL (m)**
ICE 1A*	Bow	0.60	1.20
	Midbody		1.20
	Stern		1.00
ICE 1A	Bow	0.50	0.90
	Midbody		0.75
	Stern		0.75
ICE 1B and ICE 1C	Bow	0.40	0.70
	Midbody		0.60
	Stern		0.60

3.3.1.2 Additional areas to be strengthened

Fore foot:
For ice class **ICE-1A*** and **ICE-1A*F** the shell plating below the ice belt from the stem to a position five main frame spaces abaft the point where the bow profile departs from the keel line shall have at least the thickness required in the ice belt in the Midbody region, calculated for the actual frame spacing.

Upper Bow Ice Belt:
For ice classes **ICE-1A*** and **ICE-1A** on ships with an open water service speed equal to or exceeding 18 knots, the shell plate from the upper limit of the ice belt to 2 m above it and from the stem to a position at least 0.2 L abaft the forward perpendicular, shall have at least the thickness required in the ice belt in the Midbody region, calculated for the actual frame spacing.

Note: A similar strengthening of the bow region is recommended also for a ship with a lower service speed, when it is evident that the ship will have a high bow wave Eg. Based on model tests, validated computer simulations etc.

For ice class **ICE-1A*F** the upper Bow ice belt shall be taken 3 m above the normal ice belt, extending within the Bow region.

Lower Bow ice belt:
For ice class **ICE-1A*F** a Lower Bow ice belt below the normal ice belt is defined covering the Bow region aft of the forefoot and down to the lower turn of bilge.

3.3.1.3 Side scuttles shall not be suited in the ice belt. If the weather deck in any part of the ship is situated below the upper limit of the ice belt (Eg. In way of the well of a raised quarter deck), the bulwark shall be given at least the same strength as is required for the shell in the ice belt. The strength of the construction of the freeing ports shall meet the same requirements.

3.3.2 Plate Thickness in the Ice Belt

3.3.2.1 For transverse framing the thickness of the shell plating shall be determined as below:

$t = 21.1\, s \sqrt{(f_1\, P_{PL} / \sigma_F)} + t_c$ (mm)

For longitudinal framing the thickness of the shell plating shall be determined by the formula:

$t = 21.1\, s \sqrt{(p / f_2\, \sigma_F)} + t_c$ (mm)

Where,
P_{PL} = 0.75 p
P = as given in [.3.2.3.1]
$f_1 = 1.30 - \{4.2/([h/s+1.8]^2\}$, maximum 1.00
f_2 = 0.60 + 0.4/ (h/s), when h/s ≤ 1.00
= 1.40- 0.4 (h/s), when 1 ≤ h/s < 1.80
= 0.35 + 0.183 (h/s) when 1.8 ≤ h/s < 3.00
= 0.90 when h/s > 3.0
h = As provided in Sec [3.2.2]
σ_F = Yield stress of material (N/mm2)
tc = Margin for abrasion and corrosion (mm); normally 2 mm.
If a special surface coating, by experience shown capable to withstand the abrasion of ice, is applied and maintained, lower values may be approved.

3.3.2.2 For ice class **ICE-1A*F** the following additional requirements are given:

In the Bow region (below the Lower bow ice belt defined in Sec 2.3.1.2) the bottom plating shall have a thickness not less than:

$t = 0.70\, (s + 0.80) \sqrt{(235\, L / \sigma_F)}$ (mm), but not ≤ 12 mm

In the Stern region (below the ice belt defined in Sec [3.3.1.2] the side and bottom plating shall have a thickness not less than:

$t = 0.60\, (s + 0.80) \sqrt{(235\, L / \sigma_F)}$ (mm), but not ≤ 10 mm

3.4 Frames

3.4.1 The Vertical Extension of Ice Framing

3.4.1.1 Vertical extension of the ice strengthening of the framing shall be at least as provided in the Table 3.4.1 below:

Table 3.4.1 Vertical Extension of Ice Strengthening of the Framing

Ice Class	Region	Above UIWL (m)	Below LIWL (m)
ICE-1A*F, ICE-1A*	Bow	1.20	To double bottom or below top of floors
	Midbody		2.00
	Stern		1.60
ICE-1A, 1B, 1C	Bow	1.00	1.60
	Midbody		1.30
	Stern		1.00

Where an upper Bow ice belt is required .Refer Sec [3.3.1.2], the ice strengthened part of the framing shall be extended at least to the top of this ice belt.

3.4.1.2 Where the ice strengthening would go beyond a deck or a tank top (or tank bottom) by not more than 250 mm, it can be terminated at that deck or tank top (or tank bottom).

3.4.2 **Transverse Frames**

3.4.2.1 Minimum section modulus of a main or intermediate transverse frame shall be :

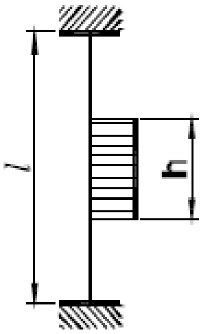
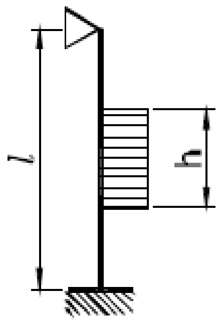
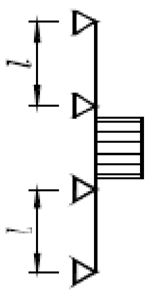
$Z = 1000\,(s\,p\,h\,l\,/\,m_t\,\sigma_F)$ (cm^3)

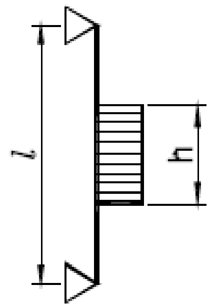
Minimum effective shear area shall be:

$A = 8.70\,f_3\,s\,p\,h\,/\,\sigma_F$ (cm^2)

Where
p = Ice pressure as provided in [3.2.3.]
h = Height of load area as provided in [3.2.2]
m_t = $7\,m_0\,/\,(7 - [5h/l])$
f_3 = Factor which takes into account the maximum shear force versus the load location and the shear stress distribution =1.20
m_0 = Values as given in Table 3.4.2 below.

Table 3.4.2 Value of m_0

Boundary Condition	m_0	Example
	7.00	Frames in a bulk carrier with top wing tanks
	6.00	Frames extending from the tank top to a single deck
	5.70	Continuous frames between several decks or stringers

	5.0	Frames extending between two decks only

The boundary conditions are those for the main and intermediate frames. Possible different conditions for main and intermediate frames are assumed to be taken care of by interaction between the frames and may be calculated as mean values. Load is applied at mid span.

If the ice belt covers less than half the span of a transverse frame, ($b < 0.5\ l$) the following modified formula may be used for the section modulus:

$Z = 1000\ (s\ p\ h\ b\ (l - b)^2 / \sigma_F\ l^2)$ (cm^3)

b = distance (m) between upper or lower boundary of the ice belt and the nearest deck or stringer within the ice belt.

Where less than 15% of the span, l, of the frame is situated within the ice-strengthening zone for frames as defined in [3.4.1], ordinary frame scantlings may be used.

3.4.2.2 Upper end of transverse framing

1. The upper end of the strengthened part of a main frame and of an intermediate ice frame shall be attached to a deck or an ice stringer (Refer Sec 3.5)

2. Where an intermediate frame terminates above a deck or an ice stringer which is situated at or above the upper limit of the ice belt .Refer [Sec 3.3.1] the part above the deck or stringer may have the scantlings required for a non ice-strengthened ship and the upper end be connected to the adjacent main frames by a horizontal

3.4.2.3 Lower end transverse framing

1. The lower end of the strengthened part of a main frame and of an intermediate ice frame shall be attached to a deck, tank top (or tank bottom) or ice stringer .Refer Sec [3.5].

2. Where an intermediate frame terminates below a deck, tank top (or tank bottom) or ice stringer which is situated at or below the lower limit of the ice belt .Refer Sec [3.3.1, the lower end to be connected to the adjacent main frames by a horizontal member of the same scantlings as the main frames. Note that the main frames below the lower edge of ice belt must be ice strengthened, Refer Sec [3.1.3.3].

3.4.3 Longitudinal Frames

3.4.3.1 Minimum section modulus of longitudinal frames with and without brackets shall be:

$Z = 1000\ (f_4\ p\ h\ l^2 / m_1\ \sigma_F)$ (cm^3)

Minimum effective shear area shall be:

$A = 8.70 (f_4 f_5 p h l) / \sigma_F$ (cm^2)

In calculating the actual shear area of the frames, the shear area of the brackets is not to be taken into account.

f_4= Load distribution factor depending on distribution to adjacent frames
= 1.00- (0.20 h/s)

f_5= Shear force versus load location and shear stress distribution factor = 2.16

p = Ice pressure as provided in Sec [3.2.3.1]

h = Height of load area as provided in Sec [3.2.2]

m_1 = Boundary condition factor

= 13.30 for continuous beam (in an end field a smaller boundary factor may be used)

= 11.00 for frames without bracket

3.4.4 **Structural Details**

3.4.4.1 All frames within the ice strengthened area shall be effectively attached to all supporting structures. Longitudinal or transverse frames crossing supporting structures, such as web frames or stringers, shall be connected to these structures on both sides (by collar plates/ lugs in way of cut-outs).

To provide proper transfer of loads, brackets or top stiffeners shall be fitted, to supporting elements, as necessary. Connection of non-continuous frames to supporting structures shall be made by brackets or similar construction. When a bracket is installed, it has to have at least the same thickness as the web plate of the frame, and the edge shall be appropriately stiffened against buckling.

3.4.4.2 For ice class **ICE-1A*F** and **ICE-1A*,** for ice class **ICE-1A** in the Bow and midbody regions and for ice classes **ICE-1B** and **ICE-1C** in the Bow region, the following shall apply in the ice strengthened area:

1. All frames shall be welded to the hell by double continuous welds. No scalloping is generally allowed except at crossing over plate butts.

2. Frames which are not at a straight angle to the shell shall be supported against tripping by brackets, intercostal, stringers or similar at a distance preferably not exceeding 1.3 m. Transverse frames perpendicular to shell which are of unsymmetrical profiles shall have tripping preventions if the span is exceeding 4.0 m.

3. Minimum web thickness of the frames shall be at least the maximum of the following:

- One half of the net shell plating requirement as given by Sec [3.3.2.1], where the yield stress, σ_F, shall not be taken large than that given for the frame.

- 2.5% of the frame spacing for transverse frames. Alternatively, the buckling capacity of the transverse frame may be assessed by direct calculation. Direct calculations are to be based on design loads as given in Sec 3.1.2.4 and bucking calculation procedures according to Pt 3 Ch 14.

- ($h_w \sqrt{\sigma_F} / C$), where h_w is the web height, C = 805 for profiles and C = 282 for flat bars

- 9 mm thickness.

Where there is a deck, tank top (or tank bottom) or bulkhead in lieu of a frame the plate thickness of this shall be as above, to a depth corresponding to the height of adjacent frames.

3.5 Ice Stringers

3.5.1 Stringers in way of Ice Belt

3.5.1.1 Minimum section modulus of stringers in way of ice belt (Refer Sec 2.3.1) shall be:

Z = 1000 f_6 f_7 p h l^2 /(m_1 σ_F) (cm^3)

Minimum effective shear area shall be:

A = 8.7 f_6 f_7 f_8 p h l / (σ_F) (cm^2)
Where,
p = Ice pressure as provided in Sec 2.2.3
h = Height of load area as provided in Sec 2.2.2
The product ph shall not be taken less than 150

l = Span of stringer (m)
m_1 = Boundary condition factor as given in Sec 2.4.3.
f_6 = Factor taking into account of the load distribution to the transverse frame = 0.90
f_7 = Stringer factor = 1.80
f_8 = Shear force versus load location and shear stress distribution factor = 1.20

3.5.2 Stringers Outside Ice Belt

3.5.2.1 Minimum section modulus of stringers outside ice belt but supporting ice strengthened frames shall be:

Z = 1000 (f_9 f_{10} p h l^2 [1 – h_s/l_s]) / (m_1 σ_F) (cm^3)

Minimum effective shear area shall be:

A = 8.70 (f_9 f_{10} f_{11} p h l) / σ_F (cm^2)

Where
p = Ice pressure as provided in Sec [3.2.3.1]
h = Height of load area as provided in Sec [3.2.2]

The product ph shall not be taken less than 150

l = Span of stringer (m)
m1= Boundary condition factor as given in Sec [2.4.3].
l_s = Distance of the adjacent ice stringer (m)
h_s = The distance of the ice belt (m)
f_9 = Factor taking into account of the load distribution to the transverse frame = 0.80
f_{10} = Safety factor of stringers = 1.80
f_{11} = Shear force versus load location and shear stress distribution factor = 1.20

3.5.3 Deck Strips

3.5.3.1 Narrow deck strips abreast of hatches and serving as ice stringers shall comply with the section modulus and shear area requirements in Sec 2.5.1 and Sec 2.5.2. respectively. In the case of very long hatches the lower limit of the product p h may be reduced to 100.

3.5.3.2 Regard shall be paid to the deflection of the ship's sides due to ice pressure in way of very long hatch openings (more than B/2), when designing weather deck hatch covers and their fittings.

3.6 Web Frames

3.6.1 Design Ice Load

3.6.1.1 The design ice load transferred to a web frame from an ice stringer or from longitudinal framing shall be:

F = f_{12} p h s (kN)

Where

p = Ice pressure as provided in [3.2.3.1], while calculating factor c_a, l_a shall be taken as 2 s

h = Height of load area as provided in Sec [3.2.2]

The product p h shall not be taken less than 150.

s = Web frame spacing (m)

f_{12} = Web frame factor = 1.80

In case the supported stringer is outside the ice belt, the load F may be multiplied by (1 – h_s/l_s) as provided in Sec .[3.5.2]

3.6.2 Section Modulus and Shear Area

3.6.2.1 Minimum section modulus shall be:

Z = 1000 (M / σ_F) ($\sqrt{}$ [1 / γ']) (cm^3)

Where

γ' = 1 – (γ A / A_a)^2

M = Maximum bending moment calculated due to ice load F, as given in Sec [3.6.1.1]

= 0.193 F l.

γ = Factor as provided in .Table.3.6.1

A = Required shear area from Sec [3.6.2.2]

A_a = Actual cross sectional area of web frame = A_f + A_w

A_f = Cross sectional area of free flange

A_w = Cross sectional area of web plate

3.6.2.2 The shear area of a web frame (boundary conditions as in Sec [3.4.2.]):

A = (17.30 α f_{13} Q) / σ_F (cm^2)

Where,

Q = Maximum calculated shear force under the load F as provided in Sec 2.6.1.

F_{13} = Shear force distribution factor = 1.10

α = Factor as provided in Table .[3.6.1]

Table 3.6.1 Values of α and γ

A_f / A_w	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
α	1.5	1.23	1.16	1.11	1.09	1.07	1.06	1.05	1.05	1.04	1.04
γ	0.0	0.44	0.62	0.71	0.76	0.80	0.83	0.85	0.87	0.88	0.89

3.7 Bilge Keels

3.7.1 Arrangement

3.7.1.1 The connection of bilge keels to the hull shall be so designed that the risk of hull damage due to bilge keel rip off is minimized.

3.7.1.2 For class ICE-1A*F bilge keels are normally to be avoided and should be replaced by roll damping equipment. Bilge keel with special strengthening may be considered.

3.8 Special Arrangement and Strengthening Forward

3.8.1 Stem, Baltic Ice Strengthening

3.8.1.1 Rolled, cast or forged steel or shaped steel plates may be used in the fabrication of stem structure as shown in Fig. 4 below.

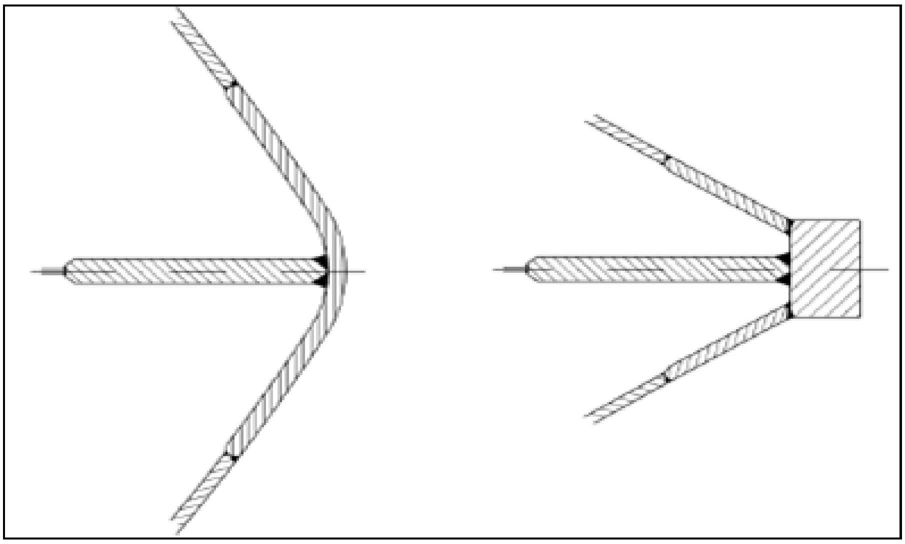


Fig.. 4 Recommended Stem Arrangements

3.8.1.2 The plate thickness of a shaped plate stem and in the case of blunt bow, any part of the shell where $\alpha \geq 30^0$ and $\psi \geq 75^0$, (Refer Sec 3.2.1.3 for angle definition) shall be calculated according to the formulae in [3.3.2]assuming that:

s = Spacing of elements supporting the plate (m)
P_{PL} = p (Refer ~~Sec~~ [3.2.3.1]
l_a = Spacing of vertical supporting elements (m) (Refer Table 3.2.8)

For class ICE-1A*F the front plate and upper part of the bulb and the stem plate up to a point 3.60m above UIWL (lower part of bow door included) shall have a minimum thickness as below:

t = c √ (235 L / σ_F) (mm)

Where
c = 1.80 for bulb plating
= 2.30 for stem plate

The width of the increased bulb plate shall not less than 0.20 b on each side of the centre line, where b is the breadth of the bulb at forward perpendicular.

3.8.1.3 The stem and the part of a blunt bow defined above shall be supported by floors or brackets spaced not more than 0.60 m apart and having a thickness of at least half the plate thickness. The reinforcement of the stem shall extend from the keel to a point 0.75m above UIWL or, in case an upper bow ice belt is required (Refer [3.3.1.2] to the upper limit of this.

3.8.2 Arrangement for Towing

3.8.2.1 The vessel shall be provided with a towing arrangement.

3.8.2.2 A suitable towing bitt or other means for securing the towline, suitable to withstand the breaking force of the towline of the ship shall be fitted.

3.9 Special Arrangement and Strengthening Aft

3.9.1 Stern

3.9.1.1 Design of aft / stern structure shall consider the increased ice loading of the stern region due to the introduction of new propulsion arrangements with azimuthing thrusters or "podded" propellers with improved manoeuvrability.

3.9.1.2 To minimise very high loads on propeller blade tips, the minimum distance between propeller(s) and hull (including stern frame) should not be less than h_0 (Refer Sec [3.2.2]

3.9.1.3 For double and triple screw vessels the ice strengthening of the shell and framing shall be extended to the double bottom for 1.50 meter forward and aft of the side propellers.

3.9.1.4 Shafting and stern tubes of side propellers are normally to be enclosed within plated bossing. If detached struts are used, their design, strength and attachment to the hull shall be duly considered.

For class ICE-1A*F the skin plating of propeller shaft bossing shall not be less than:

$t = 13.80 (s + 0.80) \sqrt{(L / \sigma_F)}$ (mm)

The transom areas within the ice belt shall be strengthened as for the midship region.

3.9.2 Rudder and Steering Arrangements

3.9.2.1 The scantlings of rudder, rudder post, rudder stock, pintles, steering gear etc. as well as the capacity of the steering gear shall be determined according to the rules. The maximum service speed of the ship to be used in these calculations is, however, not to be taken less than that stated below:

Table 3.9.1 Maximum Service Speed

Ice Class	Maximum service speed (knots)
ICE-1A*	20
ICE-IA	18
ICE-1B	16
ICE-1C	14
Note: If the actual maximum service speed of the ship is higher, then that speed shall be used	

.

When calculation the rudder force according to the formulae given in Pt 4, Ch 2, Sec 4 and with the speed V in ahead condition, the factors $k_1 = k_2 = 1.0$ as minimum irrespective of condition, rudder profile type or arrangement. Half of the speed values shall be used in the astern conditions.

3.9.2.2 For vessels with **ICE-1A*** and **ICE-1A** notation, the upper part of the rudder and the rudder stock shall be protected from direct contact with intact ice by an ice knife that extends below the LIWL. Special consideration shall be given to the design of the rudder and the ice knife for ships with flap-type rudders.

3.9.2.3 For vessels with **ICE-1A*** and **ICE-1A** notation, due regard shall be paid to the large loads that arise when the rudder is forced out of the midship position while going astern in ice or into ice ridges. Suitable arrangement such as rudder stoppers shall be installed to absorb these loads.

3.9.2.4 The components of the rudder actuator, rudder stock and rudder coupling shall be dimensioned to withstand loading corresponding to the required diameter of the rudderstock. Relief valves for hydraulic pressure in rudder turning mechanism(s) shall be installed.

3.9.2.5 The rudder plating and frames are to be designed using the ice pressure p for the plating and frames in the Midbody Region. The local scantlings of rudders are to be determined assuming that the whole rudder belongs to the icebelt.

3.10 Propulsion Machinery

3.10.1 Materials

3.10.1.1 Materials Exposed to Sea Water:
Charpy V impact test shall be carried out for materials other than bronze and austenitic stainless steel. An average impact energy value of 20 J taken from three tests shall be obtained at minus 10ºC. Materials of components exposed to sea water, such as propeller blades, propeller hubs, and thruster body, shall have an elongation of not less than 15% on a test specimen, the gauge length of which is five times the diameter.

3.10.1.2 Materials Exposed to Sea Water Temperature:
Materials exposed to sea water temperature shall be of ductile material. An average impact energy value of 20 J taken from three tests is to be obtained at minus 10ºC. This requirement applies to blade bolts, CP mechanisms, shaft bolts, strut-pod connecting bolts etc. This does not apply to surface hardened components, such as bearings and gear teeth.

3.10.2 Design Loads for Propeller and Shafting

3.10.2.1 These regulations apply to propulsion machinery covering open- and ducted-type propellers with controllable pitch or fixed pitch design for the ice classes **ICE-IA*, ICE-IA**, **ICE-IB** and **ICE-IC**. The given loads are the expected ice loads for the whole ship's service life under normal operational conditions, including loads resulting from the changing rotational direction of FP propellers. However, these loads do not cover off design operational conditions, for example when a stopped propeller is dragged through ice.

The regulations also apply to azimuting and fixed thrusters for main propulsion, considering loads resulting from propeller-ice interaction. However, the load models do not include propeller/ice interaction loads when ice enters the propeller of a turned azimuting thruster from the side (radially) or load case when ice block hits on the propeller hub of a pulling propeller.

3.10.2.2 Design Ice Conditions

In estimating the ice loads of the propeller for ice classes, different types of operation as given in Table 3.10.1 were taken into account. For the estimation of design ice loads, a maximum ice block size is determined. The maximum design ice block entering the propeller is a rectangular ice block with the dimensions Hice x 2Hice x 3Hice. The thickness of the ice block (Hice) is given in Table 3.10.2

Table 3.10.1 Ships Operation	
ICE-1A*	Operation in ice channels and in level ice. The ship may proceed by ramming
ICE-1A , ICE-1B, ICE-1C	Operation in ice channels

Table 3.10.2 Thickness of the maximum design ice block H_{ice} entering the Propeller

Ice Class	ICE-1A*	ICE-1A	ICE-1B	ICE-1C
H_{ice}	1.75 m	1.50 m	1.20 m	1.0 m

Table 3.10.3 List of Symbols

Symbol	Unit	Definition
A.P.		Aft perpendicular is the perpendicular at the aft end of the length L
c	m	Chord length of blade section
$C_{0.7}$	m	Chord length of blade section at 0.7R propeller radius
CP		Controllable pitch
D	m	Propeller diameter
d	m	External diameter of propeller hub
D_{limit}	m	Limit value for propeller diameter
EAR		Expanded blade area ration
F_b	kN	Maximum backward blade force for the ships service life
F_{ex}	kN	Ultimate blade load resulting from blade loss through plastic bending
F_f	kN	Maximum forward blade force for the ships service life
F_{ice}	kN	Ice loads
$(F_{ice})_{max}$	kN	Maximum ice load for the ships service life
FP		Fixed pitch
F.P.		Forward perpendicular is the perpendicular at the intersection of the summer load waterline with the fore side of the stem. For ships with unusual bow arrangements the position of the F.P. will be especially considered.
h_0	m	Depth of propeller centreline from winter waterline
H_{ice}	m	Thickness of maximum design ice block entering to propeller
I	Kg m^2	Equivalent mass moment of inertia of all parts on engine side of component under consideration
I_t	Kg m^2	Equivalent mass moment of inertia of the whole propulsion system
k		Shape parameter for Weibull distribution
LIWL	m	Lower ballast water line in ice
m		Slope of SN curve in log/log scale
M_{BL}	kNm	Blade bending moment
MCR		Maximum continuous rating
n	Rev/s	Propeller rotational speed
n_n	Rev/s	Nominal propeller rotational speed at MCR in free running condition
N_{class}		Reference number of impacts per propeller rotational speed per ice class
N_{ice}		Total number of ice loads on propeller blade for the ship's service life
N_R		Reference number of load for equivalent fatigue stress (10^8 cycles)
N_Q		Number of propeller revolutions during a milling sequence
$P_{0.70}$	m	Propeller pitch at 0.7R radius
$P_{0.7n}$	m	Propeller pitch at 0.7R radius at MCR in free running condition
$P_{0.7b}$	m	Propeller pitch at 0.7R radius at MCR in bollard condition
Q	kNm	Torque
Q_{emax}	kNm	Maximum engine torque
Q_{max}	kNm	Maximum torque on the propeller resulting from propeller-ice interaction
Q_{motor}	kNm	Electric motor peak torque

Q_n	kNm	Nominal torque at MCR in free running condition
Q_r	kNm	Maximum response torque along the propeller shaft line
Q_{smax}	kNm	Maximum spindle torque of the blade for the ship's service life
R	m	Propeller radius
r	m	Blade Section Radius
T	kN	Propeller Thrust
T_b	kN	Maximum backward propeller ice thrust for the ship's service life
T_f	kN	Maximum forward propeller ice thrust for the ship's service life
T_n	kN	Propeller thrust at MCR in free running condition
T_r	kN	Maximum response thrust along the shaft line
t	m	Maximum blade section thickness
Z		Number of propeller blades
α_i	deg	Duration of propeller blade/ice interaction expressed in rotation angle
γ_ε		The reduction factor for fatigue; scatter and test specimen size effect
γ_v		The reduction factor for fatigue; variable amplitude loading effect
γ_m		The reduction factor for fatigue; mean stress effect
ρ		Reduction factor for fatigue correlating the maximum stress amplitude to the equivalent fatigue stress for 108 stress cycles
$\sigma_{0.2}$	MPa	Proof yield strength of blade material
σ_{exp}	MPa	Mean fatigue strength of blade material at 10^8 cycles to failure in sea water
σ_{fat}	MPa	Equivalent fatigue ice load stress amplitude for 10^8 stress cycles
σ_{fl}	MPa	Characteristic fatigue strength for blade material
σ_{ref}	MPa	Reference stress (ultimate strength) $\sigma_{ref} = 0.60\ \sigma_{0.2} + 0.40\ \sigma_u$
σ_{ref2}	MPa	Reference stress (blade scantlings) $\sigma_{ref2} = 0.70\ \sigma_u$ (or) $= 0.60\ \sigma_{0.2} + 0.40\ \sigma_u$, whichever is less
σ_{st}	MPa	Maximum stress resulting from F_b or F_f
σ_u	MPa	Ultimate tensile strength of blade material
$(\sigma_{ice})_{bmax}$	MPa	Principal stress caused by the maximum backward propeller ice load
$(\sigma_{ice})_{fmax}$	MPa	Principal stress caused by the maximum forward propeller ice load
$(\sigma_{ice})_{max}$	MPa	Maximum ice load stress amplitude

Table 3.10.4 Definition of Ice Loads

Load	Definition	Use of the Load in Design Process
F_b	Extreme lifetime backward force on a propeller blade resulting from propeller/ice interaction, including hydrodynamic loads on that blade. The direction of the force is perpendicular to 0.7 r/R chord line. Refer Fig.ure below	Design force for strength calculation of the propeller blade.
F_f	Extreme lifetime forward force on a propeller blade resulting from propeller/ice interaction, including hydrodynamic loads on that blade. The direction of the force is perpendicular to 0.7 r/R chord line.	Design force for calculation of strength of the propeller blade.
Q_{smax}	Extreme lifetime spindle torque on a propeller blade resulting from propeller/ice interaction, including hydrodynamic loads on that blade.	In designing the propeller strength, the spindle torque is automatically taken into account because the propeller load is acting on the blade as distributed pressure on the leading edge or tip area.
T_b	Extreme lifetime thrust on propeller (all blades) resulting from propeller/ice interaction. The direction of the thrust	For estimation of the response thrust T_r. T_b can be used as an estimate of excitation for axial vibration calculations. However, axial

	is the propeller shaft direction and the force is opposite to the hydrodynamic thrust.	vibration calculations are not required in the rules.
T_f	Exreme lifetime thrust on propeller (all blades) resulting from propeller/ice interaction. The direction of the thrust is the propeller shaft direction acting in the direction of hydrodynamic thrust.	For estimation of the response thrust Tr. Tf can be used as an estimate of excitation for axial vibration calculations. However, axial vibration calculations are not required in the rules.
Q_{max}	Extreme ice-induced torque resulting from propeller/ice interaction on one propeller blade, including hydrodynamic loads on that blade.	Used for estimation of the response torque (Q_r) along the propulsion shaft line and as excitation for torsional vibration calculations.
F_{ex}	Ultimate blade load resulting from blade loss through plastic bending. The force that is needed to cause total failure of the blade so that plastic hinge is caused to the root area. The force is acting on 0.8 r/R. Spindle arm is to be taken as 2/3 of the distance between the axis of blade rotation and leading/trailing edge (whichever is the greater) at the 0.8R radius.	Blade failure load is used to dimension the blade bolts, pitch control mechanism, propeller shaft, propeller shaft bearing and trust bearing. The objective is to guarantee that total propeller blade failure should not cause damage to other components
Q_r	Extreme response torque along the propeller shaft line, taking into account the dynamic behaviour of the shaft line for ice excitation (torsional vibration) and hydrodynamic mean torque on propeller.	Design torque for propeller shaft line components.
T_r	Maximum response thrust along shaft line, taking into account the dynamic behaviour of the shaft line for ice excitation (axial vibration) and hydrodynamic mean thrust on propeller.	Design thrust for propeller shaft line components.
Q_g	Fatigue torque at reduction gear for N_g load cycles.	Design torque for reduction gear.

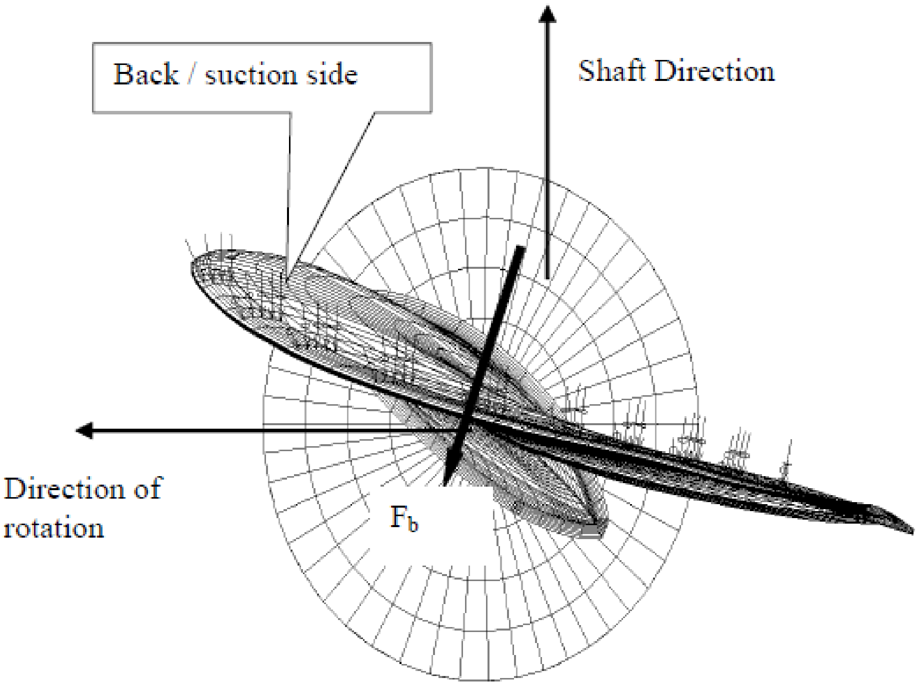


Fig. 5 Direction of backward blade force resultant taken perpendicular to chord line at 0.7 r/R

3.10.3 Design Loads

3.10.3.1 The loads provided are intended for component strength calculations only and are total loads including ice induced loads and hydrodynamic loads during propeller/ice interaction.

3.10.3.2 The values of the parameters in the formulae in this section shall be given in the units shown in the symbol list.

3.10.3.3 When the propeller is not fully submerged (ballast condition etc), the propulsion system shall be designed according to ice class **ICE-IA** for ice classes **ICE-IB** and **ICE-IC**.

3.10.4 Design Loads on Propeller Blades

3.10.4.1 The maximum force, F_b, experienced during the lifetime of the ship that bends a propeller blade backwards when the propeller mills an ice block while rotating ahead. F_f is the maximum force experienced during the lifetime of the ship that bends a propeller blade forwards when the propeller mills an ice block while rotating ahead. F_b and F_f originate from different propeller/ice interaction phenomena, not acting simultaneously. Hence they are to be applied to one blade separately.

3.10.4.2 Maximum backward blade force F_b for open propellers.

$F_b = 27\, D^2\, [\, n\, D\,]^{0.7}\, [EAR / Z]^{0.3}$ (kN); when $D \le D_{limit}$
$F_b = 23\, D\, H_{ice}^{1.4}\, [\, n\, D\,]^{0.7}\, [EAR / Z]^{0.3}$ (Kn); when $D > D_{limit}$

Where,
$D_{limit} = 0.85\, H_{ice}^{1.40}$ (m)

Where, n is the nominal rotational speed (at MCR in free running condition) for a CP propeller and 85% of the nominal rotational speed (at MCR in free running condition) for an FP propeller.

3.10.4.3 Maximum forward blade force F_f for open propellers.

F_f = 250 D^2 [EAR / Z], (kN); when D ≤ D_{limit}

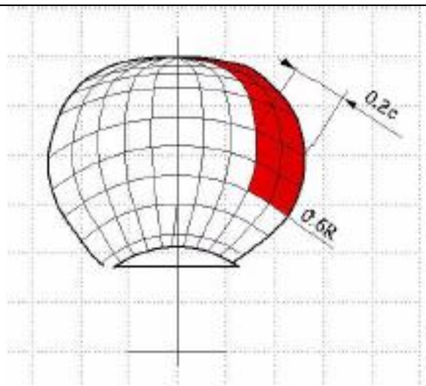
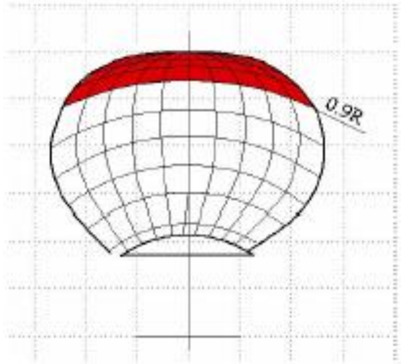
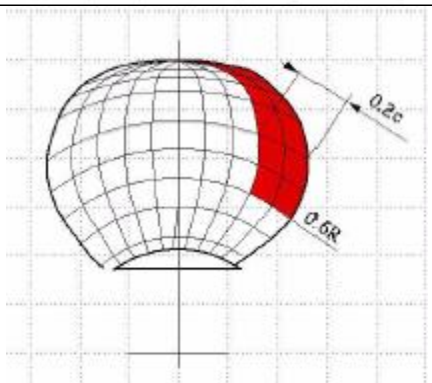
F_t = 500 [EAR / Z] D H_{ice} [1/ {1-(d/D)}] (Kn); when D > D_{limit}

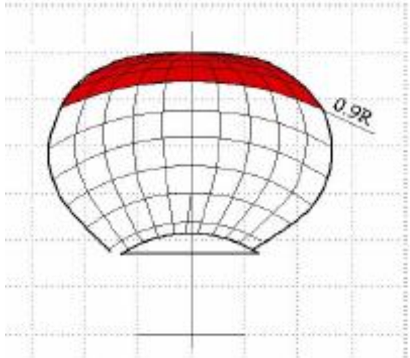
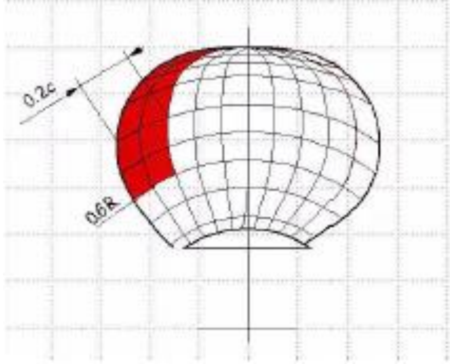
Where,
D_{limit} = (2 H_{ice}) / [1 – {d/D}] (m)

3.10.4.4 Loaded area on the blade for open propellers

Load cases 1 to 4 have to be covered, as given in Table 3.10.5 below, for CP and FP propellers. The load case 5 applies to reversible propellers in addition to the cases 1 to 4.

Table 3.10.5 Load Cases for Open Propellers

Load Case	Right-handed propeller blade seen from behind	Force	Loaded Area
LC 1		F_b	Uniform pressure applied on the back of the blade (suction side) to an area from 0.6R to the tip and from the leading edge to 0.2 times the chord length.
LC 2		50% F_b	Uniform pressure applied on the back of the blade (suction side) on the propeller tip area outside 0.9R radius.
LC 3		F_f	Uniform pressure applied on the blade face (pressure side) to an area from 0.6R to the tip and from the leading edge to 0.2 times the chord length.

LC4		50% F_f	Uniform pressure applied on propeller face (pressure side) on the propeller tip area outside 0.9R radius.
LC 5		Highest of 60% F_f (or) F_b	Uniform pressure applied on propeller face (pressure side) to an area from 0.6R to the tip and from the trailing edge to 0.2 times the chord length

3.10.4.5 Maximum backward blade force Fb for ducted propellers

F_b = $9.5\ D^2\ [\ n\ D\ ]^{0.7}\ [EAR\ /\ Z]^{0.3}$ (kN); when $D \leq D_{limit}$

F_b = $66\ D^{0.6}\ H_{ice}^{1.4}\ [\ n\ D\ ]^{0.7}\ [EAR\ /\ Z]^{0.3}$ (Kn); when $D > D_{limit}$

Where,
D_{limit} = $4.0\ H_{ice}$ (m)

n is the nominal rotational speed (at MCR in free running condition) for a CP propeller and 85% of the nominal rotational speed (at MCR in free running condition) for an FP propeller.

3.10.4.6 Maximum forward blade force Ff for ducted propellers.

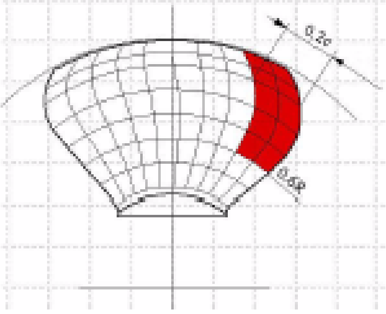
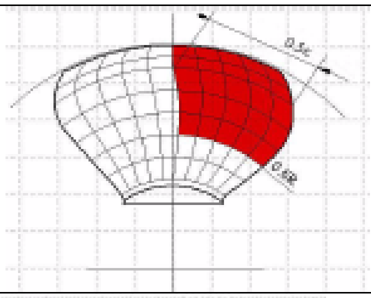
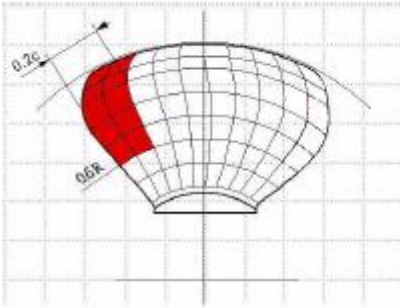
F_f = $250\ D^2\ [EAR\ /\ Z]$, (kN); when $D \leq D_{limit}$

F_f = $500\ [EAR\ /\ Z]\ D\ H_{ice}\ [1/\ \{1-(d/D)\}]$ (Kn); when $D > D_{limit}$

Where,
D_{limit} = $(2\ H_{ice})\ /\ [1 - \{d/D\}]$ (m)

3.10.4.7 Loaded area on the blade of ducted propellers

Load cases 1 and 3 have to be covered as given in Table 3.10.5 for all propellers, and an additional load case (load case 5) for an FP propeller, to cover ice loads when the propeller is reversed.

Table 3.10.6 Load Cases for Ducted Propellers			
Load Case	**Right-handed propeller blade seen from behind**	**Force**	**Loaded Area**
LC 1		F_b	Uniform pressure applied on the back of the blade (suction side) to an area from 0.6R to the tip and from the leading edge to 0.2 times the chord length.
LC 3		F_f	Uniform pressure applied on the blade face (pressure side) to an area from 0.6R to the tip and from the leading edge to 0.5 times the chord length.
LC 5		Highest of 60% F_f (or) F_b	Uniform pressure applied on propeller face(pressure side) to an area from 0.6R to the tip and from the trailing edge to 0.2 times the chord length.

3.10.4.8 Maximum blade spindle torque Q_{smax}, for open and ducted propellers

The spindle torque Qsmax around the axis of the blade fitting shall be determined both for the maximum backward blade force Fb and forward blade force Ff, which are applied as in 3.10.5 and Table 3.10.6 If the above method gives a value which is less than the value given by the formula below, the value below shall be used.

$Q_{smax} = 0.25\ F\ C_{0.7}$ (kNm

Where,
$C_{0.7}$ = Length of blade section at 0.7R
F = Greater of absolute value of F_b or F_f

3.10.4.9 Blade load Distribution

For the fatigue design of the propeller blade, a Weibull distribution (probability of exceedance) as given in Fig. 6 is considered.

$P(F_{ice} / F_{ice\ max} \geq F / F_{ice\ max}) = e^{s}$

Where

$s = -[F / F_{ice\ max}]^{k} \ln(N_{ice})$
N_{ice} = Number of load cycles in the spectrum

F_{ice} = Random variable for ice loads on the blade, $0 \le F_{ice} \le F_{ice\ max}$
k = Shape parameter of the spectrum
k = 0.75, shape parameter for an open propeller (ice force distribution)
= 1.00, shape parameter for ducted propeller (ice force distribution)

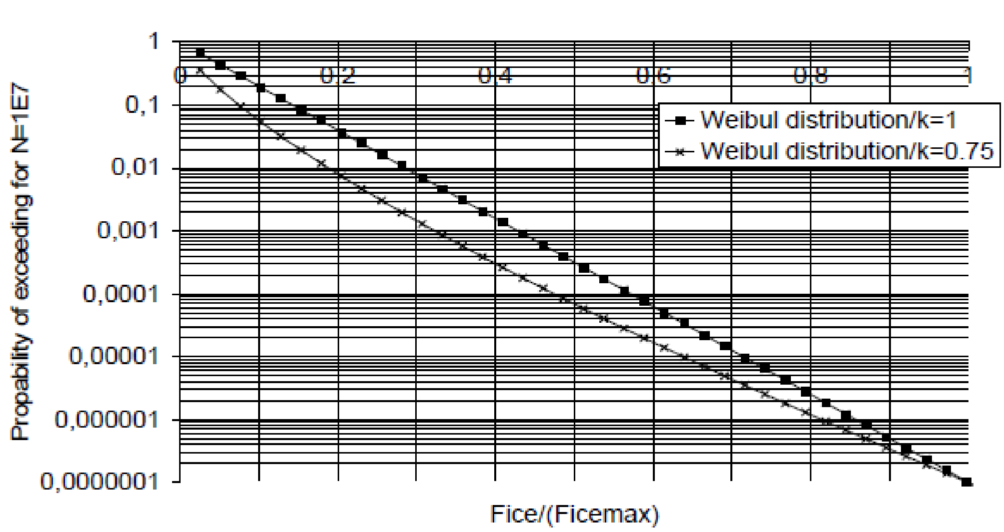


Fig. 6 The Weibull Distribution (Probability of Exceedance) for Fatigue Design

3.10.4.10 Number of Ice Loads

The number of ice load cycles per propeller blade in the load spectrum shall be determined according to the formula:

$$N_{ice} = k_1\, k_2\, k_3\, k_4\, N_{class}\, n$$

Where,
n= Nominal propeller rotations per second (rps) as defined for loads

Table 3.10.7 Number of Loads for Ice Class, N_{class}	
Ice Class	**Number of Loads**
ICE-1A*	9.00×10^6
ICE-1A	6.00×10^6
ICE-1B	3.40×10^6
ICE-1C	2.10×10^6

Table 3.10.8 Propeller Location Factor k_1		
	Single Propeller	**Twin Propeller**
Location	**Centreline**	**Twin wing**
k_1	1.00	1.35

Table 3.10.9 Propeller Type Factor k_2		
Type	**Open Propeller**	**Ducted Propeller**
K_2	1.00	1.10

Table 3.10.10 Propulsion Type Factor k_3		
Type	**Fixed Propeller**	**Azimuthing Propeller**
K_3	1.00	1.20

The submersion factor k_4 is determined from the equation

k_4	$= 0.80 - f$	When $f < 0$
	$= 0.80 - 0.40\ f$	When $0 \le f \le 1$
	$= 0.60 - 0.20\ f$	When $1 < f \le 2.50$
	$= 0.10$	When $f > 2.50$

Where the immersion function f is:

$$f = [2\ (h_0 - H_{ice})\ /D] - 1$$

Where
h_0 = Depth of the propeller centreline at the lower ballast water line in ice (LIWL) of the ship

For component that are subject to loads resulting from propeller/ ice interaction with all the propeller blades, the number of load cycles (N_{ice}) is to be multiplied by the number of propeller blades Z.

3.10.5 Axial Design Loads for Open & Ducted Propellers

3.10.5.1 Design Ice Thrust on Propeller T_f and T_b for Open and Ducted Propellers

Maximum forward Ice Thrust, $T_F = 1.10\ F_f$ (kN)
Maximum backward Ice Thrust, $T_b = 1.10\ F_b$ (kN)

3.10.5.2 Design Thrust Along the Propulsion Shaft Line for Open and Ducted Propellers

Design thrust along propeller shaft line in the forward direction,
T_r: $= T + 2.20\ T_f$ (kN)

Design thrust along propeller shaft line in the backward direction,
T_r: $= 1.50\ T_b$ (kN)

The factors 2.2 and 1.5 take into account the dynamic magnification resulting from axial vibration. The greater value of the forward and backward direction loads shall be taken as the design load for both directions.

If the hydrodynamic bollard thrust, T, is not known, T is to be taken from Table 2.10.11, where T_n is the nominal propeller thrust at MCR in free running open water condition.

Table 3.10.11 Propeller Bollard Thrust

Propeller Type	**T**
Fixed Pitch Propellers driven by turbine or electric motor	T_n
Fixed Pitch Propellers driven by diesel engine (Open)	T_n / 1.18
Fixed Pitch Propellers driven by diesel engine (Ducted)	T_n / 1.33
Controllable Pitch Propellers (Open)	T_n / 0.80
Controllable Pitch Propellers (Ducted)	T_n / 0 .91
Note: The above to be considered if the Bollard thrust is not known.	

3.10.6 **Torsional Design Loads**

3.10.6.1 Design ice torque on propeller Qmax for open propellers

Maximum propeller torque resulting from propeller/ ice interaction;

Q_{max} = 10.90 (1-[d/D]) $(P_{0.7}/D)^{0.16}$ $(nD)^{0.17}$ D^3 (kNm); When D ≤ $D_{limit;}$

Q_{max} = 20.70 (1-[d/D]) $(P_{0.7}/D)^{0.16}$ $(nD)^{0.17}$ $D^{1.9}$ $H_{ice}^{1.1}$ (kNm); When D > D_{limit} ;

Where,

D_{limit} = 1.80 H_{ice} (m)

For CP propellers, the propeller pitch, $P_{0.7}$ shall correspond to MCR in bollard condition. If not known, $P_{0.7}$ is to be taken as 0.7·$P_{0.7n}$, where $P_{0.7n}$ is the propeller pitch at MCR in free running condition.

Table 3.10.12 Selection of Rotational Speed	
Propeller Type	**Rotational Speed, n**
Fixed pitch propeller driven by turbine/ electric motor	N_n
Fixed pitch propeller driven by diesel engine	0.85 n_n
Controllable pitch propellers	n_n
Note: n_n refers to free running condition at MCR	

3.10.6.2 Design ice torque on propeller Qmax for ducted propellers

Maximum propeller torque resulting from propeller/ ice interaction;

Q_{max} = 7.70 (1-[d/D]) $(P_{0.7}/D)^{0.16}$ $(nD)^{0.17}$ D^3 (kNm); When D ≤ $D_{limit;}$
Q_{max} = 14.60 (1-[d/D]) $(P_{0.7}/D)^{0.16}$ $(nD)^{0.17}$ $D^{1.9}$ $H_{ice}^{1.1}$ (kNm); When D > $D_{limit;}$

Where,
D_{limit} = 1.80 H_{ice} (m)

$P_{0.7}$ and n as defined for open propeller.

3.10.6.3 Ice torque excitation for open and ducted propellers

The propeller ice torque excitation for shaft line transient torsional vibration analysis shall be described by a sequence of blade impacts which are of a half sine shape, Refer Fig.7.

The torque resulting from a single blade ice impact as a function of the propeller rotation angle is:

Q (φ) = C_q Q_{max} Sin (φ [180 / α_i]); when φ = 0…α_i

Q (φ) = 0; when when φ = α_i….360

Cq and α_i parameters are given in the Table 3.10.13 and α_i is duration of propeller blade/ice interaction expressed in propeller rotation angle.

Table 3.10.13 Torque Exciting Parameters

Torque Excitation	Propeller/ Ice Interaction	C_q	a_i
Case 1	Single ice block	0.75	90
Case 2	Single ice block	1.00	135
Case 3	Two ice blocks (Phase shift 45 deg)	0.50	45

Total ice torque is obtained by summing the torque of single blades, taking into account the phase shift 360 degrees/Z. In addition, at the beginning and at the end of the milling sequence a linear ramp functions for 270 degrees of rotation angle shall be used.

Number of propeller revolutions during a milling sequence shall be:

$N_Q = 2 H_{ice}$

The number of impacts is Z- N_Q for blade order excitation.

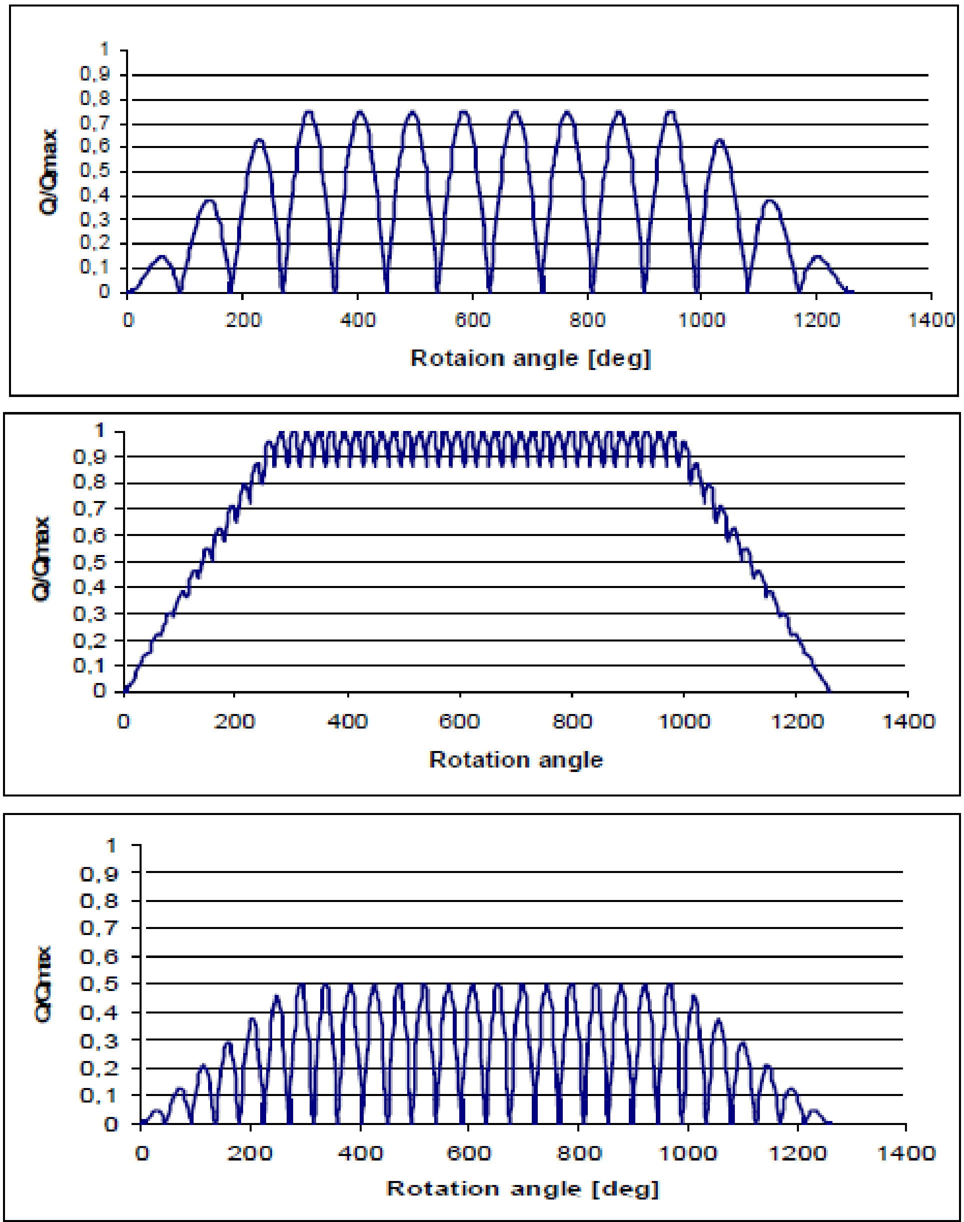


Fig. 7 Shape of Propeller Ice Torque Excitation

For 90 and 135 degree single blade impact sequences and 45 degree double blade impact sequence (Figures apply for propellers with 4 blades)

3.10.6.4 Design torque along propeller shaft line

If there is not any relevant first blade order torsional resonance within the designed operating rotational speed range extended 20% above the maximum and 20% below the minimum operating speeds, the following estimation of the maximum torque can be used:

$Q_r = Q_{e\,max} + Q_{max} (I / I_t)$ (kNm)

Where I is equivalent mass moment of inertia of all parts on engine side of component under consideration and It is equivalent mass moment of inertia of the whole propulsion system. All the torques and the inertia moments shall be reduced to the rotation speed of the component being examined.

If the maximum torque, Q_{emax}, is not known, it shall be taken as follows, where Q_{motor} is the electric motor peak torque:

Table 3.10.14 Selection of Maximum Motor Torque Q_{emax}	
Propeller Type	**Q_{emax}**
Propellers driven by electric motor	Q_{motor}
CP Propellers not driven by electric motor	Q_n
FP Propellers driven by turbine	Q_n
FP propellers driven by diesel engine	$0.75\ Q_n$

If there is a first blade order torsional resonance within the designed operating rotational speed range extended 20% above the maximum and 20% below the minimum operating speeds, the design torque (Qr) of the shaft component shall be determined by means of torsional vibration analysis of the propulsion line.

3.10.7 **Blade Failure Load**

3.10.7.1 The ultimate load is acting on the blade at the 0.8R radius in the weakest direction of the blade. The ultimate load resulting from blade failure as a result of plastic bending around the blade root shall be calculated with the formula below. For calculation of the extreme spindle torque, the spindle arm is to be taken as 2/3 of the distance between the axis of blade rotation and the leading/trailing edge (whichever is the greater) at the 0.8R radius.

$F_{ex} = (300.c.t^2.\sigma_{ref}) / (0.80\ D - 2r)$ (kN)

Where
$\sigma_{ref} = 0.40\ \sigma_u + 0.60\ \sigma_{0.2}$
c, t, r = Length, thickness and radius of the cylindrical root section of the blade at the weakest section outside the root fillet.

3.10.8 **Design Principle**

3.10.8.1 The propulsion system shall be designed in such a way that the complete dynamic system is free from harmful torsional, axial, and bending resonances at a 1-order blade frequency within the designed running speed range, extended by 20 per cent above and below the maximum and minimum operating rotational speeds. If this condition cannot be fulfilled, a detailed vibration analysis has to be carried out in order to determine that the acceptable strength of the components can be achieved.

3.10.8.2 The strength of the propulsion line shall be designed according to the pyramid strength principle. This means that the loss of the propeller blade shall not cause any significant damage to other propeller shaft line components.

3.10.9 Propeller Blade Design

3.10.9.1 Calculation of blade stresses

The blade stresses shall be calculated for the design loads given in [3.10.5]. Finite element analysis shall be used for stress analysis for final approval for all propellers.

The following simplified formulae can be used in estimating the blade stresses for all propellers at the root area (r/R < 0.5). The root area dimensions will be accepted even if the FEM analysis would show greater stresses at the root area.
$\sigma_{st} = (0.01\ C_1\ M_{BL}) / (ct^2)$ (MPa)
Where,
C_1 is the "actual stress/ stress obtained with beam equation".
If the actual value is not available, C_1 should be taken as 1.60

$M_{BL} = (0.75 - r/R)\ R\ F$

For relative radius r/R < 0.50.
F is the maximum of F_b and F_f.

3.10.9.2 Acceptability Criterion – Maximum load (static)

The calculated blade stress is to fulfil the following:

$(\sigma_{ref2} / \sigma_{st}) \geq 1.50$

Where σ_{st} is the calculated stress for the design load. If finite element analysis is carried out in estimating the strength, Von Mises stress shall be considered.

σ_{ref2} = Lesser of $0.70\ \sigma_u$ (or) $0.60\ \sigma_{0.2} + 0.40\ \sigma_u$

3.10.9.3 Fatigue Design of Propeller Blade

Fatigue design of the propeller blade is based on an estimated load distribution over the service life of the ship and the S-N curve as applicable to the material of the blade. An equivalent stress that produces the same fatigue damage as the expected load distribution shall be calculated and the acceptability criterion for fatigue should be fulfilled as given in this section. The equivalent stress is normalised for 100 million cycles.

Fatigue calculation as in this section is not required if the criteria below is fulfilled:

$\sigma_{exp} \geq B1\ \sigma_{ref2}^{B2}\ \log(N_{ice})^{B3}$

Where,
B1, B2, B3 are coefficients for open and ducted propellers are detailed in Table 2.10.15 below:

Table 3.10.15 Propeller Coefficients

Propeller Type	B1	B2	B3
Open Propeller	0.00270	1.007	2.101
Nozzle Propeller	0.00184	1.007	2.470

Two types of SN curves are available for the calculation of equivalent stress:

a) Two slope SN curve (Slopes 4.5 and 10.0) Refer Fig. 8
b) One slope SN curve (Slope can be chosen) Refer Fig. 9

The type of the SN-curve shall be selected to correspond to the material properties of the blade. If SN-curve is not known the two slope SN curve shall be used.

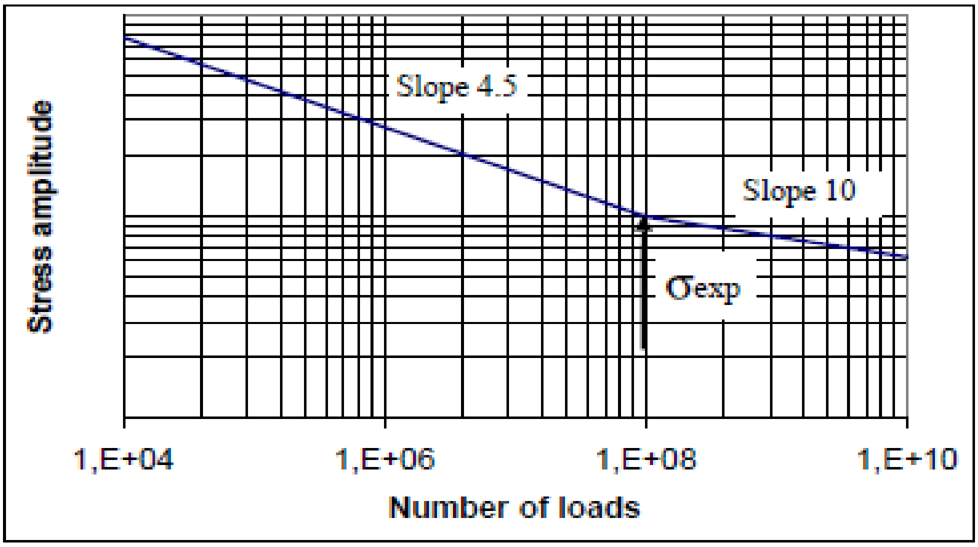


Fig.. 8 Two Slope SN Curve

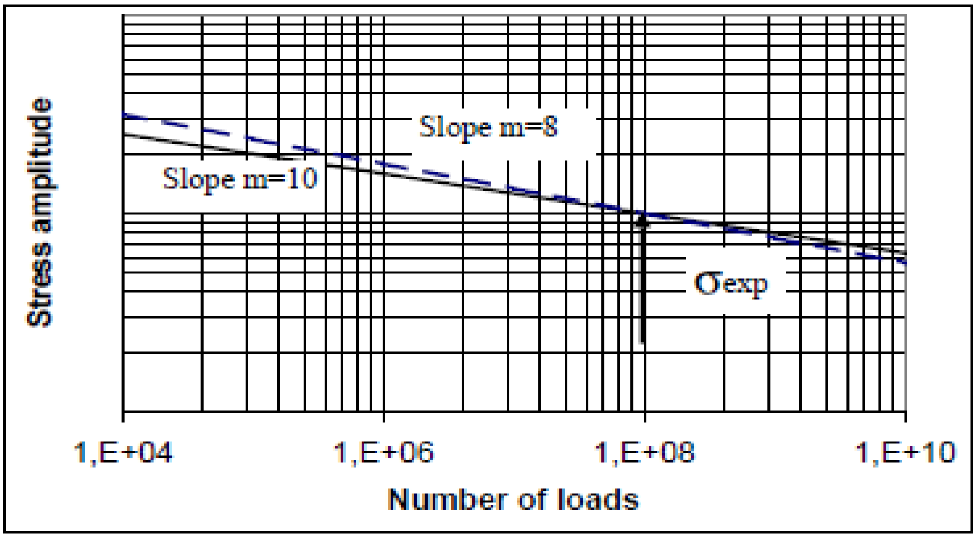


Fig.. 9 Constant Slope SN Curve

3.10.9.4 Equivalent Fatigue Stress

The equivalent fatigue stress for 100 million stress cycles which produces the same fatigue damage as the load distribution is:

$\sigma_{fat} = \rho\ (\sigma_{ice})_{max}$

Where

$(\sigma_{ice})_{max} = 0.50\ [(\sigma_{ice})_{fmax} - (\sigma_{ice})_{bmax}]$

$(\sigma_{ice})_{max}$ = The mean value of the principal stress amplitudes resulting from design forward and backward blade forces at the location being considered.
$(\sigma_{ice})_{fmax}$ = Principal stress resulting from forward load
$(\sigma_{ice})_{bmax}$ = Principal stress resulting from backward load

In calculation of $(\sigma_{ice})_{max}$, load case 1 and load case 3 (or case 2 and case 4) are considered as a pair for $(\sigma_{ice})_{fmax}$ and $(\sigma_{ice})_{bmax}$ calculations. Load case 5 is excluded from the fatigue analysis.

3.10.9.5 Calculation of ρ Parameter for Two Slope SN Curve

The parameter ρ relates the maximum ice load to the distribution of ice loads according to the regression formulae:

$$\rho = C_1 (\sigma_{ice})_{max}{}^{c2} \sigma_{fl}{}^{c3} \log(N_{ice})^{c4}$$

Where
σ_{fl} = $\gamma_\varepsilon \gamma_\nu \gamma_m \sigma_{exp}$

Where

γ_ε= Reduction factor for scatter and test specimen size effect
γ_ν = Reduction factor for variable amplitude loading
γ_m = Reduction factor for mean stress
σ_{exp} = Mean fatigue strength of the blade material at 10^8 cycles to failure in seawater

The following values should be used for the reduction factors if actual values are not available.
γ_ε= 0.67
γ_ν = 0.75
γ_m = 0.75

The coefficients C_1, C_2, C_3 and C_4 are provided in the Table 3.10.16

Table 3.10.16 Coefficients

Propeller Type	**C_1**	**C_2**	**C_3**	**C_4**
Open Propeller	0.000711	0.0645	-0.0565	2.22
Nozzle Propeller	0.000509	0.0533	-0.0459	2.584

3.10.9.6 Calculation of ρ Parameter for Constant Slope SN Curve
For materials with a constant-slope S-N curve, refer Fig. 9. The ρ-factor shall be calculated with the following formula:

$$\rho = [(G N_{ice}) / N_R]^{1/m} [\ln (N_{ice})]^{(-1/k)}$$

Where,
k = Shape parameter of the Weibull distribution,
= 1.00; for ducted propellers
= 0.75; for open propellers
N_R = Reference number of load cycles (100 million)
G = Refer Table Table 3.10.17 below.

Table 3.10.17 G Parameters for Different m/k Ratios

G	3	3.5	4	4.5	5	5.5	6	6.5
m/k	6	11.6	24	52.3	120	287.9	720	1871

Table 3.10.17 G Parameters for Different m/k Ratios (Continued)								
G	7	7.5	8	8.5	9	9.5	10	G
m/k	5040	14034	40320	119292	362880	$1.133*10^6$	$3.623*10^6$	m/k

3.10.9.7 Acceptability Criterion for Fatigue

Equivalent fatigue stress at all locations on the blade has to fulfil the following acceptability criterion:

$\sigma_{fl} / \sigma_{fat} \geq 1.50$

$\sigma_{fl} = \gamma_\varepsilon \gamma_\nu \gamma_m \sigma_{exp}$
γ_ε= Reduction factor for scatter and test specimen size effect
γ_ν = Reduction factor for variable amplitude loading
γ_m = Reduction factor for mean stress
σ_{exp} = Mean fatigue strength of the blade material at 10^8 cycle to failure in sea water

The following values should be used for the reduction factors if actual values are not available:
γ_ε= 0.67
γ_ν = 0.75
γ_m = 0.75

3.10.10 **Propeller Bossing and Controllable Pitch Mechanism**

3.10.10.1 The propeller boss, propeller blade bolts, the CP mechanism, and the fitting of the propeller to the propeller shaft shall be designed to withstand the maximum and fatigue design loads, as defined in Sec [3.10.5]. The safety factor against yielding shall be greater than 1.3 and that against fatigue greater than 1.5. In addition, the safety factor for loads resulting from loss of the propeller blade through plastic bending as defined in Sec [3.10.8] shall be greater than 1.0 against yielding.

3.10.11 **Propulsion Shaft Line**

3.10.11.1 Shafts and shafting components, such as the thrust and stern tube bearings, couplings, flanges and sealing, shall be designed to withstand the propeller/ice interaction loads as given in Sec [3.10.5] to [3.10.7]. The safety factor is to be at least 1.3.

3.10.11.2 The design torque Qr determined according to Sec [3.10.7] shall be applied for low cycle and high cycle strength analysis respectively.

3.10.11.3 Shafts and Components of Shafting
Yielding in shafts and shaft components should not occur due to total blade failure as defined in.[3.10.8] The loading shall consist of axial, bending, and torsion loads and also their combined effect, wherever this is significant. The minimum safety factor against yielding is to be 1.0 for bending and torsional stresses. Forward of the after peak bulkhead, the shaft may be evenly tapered down to 1.05 times the rule diameter of intermediate shaft, but not less than the actual diameter of the intermediate shaft.

3.10.12 **Design of Shaft line components not specifically mentioned in FSICR**

3.10.12.1 Below criteria are given for application of. Pt 5A,Ch 4 for determination of scantlings for intermediate shafts, couplings, reduction gears and crank shafts.

Application factor $K_{Aice} = Q_r/Q_n$ for low cycle criteria and/or static load criteria (Refer Sec 3.10.13.3). For components where fatigue is dimensioning, e.g. shaft and reduction gear, cumulative fatigue analysis are required. The actual Q_r/Q_n ratios shall be determined as provided in Sec [4.7.7.4].

3.10.12.2 The diameter of intermediate shafts shall be determined based on methods given in Pt 5A,Ch 4,Sect 3

With $Q_r/Q_n \leq 1.40$ the method in Pt 4 Ch 4 may be used, ie no ice reinforcement beyond 1A1 rules.

When using the method in Pt 4 Ch 4 Sec 1
, the minimum diameter in item 3 of that paragraph shall be multiplied by $(Q_r/1.4\ Q_n)^{1/3}$, where Q_r is the relevant maximum value, but not less than 1.0.

In item 4 of same paragraph, the vibratory torsional stress τ_v is to be replaced by:

τ_v = 0.50 [(Q_r / Q_n)-1] T_0 and shall not exceed τ_c

3.10.12.3 Regarding shaft connections, use Q_r/Q_n in Pt 5A as follows:

Flange connections, — Pt 5A,Ch4 Sect 3
Shrink fit connections, Pt 5A,Ch4 Sect 3
Keyed connections, — Pt 5A,Ch4 Sect 3.4

Connections transmitting ice axial load determined insect [3.10.5] from the propeller to the thrust bearing shall be capable of transmitting relevant loads without consequential damage.

3.10.12.4 In case of reduction gears, use Q_r/Q_n in Pt 5A Ch 3

3.10.12.5 In case of clutches use, Q_r/Q_n in Pt 5A Ch4 Sect [3.10.6]

3.10.12.6 For torsional elastic coupling, use Qr/Qn in Pt 5A Ch.4

3.10.12.7 For crank shafts in direct coupled diesel engines, refer .Pt 5A, Ch 2

3.10.13 **Azimuthing Main Propulsion and Other Thrusters**

3.10.13.1 Due consideration shall be given to those loading cases which are different for propulsion units when compared with conventional propellers; in addition to the requirements detailed above. The estimation of loading cases has to reflect the way of operation of the ship and the thrusters. In this respect, for example, the loads caused by the impacts of ice blocks on the propeller hub of a pulling propeller have to be considered. Furthermore, loads resulting from the thrusters operating at an oblique angle to the flow have to be considered. The steering mechanism, the fitting of the unit, and the body of the thruster shall be designed to withstand the loss of a blade without damage. The loss of a blade shall be considered for the propeller blade orientation which causes the maximum load on the component being studied. Typically, top-down blade orientation places the maximum bending loads on the thruster body.

3.10.13.2 Azimuth thrusters shall also be designed for estimated loads caused by thruster body/ice interaction. The thruster body has to stand the loads obtained when the maximum ice blocks, which are given in the “Design ice conditions” section, strike the thruster body when the ship is at a typical ice operating speed. In addition, the design situation in which an ice sheet glides along the ship's hull and presses against the thruster body should be considered. The thickness of the sheet should be taken as the thickness of the maximum ice block entering the propeller, as defined in the “Design ice conditions” section.

3.10.13.3 Tunnel Thrusters
Generally, for tunnel thrusters Ice Strengthening is not required.

3.10.13.4 Other Thruster
Thrusters other than propulsion thrusters and tunnel thrusters need only comply with the relevant requirements in [3.10.14] if they shall be used in ice conditions or for any reason be exposed to ice loads. For thrusters that are not intended for use in ice conditions, this will be stated in the class certificate and on signboards fitted at all relevant manoeuvring stands.

3.10.13.5 Relevant parts of structure of non-retractable thrusters shall be strengthened with respect to ice loads, independent of whether they are used in ice conditions or not.

3.10.14 **Alternative Design**

3.10.14.1 Scope

As an alternative to Sec [3.10.3]-[3.10.14] a comprehensive design study may be carried out to the satisfaction of the Administration. The study has to be based on ice conditions given for different ice classes in Sec [3.1.2]. It has to include both fatigue and maximum load design calculations and fulfil the pyramid strength principle, as given in Sec [3.10.9]

3.10.14.2 Loading

The propeller blade and propulsion system loads shall be based on an acceptable estimation of hydrodynamic and ice loads.

3.10.14.3 Design Levels

The analysis is to indicate that all components transmitting random (occasional) forces, excluding propeller blade, are not subjected to stress levels in excess of the yield stress of the component material, with a reasonable safety margin. Vibration analysis is to be carried out and is to indicate that the complete dynamic system is free from harmful torsional resonances resulting from propeller/ice interaction. Cumulative fatigue damage calculations are to indicate a reasonable safety factor. Due account is to be taken of material properties, stress raisers, and fatigue enhancements.

3.11 Miscellaneous Machinery Requirements

3.11.1 **Starting Arrangements**

3.11.1.1 The capacity of the air receivers shall be according to the requirements in Pt 5A,Ch8, Sect [4.5.3]

The capacity of the air compressors shall be sufficient for charging the air receivers from atmospheric to full pressure in one (1) hour, except for a ship with the ice class **ICE-1A*** if its propulsion engine has to be reversed for going astern, in which case the compressors shall be able to charge the receivers in half an hour.

If the air receivers serve any other purposes than starting the propulsion engine, they shall have additional capacity sufficient for these purposes.

3.11.2 **Sea Inlet and Cooling Water Systems**

3.11.2.1 The cooling water system shall be designed to ensure supply of cooling water when navigating in ice.

The sea cooling water inlet and discharge for main and auxiliary engines shall be so arranged that blockage of strums and strainers is prevented.

For this purpose, at least one cooling water inlet chest shall be arranged as follows:

a) The area of the strum holes shall be not less than four (4) times the inlet pipe sectional area.

b) A pipe for discharge cooling water, allowing full capacity discharge, shall be connected to the chest. Where the sea chest volume and height specified in (c) and (d) are not complied with, the discharge shall be connected to both sea chests. At least one of the fire pumps shall be connected to this sea chest or to another sea chest with de-icing arrangements.

c) To allow for ice accumulation above the pump suction the height of the sea chest shall not be less than:

$$h_{min} \geq 1.50\ (V_s)^{1/3}$$

Where
V_s = Volume of sea chest according to Item (d) below.
The suction pipe inlet shall be located not higher than $h_{min}/3$ from top of sea chest.

d) The volume of the chest shall be about one cubic metre for every 750 kW engine output of the ship (for guidance only) including the output of the auxiliary engines necessary for the ship's service.

e) Sea inlet shall be situated near the centre line of the ship and well aft as far as practicable. The inlet grids shall be specially strengthened.

If there are difficulties in meeting the requirements specified in (c) and (d) above, two smaller chests may be arranged for alternating intake and discharge of cooling water. The arrangement and situation otherwise shall be as above.

Heating coils may be installed in the upper part of the chest or chests.

Arrangements using ballast water for cooling purposes may be useful as a reserve in ballast condition but cannot be accepted as a substitute for sea inlet chests as described above.

3.11.3 **Ballast System**

3.11.3.1 Prevention of freezing of the ballast water shall be ensured by providing an arrangement located fully or partly above the LIWL, adjacent to the ships shell and need to be filled for operation in ice conditions according to Sec [3.1.3.2] The following ambient temperatures shall be considered in the design:
Sea water temperature: 0^0 C
Air temperature : -10^0 C

Relevant calculation shall be documented and submitted.

3.11.3.2 An air bubbling arrangement or a vertical heating coil, capable of maintaining an open hole in the ice layer, may normally be accepted when the tank is located partly above the LIWL.

In such instance, the required heat-balance calculations may be omitted

Note: Prior to pumping of ballast water, proper functioning of level gauging system is to be verified and ensure no blockage of air pipe by ice.

3.12 Guidelines for Strength Analysis of the Propeller Blade using Finite Element Method

SECTION 4 VESSELS FOR ARCTIC AND ICE BREAKING SERVICE

Contents

4.1 General

4.1.1 Classification

4.1.1.1 This section and the requirements are applicable to icebreaker and to passenger and cargo vessels intended to operate unassisted in ice-infested waters of sub-Arctic, Arctic and / or Antarctic regions.

4.1.1.2 Vessels intended for ice breaking as their main purpose and built in compliance with the following requirements may be given one of the class notations **ICE-05** (or **-10** or **-15**) Icebreaker or **POLAR-10** (or **-20** or **-30**) Icebreaker, whichever is relevant.

Vessels built for another main purpose, while also intended for ice breaking, may be given the additional class notation **ICE-05 (or -10 or -15)** or the notation **POLAR-10 (or -20 or -30)**.

4.1.1.3 Arctic class vessels intended for special services where intermediate ice condition values are relevant may, upon special consideration, be given intermediate notations (e.g. **POLAR-25**).

4.1.1.4 For **POLAR** class vessels the design ambient air temperature on which the classification has been based will be given the special feature notation **DAT(-X°C)**. For details, Refer Sec 7.

4.1.1.5 For vessels with the class notation **Icebreaker**, and for other **POLAR** class vessels the maximum operational speed on which the ramming design requirements have been based will be stated in the “Appendix to the classification certificate”. The operational speed is in no case to be taken as smaller than stated in Sec 4.1.3 for the various class notations.

4.1.2 Scope

4.1.2.1 The following are considered by the classification:

- Materials of structures exposed to low ambient air temperatures
- Subdivision, intact and damage stability
- Hull girder longitudinal and transverse strength
- Local hull structures exposed to ice load
- Rudders and steering gears
- Propellers and propulsion machinery
- Sea suction for cooling water
- Air starting system

MEHT : Monthly Extreme High Temperature (ever recorded)
MELT : Monthly Extreme Low Temperature (ever recorded)
MDHT : Mean Daily High Temperature (Maximum)
MDAT : Mean Daily Average Temperature
MDLT : Mean Daily Low Temperature (Minimum)
MAMDHT : Monthly Average of MDHT
MAMDAT : Monthly Average of MDAT
MAMDLT : Monthly Average of MDLT

Mean : Statistical mean over observation period (minimum 20 years)
Average : Average during one day and night

4.1.3 Design Principles and Assumptions

4.1.3.1 Each class notation is related to a particular ice condition that the vessel is expected to encounter. Relevant design ice conditions are as given in Table 1.1.1. In case intermediate ice conditions are relevant (Refer Sec [4.1.1.3]), nominal ice strength shall be related to the selected nominal ice thickness.

4.1.3.2 Vessels with the class notation **Icebreaker**, and other **POLAR** class vessels are expected to encounter pressure ridges and other ice features of significantly greater thickness than the average thicknesses specified in Table 4.1.1. Vessels with the class notation **POLAR** only are assumed not to make repeated ramming attempts if the ice fails to break during the first (occasional) ram unless the vessel's speed is kept well below the design ramming speed. Vessels with class notation **Icebreaker** may make several consecutive attempts to break the ice at maximum ramming speed. The design speed in ice infested waters when ramming may occur, VRAM, shall be specified by the builder. In general, this speed shall not be taken less than:

$V_{RAM} = V_B + V_H$ (m/s)

V_B = Specified continuous speed, when breaking maximum average ice thickness
V_H = Speed addition in thinner ice (h_{ice}) Refer Table 4.1.1.
V_{RAM} = Minimum 2.0 m/s (3.90 knots) for **POLAR-10** notation
= Minimum 3.0 m/s (5.80 knots) for **POLAR-10** notation
= Minimum 4.0 m/s (7.80 knots) for **POLAR-10** notation

For vessels with the class notation Icebreaker the minimum speed is 2 m/s (3.9 knots) but not less than 1.5 times the speed specified above when POLAR class notation is also specified.

4.1.4 Definitions

4.1.4.1 General symbols and terms are provided in Sec [1.2.1].

4.1.4.2 Additional Symbols detailed below:

s = Stiffener spacing (m)
l = Stiffener span (m). Web height of in-plabe girders may be deducted
t = Rule thickness of plating (mm)
t_k = corrosion addition (mm)
t_w = Rule web thickness (mm)
Z = Rule section modulus (cm^3)
A_w = Rule web area (cm^2). Product of web thickness time the web height including flange.
thickness
A = Rule cross-sectional area (cm^2)
σ_{ice} = Nominal strength of ice (N/mm^2)
h_{ice} = Average ice thickness (m). Refer Table 1.1.1.
V_{RAM} = Design speed (m/s) while ramming. Refer .[4.1.3.2]
E_{KE} = Vessel's kinetic energy before ramming (kNm) = $0.50\ \Delta\ V_{RAM}^2$
α, γ = Bow shape angles. Refer Fig. 1 below.
C_{WL} = Ships water plane area coefficient at UIWL

Table 4.1.1 Ice Conditions

Class Notation	Type of Ice	Nominal Strength Of ice σ_{ICE} (N/mm^2)	Nominal Strength Of ice h_{ICE} (m)	Limiting impact conditions
ICE-05	Winter ice with pressure ridges	4.2	0.5	No ramming expected
ICE-10		5.6	1.0	
ICE-15		7.0	1.5	
POLAR-10	Winter ice with pressure ridges and multi layer ice-floes and glacial ice inclusions	7.0	1.0	Occasional Ramming
POLAR-20		8.5	2.0	
POLAR-30		10.0	3.0	
Icebreaker	As above	As above	As above	Repeated Ramming

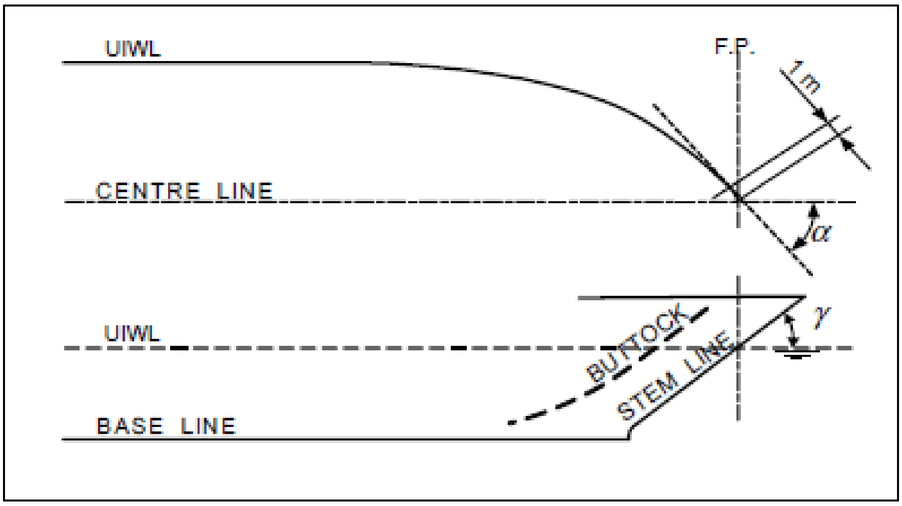


Fig..1 Bow Shape Angles

4.1.4.3 The stiffened shell plating of the hull to be reinforced against local ice loads and is divided into 7 different areas. The areas are defined as follows (Refer Fig..2):

Bow Area

The bow area need not extend aftwards beyond 30%L form the FP (forward perpendicular)

Longitudinally from stem to a line parallel to and 40% L aft of the border line of flat side of hull forward. If the hull breadth is increased over a limited length forward of the flat side the bow area need normally not extend aftwards beyond the widest section of each waterline.

Vertically from a line defined by the distance z_{lm} below LIWL (aft) and the intersection between the keel line and the stem line (forward) to a line defined by the distances z_{ua} (aft) and z_{uf} (forward) above UIWL. For ships with an ice knife fitted, the line of the lower vertical extension may be drawn to a point 0.04 L aft of the upper end of the knife and further down to the base line (Refer also Fig. 2).

Stem Area

Vertically from a line defined by the distance z_{la} below LIWL, to a line defined by the distance z_{ua} above UIWL
The part of the bow area between the stem line and a line 0.06 L aft of the stem line or 0.125 B outboard from the centre line, whichever is first reached.

Stern Area

Vertically from a line defined by the distance z_{la} below LIWL, to a line defined by a distance z_{ua} above UIWL.

Longitudinally from the stern to a line parallel to and 0.04 L forward of the border line of flat side of hull aft, or to a line 0.2 L aft of amidships, whichever is the aftermost.

Midship Area

Vertically from a line defined by the distance z_{lm} below LIWL, to a line defined by a distance z_{ua} above UIWL.

Longitudinally from the stern area to the bow area.

Bottom Area

Longitudinally aft of 0.3 L from forward perpendicular and transversely over the flat bottom including dead rise. For ships with bow ice knife, the bottom area may be extended forward to the ice knife.

Lower Transition area

Transition area between the bottom area and the adjacent stern, and midship areas respectively.

Lower Bow area

The area below the bow area.

UIWL and LIWL are defined in [1.2.2]

Parameters of z_{la}, z_{lm}, z_{ua}, and z_{uf} are given for various class notations in Table 4.1.2.

Table 4.1.2 Vertical Extend of Ice Reinforced Areas

Class Notation	Parameters for Vertical Extend (m)			
	z_{la}	$z_{lm}^{(*)}$	z_{ua}	z_{uf}
ICE-05	1.7	1.1	0.8	1.5
ICE-10	2.2	1.6	1.0	2.0
ICE-15	4.6	3.7	1.9	2.5
POLAR-10	2.9	2.3	1.4	2.2
POLAR-20	6.0	4.6	2.8	3.7
POLAR-30	11.9	9.2	4.2	5.2

(*) z_{lm} (maximum) = The vertical distance from the LIWL to the point on the frame contour amidships where the tangent is at 45 degrees

4.1.5 **Documentation**

4.1.5.1 For documentation in connection with stability and watertight integrity, Refer Sec [4.12.3].

4.1.5.2 Documentation requirements for stability and watertight integrity can be found in Sec [4.12].

4.1.5.3 Where ice exposed plating is fitted with a special wear addition, the plate thickness including wear addition shall be given on the shell expansion plan in addition to the net thickness required by the rules.

4.1.5.4 Ice Waterlines of UIWL and LIWL as well as the border line of flat side shall be indicated on the shell expansion plan together with the ice reinforced areas as given in Fig. 2.

4.1.5.5 Maximum design ramming speed (V_{RAM}) in ice infested waters as well as design speed for continuous ice breaking operations (V_B) shall be stated on the midship section plan for ships with class notations **POLAR** or **Icebreaker.**

4.1.5.6 Applicable design specifications for the operation of the vessel in ice infested waters shall be stated in the ship's loading manual, refer Pt 3, Ch 5, Sec 6.

Design specifications to include the following as minimum.

- Ambient temperature
- Allowable draft (minimum and maximum)
- Design Speed
- Ramming Speed
- Loading conditions with respect to strength and stability
- Astern Operation in ice
- Ballast tank filling instructions

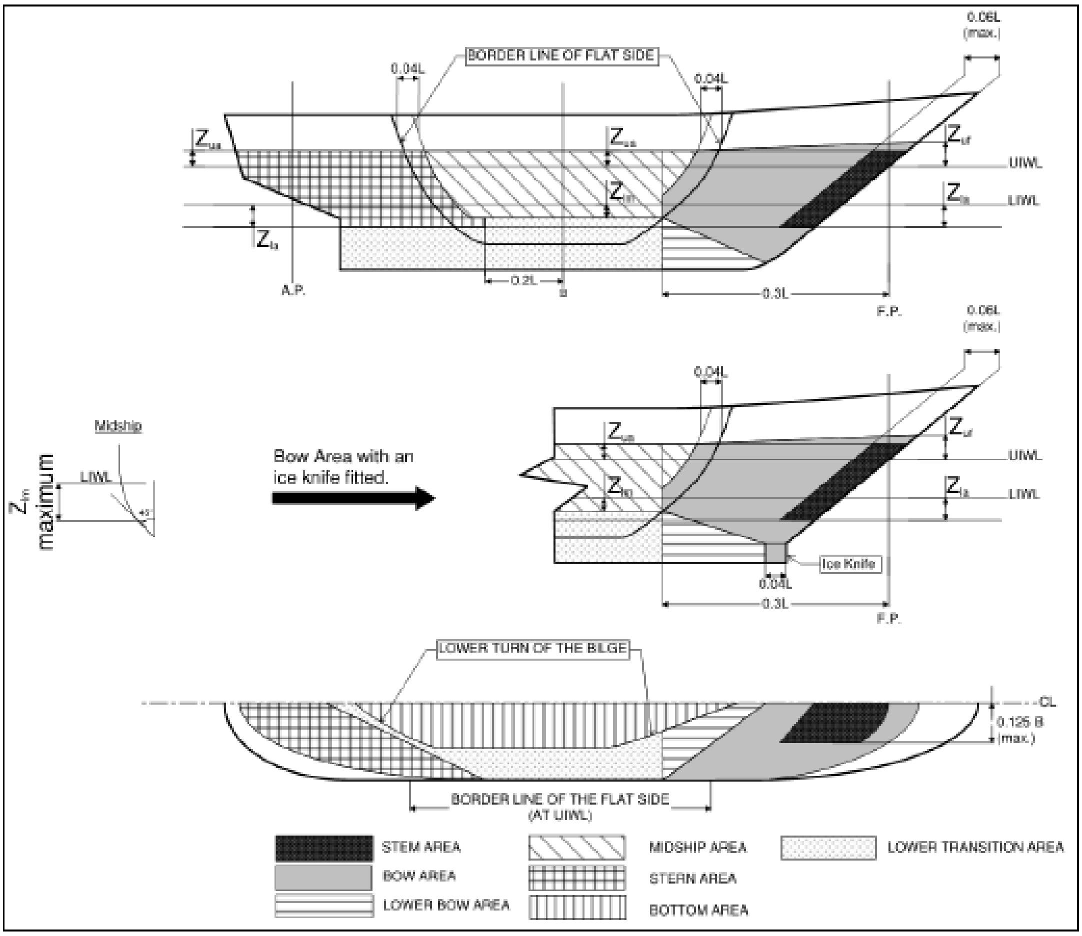


Fig..2 Ice Reinforced Area

4.2 Materials and Corrosion Protection

4.2.1 Design Temperatures

4.2.1.1 For **ICE** class notations no special consideration for low ambient air temperatures are given unless specified by the builder.

4.2.1.2 Steel grades to be used in hull structural members shall be determined based on the design temperature for the structure in question with requirements as given in Section 7.

4.2.1.3 For **POLAR** class notations steel grades in exposed structures (external structure as defined in Section 7) shall be based on air temperatures lower than those generally anticipated for world wide operation. Unless a service restriction notation is also given, limiting the navigation to specified areas and/or time of year, the design temperature shall not be taken higher than -30°C (corresponding extreme low temperature -50ºC).

For operation in lower design temperatures, this must be clearly specified.

4.2.2 Selection of Steel Grades

4.2.2.1 Plating materials for various structural categories of exposed members above the ballast waterline of vessels with class notation **POLAR** shall not be of lower grades than obtained from Section 7 using design temperatures as defined in Sec 4.2.1 above.

4.2.2.2 Plating materials of non-exposed members and of vessels with class notation **ICE** shall not be of lower grade than obtained according to Pt 3, Ch 2.

Cranes shall be in compliance with National or International Standards but complying to requirements for operation at Low Temperatures as required.

4.2.3 Coatings

4.2.3.1 Wear resistant coating is assumed used for the external surfaces of plating in ice reinforced areas.

4.2.4 Corrosion Additions

4.2.4.1 Hull structures are in general to be given a corrosion addition t_k as required by the main class, Refer Pt 3, Ch 2.

4.3 Ship Design and Arrangement

4.3.1 Hull form

4.3.1.1 The ships bow shall be provided with a shape which can break level ice effectively at a continuous speed. For various class notation the thickness of the ice are provided in Table 1.1.1.

4.3.1.2 Icebreaker and other POLAR class vessels shall have a suitable bow shape so that the bow will ride up on the ice when encountering pressure ridges or similar ice features that will not break on the first ramming.

4.3.1.3 Excessive accumulation of ice should be avoided by efficient design of masts, rigging, deckhouse, superstructure and such items on the deck.

4.3.1.4 Materials suitable for use in low temperature application shall be used for design of weather tight doors and hatches including the following:

- Strength of cleats and the choice of steel with adequate ductility
- Ease of operation (ie low weight, hand wheel operate cleats etc)
- Ease of maintenance (ie well accessible grease fittings etc.)
- High quality and flexible packing materials

4.3.1.5 Closing mechanism of air pipe shall be efficiently designed so that icing or freezing will not make them inoperable.

4.3.1.6 Freeing ports shall be so designed that blockage by ice is avoided as far as possible. In case of a blockage these are to be easily accessible for removal of the blockage.

4.3.2 Appendages

4.3.2.1 Vessel with class notation **Icebreaker** and in other **POLAR** class vessels an ice knife may be required forward to avoid excessive beaching and submersion of the deck aft. This requirement will be based on consideration of design speed and freeboard, and may result in additional requirements regarding accelerations and strength.

4.3.2.2 Aft of each rudder shall be fitted with ice horns such that:

- Ice is prevented from wedging between the top of the rudder and the vessel's hull.
- While going astern the upper edge of the rudder is protected within two degrees to each side of mid position.

4.3.3 Mooring Equipment

4.3.3.1 The design of the anchor housing shall be such that possible icing will not prevent the anchor from falling when released.

4.4 Design Loads

4.4.1 Ice Impact Force on the Bow

4.4.1.1 Head on ramming load induced vertical design force component (not applicable to vessels with class notation **ICE** only) :

$P_{ZR} = P_R F_{EL}$ (kN)

Where,

$P_R = 28 [C_R E_{IMP} / \tan(\gamma)]^{0.60} [\sigma_{ice} \tan(\alpha)]^{0.40}$

C_R = 1.00 for class notation **POLAR**
= 2.00 for class notation **Icebreaker**

$E_{IMP} = [E_{KE} \tan^2 \gamma] / [\tan^2 \gamma + 2.5]$

$\tan(\alpha) = (1.20 B^{0.10}) / [\cos(\gamma)]^{0.50}$: for Spoon bows

$F_{EL} = [E_{IMP} / (E_{IMP} + C_L P_R^2)]^{0.5}$

$C_L = [L^3 / (3 \times 10^{10} I_V)]$

EKE , σ_{ice}, α and γ as defined in Sec 4.1.4.
L as defined in Sec 1.2.1
Iv is the moment of inertia (m4) about the horizontal neutral axis of the midship section.

4.4.1.2 The total design force normal to the shell plating in the bow area due to an oblique impact with an ice feature:

P_{OI} = $[P_{ZR}\ F_{SIDE} / \cos(\gamma)]$ (kN)

Where,
F_{SIDE} = $\{1.99 / [(\tan(\alpha))^{0.40}\} \{\sigma_{ice} / \sigma_{KE}\}^{0.05}$; in general
$\tan\alpha$ = $[1.20\ B^{0.10}] / [\cos(\gamma)]^{0.50}$; for spoon shaped bows

P_{ZR} = Vertical ramming load as given in Sec [4.4.1.1].

E_{KE} , σ_{ice}, α and γ as defined in Sec [4.1.4].
L and B as defined in Sec 1.2.1

4.4.2 Beaching Forces

4.4.2.1 Beaching (on large ice feature) induced vertical design force (not applicable to vessels with class notation ICE only):

P_{ZB} = $G_B\ (k_b\ E_{KE}\ LB)^{0.50}$ (kN)

Where;
G_B = $\{[C_{WL}\ (C_{WL} – 0.50)] / [C_{WL} + 1.00]\}^{0.50}$
K_b = $2\ g_0\ (1 – r_{fw})$
r_{fw} = Reduction factor due to energy lost in friction and waves= 0.30
E_{KE} , σ_{ice}, α and γ as defined in [4.1.4].
L, B and g_0 as defined in [1.2.1].

4.4.2.2 The vertical design force in beaching for vessels with ice knife as shown in Fig. 2 is need not be taken greater than:

P_{ZB} = $\{[10.60\ C_{WL}\ BLX \tan(\gamma)] / [1 + 15(0.55 – (X/L))^2]\}$ (kN)

Where,
X = Horizontal distance (m) from FP_{ICE} to centre of vertical ram bow
FP_{ICE} = Intersection point of stem line and deepest icebreaking waterline
C_{WL} = Waterline area coefficient
L and B as defined in Sec [1.2.1]

4.4.3 Ice Compression Loads Amidships

4.4.3.1 All vessels shall withstand line loads acting simultaneously in the horizontal plane at the water level on both sides of the hull. These loads are assumed to arise when a vessel is trapped between moving ice floes.

4.4.3.2 The design line load shall be:

q = $[165 / \sin(\beta_f)]\ [h_{ice}]^{1.50}$ (kN/m)
= $950\ (h_{ice})^{1.50}$ (kN/m) for vertical side shells (β_f < 10 degree)
H_{ice} = Average ice thickness as defined in Sec [4.1.4].
β_f = Angle of outboard flare at the water level. The outboard flare angle shall not be taken as less than 10 degrees.

4.4.4 Local Ice Pressure

4.4.4.1 The design pressure shall be applied over a corresponding contact area based on the type of load. All vessels shall withstand local ice pressure as defined for the different ice class notations and as applied to the different ice reinforced areas.

4.4.4.2 The basic ice pressure shall be taken as:

p_0 = 1000 σ_{ice} F_A (kN/m^2)

Where;
σ_{ice}, as defined in Sec [4.1.4].
F_A as provided in Table 4.4.1 below.

Table 4.4.1 Correction Factor, F_A for Ice Reinforced Area

F_A	Applicability
1.00	For bow and stern area in general
0.60	For midship area in general
0.50	For midship area if ship breadth in bow area larger than ship breadth in midship area
0.20	For bottom area of vessel with notation **Icebreaker** or **POLAR**
0.10	For bottom area of vessel notation **ICE** only
0.60	For stern area in general
0.80	For stern area in ships with class notation **Icebreaker**
1.00	For the stern area in ships with class notation **Icebreaker** or **POLAR**,
0.80	For ships with ICE notations, fitted wiith pod or thruster propulsion units and designed for continuous operation astern.(*)
(*) The stern area structure shall be dimensioned as outlined for bow structure. Refer also [4.7.7].	
For transition areas and lower bow area, 2/3 of the F_A value for the adjacent area above may be used in general.	

4.4.4.3 The design pressure in general to be taken as:

p = F_B p_0 (kN/m^2)

Where;
F_B = Correction factor for size of design contact area A_c
= [0.58/ ($A_c^{0.5}$)] for $A_c \leq 1.00$ m^2
= [0.58/ ($A_c^{0.15}$)] for $A_c > 1.00$ m^2
Where;

A_c = h_0 w (m^2)

h_0 = h, in general
= s, maximum for longitudinal
= l, maximum for non-longitudinal frames
= 1.40l, maximum for connection area of non-longitudinal frames
= S, maximum for girders supporting longitudinal
= l, maximum for stringers supporting non-longitudinal frames

h_{stem} = h as provided for stem area

h = effective height of contact area (m)
= 0.40 h_{ice} (m) in general
= 0.64 h_{ice} (m) in the stern area; for vessels fitted with pod or thruster propulsion units, and designed for continuous operation astern.
= 0.80 h_{ice} (m) in stem area in general
= $(P / 645\ \sigma_{ice})^{0.60}$ $([\tan^2\gamma + \tan^2\alpha] / \tan(\alpha))^{0.50}$ in stem area for vessels with class notation **POLAR** or **Icebreaker**
= 0.80 h_{stem} (m) in bow area outside stem area

$\tan\alpha$ = [1.20 $B^{0.10}$] / [cos (γ)] ; For spoon bows

P = Largest of PZR and PZB as given in Sec [4.4.1] and Sec [4.4.2]
w = Critical width of contact area (m)
= S for stringers supporting vertical main frames
= l for vertical girders supporting longitudinal main frames
= 1.4l for connection area for longitudinal
= s for non-longitudinal frames
= l for longitudinal
L, S, α and γ as defined in Sec [4.1.4].

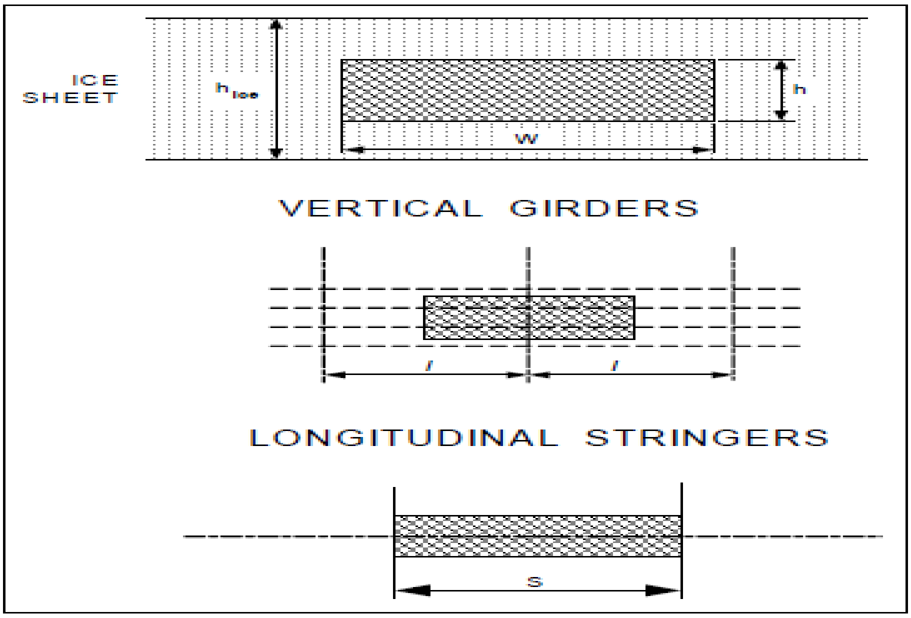


Fig. 3 Design Contact Areas

4.4.5 **Accelerations**

4.4.5.1 Accelerations arising due to impact with ice features are significant. Substructures, equipment and supporting structures shall be designed to withstand such accelerations.

4.4.5.2 Combined vertical acceleration at any point along the hull girder:

$a_v = 2.50 (P_{ZR} F_x) / \Delta$ (m/s²)

Where,
F_x = 1.20 for FP
= 0.10 at midship
= 0.40 at AP
Intermediate values may be derived by linear interpolation.
a_v does not include the acceleration due to gravity.
Δ as defined in [1.2.1]
P_{ZR} as defined in [4.4.1]

4.4.5.3 The combined transverse acceleration at any point along the hull girder:

$a_t = 3.00 (P_{OI} F_x) / \Delta$ (m/s²)

Where,
F_x = 1.50 for FP
= 0.25 at midship
= 0.50 at AP

Intermediate values may be derived by linear interpolation.
a_t does not include the acceleration due to gravity.
Δ as defined in [1.2.1]
P_{ZR} as defined in [4.4.1]

4.4.5.4 The maximum longitudinal acceleration assumed same at any point along the hull girder

a_l = {[1.10 P_{ZR} tan($\gamma + \phi$)] / Δ} + {(7 P_{ZR} H) / (ΔL)} (m/s^2)

Where,
ϕ = Friction angle between steel and ice (maximum) considered 10^0
H = Distance from lowest waterline to position considered (m)
Δ as defined in Sec [1.2.1]
P_{ZR} as defined in Sec [4.4.1]
γ as defined in Sec [4.1.4.]

4.5 Global Strength

4.5.1 General

4.5.1.1 Hull girder shear forces and bending moments as provided in this subsection shall be combined with relevant still water conditions as stipulated for the main class. Wave load conditions as stipulated for the main class need not be regarded as occurring simultaneously with the shear forces and bending moments resulting from ramming and beaching.

4.5.1.2 The shear forces and bending moments shall be regarded as the design values at probability level equivalent to the maximum load in a service life of 20 years.

4.5.1.3 In addition to the maximum stress requirements given in this subsection, individual elements shall be checked with respect to buckling under the ramming and beaching load conditions, according to acceptance criteria as detailed in the main class rules.

4.5.2 Longitudinal Strength

4.5.2.1 The requirements provided herein are applicable to vessels with class notation **Icebreaker** and other **POLAR** class vessels (i.e. not to vessels with class notation **ICE** only).

4.5.2.2 The design vertical shear force at any position of the hull girder due to ramming and/or beaching:

Q_{ice} = k_{iq} P (kN)

Where,
k_{iq} = 0.40 at FP
= 1.00 between 0.05 L and 0.10 L from FP
= 0.40 between 0.70 L and 0.20 L from AP
= 0.00 at AP
Intermediate values of k_{iq} may be linearly interpolated. Values of k_{iq} may also be obtained from Fig. 4 below.

P = P_{ZR} as provided in [4.4.1] or
= P_{ZB} as provided in Sec [4.4.2] whichever is greater

The thickness requirements for side shell and possible longitudinal bulkhead plating shall be calculated for different cargo and ballast conditions as stipulated in Pt 3, Ch 5, Sec 4, replacing Q_W with Q_{ICE} as calculated above.

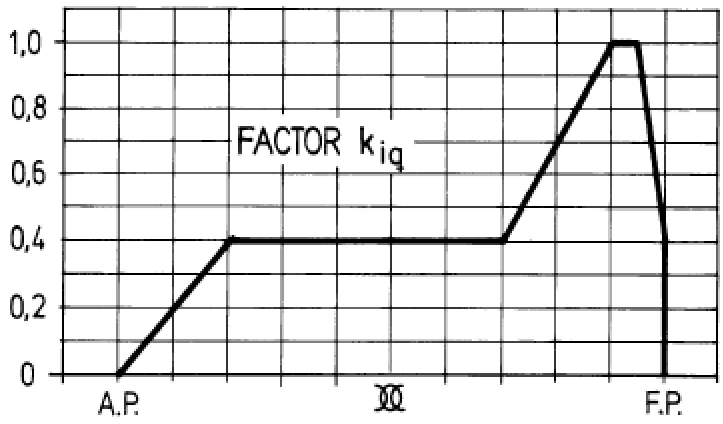


Fig. 4 Vertical Shear Force Distribution due to Ramming and Beaching

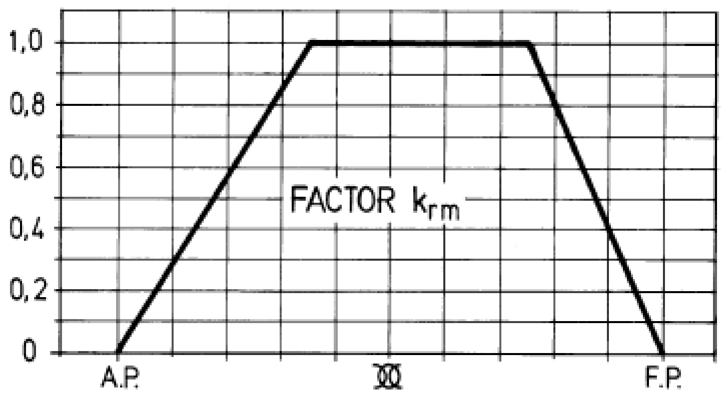


Fig. 5 Vertical Bending Moment Distribution due to Ramming

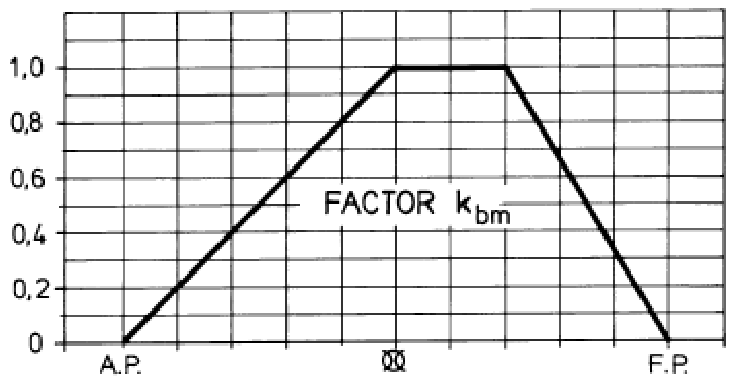


Fig. 6 Vertical Bending Moment Distribution due to Beaching

4.5.2.3 The design vertical bending moment at any position of the hull girder due to ramming and/or beaching:

$M_{ICE\ SR} = (k_{im}\ PL) / 4$ (kNm)

Where,

K_{iq} = 0.00 at AP and FP

= 1.00 between 0.25 L from FP to 0.35L from AP for ramming load condition

= 1.00 between 0.30 L and 0.50L from FP for beaching load condition

Between specified positions k_{im} shall be varied linearly. Values of k_{im} may also be obtained from Fig. 5 and Fig. 6 for ramming and beaching load conditions respectively.

P = P_{ZR} or P_{ZB} as provided in 4.4.1 or 4.4.2

4.5.2.4 Design vertical bending moment (hogging) at any position of the hull girder due to vibration following the initial ramming:

$M_{ICE\ H}$ = (3/5) $M_{ICE\ SR}$ (kNm)

Where,

$M_{ICE\ SR}$= Vertical sagging hull girder bending moment. Refer Sec [4.5.2.3].

4.5.2.5 The section modulus requirement about the transverse neutral axis:

Z = [1000 (M_S + M_{ICE})] / (0.70 σ_F) (cm^3)

Where,

M_S = Design still water bending moment according to Pt 3, Ch 5, Sec 2

M_{ICE} = Design bending moment due to ramming and/or beaching. Refer Sec [4.5.2.3] and Sec [4.5.2.4].

The most severe combination of still water and ramming/ beaching bending moment to be applied.

4.5.2.6 Buckling strength of longitudinal strength members in bottom, side and deck as well as longitudinal bulkheads subject to compressive and/or shearing loads shall be checked according to Pt.3 Ch 14.

4.5.3 Amidships Transverse Strength

4.5.3.1 Line loads specified in Sec [4.4.3]. shall be applied at different water levels including UIWL and LIWL as found necessary depending on the structural arrangement of the vessel.

4.5.3.2 To realistically assess the structural strength of transverse bulkheads and deck supporting the ice reinforced regions, line loads shall be applied over one full hold/tank length or as found necessary.

4.5.3.3 The most severe realistic combination of ice compression loads and static load conditions shall be considered in the calculations of transverse strength amidships.

4.5.3.4 The calculated stresses shall not exceed allowable stresses as stipulated in Pt 3, Ch 13, Sec [2.4].

4.5.3.5 Recognized structural idealization and calculation methods shall be considered. Effects to be considered are indicated in Pt 3 Ch 13 Sec 4.

4.5.4 Overall Strength of Substructure at Foreship

4.5.4.1 The impact loads are assumed to be evenly distributed in such a manner that local pressures will not exceed those stipulated for local members directly exposed to the load as given in [4.4.4.2]. The total impact forces detailed in Sec [4.4.1] may have a major impact on primary structural systems in the foreship.

4.5.4.2 Design ramming load (Not applicable for vessels with class notation ICE only):

4.5.4.3 PZR / cos(γ)

4.5.4.4 This shall be applied with its center on the stem line at the waterline forward. The most unfavorable design draught forward shall be assumed with regard to positioning of the load.

4.5.4.5 The design bow side impact load taken as POI should be positioned at various positions within bow side area considered critical for the overall strength of the substructure. Such parts of the bow side area which are aft of the border line of the flat side need normally not be considered with respect to POI.

4.5.4.6 Realistic structural idealization and calculation methods shall be considered. Refer to the various aspects indicated in Pt 3 Ch 13 Sec 5 for details.

4.5.4.7 The equivalent stress as defined in Pt 3, Ch13, Sec [2.4] shall not exceed σ_F. This is normally achieved for girder type members when the bending stress is not exceeding 0.90 σ_F and the mean shear stress over a web cross-section is not exceeding 0.45 σ_F.

4.6 Local Strength

4.6.1 General

4.6.1.1 The requirements in this subsection apply to members that may be directly exposed to local ice pressure.

4.6.1.2 The buckling strength of web plates and face plates in girders and stringers subject to ice loads shall be checked according to methods given in Pt 3, Ch 14.

4.6.1.3 In ice exposed regions with curved plates, the stiffening is normally to be in the direction of the maximum curvature.

4.6.1.4 Ice reinforced regions are in general to have symmetrical cross-section for frames with the web to the extent possible positioned at right angle to the plane of the plate. The bending efficiency and tripping capacity of frames shall be documented by calculations according to recognized methods as considered necessary.

4.6.1.5 Carling or equivalent structures to be provided in way of knuckles exposed to ice region.

4.6.1.6 Plate fields adjacent to stem and possible knuckles in the forward shoulder shall be supported so as to be of square shape or otherwise locally strengthened to equivalent standard.

4.6.2 Plating

4.6.2.1 Minimum thickness of plating exposed to patch load :

$$t = 23\, k_a\, (s^{0.75} / h_0^{0.25})\, [(k_w\, p_0 / m_p\, \sigma_f)^{0.5}] + t_k \quad \text{(mm)}$$

k_a = Aspect ratio factor for plate field
= 1.10 – 0.25 (s / l), maximum 1.0, minimum 0.85
s, l = As defined in [4.1.4.2].
K_w = Influence factor for narrow strip of load (perpendicular to s)
= $1.30 - (4.2 / [(a/s) + 1.8]^2)$, maximum 1.0
m_p = Bending moment factor
= f(b/s). Refer Table 4.6.1 (considering r as b/s)
A = s, in general

= h_0, for transversely stiffened panels
h_0 = h . Refer [4.4.4] or s, whichever is smaller
b = s, in general
= h_0, for longitudinally stiffened plating
p_0 = Basic ice pressure (kN/m^2) as detailed in Sec [4.4.4].
t_k = Corrosion addition as given in Sec [4.2.4].

4.6.3 **Longitudinal Stiffeners**

4.6.3.1 Stiffeners in the bow, midship and stern ice reinforced areas which are largely parallel to the waterline are defined as longitudinals.

4.6.3.2 Transverse web area of stiffeners in the ice reinforced areas shall be minimum (for flanged profiles):

A_W = $\{[(l – 0.50s)\ h_0^{(1-\alpha)}\ p_0] / [0.27\ \tau \sin(\beta l)^{\alpha}]\} + A_K$ (cm^2)

The web thickness shall be minimum (for flanged profiles):

t_w = $1.50\ \{[p_0/(\sigma_f \sin\beta)]^{0.67}\}\ \{[(h_w\ h_0) / t_s]^{0.33}\} + t_k$ (mm)

Table 4.6.1 Local Strength Parameters		
r	**m_p**	**m_e**
0.05	27.4	132.3
0.10	14.25	67.9
0.15	9.87	46.5
0.20	7.69	35.80
0.25	6.40	29.50
0.30	5.57	25.3
0.35	4.95	22.3
0.40	4.50	20.2
0.45	4.09	18.50
0.50	3.77	17.2
0.60	3.31	15.4
0.70	3.02	14.1
0.80	2.83	13.4
0.90	2.72	13.0
1.00	2.68	12.90
Note: Intermediate values may be obtained by linear interpolation		

Minimum section modulus shall be:

$Z = (41\ h_0^{1-\alpha}\ l^{2-\alpha}\ p_0\ w_k) / (\sigma \sin\beta)$ (cm^3)

The stiffener connection area a_0 as defined in Pt 3 Ch 11 Sec 3.3.4 shall not be less than:

a_0 = $[(10\ Cp) / (\tau \sin\beta)]$
= $[(6.50\ c\ h_0^{1-\alpha})\ (l – 0.50\ s)\ p_0] / [\tau \sin\beta\ (1.40\ l)^{\alpha}]$ (cm^2)

Where,

h_0 = h .Refer [4.4.4] or s, (mm) whichever is smaller
h_w = web height (mm)
p_0 = Basic ice pressure (kN/mm^2) as detailed in Sec [4.4.4]
$\tau = 0.45\ \sigma_F$
$\sigma = 0.90\ \sigma_F$

t_s = Shell plate thickness (mm)
s, l = As defined in [4.1.4.2].
A_K = $(t_k\, h_w) / 100$ (cm^2)
w_k = Section modulus corrosion factor Pt 3 Ch 3 Sec [3.10.5]
c = Factor as given in Table 3.3.1 of Pt 3 Ch 3 Sec [3.4.2]
α = 0.50 for $A_c \le 1.0$
= 0.15 for $A_c > 1.0$
β = angle of web with shell plating
$\beta = \tan^{-1} (\tan\gamma / \sin\theta)$, where γ and θ as indicated in Fig. 7
A_c = As defined in Sec [4.4.4.3]

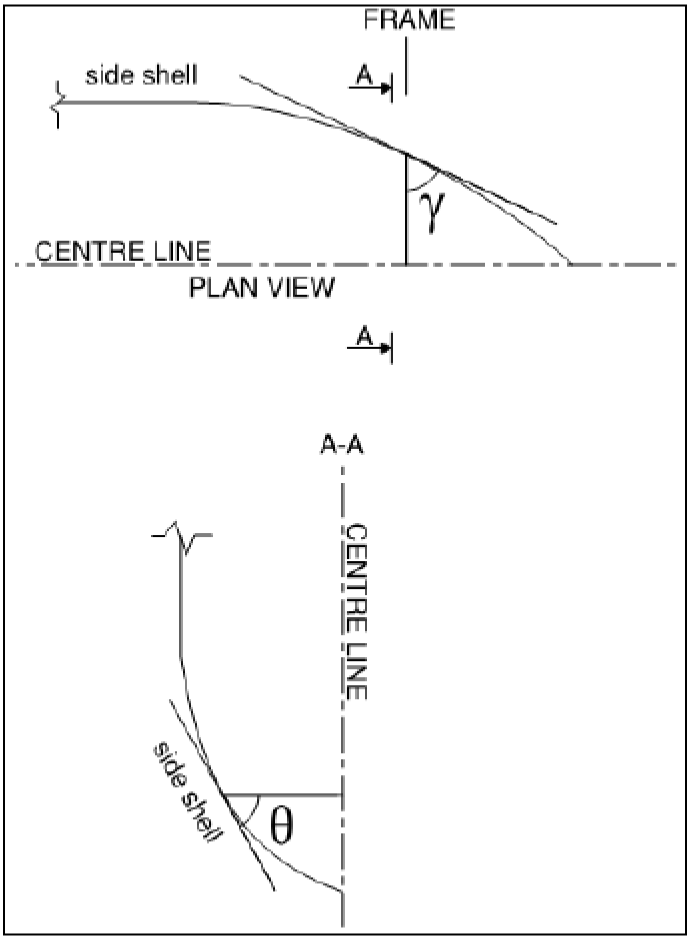


Fig. 7 Determination of β Angle

4.6.4 **Other Stiffeners**

4.6.4.1 Transverse web area of stiffeners in the ice reinforced areas shall be minimum (for flanged profiles):

$$A_W = [5.8\, k_s\, (h_0\, s)^{1-\alpha}\, (l - 0.5s) p_0] / [\, l\, \tau\, \sin\beta] + A_K \qquad (cm^2)$$

The web thickness shall be minimum (for flanged profiles):

$$t_w = 1.5\, (p_0 / (\sigma_f \sin\beta)^{0.67}\, (h_w\, s / t_s)^{0.33} + t_k \qquad (mm)$$

The section modulus shall not be less than:

$$Z = [520\, l^2\, s^{(1-\alpha)}\, p_0\, w_k] / [h_0^{\alpha}\, \sigma\, m_e \sin\beta] \qquad (cm^3)$$

For end connections with brackets, section modulus including bracket shall be at least 1.2 Z. The bracket thickness shall not be less than t_w.

The connection area a_0 defined in Pt 3 Ch 3 Sec [3 2] shall not be less than:

a_0 = $\{5.80\ c\ s^{1-\alpha}\}\ \{1 - [0.10\ (h_1^2 / l^2)]\}\ \{(l - 0.5s)\ h_0^{(1-\alpha)}\ p_0\ \{1 / [l\ \tau\ \sin\beta]\}$ (cm²)

k_s = $1 + [0.50\ (C_1 + 0.5h_0)^3\ (1 / l^3)] - [1.5\ (C_1 + 0.5h_0)^2\ (1 / l^2)]$
= 0.69 minimum

C_1 = Bracket arm length (m)
h_0 = h, Refer 4.4.4.
h_1 = 1.4l (or) h , whichever is smaller
h_w = Web height (mm)
m_e = Bending moment factor
= f (h_0 / l); Refer Table 4.6.1 ; considering r = h_0 / l in general
= 8 / { [2 – (h_0 / l)] [h_0 / l] }; for stiffener with ends simply supported
p_0 = Basic ice pressure (kN/m²). Refer Sec [4.4.4].
τ = 0.45 σ_f
σ = 0.90 σ_F; in general
= 0.80 σ_F; when simply supported at both ends
t_s = Shell plate thickness (mm)

s, l, σ_y as defined in [4.1.4]

A_K = $t_k\ h_w / 100$ (cm²)

W_k = Section modulus corrosion factor (Refer Pt 3,Ch 3,Sect [3.1]
c = Factor (Refer Pt3,Ch 11, Sect [3.4] table 11.3.4
α = 0.50 for $A_c \leq 1.00$
= 0.15 for $A_c > 1.00$
β = Angle of web with shell plating
A_c = As provided in Sec [4.4.4.3].

4.6.5 Girders

4.6.5.1 In way of ice reinforced areas, girder structures supporting shell stiffeners shall be considered for ice loading. The ice load area to be applied for the girder system will depend on the structure considered, its position and orientation etc. The ice pressure load and load area are generally to be taken as given in [4.4.4.3].

4.6.5.2 Girders which are part of a complex system of primary structures, analysis by direct calculation may be required. For such girder structures in the foreship, the requirements given in Sect [4.5.4] shall apply.

4.6.5.3 The requirements detailed below apply to evenly spaced girders for which the ends may be considered as fixed, simply supported or constrained due to repetitive continuation of the member beyond the support. The stiffness of supported members (frames or longitudinals) is assumed to be much smaller than the stiffness of the girder considered.

Transverse web area of girder at any point along length shall be minimum:

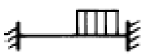
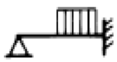
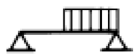
A_W = $[(5.80\ k_s\ a\ b\ p_0) / (\gamma\ \sin\beta\ A_c^{\alpha})] + A_K$ (cm²)

The section modulus of the girder shall be minimum:
Z = $[(550\ S^2\ b\ p_0\ w_k) / (m_e\ \sigma\ \sin\beta\ A_c^{\alpha})]$ (cm³)

Where,

k_s = shear factor, Refer Table 4.6.1. considering r as (a+s)/S
s = Secondary member spacing (m)
m_e = Bending moment factor
= f (a/S) for continuous member, Refer Table 4.6.1, considering r as a/S
= 24 / {[3 – $(a/S)^2$] [a/S]}; for fixed ends
= 8 / {[2 – (a/S)] [a/S]}; for simply supported ends
a = S in general
= h_0, maximum for girders supporting longitudinals
b = l in general
= h_0, maximum for girders supporting non-longitudinal frames
h_0 = h, Refer Sect [4.4.4].
p_0 = Basic ice pressure (kN/m^2) as fiven in Sect [4.4.4].
τ = 0.45 σ_F
σ = 0.90 σ_F; in general
= 0.80 σ_F; when simply supported at both ends
α = 0.50 for $A_c \le 1.00$
= 0.15 for $A_c > 1.00$
A_c = As provided in Sect [4.4.4.3].
β = Angle of web with shell plating
l and s as defined in Sect [4.1.4].
A_K, w_k =Refer Sect [4.6.3].

Table 4.6.1 Shear Factor k_s

r			
0.0	1.00	1.00	1.00
0.1	0.99	0.99	0.95
0.2	0.96	0.98	0.90
0.3	0.92	0.96	0.85
0.4	0.87	0.93	0.80
0.5	0.81	0.89	0.75
0.6	0.75	0.85	0.70
0.7	0.69	0.80	0.65
0.8	0.62	0.74	0.60
0.9	0.56	0.69	0.55
1.0	0.50	0.63	0.50
1.1	0.5 - 0.05 i	0.63-0.06 i	0.5-0.05 i
1.2	0.5 - 0.10 i	0.63-0.12 i	0.5-0.10 i
1.3	0.5 – 0.15 i	0.63-0.18 i	0.5-0.15 i
1.4	0.5 – 0.20 i	0.63-0.24 i	0.5-0.20 i
1.5	0.5 – 0.25 i	0.63-0.30 i	0.5-0.25 i
i = b/2s with maximum 1.00			

4.7 Hull Appendages and Steering Gear

4.7.1 General

4.7.1.1 Stern frames, rudders,and propeller nozzles are in general to be designed according to the rules given in Pt 4, Ch 2.

4.7.1.2 For ice reinforced vessels, additional requirements are given in the following. For vessels with rudders which are not located behind the propeller, special consideration will be made with respect to the longitudinal ice load.

4.7.1.3 Material of plating in rudders, rudder horns and propeller nozzles shall be in accordance with Section 7. Forged or cast materials in structural members' subject to lower design temperatures, lower than -10°C according to Sect [4.2.1] shall be impact tested at 5°C below (colder than) design temperature.

4.7.1.4 Upper edge of rudder and the rudder stock shall be effectively protected against ice pressure.

4.7.1.5 Ice horn with a minimum depth of 0.80 h_{ice} or an equivalent arrangement shall be provided aft of rudder.

4.7.1.6 Exposed seals of rudder stock are assumed to be designed for the given environmental conditions such as ice formation and the specified design temperature.

4.7.2 Ice loads on rudders

4.7.2.1 Ice load area is defined on the rudder with a length equal to the length of the rudder profile lr and height equal to the effective ice load height (h). The general design rudder force (FR) is given by:

$F_R = [(h\ l_r)^{0.85}\ K\ p_0] / 5$ (kN)

Where,
$K = 1 + \{z / (z_{bl} – [L/100])\}$
z = Distance (m) from rudder bottom to center of the assumed ice load area
z_{bl} = Distance (m) from rudder bottom to the ballast waterline
L = As defined in Sec [1.2.1]
p_0 = As provided in Sec [4.4.4].

The rudder force F_R gives rise to a rudder torque (M_{TR}) and a bending moment in the rudder stock (M_B), both of which will vary depending on the position of the assumed ice load area, and one the rudder type and arrangement used.

The load given the most severe combination of F_R, M_{TR} and M_B with respect to the consideration shall be applied in a direct calculation of the rudder structure.

$M_{TR} = F_R (0.6\ l_r – X_F)$ (kNm)
$= 0.15\ FR\ l_r$ (Minimum)
X_F = Longitudinal distance (m) from leading edge of the rudder to the center line of the rudder stock.

In lieu of direct calculation design values of M_B and F_R, applicable for the rudder stock diameter at the lower end, may normally be taken as:

For spade rudders:
$F_R = [(h\ l_r)^{0.85}\ K\ p_0] / 5$ (kN)
$M_B = F_R\ H_B$ (kNm)

For semi spade rudders:
$F_R = [(h\ l_r)^{0.85}\ K\ p_0] / 5$ (kN)
$M_B = (F_R\ H_p)/2$ (kNm)

For balanced rudders:
$F_R = [(h\ l_r)^{0.85}/5]\ [1 + [H_B / (2\ z_{bl} - 0.02L)]\ p_0$ (kN)
$M_B = (F_R\ H_h)/4$ (kNm)

H_B = Distance (m) from lower end of rudder to middle of neck of bearing
H_p = Distance (m) from lower end of rudder to middle of pintle bearing
H_H = Distance (m) from center of heel bearing to center of neck bearing
h = As provided in Sec [4.4.4.3]

4.7.2.2An additional ice load area is defined on the uppermost part of the rudder including ice knife with a length equal to the rudder (including ice knife) (lr) and height below the hull equal to the nominal ice height (hice). This gives rise to a force (F) given by:

$F = k\ p\ h_{ice}\ l_r$ (kN)

Where,

p = Design ice pressure (kN/m^2) in stern area s given in Sec [4.4.4]

k = 0.70 in general

= 1.00 for vessels with class notation **POLAR** or **Icebreaker**

The force F shall be divided between rudder and ice knife according to their support position. The force acting on the ice knife may generally be taken as:

$F_K = F\ (X - X_F)\ /\ (X_K - X_F)$

Where,

X = Distance from leading edge of rudder to point of attack of force F

= 0.50 l_r (m) as minimum

= 0.67 l_r (m) as maximum

X_K = Distance (m) from leading edge of rudder to center of ice knife

4.7.3 Scantling of Rudder

4.7.3.1 The scantling of rudders, rudder stocks, rudder horns, pintles and rudder actuators shall be calculated from the formulae given in Pt 4, Ch 2, with rudder torque MTR, bending moment M_B and rudder force F_R as given in Sec [4.7.2.1], and all factored by 0.70.

4.7.3.2 Provided an effective torque relief arrangement is installed for the steering gear, and provided effective ice stoppers are fitted, the design rudder torque need not be taken greater than:

$M_{TR} = M_{TRO}$

Where,

M_{TRO} Steering gear relief torque (kNm)

4.7.3.3 For rudder plating the ice load thickness shall be calculated as given in Sec 4.6.2 using the basic ice pressure as given for the stern area reduced linearly to half value at the lower end of the rudder.

4.7.3.4 Scantlings of rudder, rudder stock, rudder horn, rudder stoppers and ice knife as applicable are also to be calculated for the rudder force given in Sec [4.7.2.2], acting on the rudder and ice knife, with respect to bending and shear. Allowable stresses as given in Sec [4.6.4].

4.7.4 Ice loads on propeller nozzles

4.7.4.1 Transverse ice load area located at the level of the nozzle center is defined on the nozzle with a length equal to the nozzle length and a height equal to the ice load height h given by:

h = 0.80 h_{ice}; in general

= 0.60 $h_{ice;}$ for nozzle directly inside of protecting structures (eg. Other nozzle of propeller)

4.7.4.2 The following two alternative longitudinal ice load areas shall be considered:

- an area positioned at the lower edge of the nozzle with a width equal to 0.65

D and a height equal to the height of the nozzle profile

- an area on both sides of the nozzle at the propeller shaft level, with a transverse width equal to the height of the nozzle profile and with a height equal to 0.35 D. Both symmetric and asymmetric loading shall be checked.

Where D is the nozzle diameter (m)

4.7.4.3 The design ice pressure p (kN/m2) for the stern area as given in Sec [4.4.4] shall be assumed for the ice load areas specified under Sec [4.7.4.1] and Sec [4.7.4.2] giving rise to a force (F) given by:

$$F = k\ p\ A\ \ (kN)$$

Where,
K = 0.7 in general; =1 for vessels with class notation POLAR or Icebreaker
A = Ice load area as defined in Sec [4.7.4.1] and Sec [4.7.4.2]

4.7.5 Propeller nozzle scantlings

4.7.5.1 The scantlings of the propeller nozzle and its supports in the hull shall be calculated for the ice loads given in Sect [4.7.4], with stresses not exceeding allowable values given in Sec [4.6.4]. For nozzle plating the ice load thickness shall be taken as given in Sec [4.6.2] using the design ice pressure as given for the stern area.

4.7.6 Steering Gear

4.7.6.1 The main steering gear shall be capable of putting the rudder over from 35° on one side to 30° on the other side in 20 seconds, when the vessel is running ahead at maximum service speed (corresponding to MCR) and at deepest ice draught.

4.7.6.2 For the additional class notation Icebreaker the above time shall not exceed 15 seconds.

4.7.6.3 The effective holding torque of the rudder actuator, at safety valve set pressure, shall be capable of holding the rudder in the preset position, when backing in ice, unless arranged in accordance with Sec [4.7.3.2] and Sec [4.7.6.5].

4.7.6.4 The holding torque means the rudder torque the actuator is capable to withstand before the safety valve discharges. The holding torque need normally not exceed the values given in Table 4.7.1.

Table 4.7.1 Holding Torque Values

ICE-05 to ICE-15	POLAR-10 to POLAR-30	Icebreaker
0.50 M_{TR}	0.75 M_{TR}	M_{TR}

Note: M_{TR} as given in Sec [4.7.2]

4.7.6.5 The torque relief arrangement, when installed, shall provide protection against excessive rudder ice peak torque, e.g. when backing towards ice ridges.The arrangement shall be such that steering capability is either maintained or speedily regained after activation of such arrangement.

4.7.6.6 All hydraulic rudder actuators shall be protected by means of relief valves. Discharge capacity at set pressure shall not be less than given in Table 4.7.2.

Table 4.7.2 Relief Valve Discharge Capacity			
	ICE-05 to ICE-15	**POLAR-10 TO POLAR-30**	**Ice braker**
Rudder speed (deg/s)	4.50	5.00	6.50

4.7.6.7 Rudders stoppers working on the rudder blade or rudder head shall be fitted where practicable.

4.7.7 Podded Propulsors and Azimuth Thrusters

4.7.7.1 Vessels operating in ice and equipped with podded propulsors or azimuth thrusters shall be designed according to operational mode and purpose stated in the design specification. If not given, it shall be assumed that the vessel will be intended for continuous operation astern. This information shall also be stated in the ship's papers.

4.7.7.2 Astern ramming is not anticipated.

4.7.7.3 The structure of the pod/thruster including housings, struts, bearings etc. shall be dimensioned for basic ice pressures as given in Sec [4.4.4] for stern area in accordance with requested class notation and the operational mode.

4.7.7.4 Documentation of both local and global strength capacity of the pod and or thruster shall be submitted for Class review. Recognized structural idealization and calculation methods shall be adopted.

4.7.7.5 The equivalent stress as defined in Pt 3, Ch 13, Sec [2.4] shall not exceed σ_y. This is normally achieved for girder type members when the bending stress is not exceeding $0.9\sigma_y$ and the mean shear stress over a web cross-section is not exceeding $0.45\sigma_y$

4.8 Welding

4.8.1 General

4.8.1.1 The requirements in this subsection apply to members that may be directly exposed to local ice pressure and support structures for these. Otherwise weld dimensions shall be in accordance with the rules for main class.

4.8.2 External Welding

4.8.2.1 The welding of ice strengthened external plating to stiffeners and to webs and bulkheads fitted in lieu of stiffeners is to have a double continuous weld with throat thickness which is not less than:

$$t = [0.55\ p0\ (s^{0.50}) / \sigma_{fw}] + 0.50\ t_k\ \text{(mm)}$$

Where,
σ_{fw} = Yield strength (N/mm^2) of weld deposit. Refer Pt 3, Ch 11
Need not be greater than;
= 45% x plate thickness for mild steel (and)
= 50% x plate thickness for high strength steel.

If the welding method leads to deeper penetration than normal, the additional penetration can be included in the throat thickness. Weld throat shall in no case be less than for main class requirements.

4.9 Machinery Systems

4.9.1 Starting Arrangement – Pneumatic

4.9.1.1 For vessels having a propulsion engine(s) in addition to the requirements given in Pt 5A,Ch 8 Sect [4.5] which has to be reversed for going astern, the compressors shall have the capacity to charge the receivers in half an hour.

4.9.2 Sea Inlets and Discharges

4.9.2.1 Seawater cooling inlet and discharge for main and auxiliary engines shall be so arranged that blockage of strums and strainers by ice is prevented.

4.9.2.2 The requirements in Pt5A,Ch 8 Sect [4.4] shall be complied with in addition.

4.9.2.3 At least one of the sea chests shall be sufficiently high to allow ice to accumulate above the pump suctions and cooling water tank inlet, arranged as follows:

a. As a guidance for design the volume of the chest shall be about one cubic metre for every 750 kW engine output of the ship including the output of the auxiliary engines necessary for the ship's service.

b. The sea inlet shall be situated near the centre line of the ship and well aft if possible. The inlet grids shall be specially strengthened.

c. The area of the strum holes shall be not less than four (4) times the inlet pipe sectional area.

d. To allow for ice accumulation above the pump suction the height of the sea chest shall not be less than:

$h_{min} = 1.50 (V_s)^{1/3}$

Where
V_s = Volume of sea chest as in (a) above.
The suction pipe inlet shall be located not higher than h_{min} / 3 from top of sea chest. Heating coils may be installed in the upper part of sea chest.

4.9.2.4 A full capacity discharge branched off from the cooling water overboard discharge line shall be connected to the sea chests. At least one of the fire pumps shall be connected to this sea chest or to another sea chest with de-icing arrangement.

4.9.3 Sea Water Cooling Arrangements

4.9.3.1 The sea water cooling inlets and discharges for main and auxiliary engines shall be connected to a cooling water double bottom tank having direct supply from the sea chests. The cross-sectional area of the supply line between each sea chest and the cooling water tank shall be twice that of all pump suctions connected to the tank.

4.9.3.2 The cooling water tank volume (m3) shall be at least 0.01 times the output in kW of the main and auxiliary engines.

4.9.3.3 The sea water suction line strainers required in Pt 5A,Ch8,Sect [4.4.4.2]shall be arranged out stream from the cooling water tank.

4.9.3.4 The sea water cooling pumps shall be of the self-priming type or connected to a central priming system.

4.9.3.5 The sea water cooling and ballast piping shall be arranged so that water in the cooling water tank can be circulated through the ballast tanks for the purpose of spare cooling capacity in the case of blocked sea chests.

4.9.3.6 Arrangements providing additional cooling capacity equivalent to that specified in Sec [4.9.3.1] through Sec [4.9.3.5] may be considered.

4.9.3.7 Vessels with the class notation Icebreaker or POLAR shall comply with the requirements as in Sec [4.9.3.2] to Sec [4.9.3.6].

4.9.4 **Ballast System**

4.9.4.1 Arrangement to prevent freezing shall be provided for ballast tanks were found necessary.

Note: Double bottom tanks are normally not required to be provided with arrangement to prevent freezing.

4.10 Propellers and Propulsion Machinery

4.10.1 **General**

4.10.1.1 Special cold climate environmental conditions shall be taken into consideration in machinery design as applicable.

4.10.1.2 Materials exposed to sea water:
Materials exposed to sea water, such as propeller hub, propeller blades and blade bolts shall have an elongation not less than 15% on a test piece the length of which is five times the diameter. Charpy V impact test shall be carried out for other than bronze and austenitic steel materials. Test pieces taken from the propeller castings shall be representative of the thickest section of the blade. An average impact energy value of 20 J taken from three Charpy V tests is to be obtained at minus 10ºC.

Materials exposed to sea water temperature:
Materials exposed to sea water temperature shall be of steel or other approved ductile material. An average impact energy value of 20 J taken from three tests is to be obtained at minus 10ºC. Nodular cast iron as specified in Pt 2, Ch 2, Sec 10 may be used for relevant parts in CP-mechanism. Other type of nodular cast iron with elongation ≥ 12% may be accepted upon special consideration for same purposes.

4.10.1.3 For components subject to ice shocks, grey cast iron is normally not accepted, as e.g. thrust bearing housings.

4.10.1.4 Shafting systems equipped with specially designed mechanical torque limiting devices are subject to special consideration. Such devices, when accepted, shall comply with redundancy type R2 in Pt.4 Ch.1 The torque limit is normally not less than 1.5 K_A T_o.
Where,
K_A, T_o = Refer Sec [4.10.5]

4.10.1.5 Ice induced vibrations (repetitive ice chocks) in the shafting system shall be considered.

Evaluation of transient vibrations excited by ice on the propeller shall be included in the forced torsional vibration analysis.

4.10.1.6 Special means for reversing propellers stuck in ice shall be provided for those machinery plants which are non-reversible.

4.10.1.7 The propulsion line shall be designed such that the blade failure load Fice given in Sect [4.10.4.5] shall not cause damage in the blade bolt connection, pitch mechanism, propeller hub, propeller shaft, shaft connection and thrust bearing.

Note: Blade failure load (Fice) is the load causing plastic bending of the propeller blade in a section just outside the root fillet. Damage, in this context, means when the stresses in the highest loaded part of the considered cross section reaches yield stress. The local effect of stress raisers may be ignored.

4.10.2 Engine Output

4.10.2.1 The maximum continuous output of propulsion machinery shall be (minimum):

$$P = 1.50\, c_s\, c_p\, I\, N\, B\, [1 + 1.6\, T + 27\, (0.10\, IN / T^{0.25})^{0.50}] \text{ (kW)}$$

Where,
c_s = 1.00; for vessels with conventional ice breaker stem
= 0.90 + γ / 200; minimum 1.00 and maximum 1.20
c_p = 1.00; for Controllable pitch propeller
= 1.10; for Fixed pitch propeller
IN = Ice class number
B = molded breadth at waterline (m), local increase in way of stem area is normally not to be taken into account
T = Rule draught (m)
γ = Stem angle (Refer Fig. 1)

4.10.2.2 When the vessel is provided with special means which will improve her performance in ice (e.g. air bubbling system), the input rating of machinery used for such purpose may be added to the actual rating of propulsion machinery.

The propeller rating however is not be less than 85% of that required in Sec [4.10.2.1].

4.10.2.3 When the vessel is provided with a nozzle of efficient design, a reduction of required engine output corresponding to increase of thrust in ice conditions will be considered. The reduction is, however, not to exceed 20% of required output in Sec [4.10.2.1] and Sec [4.10.2.2].

4.10.2.4 Additional reduction of the required output may be considered for a vessel having design features improving her performance in ice conditions. Such features shall be documented, either by means of model tests or full scale measurements. Such approval can be revoked based on experience which supports it.

4.10.3 Determination of Ice Torque and Loads

4.10.3.1 The ice torque (T_{ICE}), used for determination of propeller and shaft scantlings shall be taken as follows:

$$T_{ICE} = m\, D^2 \text{ (kNm)}$$

Where,
D = Propeller diameter (m)
Factor m is provided in Table 4.10.1 below:

Table 4.10.1 Values of m

Ice Class	m	Icebreaker	m
ICE-05	16	ICE-05	21
ICE-10	21	ICE-10	30

ICE-15	27	ICE-15	30
POLAR	33	POLAR	40

4.10.3.2 For propellers running in nozzles of satisfactory design, the ice torque will be considered based on submitted documentation, e.g. measurements carried out on similar vessels.

If no documentation is provided the following may be used:

T_{ICE} = $(0.90 – 0.01\ mD^{-0.5})\ mD^2$ (kNm)

Large fragments of ice shall not have free access into or towards the front of the nozzle.

2.1.1.1Axial loads in shaft line:

F = $T_H + 1.50\ F_{LE}$ (Axial load in ahead mode)
F = $0.80\ T_H + F_{LE}$ (Axial load in astern mode)

Where
$T_{H,}\ F_{LE}$ = Refer Sec [4.10.4] and Sec [4.10.5]

4.10.4 Propeller

4.10.4.1 Blade scantling requirements given in Sec.2 shall be complied with, except as given below. In calculations involving the ice torque, TICE according to Sec 4.10.3 shall be applied.

4.10.4.2 Propeller blade scantlings of martensitic-austenitic and ferrite-martensitic stainless steel may be specially considered.

4.10.4.3 Propeller arrangements in ice classes ICE-15 and POLAR-10 to POLAR-30 shall be such that large fragments of ice do not have free access into the front of the propeller disc within 0.7 radius.

4.10.4.4 When the outer sections of the propeller blade is not subject to special consideration according to Sect [2.3.2.1], the blade tip thickness at the radius 0.95 R shall be minimum:

t = $(m + 2D)\ [(490 / \sigma_b\ )^{0.50}]$ (mm)

Where,
D, σ_b = Refer Sec 4.10.4.4.
σ_b = Not to exceed 2.50 σ_y

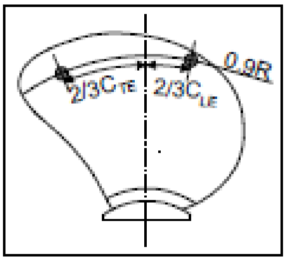
For propellers running in nozzles reduced blade thickness may be accepted. The tip thickness, however, shall not be less than 3/4 of the above value.

The thickness of the blade edge and the propeller tip shall not be less than 50% of minimum t as given above, measured at 1.25 t from the edge or tip, respectively. For propellers where the direction of rotation is not reversible, this requirement only applies to the leading edge and propeller tip.

4.10.4.5 The fitting of the propeller blades and pitch control mechanism shall withstand a minimum design static load of:

F_{ICE} = $(3 / 10^7)\ (\sigma_n\ c_r\ t_r^2 / [D\ (0.90 – R_R / R)]\ )$ (kN)

The above load shall be applied on the blade at a radius 0.9R and at an offset from bade center axis of 2/3 C_{TE} or 2/3 C_{LE} whichever is greater.



σ_n = 0.37 σ_b + 0.60 σ_y
σ_b = Ultimate tensile strength of blade (N/mm^2)
σ_y = Yield stress of blade or 0.2% offset point (N/mm^2)
c_r = The length of blade section at radius R_R (mm)
t_r = The corresponding blade thickness (mm)
D = Propeller diameter (m)
R = 0.50 D (m)
R_R = Radius to a blade section taken at the termination of the blade root fillet
(Rounded upward to the nearest R/20) Refer c_r and t_r (m)
C_{TE} = Distance from axis of rotation of the blade to the trailing edge, measured along the cylindrical section at 0.9R
C_{LE} = Distance from axis of rotation of the blade to the leading edge, measured along the cylindrical section at 0.9R

4.10.4.6 The section modulus of the propeller blade bolts, with reference to an axis tangential to the bolt pitch diameter shall be minimum:

w_{BS} = (0.15 S c_r t_r^2) (σ_n / σ_y) ([0.90 – R_B/R] / [0.90 – R_R/R])

Where,
S = 1.02 for CP propellers
= 1.25 for FP propellers
σ_y = Yield stress of bolt material (N/mm^2)
R_B = Radius to bolt plan (m)
c_r, t_r , σ_n= As detailed in Sec 4.10.4.4].

The bolts shall be designed to minimize stress concentrations in transition zones to threads and bolt head as well as in way of the threads, and reduces risk for plastic deformations in the threads.

4.10.4.7 The various components in the pitch control mechanism, which are subject to variable ice loads, stress concentration shall be taken into consideration.

4.10.4.8 The blade fitting and other parts in the pitch control mechanism shall be designed to withstand all forces produced by the pitch control system at its maximum power. The forces shall be assumed to act towards one blade at a time.

Note: The pitch control mechanism shall be designed for the following dynamic ice loads, applied at 0.90 radius perpendicular to the blade plane at the respective blade edges:

F_{LE} = T_{ICE} / (0.90 R) (kN) at leading edge
F_{LE} = -0.50 F_{LE} (kN) at trailing edge

*The number of load cycles to be considered shall not be taken less than one million for ice classes **ICE-05** to **-15** and infinity for **POLAR-10** to **-30** and class notation Icebreaker. The design pressure of the hydraulic system shall not be taken less than twice the pressure needed to produce the blade spindle torque based on the above forces. The forces are assumed to act on one blade at a time only.*

4.10.4.9 Fitting of the propeller to the shaft is given in Pt 5A,Ch 5 as below, considering 0^0C as sea water temperature:

- Flanged connections Pt 5A,Ch 5
- Keyless cone connection in Pt 5A,Ch 5
- Keyed cone connection in Pt 5A,Ch 5

If the propeller is bolted to the propeller shaft, the bolt connection shall have at least the same bending strength as the propeller shaft.

4.10.5 Reinforcements of Propulsion Shaft Line

4.10.5.1 Determination of factors for ice reinforcement of shaft line.

T_o = Torque in the actual component (kNm)
T_{ICE} = Ice torque (kNm) according to Sect [4.10.3]
u = Gear ratio (if no reduction gear, or for components on the propeller side of a reduction gear u = 1)
I = equivalent mass moment of inertia in kgm2 based on torque of all parts on engine side of component under consideration
Masses rotating with engine speed to be transformed according to:
$I_{equiv} = I_{actual}\, u^2$

In propulsion systems with hydraulic coupling, torque converter or electromagnetic slip coupling, the masses in front of the coupling shall not be taken into consideration:

I_{actual} = Equivalent mass moment of inertia (kgm^2) of propulsion system. (Masses in front of hydraulic or electromagnetic slip coupling shall not be taken into consideration.)

4.10.5.2 Application factor for diesel and or turbine machinery in general:

$K_{Aice} = 1 + [T_{ice}\, I / (uT_0\, I_T)]$

4.10.5.3 Application factor for electric motor machinery or diesel machinery with hydro dynamic torque converter:

1. Diesel engine with torque converter (or) hydrodynamic coupling:

$K_{Aice} = (T_{TCmax} / T_0) + (T_{ice}\, I / u\, T_0\, I_t)$

Where,
T_{TCmax} = Maximum possible transmittable torque through converter/ coupling.

2. Electric motor drive:

$K_{Aice} = (T_{max} / T_0) + (T_{ice}\, I / u\, T_0\, I_t)$

Where,
T_{max} = Peak torque at motor (steady state condition)

Alternative to the above criteria, the ice impact load may be documented by simulation of the transient dynamic response in the time domain. For branched systems, such simulation is in general recommended.

4.10.5.4 Regarding shaft connections, use K_{Aice} in Pt 5A,Ch 4as follows:

- Flange connections, Refer Pt 5A,Ch 5
- Shrink fit connections, Refer Pt 5A,Ch 4
- Keyed connections, Refer Pt 5A,Ch 4

4.10.5.5 The diameter of the propeller shaft in way of aft bearing and at least a length 2.5 times the required diameter forward of propeller flange or hub, shall not be less than:

$d_p = 1.16\ (0.90\ \sigma_n\ c_r\ t^2 / R_{R1})^{1/3}$ (mm)

Where,
$R_{R1} = [0.90 – (R_R / R)]\ \sigma_y$
$cr\ t^2$ = Actual value of blade section considered at the termination of the blade root fillet (rounded upwards to nearest 1/20 of R).
σ_y = Yield stress of shaft material (N/mm^2)
σ_n = Yield stress of blade material (N/mm^2) Refer Sec [4.10.4.4].
c_r, t = Refer Sec [4.10.4.4].

The diameter of the propeller shaft may be evenly tapered to 1.15 times the required intermediate shaft diameter between the aft bearing and the second aft bearing. Forward of this bearing the propeller shaft diameter may be reduced to 1.05 times the required diameter of the intermediate shaft (using material factor valid for propeller shaft).

The flange thickness (propeller fitting) of the propeller shaft shall be at least 0.3 times the actual shaft diameter. The fillet radius shall be at least 1/8th of the actual shaft diameter.

4.10.5.6 The diameter of intermediate shafts shall be determined based on methods given in .Pt 5A, Ch 4

a. With $K_{Aice} \leq 1.4$ the method in –Pt 5A Ch 4 may be used, i.e. no ice reinforcement beyond 1A1 rules.

b. When using the method in Pt.5A, the minimum diameter in item of that paragraph shall be multiplied with:

$(K_{Aice} / 1.40)^{1/3}$; but not less than 1.00

In item 4 of same paragraph, the vibratory torsional stress τ_v is to be replaced by:

$\tau_v = 0.50\ (K_{Aice} – 1)\ T_0$, and shall not exceed τ_c.

4.10.5.7 Support and construction of the thrust bearing shall be designed to avoid excessive axial shaft movements caused by heavy axial forces when the propeller hits ice. The thrust bearing shall have static strength designed for not less than the nominal thrust plus the static ice force as defined in Sect 4.10.4.4. The ice force is assumed to act in the axial direction. Both forward and astern directions shall be considered.

The basic static load ratings of roller bearings shall not be less than 2 times the load.
For calculation of the bearing pressures in the ice conditions, the following thrust force shall be considered:

T_{HI} = 1.10 T_H + 0.25 F_{LE} $\pm$ 0.75 F_{LE} (kN)

Where,
F_{LE} = As per [4.10.4.7]
T_H = Mean bollard thrust (kN) of the propeller or 1.25 times the mean thrust at maximum continuous ahead speed.

Calculated lifetime (B_{10}) of roller bearings shall be minimum 40,000 h, by applying the load T_{HI}.

4.10.5.8 For reduction gears, K_{Aice} as in Pt 5A,Ch 3

Axial ice load according to Sec [4.10.5.7], when applicable, shall be considered with respect to bearing arrangement and stiffness of the gear housing.

4.10.5.9 For clutches, K_{Aice} shall be as in Pt 5A,Ch 3,Sect 3
For torsional elastic coupling, use K_{Aice} in Pt 5A,Ch 3,Sect 3

4.11 Thrusters

4.11.1 General

4.11.1.1 Thruster design shall take into considering special cold climate environmental conditions.

4.11.1.2 Lubrication oil, hydraulic oil shall be heated and circulated and suitable means for this shall be provided.

4.11.2 Propulsion Thrusters

4.11.2.1 Relevant requirements as stipulated in Sec [4.10] shall be complied with for thrusters engaged in propulsion of the vessel.

Note:
Propulsion thrusters are those intended to be used for propulsion in ice, not alone the main propulsion thrusters.

4.11.2.2 Steering gear for azimuth thrusters shall be designed to withstand all relevant ice loads. Both ice loads on propeller nozzle Sec [4.7.4] and on propeller blade Sec [4.10.4] shall be considered.

4.11.3 Other Thrusters

4.11.3.1 For shafting the maximum peak torque, which may occur due to ice in the propeller, shall be taken into consideration. Load F as provided in Sec [4.11.3.2] below shall be considered in the design of the propeller shaft.

Maximum permissible equivalent stress is 80% of the yield stress or 0.2% proof stress of the material.

4.11.3.2 For reduction gears the application factor (KA) shall be taken as minimum 1.2.

4.11.3.3 Propeller blade shall be designed to withstand a peak load, F without exceeding 80% of yield of the blade material or 0.2% proof stress.

$F = T / (0.85\ R\ \sin\alpha_{0.85})$ (kN)
The load F is assumed to apply at 0.85R, perpendicular to the blade plane.

Where,
T = Maximum peak torque of prime mover (kNm)
R = Propeller radius (m)
$\alpha_{0.85}$ = Pitch angle at radius 0.85R

4.12 Stability and Watertight Integrity

4.12.1 General

4.12.1.1 Vessels with a length L_F of 24 meters and above and class notation Icebreaker or POLAR shall comply with the relevant requirements of Part 7B nd IMO Resolution A.1024(26) “Guidelines for Ships Operating in Polar Waters” Chapter 3 “Subdivision and Stability” as well as the requirements of this subsection.

4.12.2 Documentation Requirements

4.12.2.1 Document submission shall be as in Table 4.12.1 below:

Table 4.12.1 Documentation Requirements

Topic	Documentation Type	Remarks	(A)/(I)
Stability	Preliminary damage stability calculation		(A)
	Final damage stability calculation		(A)
	Internal watertight integrity plan		(I)

4.12.2.2 General requirements to documentation are detailed in Part 1 of INTLREG rules.

4.12.2.3 For definition of the documentation types refer to Part 1 of the INTLREG rules.

4.12.3 Intact Stability

4.12.3.1 The initial metacentric height GM shall not be less than 0.50 m.

4.12.4 Requirements of Watertight Integrity

4.12.4.1 Tunnels, ducts or pipes which might cause progressive flooding in case of a hull damage shall be avoided in the damage penetration zone as far as practicable. If that nor possible, effective arrangements shall be made to prevent progressive flooding of spaces assumed intact. Alternatively, these volumes shall be assumed flooded in the damage stability calculations if such arrangements cannot be provided.

4.12.4.2 The scantlings of bulkheads, deck, staircases, doors, pipes, ducts and tunnels forming watertight boundaries, shall be adequate to withstand pressure heights corresponding to the deepest equilibrium waterline in damaged condition.

SECTION 5 SEALERS

Contents

5.1 General

5.1.1 Classification

5.1.1.1 Vessels build in compliance with the below requirements shall be provided the class notation **“Sealer”.**

5.1.1.2 This section applies to vessels specially built for catching.

5.1.2 Hull Form

5.1.2.1 The hull form of the vessel shall be suitable for navigation in pack ice and shall be such that the ship cannot be pressed down by ice. The sides of the hull shall be convex, with the greatest breadth at the first continuous deck above the design waterline. The angle between the tangent to the ship's side at the deck and the vertical shall not be less than 5 degrees.

5.2 Strength of Hull and Superstructure

5.2.1 Ships sides and stem

5.2.1.1 The shell plating, frames, girders and stem scantlings shall at least be as required for ice class ICE- 05, refer Section 4.

5.2.2 Superstructure

5.2.2.1 Side plating in superstructures shall have increased thickness in an area extending not less than 1 m above the upper ice waterline (UIWL), as defined in Section 1.2, of the vessel or above deck if the vessel has no freeboard mark. In the mentioned area the plate thickness forward of 0.25 L from F.P. shall be minimum:

$t = 10.00 + 0.08 L$ (mm)

Aft of 0.25L from forward perpendicular, the plate thickness shall be minimum:
$t = 7.50 + 0.06 L$ (mm)

5.2.2.2 The frames shall have brackets at both ends. Frames in superstructures in way of crew accommodation shall have a section modulus at least 50% in excess of the requirement for main class.

5.2.2.3 The top of intermediate frames shall be connected to a horizontal girder of same depth as the frames and with a flange area not less than 10 cm2. The horizontal girder shall be attached to all side frames. Intermediate frames with section modulus as for frames according to Sec [5.2.2.2], shall be fitted in way of the strengthened side plating stated in Sec 5.2.2.1.

5.3 Stern frame, Rudder and Steering Gear

5.3.1 Design Rudder Force

5.3.1.1 A rudder force of 3 times the design rudder force for main class shall be considered for the scantling assessment.

5.3.2 Protection of rudder and propeller

5.3.2.1 Rudders and propeller shall be fitted with ice fins for protection.

5.4 Anchoring and Mooring Equipment

5.4.1 General

5.4.1.1 Anchoring and mooring equipment shall be same as those required for fishing vessels.

5.5 Machinery

5.5.1 Output of Propulsion Machinery

5.5.1.1 A minimum propulsion machinery output of 735 kW shall be installed. If the vessel has a controllable pitch propeller, the above output requirement may be reduced by 10%.

5.5.2 Thrust bearing, Reduction Gear, Shafting and Propeller

5.5.2.1 The scantlings are to be at least as that required for the class notation ICE-05, refer Sec 4.

5.5.3 Machinery Systems

5.5.3.1 Refer to Sec 3.11.2 for the requirements for sea inlets and cooling water systems.

SECTION 6 TENTATIVE RULES FOR WINTERIZATION

Contents

6.1 Introduction

6.1.1 General

6.1.1.1 Objective

Winterization ensures that a vessel is capable of and suitably prepared for operations in low temperatures.

This is provided for by setting requirements to important shipboard functions, systems and equipment intended to be in operation in the specified design environmental conditions. The design environmental conditions include cold air, cold sea water and wind.

6.1.1.2 Scope

The scope of the notation includes functions, systems and equipment essential for safety of the vessel, personnel and the environment. Winterization is primarily focused on the adverse effects and control of freezing, sea spray and atmospheric icing, and wind chill on board the vessel, as well as material properties in cold temperature.

Winterization measures include:
a. Implementing procedures for safe operation and personnel welfare
b. Protecting important shipboard functions, systems and equipment
c. Providing suitable equipment and supplies

Note:
Other functions, equipment and system important for commercial operations may also be affected by cold climate and can benefit from winterization measures; however, the winterized notation does not address them where they are not essential to safety. Winterization does not address those hull and machinery requirements necessary for safe navigation through sea ice, which are rather addressed in the ice class rules.

6.1.1.3 Application

Vessels constructed and equipped, surveyed and tested in accordance with the rules of this section will be assigned the class notation **Winterized** with relevant qualifiers defined in Table 6.1.1.

Table 5.1.1 Winterized- Class Notation

Class Notation	Description	Name	Description	Requirements
Winterized	Cold climate operation	Basic	Operation occasionally in cold climate for short periods	Sec [6.1.1.8] Sec [6.2] and Sec [6.3]
		Cold	Operation in cold climate regularly or for an extended period of time through not necessarily an ice infested waters	Sec [6.1.1.8] Sec [6.2] and Sec [6.3]
		Polar	Operation in extreme cold climate of the polar regions year-round, in ice-infested waters	Sec [6.1.1.8] Sec [6.2] and Sec [6.3]
		t_d	Design temperature	Sec [6.1.1.6]
		Enhanced	Additional requirements of a higher level of winterization	Sec [6.1.1.4]

6.1.1.4 Qualifiers

One of the qualifiers **Basic**, **Cold** or **Polar** is mandatory. The basic qualifier t_d is mandatory for **Cold** or **Polar**; but optional for **Basic**. The qualifier Enhanced is optional and can be selected together with **Basic** or **Cold**.

The qualifier **Enhanced** may be assigned to a vessel that fulfills additional requirements of a higher level of winterization. As an example, a vessel that fulfills all requirements for qualifier **Basic** and several additional elements from **Cold** may receive the qualifier **Enhanced**. The specific enhancements will be listed in the Appendix to the vessel's Classification Certificate.

Note:
This feature is meant to recognize and document additional winterization enhancements of a vessel and include them in survey process, as particular winterization features are of increasing importance to vessel owners, charterers and vetting agents.

6.1.1.5 Syntax

The order of appearance shall be, first **Winterized**, second **Basic**, **Cold** or **Polar** and third $\mathbf{t_d}$ and forth **Enhanced.** $\mathbf{t_d}$ shall be indicated in ^{0}C and both $\mathbf{t_d}$ and **Enhanced** shall be surrounded by parenthesis.

Examples:
Winterized Basic
Winterized Cold (-20^0 C)
Winterized Cold (-20^0 C) (Enhanced)

6.1.1.6 Design Environmental Conditions

The design temperature (**td**) value shall be specified in degrees Celsius. Where the vessel has also the class notation **DAT**(**td**), the **td** value for the two notations shall be the same.

The various environmental conditions for qualifiers **Basic**, **Cold** and **Polar** are listed in Table 6.1.1. The values are representative but not necessarily prescriptive.

Table 6.1.1.Typical Design Environmental Conditions

Qualifier	Air temperature (t_d)	Sea Water Temp (^{0}C)	Wind Speed
Basic	< -10^0 C	+4^0 C without ice class	20 m/s
	(-10^0 C is default)	-2^0 C with ice class	
Cold	-15^{0}C to -30^{0}C	+2^0 C without ice class	20 m/s
		-2^0 C with ice class	
Polar	< -25^0 C	-2^0 C	20 m/s

Note:
The lowest value during the period of operation is applicable for seasonally restricted service.

For vessels with ice class, the design sea water temperature is the freezing point of sea water. As the freezing point varies with salinity (from −2°C in normal sea water to 0°C in fresh water), this should be taken into consideration where appropriate when carrying out analysis in connection with the notation.

t_d should reflect the lowest mean daily average air temperature in the area of operation, considering the following:

Lowest : Lowest during the year

Daily average : Average during 24 hour period
Mean : Statistical mean over the observation period of minimum 20 years

6.1.1.7 Specific requirements to winterized are listed in Table 6.1.2. In the table, items marked with an X are applicable for the relevant qualifier.

6.1.1.8 Required Additional Class Notations

For qualifier **Cold**, either class notation **DAT**(**t_d**) or **PC** is mandatory.
For qualifier **Basic**, class notation **DAT**(**t_d**) is mandatory if **t_d** < −10°C.
For qualifier **Polar**, an ice class notation (either **ICE**, **POLAR** or **PC**), class notation **CLEAN**, and either class notation **DAT**(**t_d**) or **PC** are mandatory.

6.1.1.9 Functional, Performance and Prescriptive Requirements

The notation adopts a three-tiered approach as below:

- Winterization requirements are based upon fulfilling the stated functional requirements. The functional requirements provide the fundamental rationale and intent behind a particular rule.

- Some functional requirements are supported by one or more performance requirements. These explain in greater detail the type of performance a winterization measure must achieve in order to fulfill the intent of the functional requirement, either in part or in whole.

- Functional and performance requirements are supported by prescriptive rules and guidance notes. These provide a set of generally acceptable solutions to meet the functional and performance requirements, either in part or in whole.

6.1.1.10 Prescriptive requirements do not preclude the use of other alternative solutions. Such solutions will be considered by their ability to fulfill the relevant functional and performance requirements.

6.1.1.11 Equipment not otherwise mentioned in these rules and which in the opinion of the Society is essential for safety shall function properly in the design environmental conditions. Such equipment shall be provided anti-icing and anti-freezing protection as appropriate, and shall be constructed of material appropriate for the design temperature (t_d). Equipment material shall be selected according to Sec 6.3.10.1, as appropriate.

6.1.1.12 Terminology and Definitions

Table 6.1.2 Terminology and Definitions

1	Winterization	Measures taken to ensure a vessel is capable of and suitably prepared for operations in low temperatures. Winterization is primarily focused on the adverse effects and control of freezing, icing, wind chill and material properties in cold temperature.
2	Sea spray Icing	Icing caused by the freezing of sea spray on ship surfaces, structures and equipment.
3	Performance requirement	Requirements that explain in greater detail the type of performance a winterization measure must achieve in order to fulfill the intent of the functional requirement.
4	Passive measures	Winterization measures that do not rely primarily on energy to address the adverse effects of icing, freezing or wind chill; e.g., enclosures, shielding, insulation and building-in areas or equipment.
5	Main functions	The main functions of a vessel in the context of class: Pt1,Ch1,Sect [11.1.3.2]which includes: Strength, Weathertight Watertight integrity,

		Power generation, Propulsion, Steering, Drainage/ Bilge pumping, Ballasting, Anchoring.
6	Functional requirement	Requirements that provide the fundamental rationale behind a particular rule.
7	F.P.	The forward perpendicular is the perpendicular at the intersection of the summer load waterline with the fore side of the stem. For ships with unusual bow arrangements the position of the F.P. will be especially considered.
8	Design temperature (t_d)	Reference air temperature used as a criterion for the selection, testing and use of materials and equipment for low temperature service. Same as design temperature used in the notation **DAT** (Refer Section 7)
9	Design environmental conditions	Environmental conditions for which the vessel is designed to operate. For winterization, the key design environmental conditions are air temperature, sea water temperature and wind speed.
10	De-icing	Means to remove snow and ice accumulations from surfaces, structures or equipment. The intent of de-icing is that the surfaces, structures or equipment can be made available within a reasonable amount of time.
11	Anti-icing	Means to prevent ice from forming on surfaces, structures or equipment. The intent of anti-icing is that the surfaces, structures or equipment are immediately available
12	Active measures	Winterization means that rely primarily on energy to address the adverse effects of icing, freezing or wind chill; e.g., heating, physical force and circulation of liquids etc

6.1.1.13 Other Document References

The various documents referenced in this section are listed in Table 6.1.3 below:

Table 6.1.3 Other Document References

Sl	Document Ref.	Document Title
1	IS Code	International code on intact stability
2	SOLAS Chapter IV	Radio communication
3	MARPOL Annex I	Regulation for the prevention of pollution by oil
4	LSA Code	International life-saving appliances code
5	ISO 17899	Ships and marine technology – Marine electric window wipers
6	ISO 8863	Ship's wheelhouse windows – Heating by hot air of glass panes
7	ISO 3434	Ships and marine technology- Heated glass panes for ships rectangular windows
8	IMO Res MSC/81(70)	Revised recommendation on testing of life-saving appliances
9	IMO Res A 1024(26)	Guidelines for ships operating in polar waters
10	IEC 60945	Maritime navigation and radio communication equipment and systems – General requirements – Methods of testing and required test results
11	CSA Standard C22.2 No 0.3	Test methods for electrical wires and cables

6.1.2 Documentation Requirements

6.1.2.1 In addition to the documentation given for the assignment of main class, the following as detailed in Table 6.1.4 is to be submitted.

Table 6.1.4 Documentation Requirements

Description	Documentation Type	Additional Description	(A)/(I)	Qualifier
Winterization Arrangements	Design Basis	Including description of the overall winterization design arrangement, indicating how each applicable item in the notation has been addressed in the winterization design.	(I)	

	Single line diagrams/ consumer list for switch boards	For anti-icing and anti-freezing systems, including: full load; cable types and cross sections; make, type and rating of fuses, switching gear and heating cables.	(A)	
	Electrical schematic drawing	For anti-icing and anti-freezing systems, including: control and instrumentation circuits, including make, type and rating of all equipment.	(A)	
	Heat balance calculation	For anti-icing and anti-freezing systems, indicating heating capacities required and provided.	(I)	
	Arrangement Plan	Including anti-icing, anti-freezing and de-icing systems; heating capacity for each area; fastening arrangement and spacing of electrical cables and fluid pipes; and installation protection details of electrical cables.	(A)	
	Test procedure for quay and sea trial	Including anti-icing, anti-freezing and de-icing systems.	(A)	
	Operation Manual	Cold climate operations and planning: cold climate hazards, icing prediction, meteorological and route planning, ship handling in icing conditions Winterization preparations and procedures: general precautionary measures; description, location and operating procedures for installed winterization features; system-specific winterization measures; de-icing procedures Procedures for special operations in cold climate: ballasting, cargo operations, mooring, anchoring, and other relevant operations for vessel type; Cold climate operation checklists: winterization preparations; routine winterization checks; additional actions for special operations in cold climate.	(A)	
Survival craft arrangements	Life-saving arrangement plan	Including anti-icing protection	(A)	
Steam and thermal oil system	Capacity analysis	Indicating boiler capacity required for supplying ant icing, anti freezing and de icing arrangements.	(I)	
Stability	Final Stability Booklet	Including load conditions with ice accretion	(I)	
Rescue boat arrangements	Life-saving arrangement plan	Including anti-icing protection	(I)	
Radar Systems	Test report at manufacturer	To the design temperature (t_d) colder than -25^0 C	(I)	
Propulsion and Steering Arrangements	Specification	Stern tube and controllable pitch propeller oils	(A)	Polar

Oil pollution prevention	Calculation report	Accidental oil outflow performance in accordance with MARPOL Annex I Reg. 23	(I)	Polar
Navigation systems	Test report at manufacturer	To the design temperature (t_d) where t_d is colder than -25^0 C	(I)	
Navigation systems (other)	Horizontal field of vision drawing	Anti-icing arrangement to bridge windows, wipers and washers also to be included	(A)	
Navigation lights	Test report at manufacturer	To -25°C or the design temperature (td), whichever is colder.	(I)	
Main electric power generation	Electrical power Consumption balance	Including winterization systems as a separate mode.	(A)	
Machinery space heating system	Heat balance calculation	Calculation to be based on an external ambient temperature of 20^0 C below design temperature (t_d)	(A)	Cold/ Polar
Helideck	Strength analysis	Also to consider snow and ice loading	(I)	
Fresh water tanks and other tanks	Piping diagram;	Also to include anti-freezing arrangement	(A)	
	Heat balance calculation	Also to include anti-freezing capacity calculation	(I)	
Fire-Fig.hting systems				
	Piping and Instrumentation diagram	Also too indicate anti-freezing arrangement, including drains (for self draining systems), heat tracing and insulation	(A)	
	Heat balance calculation	Also to include anti-freezing capacity calculation	(I)	
External communications systems	Test report from manufacturer	To the design temperature (t_d), where t_d is colder than -25^0 C	(I)	
Escape routes	Escape route layout	Also to include anti-icing protection	(A)	
Emergency electric power generation arrangement	Heat balance calculation	Consider the heat consumption based on an external ambient temperature of 20^0 C below the design temperature (t_d)	(A)	Cold/ Polar
Cargo and service hatches	Strength analysis	Include conditions of snow and ice loading	(I)	Cold/ Polar
Cables	Test report from manufacturer	To at least 10^0 C colder than the design temperature (t_d)	(I)	Cold/ Polar
Ballast tanks	Piping diagram	Anti-freezing arrangement	(A)	
	Heat balance calculation	Also to provide anti-freezing capacity for tanks located fully or partly above the waterline or low ice water line (LIWL), whichever is lower.	(I)	
Accommodation heating system	Heat balance calculation	Consider heat consumption based on external ambient temperature of 20^0 C below the design temperature (t_d)	(A)	Cold/ Polar
Note: (A): For Approval (I): For Information				

6.1.3 Certification Requirements

6.1.3.1 Components shall be certified as required by Table 6.1.5.

Table 6.1.5 Certification Requirements			
Description	**Certificate Type**		**Additional Description**
Lifeboat	W	Manufacturer work certificate	Operation to -15^0 C or the design temperature (t_d), whichever is colder. Stowage down to -30^0 C or 20^0 C colder than the design temperature (t_d) whichever is colder.
Life raft	W	Manufacturer work certificate	Operation to -15^0 C or the design temperature (t_d), whichever is colder. Stowage down to -30^0 C or 20^0 C colder than the design temperature (t_d) whichever is colder.

6.2 General Requirements

6.2.1 Anti-icing, anti-freezing methods

6.2.1.1 Various winterization measures required by Table 6.3.1 shall fulfill the functional requirements, and shall be considered for approval in each case.

6.2.1.2 Wherever anti-icing and anti-freezing measures are required for areas and equipment in Table ,6.3.1 the following are examples of acceptable solutions:

Equipment and areas that require anti-icing measures should as far as possible be situated in protected locations, avoiding exposure to sea spray. This may be accomplished by using fully enclosed spaces, semi enclosures, recesses with removable “curtains” in front, or similar. A shielded location will be the simplest and most reliable solution for anti-icing wherever it is possible.

Spaces might need heating depending on the type of equipment located therein.

Some type of equipment may be provided with hard removable covers for protection. Canvas covers may be acceptable for some of equipment like fire monitors etc. Supply of heated air may be an alternative if the equipment is enclosed under a cover, hard cover or canvas.

For equipment on open deck, use of electric heating blankets or heat tracing can be an effective solution.

Note:

For higher levels of winterization, preference is given to passive measures for anti-icing/anti-freezing protection, such as enclosures etc versus de-icing or active measures for anti-icing/anti-freezing protection, such as heat tracing. Passive measures are inherently more effective, more efficient, and contribute to reducing emissions to the environment.

6.2.1.3 Anti-icing and anti-freezing arrangements must be able to maintain a surface temperature of at least +3°C under the design environmental conditions. Heating capacity for anti-icing and anti-freezing arrangements shall be sufficient to prevent icing or freezing under the design environmental conditions.

6.2.1.4 Anti-icing and anti-freezing arrangements using heating, special attention shall be paid to the heat transfer from the heating cables or pipes to the equipment or structure to be heated. The spacing and fastening of heating cables or pipes shall be appropriate for efficient heating to keep the equipment or structure ice-free under the design environmental conditions. Appropriate spacing shall be established by heat balance calculations.

6.2.1.5 For anti-icing and de-icing arrangements applying heating by fluids in pipes, the installation shall ensure that the heating fluid maintains its heating effectiveness under the design environmental conditions. The appropriate amount of insulation and the rate of circulation shall be established by heat balance calculations.

6.2.1.6 Where heated fluids are used for winterization purposes, their process plants shall have sufficient capacity to simultaneously supply all normal consumers and the winterization systems under the design environmental condition.

6.2.2 Means for De-icing

6.2.2.1 De-icing may be carried out by fixed heating arrangements or by use of portable equipment, were removal of ice prior to taking equipment into use is acceptable.

Portable equipment may consist of:
- Shovels
- Snow blowers
- Wooden, rubber or plastic hammers (Mallets)
- Hoses for heated water flushing
- Hoses for steam blowing

Note:
Mallets preferably to be made from wood and not metal, to avoid damage to equipment, structures and paintwork.

6.2.2.2 Hot water or steam shall be available where an area or equipment is intended to be de-iced manually and fixed heating is not provided. The location and number of the steam/hot water outlets and equipment shall be appropriate to the local layout and to the time scale in which the de-icing is required to be achieved.

6.2.2.3 De-icing equipment shall be located in areas where it is readily available and protected from icing and other adverse conditions. It is preferable to store de-icing equipment inside the vessel. Where it is stored outside, the storage facilities shall be afforded anti-icing protection to ensure it is readily accessible.

6.2.2.4 Water or steam-based de-icing equipment shall be stored in heated spaces or containers that are kept above freezing temperature in the design environmental condition to prevent hoses from freezing.

6.2.2.5 Any equipment or systems scheduled for de-icing shall have all vulnerable components (e.g., sensors, counters, limit switches, electric fittings) adequately protected from mechanical damage from manual de-icing activities or water ingress from water/steam de-icing.

6.3 Winterization Requirements

6.3.1 Requirements of Winterization

6.3.1.1 Winterization measures required by Table 6.3.1 below shall fulfill the functional requirements, and shall be considered for approval in each case, in addition to those given for the assignment of main class. The requirements relevant for Winterized Basic, Cold and Polar are indicated by an X in the corresponding column of the table.

Table 6.3.1 Requirement for Winterized Notation

Ref	Description	Basic	Cold	Polar	Requirements
6.3.2	**Stability, watertight and weather tight integrity**				

6.3.2.1	Cargo hatches, service hatches and shell doors		X	X	Functional requirements: - Cargo hatches, service hatches and shell doors shall maintain weather-tightness under the design environmental conditions. - Cargo hatches and service hatches shall maintain their structural integrity and weather tightness under the additional loading of snow and ice accumulation. Performance requirements: - Hatch/ door seals and other components relevant for safety shall be made from material suitable for the design temperature (td) specified in the class notation. Prescriptive requirements: - Snow and ice loading calculations in this requirement shall use the same snow and ice loads as those used for stability calculations in Sec 6.3.2.3 below. - Where not addressed by Sec 7 for **DAT** or Sec 8 for **PC** ice class notation, materials shall be selected according to Sec 6.3.10.1, as appropriate.
6.3.2.2	Freeing ports and scuppers	X	X	X	Functional requirements: - Freeing ports, drains and scuppers shall be capable of being kept clear and open under the design environmental conditions and not be blocked due to snow, ice or freezing water. Prescriptive requirements - Where muster areas, access ways and decks are required to be kept ice-free, they shall be arranged with drains and scuppers that have anti-freezing protection. - Freeing ports shall be fitted with anti-icing protection. - Increasing the freeing port are by 30% is accepted as an alternative to heating (Refer Pt 4, Ch 6, Sec 13) - If a shutter is fitted on the freeing port, it shall be provided with heating sufficient for maintaining its opening ability. - For vessels 100 m or less in length, shutters shall not be fitted in the freeing ports, as per the IS Code, Sec 6.4.1.

6.3.2.3	Stability	X	X	X	Functional Requirements: - The vessel shall have adequate stability under conditions of icing under the design environmental conditions. Performance Requirements: - The vessel shall satisfy the applicable intact and damage stability requirements under conditions of icing, taking into account the additional weights due to ice accretion. - Where there are no other damage stability requirements applicable for the vessel, the vessel shall comply with the damage stability requirements of IMO Res. A.1024(26). Prescriptive Requirements: - For decks, gangways, wheelhouse tops and other horizontal surfaces, the values found in Table 6.3.2 - For projected lateral area of each side of the vessel above the water plane; 7.5 kg/m2. - The projected lateral area of discontinuous surfaces of rail, sundry booms, spars (except masts) and rigging of vessels having no sails and the projected lateral area of other small objects shall be computed by increasing the total projected area of continuous surfaces by 5% and the static moments of this area by 10%.

Table 6.3.2 Icing Load (kg/m^2) on Horizontal Surfaces (*)

Height	From forward to 50m aft of FP	50 to 100m aft of FP	>100 m aft of FP
0 to 6 m from WL	120	60	30
6 to 12 m from WL	80	40	30
12 to 18 m from WL	40	30	30
>18 m from WL	30	30	30

Note (*):
Horizontal surface in this case includes decks, gangways, wheelhouse tops etc
The Summer Load Line shall be considered as the waterline (WL) in this case
For surfaces with anti-icing systems, the icing weight load in that area may be set to 30 kg/m^2

Table 6.2.3 Requirement for Winterized Notation (Continued)

Ref	Description	Basic	Cold	Polar	Requirements
6.3.3	**Mechanical**				
6.3.3.1	Anchor emergency release safety system (Offshore Service Vessels)	X	X	X	Functional Requirements: - The anchor emergency disconnect system on **Offshore Service Vessels** with anchor handling capability shall be usable in the design environmental conditions. Prescriptive Requirements: - The anchor emergency disconnect system shall be provided with anti-icing protection.
6.3.3.2	Anchoring arrangement	X	X	X	Functional Requirements: - The anchoring system shall be readily available in the design environmental conditions when in or approaching coastal or piloting waters. - The control systems shall not be susceptible to damage by de-icing methods. - Associated hydraulic systems shall function under the design environmental conditions Prescriptive Requirements: - The anchor windlass and windlass controls shall be provided anti-icing protection. - The anchor chain may be de-iced manually. - The hawse pipe shall be provided anti-icing protection or de-icing protection with steam or hot water. - Associated hydraulic systems shall comply with the requirements in Sec 6.3.8.5
6.3.3.3	Anchoring Arrangement		X	X	Functional Requirements: - The crew shall be able to easily access and operate the anchor windlass in an environment that protects them from wind, water spray, ice and slippery conditions, without the need to remove ice from equipment or decks. Prescriptive Requirements: - Anchor windlass, windlass controls and chain stopper shall be located inside a deckhouse, a semi-enclosure providing

					protection from water spray or inside a forecastle space.
6.3.3.4.	Anchoring Arrangement – Material Quality		X	X	Functional Requirements: - The anchor chain, chain stopper and anchor windlass shall be made from materials suitable for the design temperature (t_d). Prescriptive Requirements: - Anchor chain material quality shall be: If td > -200 C: Chain type Grade 2 or Grade 3 If td < -200 C: Chain type Grade 3 - For anchor windlass components fabricated from plate material, Class III steel grades shall be selected according to 7.2. - For equipment or parts of equipment fabricated from forged or cast material, the impact test temperature and energy shall fulfil the requirements in Sec 6.3.10.1. - The anchor windlass shall have foundation bolts and shaft bearing holding bolts made from low temperature steel. Grey cast iron shall not be used in any load bearing parts.
6.3.3.5	Cranes		X	X	Functional Requirements: - Cranes shall be able to withstand icing loads without collapsing. Performance Requirements: - Cranes shall be able to withstand icing loads used in Sec 6.3.2.3 or in Pt 4, Ch 5, Sec 1.5.3, whichever is greater. - Cranes shall be able to withstand icing loads in the stowed and operating conditions. - Crane foundations and supports shall be able to support an iced crane, using the loads specified above.
6.3.3.6	Cranes		X	X	Functional Requirements: - Cranes that are required for essential safety functions (e.g., crane used for launching the rescue boat) shall operate in the

					design environmental conditions. Performance Requirements: - Cranes and its components shall be made from materials suitable for design temperature (t_d) Prescriptive Requirements: - Material of components of crane shall be selected according to Sec 6.3.10.1, as appropriate. - Anti-icing protection shall be provided to the relevant components as required. *Note: Active (eg heating) protection or passive (eg shielding) protection from icing may be considered.*
6.3.3.7	Emergency towing arrangement (Tankers)	X			Functional Requirements: - It shall be possible for tankers to make the emergency towing arrangement available on short notice during operation and sailing in the design environmental conditions. - The emergency towing arrangement shall operate under the design environmental conditions Prescriptive Requirements: - Anti-icing protection shall be provided for the emergency towing arrangement pre-rigged for immediate use. - Anti-icing or de-icing protection shall be provided for the other emergency towing arrangement.
6.3.3.8	Emergency towing arrangement (Tankers)		X	X	Functional Requirements: - Emergency towing arrangements shall operate under the design environmental conditions. - It shall be possible to make the emergency towing arrangement available on short notice during operation and sailing in the design environmental conditions. Performance requirements: - Those components exposed to the low temperature shall be made from materials suitable for the design temperature (td) specified in the class notation.

					Prescriptive requirements: - The emergency towing arrangement pre rigged for immediate use shall have passive anti-icing protection, that is, it shall be located in an enclosed space, semi-enclosure or under deck space. - Equipment material shall be selected according to Sec 6.3.10.1, as appropriate. - The other emergency towing arrangement may be arranged with either anti-icing or de-icing protection.
6.3.3.9	Engine rooms-Restart from dead ship		X	X	Functional Requirements: - It should be possible to re-start the main machinery from a dead-ship condition after 30 minutes under design environmental conditions. Performance requirements: - With an outside ambient temperature 200C colder than the design temperature (t_d), the machinery shall be arranged such that it can re-start and operate from a dead-ship condition after 30 minutes. *Note:* - *Insulation may be necessary to ensure the machinery space maintains a sufficiently warm environment for re-starting the machinery after a dead-ship condition of 30 minutes.* - *Water cooling lines and other machinery components that are subject to freezing should be located away from vessel sides, where they will get coldest first.* - *Machinery may require air intake heating, cooling water heating and lube oil heating, depending on individual machinery specifications, to ensure it can re-start from a dead-ship condition after 30 minutes.*
6.3.3.10	Mooring Arrangement	X	X	X	Functional Requirements:

					- Crew must be able to safely and efficiently remove snow and ice accumulation from mooring winches and the surrounding work area to make operating them safe in a reasonable time prior to mooring. Prescriptive requirements: - In the vicinity of the mooring winches de-icing system is to be provided. - Covers shall be provided for mooring winches to protect them from icing.
6.3.3.11	Mooring Arrangement		X	X	Functional requirements: - Mooring equipment exposed to low temperature shall be made from materials suitable for the design temperature (t_d) specified in the class notation. Prescriptive requirements: - Mooring wires shall be lubricated with low temperature wire rope dressing appropriate for the design temperature (td). - Mooring winches shall have foundation bolts and shaft bearing holding bolts made from low temperature steel. Grey cast iron shall not be used in any load bearing parts. - Equipment material shall be selected according to Sec 6.3.10.1, as appropriate. *Note:* *Mooring equipment includes bollards, chocks, fairleads and roller pedestal (eg. body and seat of fairleads and bollards; roller, pin, boss, bush, seat of deck stand rollers); body of sunken bits; chain wheel, gear wheel, shaft, foundation bolt, drum, warping head on an anchor windlass; and mooring wires.*
6.3.4	**Electrical**				
6.3.4.1	Cables		X	X	Functional requirements: - Electrical cabling shall maintain its required performance under the design environmental conditions. Performance requirements: - Electric cables exposed to the low temperature shall be made

					from material suitable for the design temperature (t_d). Prescriptive requirements: - Cables shall comply with acceptable impact and bending test standards. Impact and bending tests shall be conducted to at least 10°C colder than the design temperature (t_d). *Note:* *The latest revision of Canadian CSA standard C22.2 No. 0.3 for impact test at –35°C and bending test at –40°C, is an acceptable test standard.*
6.3.4.2	Electric motor cooling	X	X	X	Functional requirements: - Electric motors on open deck and necessary components for safety or for supporting main functions shall be capable of operation under the design environmental conditions. Performance requirements: - Snow, ice and cold temperatures shall not adversely affect the motor's cooling system and thereby render the motor inoperable. Prescriptive requirements: - Electric motors in the category above shall be naturally cooled, without external fan.
6.3.4.3	Emergency electric power generation arrangement		X	X	Functional requirements: - Emergency generators shall be operable under the design environmental conditions. Performance requirements: - With an outside ambient air temperature of 20°C below the design temperature (td), the emergency generator shall be able to start and operate. Prescriptive requirements: - Space heating, or heating of the generator itself, is required to ensure the emergency generator will start and operate under cold conditions, unless it can be shown that it will start and operate in temperatures 20°C below the design temperature (td).
6.3.4.4	Emergency electric			X	Functional requirements:

	power generation arrangement				- The starting system of the emergency generator shall be arranged so as to avoid a common mode failure, particularly one related to cold temperatures. Performance requirements: - Two different, separate and independent starting systems shall be provided for emergency generators. *Note:* *The reference to different starting systems means that the two systems are based on different principles (e.g., one battery-powered and one air powered), so as to avoid a common mode failure, particularly one related to cold temperatures.*
6.3.4.5	Lighting	X	X	X	Functional requirements: - Deck lighting should be operable under the design environmental conditions. Prescriptive requirements: - Deck lights shall be fitted with additional heating to make them operational if they do not generate sufficient heating to stay ice-free.

6.3.4.6	Main electric power generation arrangement	X	X	X	Functional requirements:
					The capacity of the main electric generator shall be sufficient to operate essential vessel systems including anit-icing systems fitted to comply with the notation, under the design environmental conditions, and a minimum of half of the de-icing systems fitted to comply with the notation.
					
					Prescriptive requirements:
					- For calculation of required electric generator capacity (Refer Pt 6,Ch 2,Sect [2.1], the power requirements for the heating arrangements shall be included as below:
					  - 100% of electric power needed for anti-icing and anti-freezing purposes fitted to comply with the notation
					  - 100% of the power for the single largest de-icing system consumer fitted to comply with the notation or 50% of electrical power

					needed for de-icing purposes fitted to comply with the notation, whichever is the greatest. - Calculations shall be based upon power demands under the design environmental condition.
6.3.4.7	Main electric power generation arrangement			X	Functional requirements: - Sufficient main electricity power generation shall be available such that a casualty (eg. from fire or flooding) to any one engine room will not endanger the electric power generation capacity such that the vessel is inoperable or crew survivability is put at risk. Prescriptive requirements: - Main electric power generators shall be located in separate spaces so that a casualty affecting one space (eg. from fire or flooding) does not affect the other. - The vessel shall have sufficient capacity to power essential systems for operation and survivability with the loss of any one engine space. - Auxiliary systems required to operate the main electric power generators shall also be separate and independent, to reduce common fault failures. *Note:* *The redundancy requirement applies to electric power generation capacity, not for propulsion.*
6.3.4.8	Main Switchboards	X	X	X	Functional requirements: - Switchboards shall be arranged such that the crew can adequately control and monitor the performance of installed winterization systems.
					Prescriptive requirements: - Switchboard for winterization systems shall be arranged as required for distribution switchboards. A wattmeter or ampere meter, indicating the total load shall be installed on the switchboard. Marking on the switchboard shall state the load

					on each circuit, as well as the total load.
6.3.4.9	Protective earthing arrangements	X	X	X	Functional requirements: - Electrical circuits for winterization features shall be arranged such that an earthed circuit may be automatically isolated and disconnected without disabling the rest of the system. Prescriptive requirements: - All electrical circuits for winterization features shall have earth failure monitoring with automatic disconnection and alarm connected to the main alarm system.
6.3.5	**Safety**				
6.3.5.1	Access, external	X	X	X	Functional requirements: - Personnel should be able to move safely up and down the accommodation ladder and gangway in the design environmental conditions, including freezing precipitation (snow and ice). Prescriptive requirements: - The vessel shall have de-icing protection for the accommodation ladder and gangway.
6.3.5.2	Access, Internal	X	X	X	Functional requirements: - Personnel safety: The personnel should be able to move safely about weather deck areas of the vessel under the design environmental conditions. - Stability: Snow and ice accumulation on weather decks shall be controlled within vessel stability limits. Prescriptive requirements: - The vessel shall have de-icing protection to remove snow and ice accumulation from all weather deck areas where there are no other requirements for anti-icing protection, to prevent loss of stability and to make them safe for personnel. - Some areas of weather decks may need to be ice-free, eg. when those areas are important for emergency access (eg. escape routes, muster areas, embarkation areas to survival

					craft); these areas shall be provided anti-icing protection.
6.3.5.3	Access, Internal	X	X	X	Functional requirements: - Personnel shall not be at risk of injury, nor essential safety equipment/ structures at risk of damage, caused by falling ice from elevated structures, including but not limited to cranes, derricks, masts and overhanging decks. Prescriptive requirements: - Elevated structures shall be provided with de-icing or other measures adequate to prevent personnel injury or damage to essential safety equipment/structures from falling ice. *Note:* *Possible measures to prevent injury or damage from falling ice include:* *Locating elevated structures to avoid or minimize icing;* *Locating work areas and equipment away from elevated Structures to eliminate or minimize risk from falling ice;* *design and/or locate elevated structures such that they can be easily de-iced; anti-icing measures (enclosure, shielded location, or heat tracing);* *Design measures to reduce icing potential (box vs. lattice structure);* *Dropped object protection to protect people, equipment and structures from falling ice.*
6.3.5.4	Access, Internal (Tankers)	X	X	X	Functional requirements: - Personnel shall have safe access to bow (for Tankers) under the design environmental conditions. Prescriptive requirements: - Safe access to tanker bow shall be provided by a gangway raised to a sufficient height to prevent passage being impeded by snow build-up on underlying surfaces. - The safe access to tanker bow shall be provided de-icing protection.
6.3.5.5	Access, Internal (Tankers)		X	X	Functional requirements: - Personnel shall have safe access to bow (for Tankers) under the design environmental conditions. Prescriptive requirements:

					- The safe access to bow gangway shall either be provided anti-icing protection, or it shall be made of a grating with raised non-skid points that will give safe footing in the presence of minor sea spray icing. *Note:* *Anti-icing protection may be in the form of an under-deck passageway, on deck trunk, or heat tracing.*
6.3.5.6	Accommodation heating system		X	X	Functional requirements: - Accommodation spaces shall be kept at a temperature that ensures the health and safety of personnel under the design environmental conditions. Prescriptive requirements: - Accommodation heating shall be dimensioned to ensure accommodation spaces can be kept at a temperature of at least +18°C under the design environmental conditions, with a recirculation rate of 50%. - The heating consumption is to be calculated based on an external ambient temperature of 20°C below the design temperature (t_d).
6.3.5.7	Accommodation heating system			X	Functional requirements: - Accommodation spaces shall be kept at a temperature that ensures the health and safety of personnel under the design environmental conditions. Prescriptive requirements: - The accommodation and spaces essential to vessel operation shall have a redundant space heating design such that a failure of one heating source will not render the spaces without heating.
6.3.5.8	Emergency shutdown system	X	X	X	Functional requirements: - Emergency shutdown (ESD) valves for gas tankers shall be ice-free and operational at all times in the design environmental conditions. Performance requirements: - ESD valves shall be arranged with anti-icing protection.
6.3.5.9	Escape routes	X	X	X	Functional requirements: - Escape exits and escape doors must be able to readily open

					and close under the design environmental conditions, including freezing precipitation (snow and ice) and sea-spray icing. - Escape ways shall be safe to use in an emergency under the design environmental conditions. Prescriptive requirements: - Escape ways shall have anti-icing protection providing a minimum ice free width of 700 mm, enabling the use of at least one railing. - Escape exits and doors shall have anti-icing protection.
6.3.5.10	Escape routes			X	Functional requirements: - Escape routes shall be dimensioned so as not to hinder passage for persons wearing suitable polar clothing, to comply with IMO Res. A.1024(26), Sec. 4.3.2.
6.3.5.11	Fire extinguishing equipment, portable	X	X	X	Functional requirements: - Miscellaneous fire-Fighting equipment (including but not limited to portable fire extinguishers, fire blankets, etc.) shall be readily available under the design environmental conditions. Prescriptive requirements: - Miscellaneous fire-Fighting equipment shall be located in areas where it is readily available and protected from icing and other adverse conditions. The storage facilities shall be afforded anti-icing protection to ensure it is readily accessible. - Portable fire extinguishers in open or unheated spaces shall be rated for operation at the design temperature (t_d).
6.3.5.12	Fire-Fighting systems	X	X	X	Functional requirements: - Fire-Fighting systems shall be readily available under the design environmental conditions. Performance requirements: - Fire mains and fire-Fighting system piping shall not be blocked by internal freezing under the design environmental conditions.

					- Fire-Fighting equipment (including but not limited to hydrants, hoses, nozzles and monitors) shall not be blocked by external icing or by internal freezing under the design environmental conditions. Prescriptive requirements: - Anti-freezing protection of the fire mains and fire-Fighting system piping may be achieved by locating them in a heated passageway, by providing them with heat tracing, or by arranging them as a dry, self-draining system. Where piping is arranged as a dry, self-draining system, drains shall be located at the lowest points in the system, and the piping layout shall ensure all water will drain to them without being trapped in U-bends, low points or dead-ends. - Fire mains and fire-Fighting system piping shall have anti-freezing protection. - Fire-Fighting equipment shall have anti-icing and anti-freezing protection.
6.3.5.13	Fire Fighting systems		X	X	Functional requirements: - Fire-Fighting systems equipment shall be readily available under the design environmental conditions. Performance requirements: - Isolation valves shall be fitted and readily available under the design environmental conditions. - The choice of fire-Fighting systems and extinguishing agents shall be appropriate for the design environmental conditions, taking into account low temperature effects on extinguishing agents. Prescriptive requirements: - The isolation valve spindle shall be accessible from weather deck. - Isolation valves shall have anti-icing protection. - Fire extinguishing agents (foams, powders, gases) shall be rated form operation at the design temperature (t_d).

6.3.5.14	Fire and gas detection and alarm system	X	X	X	Functional requirements: - Fire and gas detection and alarm systems shall function under the design environmental condition and shall not be obstructed by ice or snow. Performance requirements: - Fire and gas detection sensors located outside or in unheated spaces shall be rated for operation at the design temperature (t_d). - Fire and gas detection sensors and dampers located outside shall be provided anti-icing protection.
6.3.5.15	Guard rails	X	X	X	Functional requirements: - Personnel safety: Icing of railings shall be controlled so that railings can maintain their safety function. Prescriptive requirements: - Railings that function only as barriers, but are not intended as handholds, can be arranged for de-icing. - Railings that are important as hand-holds (Stairs, escape ways) shall have anti-icing protection.
6.3.5.16	Helicopter safety arrangements	X	X	X	Functional requirements: - The helicopter deck and winching area, where fitted, shall be safe for personnel and helicopter operations under the design environmental conditions. Prescriptive requirements: - Helicopter deck and winching area, where fitted, shall be provided with de-icing arrangements.
6.3.5.17	Helicopter safety arrangements (Standby Vessels)		X	X	Functional requirements: - For **Standby Vessels**, the helicopter winching area and helicopter deck shall be readily available and safe for personnel and helicopter operations under the design environmental conditions. Prescriptive requirements: - For **Standby Vessels**, de-icing arrangements shall be provided for the helicopter winching zone and helicopter deck, where

					fitted, capable of making the zone/deck available within one hour under the design environmental conditions.
6.3.5.18	Immersion suits		X	X	Functional requirements: - Immersion suits shall be provided and afford the wearer the appropriate level of protection for the design environmental condition. Prescriptive requirements: - Insulated type immersion suits shall be provided for all personnel on board.
6.3.5.19	Life raft arrangements	X	X	X	Functional requirements: - The hydrostatic release mechanism for the life rafts shall be able to function safely in the design environmental condition and is protected from icing build-up. - The crew shall be able to launch/lower/release the rafts safely in the design environmental condition. Performance requirements: - Life rafts shall remain operational in ambient air temperatures down to -15°C or the design temperature (t_d), whichever is colder. - Life rafts shall not be damaged in stowage by ambient air temperatures down to -30°C or 20°C colder than the design temperature (t_d), whichever is colder. Prescriptive requirements: - Life rafts shall be tested in accordance with IMO Res. MSC/81(70) as amended and relevant for the equipment in question. - Life rafts shall be type approved and satisfy relevant criteria given in the LSA Code. - Life rafts and their release and lowering systems shall be provided with anti-icing protection.
6.3.5.20	Lifeboat arrangements	X	X	X	Functional requirements: - The crew shall be able to launch/lower/release and operate the lifeboats safely in the design environmental condition.

					Performance requirements: - Lifeboat engines shall be arranged to ensure they will start readily when required under the design environmental conditions. - Lifeboat engine fuel oil shall be suitable for operation under the design environmental conditions. - Lifeboats shall remain operational in ambient air temperatures down to -15°C or the design temperature (t_d), whichever is colder. - Lifeboats shall not be damaged in stowage by ambient air temperatures down to -30°C or 20°C colder than the design temperature (td), whichever is colder. Prescriptive requirements: - The lifeboats shall be tested to be undamaged in stowage by ambient air temperatures down to -30°C or 20°C colder than the design temperature (t_d), whichever is colder. - The lifeboats shall be tested to operate in ambient air temperatures down to -15°C or the design temperature (td), whichever is colder. - Lifeboats and their securing and launching systems shall be fitted with anti-icing protection. - Lifeboat engines shall be fitted with a heater. - Free-fall lifeboats are not acceptable for vessels that have also an ice class notation according to Sec 3, Sec 4 or Sec 8, unless the lifeboats have alternative means for lowering with their full complement onboard. - Lifeboats shall be type approved and satisfy relevant criteria given in the LSA Code.
6.3.5.21	Lifeboat arrangements		X	X	Functional requirements: - The crew shall be able to launch/lower/release and operate the lifeboats safely in the design environmental condition. Performance requirements:

					- The lifeboat shall protect occupants from extreme cold. - Lifeboat davits/securing & launching systems shall be made from materials suitable for the design temperature (t_d). Prescriptive requirements: - The lifeboat shall be outfitted with internal heating. - Materials for davit/securing & launching system components shall be selected according to Sec 6.3.10.1, as appropriate. - Anti-icing for lifeboats and lifeboat davits/securing & launching systems shall be arranged as passive protection.
6.3.5.22	Rescue boat arrangements	X	X	X	Functional requirements: - The crew shall be able to immediately access, launch, and operate the rescue boat under the design environmental conditions. Prescriptive requirements: - Anti-icing protection shall be provided for rescue boat and its deployment and recovery equipment.
6.3.5.23	Rescue boat arrangements		X	X	Functional requirements: - The rescue boat and deployment equipment shall function under the design environmental conditions. Performance requirements: - The rescue boat engine shall be arranged to ensure it will start readily when required under the design temperature (t_d). Prescriptive requirements: - The rescue boat engine shall be fitted with a heater. - Materials for rescue boat davits and related components shall be selected according to Sec 6.3.10.1, as appropriate. - Rescue boat engine fuel oil shall be suitable for operation under the design temperature (t_d).
6.3.5.24	Machinery spaces heating system		X	X	Functional requirements: - Spaces containing equipment necessary to perform main functions and safety functions shall be kept at a temperature that ensures safe operation of the essential equipment.

					Performance requirements: - Engineering spaces shall be kept at a temperature of at least +5°C. Prescriptive requirements: - The heating consumption is to be calculated based on an external ambient temperature of 20°C below the design temperature (t_d). - Engineering spaces shall be provided with heating as required. Spaces that may need heating include, but are not limited to: steering gear room, emergency fire pump room, CO_2 rooms, foam rooms, battery rooms, and bow thruster rooms.
6.3.5.25	Muster station and survival craft arrangements	X			Functional requirements: - Access to life rafts and lifeboats, muster station, and embarkation area must be immediately available and safe to use in an emergency under the design environmental conditions. Prescriptive requirements: - Access areas to lifeboat and life rafts, muster station and embarkation area shall be fitted with anti-icing protection.
6.3.5.26	Muster station and survival craft arrangements		X	X	Functional requirements: - Access to life rafts and lifeboats, muster station, and embarkation area must be immediately available and safe to use in an emergency under the design environmental conditions. Prescriptive requirements: - The muster station shall be located inside. - The embarkation area and access to the lifeboats and life rafts shall be fitted with anti-icing protection.
6.3.5.27	Muster station and survival craft arrangements			X	Functional requirements: Access areas to lifeboat and life rafts, muster station and embarkation area shall be dimensioned for people wearing suitable polar clothing.
6.3.5.28	Other safety arrangements			X	Functional requirements: The vessel shall carry survival equipment suitable for the polar environment.

					Prescriptive requirements: - Group survival kits shall be stored so that they may be easily retrieved and deployed in an emergency situation. Containers shall be located adjacent to the survival craft and be designed so that they may be easily moved over the ice and be floatable. - Personal survival kits shall be stored in dedicated lockers in the muster station. - Sufficient personal and group survival kits shall be carried to cover at least 110% of the persons on board the vessel. - The vessel shall carry personal survival kits and group survival kits as described in IMO Res. A.1024(26), Sec. 11.3 and 11.4.
6.3.5.29	Personal life-saving appliances	X	X	X	Functional requirements: - Lifesaving equipment shall be stored so that the equipment is not harmed by the cold climate, and so that it is immediately available. - The bridge life-buoy shall be kept ice-free and immediately ready to launch. Prescriptive requirements: - Anti-icing protection to be provided in storage facilities for life saving equipment. - Bridge life-buoy shall be provided anti-icing protection and be arranged such that it is immediately deployable by the crew.
6.3.5.30	Pressure relief valves	X	X	X	Functional requirements: - Pressure relief valves shall function properly in the design environmental condition and shall not be impaired by ice or snow. Prescriptive requirements: - Anti-icing protection shall be provided to pressure relief valves and vent heads associated with any pressure relief discharge line. - Associated piping arrangements shall be self-draining. The drains shall be located at the lowest points in the system, and

					the piping layout shall ensure all liquids will drain to them without being trapped in U-bends, low points or dead-ends.
6.3.5.31	Pressure relief valves		X	X	Functional requirements: - Pressure relief valves shall function properly in the design environmental condition. Performance requirements: - Pressure relief valves shall be made from materials suitable for the design temperature (t_d). Prescriptive requirements: - Materials for pressure relief valves shall be selected according to Sec 6.3.10.1, as appropriate.
6.3.5.32	Protective gear	X	X	X	Functional requirements: - Appropriate personal protective equipment shall be provided that protects the crew while working outdoors in the design environmental conditions, as well as from falling ice and slippery decks.
6.3.5.33	Stairs	X	X	X	Functional requirements: - Personnel should be able to move safely up and down Stairs in the design environmental conditions. Prescriptive requirements: - Stairs that are not part of escape ways or not in regular use may be considered, on a case-by-case basis, for de-icing protection. - External Stairs and their top railing shall have anti-icing protection to make them safe for personnel.
6.3.5.34	Ventilation systems	X	X	X	Functional requirements: - Ventilation openings for spaces containing equipment necessary to perform main functions and safety functions shall be operational at all times under the design environmental conditions. Prescriptive requirements: - Ventilation openings shall be provided with anti-icing protection. *Note:*

					For Winterized Cold and Winterized Polar, passive protection (e.g., protective cowlings or vestibules that prevent snow, ice or sea spray ingress) is preferred to active protection (eg. heat tracing).
6.3.5.35	Ventilation systems		X	X	Functional requirements: - Ventilation openings for spaces containing equipment necessary to perform main functions and safety functions shall be operational at all times under the design environmental conditions. Prescriptive requirements: - Ventilation openings shall be equipped with an alarm to indicate blockage.
6.3.5.36	Working environment		X	X	Functional requirements: - The deck/manifold watch shall be provided with a shelter that keeps them warm and protects them from wind, cold and precipitation while also allowing them to perform their essential duties. Prescriptive requirements: - The shelter shall be capable of maintaining an inside temperature of at least +5°C. The heating consumption requirements shall be calculated based on an external ambient temperature of 20°C colder than the design temperature (t_d). - A heated watchman's shelter shall be arranged at the gangway or at a location covering both the gangway and the loading manifold.
6.3.6	**Hull and Structure**				
6.3.6.1	Helicopter deck	X	X	X	Functional requirements: - The helicopter deck, where fitted, shall maintain its structural integrity under the additional loading of snow and ice accumulation. Prescriptive requirements: - The structural integrity of the helicopter deck design shall be confirmed by calculations. Snow and ice loading calculations in this requirement shall use the same snow and ice loads as those used for stability calculations in Sec 6.3.2.3.

6.3.6.2	Helicopter deck		X	X	Functional requirements: - An elevated helicopter deck, where fitted, shall be made from materials suitable for the material design temperature (t_d) specified in the class notation. Prescriptive requirements: - Materials for an elevated helicopter deck shall be selected according to Sec [6.3.10.1], as appropriate. *Note:* - *Material requirements for the main supporting structure for the helicopter deck sub-structure and helicopter decks that are part of the hull structure are covered by Section 7 for vessels with the DAT notation or by Section 8 for vessels with a PC ice class notation.* - *Aluminum helidecks are suitable to all levels of winterization.*
6.3.7	Navigation				
6.3.7.1	Navigation bridge		X	X	Functional requirements: - The navigating officers shall be able to navigate the vessel without being exposed to the outside environment. Prescriptive requirements: - Navigation bridge wings shall be fully enclosed. - Additional conning positions (eg. aloft conning position for use in ice navigation, aft-facing conning positions), if fitted, shall also be fully enclosed. - The ship's side shall be visible from the bridge wings without opening the bridge windows.
6.3.7.2	Navigation lights	X	X	X	Functional requirements: - Navigation lighting shall be operable under the design environmental conditions. Prescriptive requirements: - Navigation lights shall be tested for proper operation as per Sec [6.3.7.3]. - Sidelight screens shall be provided with anti-icing protection to ensure the required lighting sector is not obstructed by snow or ice accumulated on the screen.

					- Navigation lights must either generate sufficient heat to keep the light fixture ice-free under the design environmental conditions or be provided with anti-icing protection.
6.3.7.3	Navigation systems	X	X	X	Functional requirements: - Navigation equipment required by SOLAS Ch V and additional navigation equipment fitted to fulfil the requirements of other class notations assigned to the vessel (eg. **DYNPOS**) shall be available and operable under the design environmental condition. Prescriptive requirements: - Relevant navigation equipment located outside or in unheated compartments shall be tested for proper operation at a temperature of -25°C or the design temperature (t_d) specified in the notation, whichever is colder. *Note:* *Test procedures found in IEC 60945 may be adopted, using the test temperature specified in the prescriptive requirement, above.*
6.3.7.4	Navigation systems	X	X	X	Functional requirements: - Positioning sensors (eg. anemometers) fitted to fulfil equipment requirements of other class notations assigned to the vessel (eg. **DYNPOS**) shall operate under the design environmental conditions. Prescriptive requirements: - Such positioning sensors shall be either of a type not adversely affected by icing, or they shall have anti-icing protection.
6.3.7.5	Navigation systems	X	X	X	Functional requirements: - Antennae to navigation equipment required by SOLAS Ch.V and additional navigation equipment fitted to fulfil requirements of other class notations assigned to the vessel (eg. **DYNPOS**) shall function properly in the design environmental conditions. Performance requirements:

					- The movement of rotating antennae (eg. radar) shall not be inhibited by snow or ice. - Relevant antennae shall be protected from snow and ice accumulation that interferes with signal performance. Prescriptive requirements: - The pedestals for rotating antennae (e.g., radar) shall have anti-icing to ensure rotation of the antenna is not inhibited by snow or ice under the design environmental conditions. - Dome and rod antennae shall be located such that heavy snowfall will not bury the antennae. - Relevant antennae shall be provided anti-icing protection. Antennae may be heated or placed in heated domes. Whip type antennae do not require heating arrangements. Where relevant equipment requires antennae that cannot be heated, then provision shall be made for easy access for manual de-icing.
6.3.7.6	Navigation systems, others	X	X	X	Functional requirements: - Windows to the navigation bridge shall be ice and frost free under the design environmental conditions. Prescriptive requirements: - Window washers shall be protected from freezing under the design environmental conditions - Windows shall be fitted with window wipers that will operate and remain ice-free under the design environmental conditions. - All windows within the required field of vision shall be provided with appropriate heating arrangements. Windows shall comply with ISO 3434 and ISO 8863. The heating capacity shall be designed for an outside temperature of -20°C or less *Note:* - *When a field of vision larger than defined by SOLAS is required by a class notation, eg.*

					***NAUT-AW**, this should be taken into account.* - *Reference is made to ISO 17899 for marine electric window wipers.*

6.3.7.7	Searchlights		X	X	Functional requirements:
					- The ice searchlights shall function in the design environmental conditions.
					- The vessel shall have ice searchlights to aid in detection of ice during navigation in darkness.
					
					Performance requirements:
					- The luminous intensity of the focused position of the ice searchlight shall be sufficient to provide an illumination of 5.6 lux at a distance of at least 1000 meters from the foremost part of the vessel or twice the vessel's stop distance at full speed, whichever is greater, with an atmospheric transmission of 0.8.
					
					Prescriptive requirements:
					- To function in the design environmental conditions, ice searchlights shall be fitted with the following:
					  - anti-icing protection of the rotation mechanism, if the light is rotatable.
					  - anti-condensation function of the searchlight housing;
					  - means for securing the starter function at low temperatures;
					- The lights shall be operable remotely from the wheelhouse.
					- The lights shall include functionality for focusing the cone of light from the wheelhouse.
					- Ice searchlights shall be located and mounted so that the wheelhouse visibility is not obstructed in snow (i.e., the lights should be positioned as far forward as practicable and should not be mounted above the viewing level of the navigation bridge).
					- The vessel shall have at least one ice searchlight, which shall in so far as possible be located in the forepart of the ship, and shall be of sufficient luminous

					intensity to meet the performance requirement.
6.3.7.8	Sound signal appliances	X	X	X	Functional requirements: - The vessel's whistle shall operate under the design environmental condition. Prescriptive requirements: - Steam or air lines to the whistle, where fitted, shall be protected from freezing at the design temperature (t_d). - The whistle shall be fitted with anti-icing to ensure it will operate under the design environmental conditions.
6.3.8	**Piping**				
6.3.8.1	Air pipes and vent heads	X	X	X	Functional requirements: - Air pipes and vent heads to tanks shall be able to maintain proper tank ventilation under the design environmental condition. Prescriptive requirements: - Anti-icing protection shall be provided for all the air pipes and vent heads for all tanks.
6.3.8.2	Ballast, fresh water and other tanks	X	X	- X	Functional requirements: - For fresh water tanks and other tanks intended for holding liquids subject to freezing under the design environmental conditions, freezing of tank contents shall be controlled such that it does not cause any harm to the tank or equipment. - Freezing of ballast water shall be controlled such that it does not cause any harm to the tank or equipment, and does not interfere with ballasting, de-ballasting or shifting of ballast. - The vessel shall be able to safely ballast, de-ballast and shift ballast in the design environmental condition. Prescriptive requirements: - In determining the need for anti-freezing protection of fresh water and other relevant tanks, the freezing point of the intended tank contents shall be used in tank calculations. - Where arrangements to prevent freezing of ballast water are required under other sections of these Rules, the more stringent

					design environmental conditions shall be used in calculations. - Tank level gauging shall function under the design operational conditions. - GRP piping and other systems and structures in the tanks that may be damaged by freezing and falling ice shall be suitably protected. - The vessel shall have an arrangement to prevent the surface of ballast tanks, fresh water tanks and other relevant tanks from freezing over under the design environmental conditions. *Notes:* - *Before pumping of tanks is commenced, proper functioning of level gauging arrangements is verified and air pipes are checked for possible blockage by ice.* - *An arrangement to prevent freezing of the ballast water need not be provided for ballast tanks located fully below the water line or lower ice water line (LIWL), whichever is lower, or where heat balance calculations show the tank will not freeze under the design environmental conditions.* - *When a tank is situated partly above the LIWL, an air-bubbling arrangement or a vertical heating coil, capable of maintaining an open hole in the ice layer, will normally be accepted for **Winterized Basic**.*
6.3.8.3	Compressed air system	X	X	X	Functional requirements: - The supply of compressed air to essential systems shall be provided with air drying sufficient to prevent condensation under the design environmental conditions. Prescriptive requirements: - Compressed air shall be provided with air drying sufficient to lower the dew point to not warmer than -25°C or 15°C colder than the design temperature (t_d) at the actual pressure, whichever is colder.
6.3.8.4	Fuel oil system		X	X	Functional requirements:

					- Transfer of fuel oil shall be possible under the design environmental conditions. Prescriptive requirements: - Transfer lines for heavy fuel oil exposed to the low temperature environment shall have heat tracing. - Fuel oil heating system shall be sufficiently dimensioned to enable transfer of fuel under the design environmental conditions.
6.3.8.5	Hydraulic power system	X	X	X	Functional requirements: - Hydraulic systems serving main functions shall operate under the design environmental conditions. Prescriptive requirements: - For calculation of heat load and choice of hydraulic oil for systems located outdoors or in non-heated spaces, a temperature of 20°C below the design temperature (t_d) shall be considered. - Hydraulic fluid shall either be of a type that maintains an acceptable viscosity, or the hydraulic system shall have heating/circulation arrangements to keep fluids at an appropriate temperature to ensure the operability of the essential systems they serve.
6.3.8.6	Piping	X	X	X	Functional requirements: - Piping shall not be damaged by internal freezing under the design environmental conditions. Performance requirements: - Anti-freezing protection shall be provided for piping on open decks and in non-heated spaces that carry liquids susceptible to freezing under the design environmental conditions. Prescriptive requirements: - Anti-freezing protection may be achieved by locating piping in a heated passageway or trunk, by providing them with heat tracing, or by arranging them as a dry, self-draining system. Where piping is arranged as a dry, self-draining system, drains shall be

					located at the lowest points in the system, and the piping layout shall ensure all liquids will drain to them without being trapped in U-bends, low points or dead-ends.
6.3.8.7	Pollution prevention arrangements			X	Functional requirements: - The vessel shall be designed to reduce the possibility of polluting the Polar environment from oil pollution. Prescriptive requirements: - The oil used for stern tube and controllable-pitch propeller systems shall be non-toxic and biodegradable type. - For oil tankers, the accidental oil outflow index: OM shall not exceed 0.01 calculated in accordance with revised MARPOL Annex I, Reg. 23. - The vessel shall have the class notation **CLEAN**.
6.3.8.8	Sea chests	X	X	X	Functional requirements: - Cooling water systems for machinery that are essential for the propulsion and safety of the vessel, including sea chests inlets, shall be designed to ensure supply of cooling water under the design environmental conditions. Performance requirements: - The sea cooling water inlet and discharge for main and auxiliary engines shall be arranged so that blockage of strums and strainers by ice is prevented. Prescriptive requirements: - Vessels with an ice class notation shall comply with the respective requirements in Sec [2.3.3]; Sec [3.11.2]; Sec [4.9.3]; Sec [8.10.10], as appropriate for their ice class. - Vessels without an ice class notation shall comply with the requirements in either Sec [2.3.3]; Sec [3.11.2]; Sec [4.9.3]; Sec [8.10.10].
6.3.8.9	Ventilation systems for hazardous cargo areas	X	X	X	Functional requirements: - Venting system for cargo tanks shall be operational under design environmental conditions. Prescriptive requirements:

					- Cargo tank venting systems shall be fitted with anti-icing protection (pressure/vacuum valves, pressure/vacuum breakers, safety valves, flame arresters). - Cargo tank pressure/vacuum breakers shall be fitted with anti-freezing protection (e.g., glycol or heating).
6.3.9	**Telecommunication**				
6.3.9.1	External communication systems	X	X	X	Functional requirements: - External communications systems required by SOLAS Ch.V and additional communications equipment fitted to fulfil requirements of other class notations assigned to the vessel shall function properly in the design environmental conditions. Performance requirements: - Relevant antennae shall be protected from snow and ice accumulation that interferes with signal performance. - The movement of rotating antennae shall not be inhibited by snow or ice. Prescriptive requirements: - Pedestals for rotating antennae shall have anti-icing to ensure rotation of the antenna is not inhibited by snow or ice under the design environmental conditions. - Relevant antennae shall be provided anti-icing protection. Antennae may be heated or placed in heated domes to protect them from snow and ice accumulation. Whip type antennae do not require heating arrangements. Where relevant equipment requires antennae that cannot be heated, then provision shall be made for easy access for manual de-icing - Dome and rod antennae shall be located such that heavy snowfall will not bury the antennae.
6.3.9.2	External communication systems	X	X	X	Functional requirements: - Communication equipment required by SOLAS Ch.V and additional communications equipment fitted to fulfil

					requirements of other class notations assigned to the vessel shall function properly in the design environmental conditions. Prescriptive requirements: - Relevant communication equipment located outside or in unheated compartments shall be tested and certified to operate properly down to -25°C or the design temperature (td) specified in the notation, whichever is colder. -
6.3.9.3	GMDSS- EPIRB	X	X	X	Functional requirements: - The EPIRB shall be kept ice-free and immediately ready to launch Prescriptive requirements: - The EPIRB shall be provided anti-icing protection and be arranged such that it is able to float free to the surface without crew intervention. Alternatively, the EPIRB shall be arranged with de-icing protection and an additional EPIRB mounted inside the wheelhouse, ready for immediate deployment by the crew.
6.3.9.4	GMDSS – Global maritime distress and safety system			x	Functional requirements: - Suitable communication equipment shall be fitted for high latitude operations. Prescriptive requirements: - The vessel shall comply with SOLAS Ch.IV communication equipment requirements for Area A4.
6.3.10	**Multi discipline**				
6.3.10.1	Equipment material		x	x	Functional requirements: - All equipment exposed to the low temperature and being important for vessel operations shall be made from materials suitable for the material design temperature (td) specified in the class notation. Prescriptive requirements: - For equipment or parts of equipment fabricated from plate material, steel grades shall be selected as follows, according to Sec [7.2]

					- Class III:
					  - Emergency towing arrangement (tankers)
					  - Lifeboat and rescue boat davits
					  - Anchoring and mooring equipment
					
					- Class II:
					  - Cargo securing devices
					  - Mast with derrick having load greater than 3 tons
					  - Other equipment or components not specified as Class I or Class III, unless upgraded or downgraded on a case-by-case basis due to special considerations of loading rate, level and type of stress, stress concentrations and load transfer points and/or consequences of failure.
					
					- Class I:
					  - Natural vents
					  - Cargo hatches, service hatches and access hatches
					- For pipes, the pipe material shall be selected in the same manner as for plate material above or according to .Pt2 Ch 2 sect 17
					
					- For equipment or parts of equipment fabricated from forged or cast material, the impact test temperature and energy shall fulfil the requirements in Table 6.3.1

6.3.10.2	Winterization arrangements - Installations associated with optional class notation	X	X	X	Functional requirements: - Installations made in connection with optional class notations and which are essential for safety shall function properly in the design environmental conditions. Arrangements that are essential for safety include those required for a vessel to perform the primary safety-related functions of its type. Prescriptive requirements: - Fire-Fighting arrangements in a vessel with the class notation **Fire Fighter** shall be provided

					with anti-icing and anti-freezing protection. - Rescue arrangements in a vessel with class notation **Standby Vessel** shall be provided with anti-icing protection.

Table 6.3.1 Material Testing		
t_d	**t_{test}**	**Charpy (Min)**
$t_d \geq -20^0C$	0^0C	27 J
$-20^0C > t_d \geq -35^0C$	-20^0C (or) 0^0C	27 J
		48 J
$-35^0C \geq t_d$	-20^0C	27 J

SECTION 7 DAT (-X^0 C)

Contents

7.1 General

7.1.1 Classification

7.1.1.1 The requirements in this section apply to materials in ships of any type intended to operate for longer periods in areas with low air temperatures (i.e. regular service during winter to Arctic or Antarctic waters). Vessels built in compliance with the requirements of Sec 6, will be assigned the notation **DAT(-X°C),** indicating the design temperature applied as basis for approval.

7.1.2 Documentation

7.1.2.1 The design temperature to be specified and documented.

7.1.3 Definitions

7.1.3.1 External structure is defined, with respect to design temperature, as the plating with stiffening to an inwards distance of 0.6 metre from the shell plating, exposed decks and exposed sides and ends of superstructure and deckhouses.

7.1.3.2 Temperature terms definitions

Design temperature is a reference temperature used as a criterion for the selection of steel grades. The design temperature for external structures is defined as the lowest mean daily average air temperature in the area of operation. This temperature is considered to be comparable with the lowest monthly mean temperature in the area of operation −2°C. If operation is restricted to «summer» navigation the lowest monthly mean temperature comparison may only be applied to the warmer half of the month in question.

Note:
The design temperatures are defined by the user when signing the class contract(Refer Fig. 1 Definition of Temperature). The extreme design temperature may be set to about 20°C below the lowest mean daily average air temperature, or the material design temperature, if information for the relevant trade area is not available.

Lowest mean daily average temperature is the lowest value on the annual mean daily temperature curve for the area in question. For seasonally restricted service the lowest value within the time of operation applies.

Lowest monthly mean temperature is the monthly mean temperature for the coldest month of the year.

Monthly mean temperature (MAMDAT) is the average of the mean daily temperature for the month in question.

Mean daily average temperature (MDAT) is the statistical mean average temperature for a specific calendar day, based on a number of years of observations.

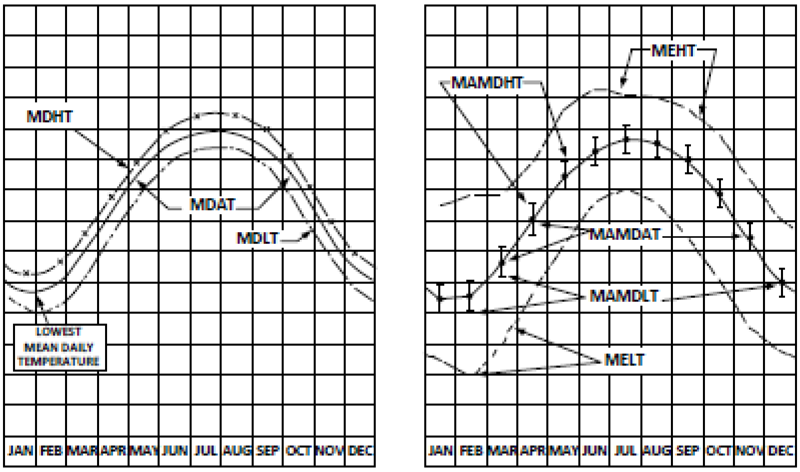


Fig. 1 Definitions of Temperatures

MDHT	Mean(*)Daily High (or maximum) Temperature
MDAT	Mean(*) Daily Average Temperature
MDLT	Mean(*)Daily Low (or minimum) Temperature
MAMDHT	Monthly Average(**) of MDHT
MAMDAT	Monthly Average(**) of MDAT
MAMDLT	Monthly Average(**) of MDLT
MEHT	Monthly Extreme High Temperature (ever recorded)
MELT	Monthly Extreme Low Temperature (ever recorded).
(*) Mean: Statistical mean over observation period (at least 20 years)	
(**) Average: Average during one day and night	

7.2 Material Selection

7.2.1 Structural categories

7.2.1.1 Structural strength members or areas are classified in 4 different classes for the purpose of selecting required material grades. The relevant members are classified as specified in Table B1. The classes are generally described as follows:

Class IV:
- Strakes in the strength deck and shell plating amidships intended as crack arrestors.
- Highly stressed elements in way of longitudinal strength member discontinuities.

Class III:
- Fore ship substructure in vessels with notations Icebreaker or POLAR.
- Plating chiefly contributing to the longitudinal strength.
- Critical appendages for the main functions of the vessel, eg. stern frames, rudder horns, rudder.
- Shaft bracket and propeller nozzles.
- Aft ship substructures in vessels equipped with podded propulsors and azimuth thrusters, and intended for continuous operation astern.
- Foundations and main supporting structures for heavy machinery and equipment.
- Crane pedestal and main supporting structure
- Main supporting structure for helideck sub-structure
- Frames for windlasses, emergency towing and chain stopper, when equipment is welded to foundation or deck (ie. not applicable when

equipment is bolted to foundation or deck).

Note:
Main supporting structures are primary load bearing members such as plates, girders, web frames/bulkheads and pillars.

Class II:
- Deck house or superstructure exposed to longitudinal stresses within 0.6L amidship.
- Structures for cargo, bunkers and ballast containment.
- Structures for subdivisions.
- Gutter bars of oil spill coamings attached to hull.
- Structures contributing to longitudinal and/or transverse hull girder strength in general.
- Internal longitudinal members (stiffeners, girders) on plating exposed to external low temperatures where class III and IV is required.

Class I:
  - Cargo hatch covers.
  - Deckhouse or superstructure in general.
- Local members in general unless upgraded due to special considerations of loading rate, level and type of stress, stress concentrations and load transfer points and/or consequences of failure.

Table 7.2.1 Material Class of Strength Members (General)

Structural Member	**Within 0.4L Amidships (Within 0.2L Aft of Amidships and 0.30L Fwd of Amidships in vessels with Icebreaker or POLAR notation)**	**Elsehwere**
PRIMARY: 1. Bottom plating, including keel plate 2. Strength deck plating, excluding that belonging to special category 3. Continuous longitudinal members above strength deck, excluding hatch coamings 4. Uppermost strake in longitudinal bulkhead 5. Vertical strake (hatch side girder) and upper most sloped strake in top wing tank.	III[7)]	II
SECONDARY: 1. Longitudinal bulkhead strakes, other than that belonging to the Primary category 2. Deck plating exposed to weather, other than that belonging to the Primary and Special category 3. Side plating 4. Transverse bulkhead plating	II	II
SPECAIL CATEGORY 1. Shear strake at strength deck [1) 2)] 2. Stringer plate in strength deck [1) 2)] 3. Deck strake at longitudinal bulkhead, excluding deck plating in way of inner-skin bulkhead of double-hull ships[1)] 4. Strength deck plating at outboard corners of cargo hatch openings in container carriers and other ships with similar hatch opening configurations [3)] 5. Strength deck plating at corners of cargo	IV	III[6)]

hatch openings in bulk carriers, ore carriers combination carriers and other ships with similar hatch opening conFig.urations4) 6. Bilge strakes 1), 8), 9) 7. Longitudinal hatch coamings of length greater than0.15L5) 8. End brackets and deck house transition of longitudinal cargo hatch coamings5)		

1) Single strakes required to be of class IV or of grade NV E/EH and within 0.4 L amidships shall have breadths not less than (800 + 5 L) mm, and need not to be taken greater than 1 800 mm, unless limited by the geometry of the ship's design.
2) Not to be less than grade NV E/EH within 0.4 L amidships in ships with length exceeding 250 m.
3) Min. class IV within cargo region.
4) Class IV within 0.6L amidships and class III within rest of cargo region.
5) Not to be less than grade NV D/DH.
6) May be class II outside 0.6 L amidships
7) May be class II if relevant midship section modulus as built is not less than 1.5 times the rule midship section modulus, and the excess is not credited in local strength calculations.
8) Not to be less than grade NV D/DH within 0.4 L amidships in ships with length exceeding 250 m.
9) May be of class III in ships with double bottom over the full breadth and length less than 150m.

7.2.1.2 The material class requirement may be reduced by one class for:

- Laterally loaded plating having a thickness exceeding 1.25 times the requirement according to design formulae.
- Laterally loaded stiffeners and girders having section modulus exceeding 1.5 times the requirement according to design formulae.

7.2.2 Steel Grade Selection

7.2.2.1 Plating materials for various structural categories as defined in 100 of exposed members above the ballast waterline of vessels with class notation **DAT (-XºC)** shall not be of lower grades than obtained from Fig..2 using the specified design temperature.

7.2.2.2 Plating materials of non-exposed members shall not be of lower grade than obtained according to Pt 3, Ch 2, Table 2.2.8.

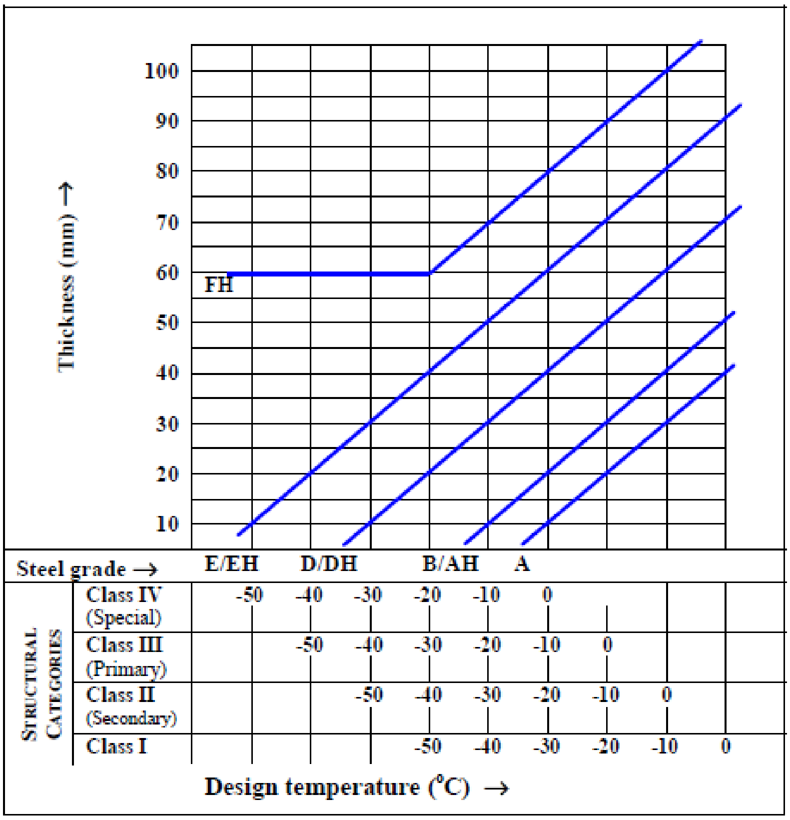


Fig. 2 Steel Grade Requirement

Note:

When the structural category is known the material grade can be selected based on the design temperature and plate thickness. Eg. if a 30 mm plate should be applied for structural category III with a design temperature of –30°C, grade E or EH need to be applied. Boundary lines form part of the lower grade.

7.2.2.3 Forged or cast materials in structural members subject to lower design temperatures than -10°C according to 7.2.1 shall fulfil requirements given in Sec 6.2.12.1, Table 6.2.4.

SECTION 8 POLAR CLASS

Contents

8.1 General

8.1.1 Application

8.1.1.1 Requirements in this section are in general equivalent to the IACS Unified Requirements for Polar Ships (UR11 to UR13), applicable to ships constructed of steel and intended for navigation in ice-infested polar waters.

8.1.1.2 The rules consider hull structure, main propulsion, steering gear, emergency and essential auxiliary systems essential for the safety of the ship and the survivability of the crew.

Note:
These rules do not consider aspects related to the operation of onboard equipment in cold climate. It is recommended that vessels intended to operate in cold climate environments for longer periods comply with the requirements as given in Sec 6, Winterization

8.1.1.3 Vessels that comply with the requirements of Section 8 can be considered for a Polar Class notation as listed in Table 8.1.1. If the hull and machinery are constructed such as to comply with the requirements of different polar classes, then the ship shall be assigned the lower of these classes in the classification certificate. Compliance of the hull or machinery with the requirements of a higher polar class is also to be indicated in the classification certificate or an appendix thereto.

8.1.1.4 Ships designed for ice breaking for the purpose of escort and ice management, and which are assigned a polar class notation **PC-1** – **PC-6**, may be given the additional notation **Icebreaker**.

8.1.2 Polar Class

8.1.2.1 Detailed description of the Polar Class (PC) notations are provided in Table 8.1.1. The owner can opt for an appropriate Polar Class, as necessary. The descriptions in Table 8.1.1 are intended to guide owners, designers and administrations in selecting an appropriate Polar Class to match the requirements for the ship with its intended voyage or service.

8.1.2.2 The Polar Class notation is used throughout the IACS Unified Requirements for Polar Ships to convey the differences between classes with respect to operational capability and strength.

Table 8.1.1 Polar Class Description

Polar Class	Ice Description (based on WMO Sea Ice Nomenclature)
PC-1	Year round operation in all Polar Waters
PC-2	Year round operation in moderate multi-year ice conditions
PC-3	Year-round operation in second-year ice which may include multi-year ice inclusions.
PC-4	Year-round operation in thick first-year ice which may include old ice inclusions
PC-5	Year-round operation in medium first-year ice which may include old ice inclusions
PC-6	Summer/autumn operation in medium first-year ice which may include old ice inclusions
PC-7	Summer/autumn operation in thin first-year ice which may include old ice inclusions

8.1.3 Documentation

8.1.3.1 As defined in Sec 1, UIWL and LIWL, shall be indicated on the shell expansion plan together with the lines separating the various hull areas .Refer Sec [8.1.5]. The ship displacement at UIWL shall also be stated.

8.1.3.2 Applicable design specifications for the operation of the vessel in ice infested waters shall be stated in the ship's loading manual, refer Pt 3, Ch 5, Sec 6. Possible design specifications are:

- Design temperature
- UIWL and LIWL
- Design Speed
- Ramming Speed
- Astern operation in ice
- Instruction for filling of ballast tanks
- Loading conditions with respect to strength and stability

Note:
*The design temperature reflects the lowest mean daily average air temperature in the intended area of operation. An extreme air temperature about 20°C below this may be tolerable to the structures and equipment from a material point of view. For calculations where the most extreme temperature over the day is relevant, the air temperature can be set 20°C lower than the design temperature in the notation. If no specification of the design temperature has been given, the values -35ºC for notations **PC-1** to **PC-5** and -25ºC for notations **PC-6** and **PC-7** will be considered.*

8.1.3.3 The required ice class for the machinery and details of the environmental conditions, if different from the ships ice class.

8.1.3.4 Information on essential main propulsion load control functions. Detailed drawings of the main propulsion machinery. Description of the main propulsion, steering, emergency and essential auxiliaries shall include operational limitations.

8.1.3.5 Detailed write up on how main, emergency and auxiliary systems are located and protected to prevent problems from freezing, ice and snow and evidence of their capability to operate in intended environmental conditions.

8.1.3.6 Calculations and documentation indicating compliance with the requirements in Sec [8.9] and Sec [8.10].

8.1.4 Ship Design and Arrangement

8.1.4.1 When the notation **Icebreaker** has been specified, the powering and the bow form shall be such that the ship can break the typical level ice condition, as defined in Table 1.1.1 for the specified Polar Class, effectively and at continuous speed.

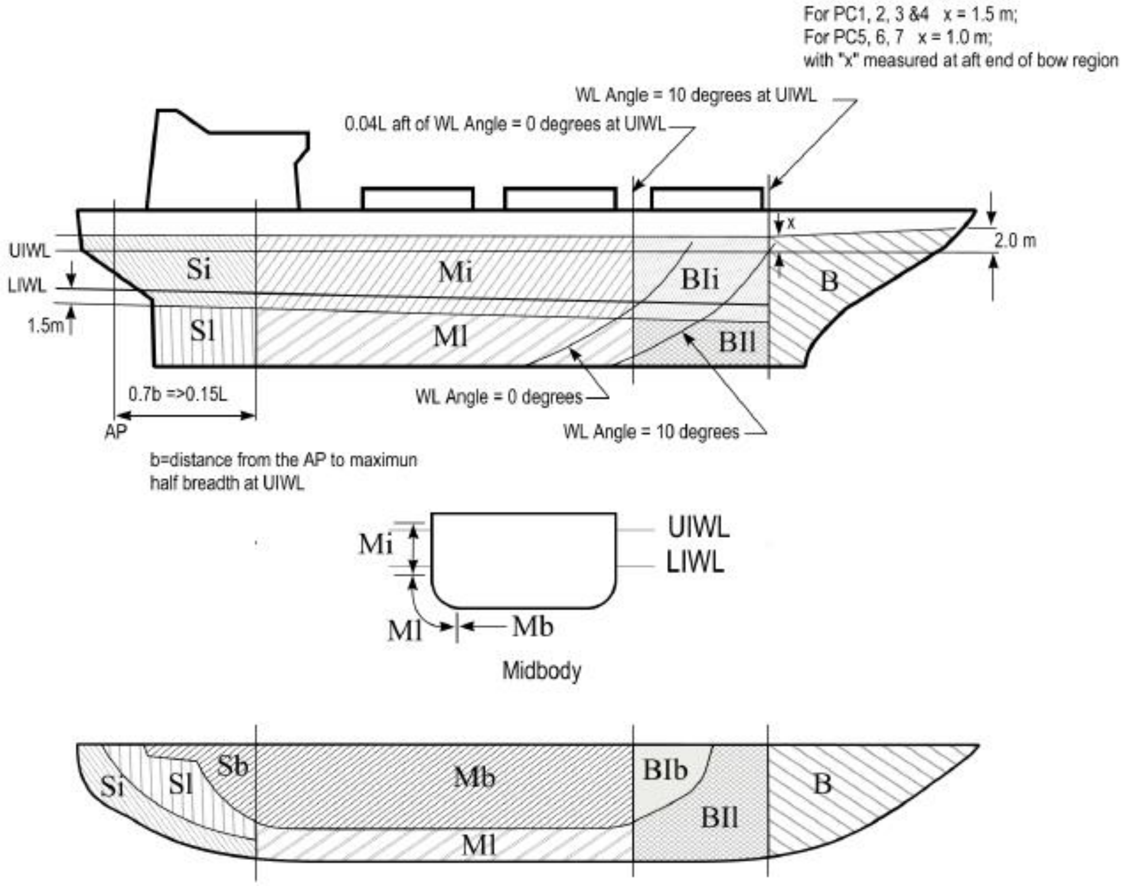


Fig. 1 Extend of Hull Area

8.1.5 Design Principles- Hull Areas

8.1.5.1 The hull of all polar class ships is divided into areas based on the magnitude of the loads the structure is subjected to. In the longitudinal direction, there are four regions: Bow, Bow Intermediate, Midbody and Stern. The Bow Intermediate, Midbody and Stern regions are further divided in the vertical direction into the Bottom, Lower and Ice belt regions. The extent of each Hull Area is illustrated in Fig..1.

8.1.5.2 The upper ice waterline (UIWL) and lower ice waterline (LIWL) are as defined in Sec.1.

8.1.5.3 At no time is the boundary between the Bow and Bow Intermediate regions to be forward of the intersection point of the line of the stem and ship baseline.

8.1.5.4 The aft boundary of the Bow region need not be more than 0.45 L aft of the forward perpendicular (FP).

8.1.5.5 The boundary between the bottom and lower regions shall be taken at the point where the shell is inclined 7° from horizontal.

8.1.5.6 If a ship is intended to operate astern in ice regions, the aft section of the ship shall be designed using the Bow and Bow Intermediate hull area requirements as given in Sec [8.2.7]

8.1.6 System Design

8.1.6.1 Any system likely to be subject to damage by freezing, shall be drainable.

8.1.6.2 Vessels classed **PC-1**, to **PC-5** inclusive shall have means provided to ensure sufficient vessel operation in the case of propeller damage including CP-mechanism (ie. pitch control mechanism).

Sufficient vessel operation means that the vessel should be able to reach safe harbor (safe location) where repair can be undertaken in case of propeller damage. This may be achieved either by a temporary repair at sea, or by towing assuming assistance is available (condition for approval).

8.1.6.3 Means shall be provided to free a stuck propeller by turning backwards. This means that a plant intended for unidirectional rotation must be equipped at least with a sufficient turning gear that is capable of turning the propeller in reverse direction.

8.1.6.4 Propulsion Power
For **PC** no explicit power requirement exists. However, according to “IMO guidelines for Ships operating in Polar waters” ships shall have sufficient propulsion power and sufficient maneuverability for operation in intended area. Engine power may be selected according to current INTLREG rule practice. Model testing is another alternative.

8.2 Design Ice Loads – Hull

8.2.1 General

8.2.1.1 A glancing impact on the bow is the design scenario for determining the scantlings required to resist ice loads for ships of all Polar Classes.

8.2.1.2 The design ice load is idealized as an average pressure (P_{avg}) uniformly distributed over a rectangular load patch of height (b) and width (w).

8.2.1.3 Within the Bow area of all polar classes, and within the Bow Intermediate Ice belt area of polar classes **PC-6** and **PC-7**, the ice load parameters are functions of the actual bow shape. To determine the ice load parameters (P_{avg}, b and w), it is required to calculate the following ice load characteristics for sub-regions of the bow area; shape coefficient (fa_i), total glancing impact force (F_i), line load (Q_i) and pressure (P_i).

8.2.1.4 In other ice-strengthened areas, the ice load parameters (P_{avg}, b_{NonBow} and w_{NonBow}) are determined independently of the hull shape and based on a fixed load patch aspect ratio, AR = 3.6.

8.2.1.5 Design ice forces, calculated according to B, are in general considered valid for bow forms where the buttock angle, γ, is less than 80 degrees and the frame angle, β, is positive and more than 10 degrees, refer Fig..2. Design ice forces for other bow forms and for bow forms that are otherwise considered to be non icebreaking will be specially considered.

8.2.1.6 Ship structures that are not directly subjected to ice loads may still experience inertial loads of stowed cargo and equipment resulting from ship/ice interaction, as given in Sec [8.2.1.6] – Sec [8.2.1.9], which shall be considered as alternative to the design accelerations given in Pt 3, Ch 4, Sec 2.

8.2.1.7 Maximum longitudinal impact acceleration at any point along the hull girder,

$$a_l = (F_{IB} / \Delta_{tk}) (1.10 \tan[\gamma + \phi] + [7H/L]) \quad (m/s^2)$$

8.2.1.8 Combined vertical impact acceleration at any point along the hull girder,

a_v = $(F_{IB} / \Delta_{tk})\ (F_x)$ (m/s^2)

Where,
F_x = 1.30 at FP
= 0.20 at Midship
= 0.40 at AP
= 1.30 at AP for vessels conducting ice breaking astern
Intermediate values may be linearly interpolated.

8.2.1.9 Combined transverse impact acceleration at any point along the hull girder,
a_t = $3\ F_{bow}\ (F_x / \Delta_{tk})$ (m/s^2)

Where,
F_x = 1.50 at FP
= 0.25 at Midship
= 0.50 at AP
= 1.50 at AP for vessels conducting ice breaking astern
Intermediate values may be linearly interpolated.

Where,

ϕ = Maximum friction angle between steel and ice normally taken at 10^0 (deg)
γ = Bow stem angle at waterline (deg)
Δ_{tk} = Displacement at UIWL (kt)
H = Vertical distance from UIWL to the point being considered (m)
F_{IB} = Vertical impact force, defined in Sec 8.4.2.
F_{BOW} = As defined in Sec 8.2.5.1.

8.2.2 Glancing Impact Load Characteristics

8.2.2.1 The parameters defining the glancing impact load characteristics are reflected in the Class Factors listed in Table 8.2.1.

Table 8.2.1 Class Factors

Polar Class	Crushing Failure Class Factor (CF_C)	Flexural Failure Class Factor (CF_F)	Load Patch Dimension Class Factor (CF_D)	Displacement Class Factor (CF_{DIS})	Longitudinal Strength Class Factor (CF_L)
PC-1	17.69	68.60	2.01	250	7.46
PC-2	9.89	46.80	1.75	210	5.46
PC-3	6.06	21.17	1.53	180	4.17
PC-4	4.50	13.48	1.42	130	3.15
PC-5	3.10	9.00	1.31	70	2.50
PC-6	2.40	5.49	1.17	40	2.37
PC-7	1.80	4.06	1.11	22	1.81

8.2.3 Bow Area

8.2.3.1 In the Bow area, the force (F), line load (Q), pressure (P) and load patch aspect ratio (AR) associated with the glancing impact load scenario are functions of the hull angles measured at the upper ice waterline (UIWL). The influence of the hull angles is captured through calculation of a bow shape coefficient (fa). The hull angles are defined in Fig..2.

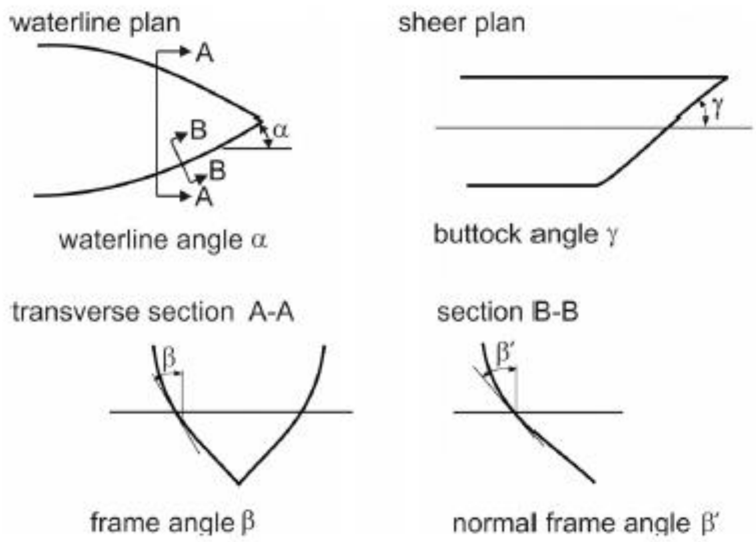


Fig. 2 Definition of Hull Angles

β = Normal frame angle at upper ice waterline (deg)
α = Upper ice waterline angle (deg)
γ = buttock angle at upper ice waterline (angle of buttock line measured from horizontal) (deg)
$\tan(\beta) = \tan(\alpha) / \tan(\gamma)$
$\tan(\beta') = \tan(\beta) \cos(\alpha)$

8.2.3.2 The waterline length of the bow region is generally to be divided into 4 sub-regions of equal length. The force (F), line load (Q), pressure (P) and load patch aspect ratio (AR) shall be calculated with respect to the mid-length position of each sub-region (each maximum of F, Q and P shall be used in the calculation of the ice load parameters P_{avg}, b and w).

8.2.3.3 The bow area load characteristics are determined as follows:

a) Shape coefficient, fa_i
fa_i = minimum ($fa_{i,1}$, $fa_{i,2}$, $fa_{i,3}$)

Where,

$fa_{i,1} = (0.097 - 0.68 [x/L_{wl} - 0.15]^2) \alpha_i / [(\beta'_i)^{0.5}]$
$fa_{i,2} = 1.20\ CF_F / [\sin(\beta'_i)\ CF_C\ \Delta_{tk}^{0.64}]$
$fa_{i,3} = 0.60$
i = Sub-region considered
L_{wl} = Ship length as defined in Pt.3 Ch1 measured on the upper ice waterline (UIWL) (m)
x = Distance from the forward perpendicular (FP) to the station under consideration (m)
α = Waterline angle (deg) Refer Fig. 2
β = Normal frame angle (deg) Refer Fig. 2
Δ_{tk} = ship displacement [kt] at UIWL, not to be taken less than 5 kt
CF_C = Crushing Failure Class Factor from Table 8.2.1
CF_F = Flexural Failure Class Factor from Table 8.2.1

b) Force, F:

$F_i = fa_i\ CF_c\ \Delta_{tk}^{0.64}$ (MN)

Where,
i = Sub region considered
fa_i = Shape coefficient of sub-region i
CF_c = Crushing Failure Class Factor from Table 8.2.1

Δ_{tk} = ship displacement (kt) at UIWL, not to be taken less than 5 kt

c) Load patch aspect ratio, AR:

$AR_i = 7.46 \sin(\beta'_i) \geq 1.30$

Where,
i = Sub region considered
β' = Normal frame angle of sub-region i (deg)

d) Line load, Q:

$Q_i = F_i^{0.61}\, CF_D / AR_i^{0.35}$ (MN/m)

Where,
i = Sub- region considered
F_i = Force of sub-region, i (MN)
CF_D = Load patch dimensions Class Factor from Table 8.2.1

AR_i = Load patch aspect ratio of sub-region i

e) Pressure, P:

$P_i = F_i^{0.22}\, CF_D^2\, AR_i^{0.3}$ (MPa)

Where,
I = Sub- region considered
F_i = Force of sub-region, i (MN)
CF_D= Load patch dimensions Class Factor from Table 8.2.1

AR_i = Load patch aspect ratio of sub-region i

8.2.4 Hull Areas Other Than Bow

8.2.4.1 In the hull areas other than the bow, the force (F_{NonBow}) and line load (Q_{NonBow}) used in the determination of the load patch dimensions (b_{NonBow}, w_{NonBow}) and design pressure (P_{avg}) are determined as follows:

a) Force, F_{NonBow} :
$F_{NonBow} = 0.36\, CF_c\, DF$ (MN)
Where,
CF_C = Crushing Force Class Factor from Table 8.2.1

CF_D = Load Patch Dimensions Class Factor from Table 8.2.1
DF = Ship displacement factor
$= \Delta_{tk}^{0.64}$ if $\Delta_{tk} \leq CF_{DIS}$
$= CF_{DIS}^{0.64} + 0.10\,(\Delta_{tk} - CF_{DIS})$ if $\Delta_{tk} > CF_{DIS}$
Δ_{tk} = Ship displacement (kt) at UIWL, not be taken less than 10 kt
CF_{DIS} = Displacement Class Factor from Table 8.2.1

b) Line Load, Q_{NonBow} :

Q_{NonBow} = 0.639 $F_{NonBow}^{0.61}$ CF_D (MN/m)

Where,
F_{NonBow} = Force from (a) (MN)
CF_D = Load Patch Dimensions Class Factor from Table 8.2.1

8.2.5 Design Load Patch

8.2.5.1 For all PC-class vessels in the bow are, and the Bow Intermediate Ice belt area for ships with class notation **PC-6** and **PC-7**, the design load patch has dimensions of width, w_{Bow}, and height, b_{Bow}, defined as follows:

w_{Bow} = F_{Bow} / Q_{Bow} (m)
b_{Bow} = Q_{Bow} / P_{Bow} (m)

Where,

F_{Bow} = Maximum force F_i in the Bow area, Sec [8.2.3.3] (b) (MN)
Q_{Bow} = Maximum line load Q_i in the Bow area, Sec [8.2.3.3] (d) (MN/m)
P_{Bow} = Maximum pressure P_i in the Bow area, Sec [8.2.3.3] (e) (MPa)

8.2.5.2 In hull areas other than those covered by Sec [8.2.5.1], the design load patch has dimensions of width w_{NonBow}, and height, b_{NonBow}, defined as below:

w_{NonBow} = F_{NonBow} / Q_{NonBow} (m)
b_{NonBow} = w_{NonBow} / 3.60 (m)

Where,
F_{NonBow} = Ice force as provided in Sec [8.2.4.1] (MN)
Q_{NonBow} = Ice line load as provided in Sec [8.2.4.1] (MN/m)

8.2.6 Pressure Within the Design Load Patch

8.2.6.1 Average pressure, P_{avg}, within a design load patch is determined a below:

P_{avg} = F / (bw) (MPa)

Where
F = F_{Bow} or F_{NonBow}; as appropriate for the hull area under consideration (MN)
b = b_{bow} or b_{NonBow}; as appropriate for the hull area under consideration (m)
w = w_{Bow} or $W_{NonBow;}$ as appropriate for the hull area under consideration (m)

8.2.6.2 In general, smaller areas have higher local pressures. Areas of higher concentrated pressure exist within the load patch. Accordingly, the peak pressure factors listed in Table 8.2.2 are used to account for the pressure concentration on localized structural members.

8.2.7 Hull area Factors

8.2.7.1 An Area Factor is associated with each hull area that reflects the relative magnitude of the load expected in that area. The area factor (AF) for each hull area is provided in Table 8.2.3

8.2.7.2 If a structural members span across the boundary of hull area, the largest hull area factor shall be used in the scantling determination of the member.

8.2.7.3 Ships having propulsion arrangements with azimuthing thruster(s) or "podded" propellers; due to their increased maneuverability shall have specially considered Stern Ice belt (S_i) and Stern Lower (S_l) hull area factors.

8.2.7.4 Those vessel operating in astern in ice regions, the area factor as for the bow shall be used for all structure within the stern ice belt area, and the bow intermediate lower and bottom area factors increased by 10% shall be used for the stern lower and bottom areas, appendages included. In addition, stern Intermediate areas shall be defined for the aft ship as for the fore ship. The Area Factor (AF) for ships intended to operate astern is listed in Table 8.2.4.

8.2.7.5 For ships for which the class notation **Icebreaker** has been requested, the area factor for any hull area shall not be taken less than as given for **PC-3**. In addition, the hull area factors for the stern ice belt and the stern lower area shall be increased by the factor 1.25. The hull area factor for the stern area need, however, in no case to be taken larger than specified for the bow region. The Area Factor (AF) for ships with class notation Icebreaker is listed in Table 8.2.5.

Table 8.2.2 Peak Pressure Factors

Structural Member		**Peak Pressure Factor (PPF_i)**
Plating	Transversely framed	$PPF_p = (1.80 – s) \geq 1.20$
	Longitudinally frame	$PPF_p = (2.20 – 1.2s) \geq 1.50$
Frames in Transversely Framed System	With load Distribution Stringers(1)	$PPF_t = (1.60 – s) \geq 1.00$
	With No load Distribution Stringers(1)	$PPF_t = (1.80 – s) \geq 1.20$
Load Carrying Stringers Side and Btm Longitudinal Web Frames		$PPF_s = 1$, if $S_W \geq 0.50\ w$ $PPF_s = 2.0 – 2.0\ S_W / w$, If $S_W < 0.50\ w$

Where,
s = Frame or longitudinal spacing (m)
S_w= Web frame spacing (m)
w = Ice load patch width (m)

(1) In order that the reduced PPF_t value may be used, the Load Distributing Stringer shall be located at or close to the middle of span of the transverse frames, to have web height not less than the 80% of the transverse frames, and to have net web thickness not less than the net web thickness of the transverse frames.

Table 8.2.3 Hull Area Factors (AF)

Hull Area		**Area**	**Polar Class**						
			PC-1	**PC-2**	**PC-3**	**PC-4**	**PC-5**	**PC-6**	**PC-7**
Bow (B)	All	B	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Bow Intermediate (BI)	Ice belt	BI_i	0.90	0.85	0.85	0.80	0.80	1.00 (*)	1.00 (*)
	Lower	BI_l	0.70	0.65	0.65	0.60	0.55	0.55	0.50
	Bottom	BI_b	0.55	0.50	0.45	0.40	0.35	0.30	0.25
Midbody (M)	Ice belt	M_i	0.70	0.65	0.55	0.55	0.50	0.45	0.45
	Lower	M_l	0.50	0.45	0.40	0.35	0.30	0.25	0.25
	Bottom	M_b	0.30	0.30	0.25	(**)	(**)	(**)	(**)
Stern (S)	Ice belt	S_i	0.75	0.70	0.65	0.60	0.50	0.40	0.35
	Lower	S_l	0.45	0.40	0.35	0.30	0.25	0.25	0.25
	Bottom	S_b	0.35	0.30	0.30	0.25	0.15	(**)	(**)

Notes:
(*) Refer Sec [8.2.1.3]
(**) Strengthening for ice loads is not necessary

Table 8.2.4 Hull Area Factors (AF) for Ships Intended to Operate Astern

Hull Area	**Area**	**Polar Class**

			PC-1	PC-2	PC-3	PC-4	PC-5	PC-6	PC-7
Bow (B)	All	B	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Bow Intermediate (BI)	Ice belt	BI_i	0.90	0.85	0.85	0.80	0.80	1.00(*)	1.00(*)
	Lower	BI_l	0.70	0.65	0.65	0.60	0.55	0.55	0.50
	Bottom	BI_b	0.55	0.50	0.45	0.40	0.35	0.30	0.25
Midbody (M)	Ice belt	M_i	0.70	0.65	0.55	0.55	0.50	0.45	0.45
	Lower	M_l	0.50	0.45	0.40	0.35	0.30	0.25	0.25
	Bottom	M_b	0.30	0.30	0.25	(**)	(**)	(**)	(**)
Stern Intermediate (SI)(***)	Ice belt	SI_i	0.90	0.85	0.85	0.80	0.80	1.00(*)	1.00(*)
	Lower	SI_l	0.70	0.65	0.65	0.60	0.55	0.55	0.50
	Bottom	SI_b	0.55	0.50	0.45	0.40	0.35	0.30	0.25
Stern (S)	Ice belt	S_i	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	Lower	S_l	0.77	0.72	0.72	0.66	0.61	0.61	0.55
	Bottom	S_b	0.61	0.55	0.50	0.44	0.39	0.33	0.28

Notes:
(*) Refer Sec [8.2.1.3]
(**) Strengthening for ice loads is not necessary
(***) The Stern intermediate region, if any, for vessels intended to operate astern is to be defied as the region forward of Stern region to section 0.04 L forward of WL angle = 0 degrees at UIWL (Refer definition of Bow Intermediate in Fig..1)

Table 8.2.5 Hull Area Factors (AF) for Ships with Class Notation Icebreaker

Hull Area		Area	Polar Class						
			PC-1	PC-2	PC-3	PC-4	PC-5	PC-6	PC-7
Bow (B)	All	B	1.00	.00	1.00	1.00	1.00	1.00	1.00
Bow Intermediate (BI)	Ice belt	BI_i	0.90	0.85	0.85	0.80	0.80	1.00 (*)	1.00 (*)
	Lower	BI_l	0.70	0.65	0.65	0.65	0.65	0.65	0.65
	Bottom	BI_b	0.55	0.50	0.45	0.45	0.45	0.45	0.45
Midbody (M)	Ice belt	M_i	0.70	0.65	0.55	0.55	0.55	0.55	0.55
	Lower	M_l	0.50	0.45	0.40	0.40	0.40	0.40	0.40
	Bottom	M_b	0.30	0.30	0.25	0.25	0.25	0.25	0.25
Stern (S)	Ice belt	S_i	0.94	0.88	0.81	0.81	0.81	0.81	0.81
	Lower	S_l	0.56	0.50	0.44	0.44	0.44	0.44	0.44
	Bottom	S_b	0.35	0.30	0.30	0.30	0.30	0.30	0.30

Notes:
(*) Refer Sec [8.2.1.3]

8.2.8 Ice Compression Load Amidships

8.2.8.1 The ship shall de designed for the load given in Sec [4.4.3]. The parameter for ice thickness to be as given in Sec.4 for an assumed similar ice class, and in agreement with Class. The load application and strength calculations to be in line with Sec [4.5.3].

8.3 Local Strength Requirements

8.3.1 Shell Plate Requirements

8.3.1.1 Required minimum shell plate thickness, t = t net + ts (mm)
Where,
t_{net} = Plate thickness (mm) required to resist ice loads according to Sec 8.3.2.
t_s = Corrosion and abrasion allowance according to][8.8.1].

8.3.1.2The orientation of the framing governs the thickness of shell plating required to resist the design ice load, t_{net}.

For transversely framed plating ($\Omega \geq 70^0$), including all bottom plating, ie the plating in hull areas B_{Ib}, M_b, and S_b, the net thickness is:

t_{net} = 500s (Af PPF_p P_{avg} / σ_F)$^{0.5}$ (1 / [1 + (s/2b)]) (mm)

In case of longitudinally framed plating ($\Omega \leq 20°$), when b ≥ s, the net thickness is:

t_{net} = 500s (Af PPF_p P_{avg} / σ_F)$^{0.5}$ (1 / [1 + (s/2l)]) (mm)

In case of longitudinally framed plating ($\Omega \leq 20°$), when b < s, the net thickness is:

t_{net} = 500s (Af PPF_p P_{avg} / σ_F)$^{0.5}$ ([2b/s] – [b/s]^2)$^{0.5}$ (1 / [1 + (s/2l)]) (mm)

For obliquely framed plating ($70° > \Omega > 20°$), linear interpolation shall be used.
Where,
Ω = Smallest angle between the chord of the waterline and the line of the first level framing as shown in Fig. 3. (deg)
s = Transverse frame spacing in transversely framed ships or longitudinal frame spacing in longitudinally framed ships (m)
AF = Hull Area Factor from Table . 8.2.3
PPF_p = Peak Pressure Factor from .8.2.2
P_{avg} = Average patch pressure as given in Sec 8.2.6. (MPa)
σ_F = Minimum upper yield stress of material (MPa)
b = height of design load patch [m], where b ≤ (l – s/4) in the case of transversely framed plating
l = distance between frame supports, ie equal to the frame span as given in Sec 8.3.2.5, but not reduced for any fitted end brackets [m]. When a load-distributing stringer is fitted, the length l need not be taken larger than the distance from the stringer to the most distant frame support

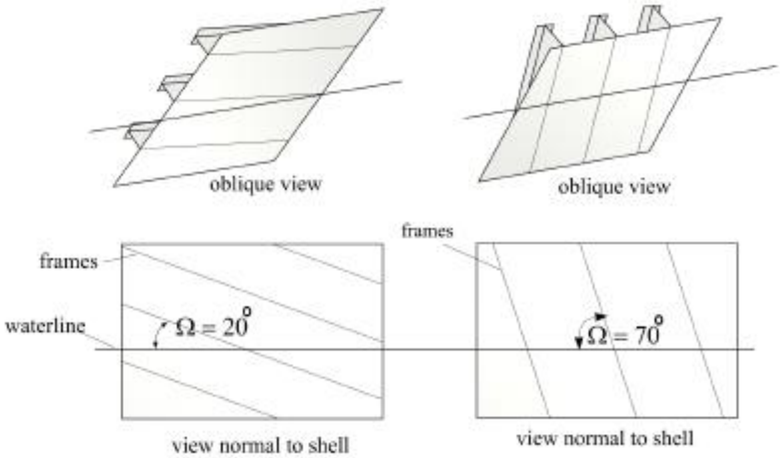


Fig. 3 Shell Framing Angle (Ω)

8.3.2 Framing General

8.3.2.1 Framing members of Polar class ships shall be designed to withstand the ice loads defined in Sec 8.2.

8.3.2.2 The usage "framing member" refers to transverse and longitudinal local frames, load-carrying stringers and web frames in the areas of the hull exposed to ice pressure, Refer Fig.1.

8.3.2.3 The strength of a framing member is dependent upon the fixity that is provided at its supports. Fixity can be assumed where framing members are either continuous through the support or attached to a supporting section with a connection bracket. In other cases, simple support should be assumed unless the connection can be demonstrated to provide significant rotational restraint. Fixity shall be ensured at the support of any framing which terminates within an ice-strengthened area.

8.3.2.4 The details of framing member intersection with other framing members, including plated structures, as well as the details for securing the ends of framing members at supporting sections, shall be in accordance with the relevant requirements as detailed in Sec 8.3.9 and Pt 3, Ch 3, Sec 3 as applicable.

8.3.2.5 Design span of framing members shall generally be determined according to Pt 3, Ch 3, Sec 3. However, the span length is only to be reduced in accordance with Pt 3, Ch 3, Sec 3 provided the end brackets fitted are flanged or the edge length in mm is equal to or less than 600 $t_{bn} / (\sigma_F)^{0.5}$.

Where,
t_{bn} = net thickness of bracket (mm)
σ_F = Minimum upper yield stress of material (N/mm^2)

8.3.2.6 Stringers and web frames, which are load bearing are to be of symmetrical cross section. When the flange is arranged to be unsymmetrical, an effective tripping support shall be provided at the midspan.

8.3.2.7 When calculating the section modulus and shear area of a framing member, net thicknesses of the web, flange (if fitted) and of the attached shell plating shall be used. The shear area of a framing member may include that material contained over the full depth of the member, ie. web area including portion of flange, if fitted, but excluding attached shell plating.

8.3.2.8 The actual net effective shear area of framing member,

$$A_w = 0.01\ h\ t_{wn} \sin\varphi_w \quad (cm^2)$$

Where,
h = Height of stiffener (mm) Refer Fig. 4
t_{wn} = Net web thickness (mm) $= t_w - t_s$
t_w = As built web thickness (mm) Refer Fig. 4
t_s = Corrosion addition (mm) as provided in Sec [8.8.1.3], to be subtracted from the web and flange thickness.
φ_w = Smallest angle between shell plate and stiffener web, measured at the midspan of the stiffener, Refer Fig..4. Angle ϕ_w may be taken as 90 degrees provided the smallest angle is not less than 75 degrees.

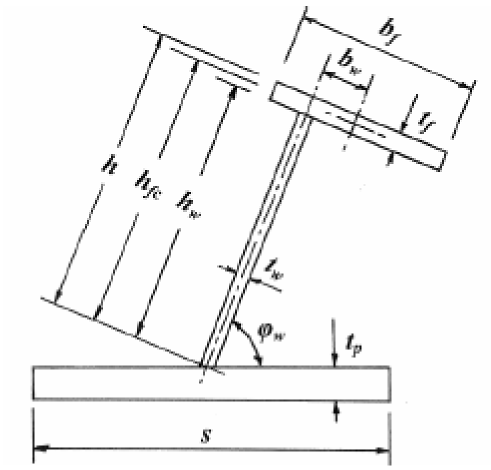


Fig. 4 Stiffener Geometry

8.3.2.9 When the cross-sectional area of the attached plate flange exceeds the cross-sectional area of the local frame, the actual net effective plastic section modulus, Z_p, is as below:

Z_p = $(0.05\ A_{pn}\ t_{pn}) + (0.0005\ h^2_w\ t_{wn}\ \sin\varphi_w) + (0.10\ A_{fn}\ [\ h_{fc}\ \sin\varphi_w - b_w\ \cos\varphi_w])$ (cm^3)

Where,

h, t_{wn}, φ_w, are as provided in Sec [8.3.2.8] and s as given in Sec [8.3.1.2]
A_{pn} = Net cross sectional are of the local frame (cm^2)
t_{pn} = Fitted net shell plate thickness (mm) (shall comply with t_{net} as required by Sec [8.3.1.2]
h_w = Height of frame web (mm) Refer Fig.4
A_{fn} = Net cross sectional area of local frame flange (cm^2)
h_{fc} = Height of local frame measured to center of the flange area (mm) Ref Fig.4
b_w = Distance from mid thickness plane of local frame web to the center of the flange area (mm) Refer Fig.4.

When the cross-sectional area of the local frame exceeds the cross-sectional area of the attached plate flange, the plastic neutral axis is located a distance z_{na} above the attached shell plate

z_{na} = $(100\ A_{fn} + h_w\ t_{wn} - 1000\ s\ t_{pn}) / (2\ t_{wn})$ (mm)

The net effective plastic section modulus Z_p,

Z_p = $(s\ t_{pn}\ [\ z_{na} + 0.5\ t_{pn}]\ \sin\varphi_w\ ) + (0.0005\ (\ [h_w - z_{na}]^2 + z^2_{na})\ t_{wn}\ \sin\varphi_w\ )) + A_{fn2}$

Where
A_{fn2} = $0.10\ A_{fn}\ (\ [h_{fc} - z_{na}]\ \sin\varphi_w - b_w\ \cos\varphi_w)$ (cm^3)

8.3.2.10 In case of oblique framing arrangement 70° > Ω > 20°, where Ω is defined as given in [8.3.1.1], linear interpolation shall be used.

8.3.3 Transversely Framed Side Structures and Bottom Structures

8.3.3.1 The local frames in transversely-framed side structures and in bottom structures (ie. hull areas B_{lb}, M_b and S_b) shall be dimensioned such that the combined effects of shear and bending do not exceed the plastic strength of the member. The plastic strength is defined by the magnitude of patch load that causes the development of a plastic hinge mechanism.

8.3.3.2 The actual net effective shear area of the frame, A_w, as defined in Sec [8.3.2.8], shall comply with the following condition:

$A_w \geq A_t$

Where,
LL = Length of loaded portion of span (lesser of a and b) (m)
a = Frame span as defined in Sec [8.3.2.5] (m)
b = Height of design ice load patch as provided in Sec [8.2.5] (m)
s = Transverse frame spacing (m)
AF = Hull Area Factor from Table 8.2.3.
PPF_t = Peak Pressure Factor from Table 8.2.2.
P_{avg} = Average pressure within load patch as provided in Sec 8.2.6. (MPa)
σ_F = Minimum upper yield stress of the material (MPa)

8.3.3.3 Actual net effective plastic section modulus of the plate/stiffener combination, Z_p, as defined in Sec [8.3.2.9], shall comply with the following condition: $Z_p \geq Z_{pt}$, where Z_{pt} shall be the greater calculated on the basis of two load conditions:

(a) Ice load acting at the midspan of the transverse frame, and
(b) Ice load acting near a support.
The parameter A_1 reflects the two conditions:

Z_{pt} = $(100^3\ LL\ Y\ s\ [\ AF\ PPF_t\ P_{avg}\ ]\ a\ A_1\ ) / (4\ \sigma_F)$ (cm^3)

Where,
LL, s, AF, PPF_t, P_{avg}, b, a, and σ_F are as provided in Sec [8.3.3.3].
Y = $1 – 0.50\ (LL / a)$
A_1 = Maximum of A_{1A}, A_{1B}
A_{1A} = $1 / (1 + j/2 + k_w\ j/2\ [(1 – a_1^2)^{0.5} - 1])$
A_{1B} = $(1 – 1/ (2\ a_1\ Y) / (0.275 + 1.44\ k_z^{0.7}\ )$
Where
j = 1 for framing with one simple support outside the ice strengthened areas.
= 2 for framing without any simple supports
a_1 = A_t / A_w
A_t = Minimum shear area of transverse frame as provided in Sec [8.3.3.3] (cm^2)
A_w = Effective net shear area of transverse frame .Refer Sec [8.3.2.8] (cm^2)
k_w = $1 / (1 + 2\ [A_{fn} / A_w]$
A_{fn} = As provided in [8.3.2.9].
k_z = z_p / Z_p in general
= 0.0 when the frame is provided with end brackets
z_p = Sum of the individual plastic section modulus of flange and shell plate as installed (cm^3)
= $(b_f\ t_{fn}^2 + b_{eff}\ t_{pn}^2) / 4000$
b_f = Flange breadth (mm) Refer Fig. 4
t_{fn} = Net flange thickness (mm)
= $t_f – t_s$, where t_s as provided in 8.3.2.8

t_f = As built flange thickness (mm) Refer Fig. 4
t_{pn} = The installed net shell plate thickness (mm) not to be less than t_{net} as provided in Sec [8.3.1.2].
b_{eff} = Effective width of shell plate flange (mm) = 500 s
Z_p = Net effective plastic section modulus of transverse frame
Refer Sec [8.3.2.9] (cm^3)

8.3.3.4 The scantlings of the frame shall meet the structural stability requirements of Sec 8.3.6.

8.3.4 Longitudinally Framed Side Structure

8.3.4.1 Side longitudinals shall be dimensioned such that the combined effects of shear and bending do not exceed the plastic strength of the member. The plastic strength is defined by the magnitude of mid span load that causes the development of a plastic collapse mechanism.

8.3.4.2 The actual net effective shear area of the frame, Aw, as defined in Sect [8.3.2.8] shall comply with the following condition:

$A_W \geq A_L$

Where,

A_L = [8666 (AF PPF_s P_{avg}) b_1 a] / (σ_F) (cm^2)

Where,

AF = Hull Area Factor (Refer Table 8.2.3)
PPF_s = Peak Pressure Factor (Refer Table 8.2.2.)
P_{avg} = Average pressure within load patch .Refer Sec 8.2.6 (MPa)
b_1 = k_0 b_2 (m)
k_0 = 1 – (0.30 / b’)
b’ = b / s
b = Height of design ice load patch .Refer [8.2.5] (m)
s = Spacing of longitudinal frames (m)
b_2 = b (1 – 0.25 b’) (m) , if b’ < 2
= s (m), if b’ ≥ 2
a = Longitudinal design span Refer Sec [8.3.2.5] (m)
σ_F = Minimum upper yield stress of material (N/mm^2)

8.3.4.3 The actual net effective plastic section modulus of the plate/stiffener combination, Z_p, as defined in Sect[8.3.2.9] shall comply with the following:

$Z_p \geq Z_{pL}$
Where,
Z_{pL} = (125000 [AF PPF_s P_{avg}] b_1 a^2 A_4) / (σ_F)

Where,
AF, PPF_s, $P_{avg,}$ b1, a and σF are as provided in [8.3.4.2].
A_4 = 1 / (2 + k_{wl} [$(1 – a_4^2)^{0.5}$ – 1])
a_4 = A_L / A_w
A_L = Minimum shear area of longitudinal as provided in Sec [8.3.4.2].
A_w = Net effective shear area of longitudinal based on Sec [8.3.2.8].
k_{wl} = 1 / (1 + 2 [A_{fn} /A_w])

Where,
A_{fn} = Refer [8.3.2.9].

8.3.4.4 The scantlings of the longitudinals shall meet the structural stability requirements of Sec [8.3.6].

8.3.5 Web Frame and Load Bearing Stringer Framing

8.3.5.1 Web frames and load bearing stringers shall be designed to withstand the ice load patch as defined in 7.2.5. The load patch shall be applied at locations where the capacity of these members under the combined effects of bending and shear is minimized.

8.3.5.2 Where load carrying stringers or web frames supporting local frames constitute regular structures with sufficient and well defined support capacity and boundary condition at end supports, and with the stringer or web frame located within the hull area considered, refer Sec [8.1.5], the required effective net web area and net section modulus is as provided in Sec [8.3.5.3] or Sec [8.3.5.5]. The required shear area and section modulus of web frames supporting load carrying stringers is as given in Sec [8.3.5.4[. Alternatively, and where web frames and load bearing stringers form part of a structural grillage system, appropriate methods of analysis as outlined in Sec [8.6.1.3] shall be considered.

8.3.5.3 The effective net web area, as defined in Pt 3, Ch 3, Sec 3.5, of web frames supporting longitudinal local frames, A_{wf}, shall not be less than:

A_{wf} = (17331 [AF PPF_s P_{avg}] LH_s LL_s K_s) / (σ_F η sinφ_w) (cm^2)

Where,
AF = Hull Area Factor from Table 8.2.3.
PPF_s = Peak Pressure Factor from Table 8.2.2.
P_{avg} = Mean pressure (MPa) within load patch as provided in Sec [8.2.6.1]
K_s = [S – 0.50 (LH_s + s)] / S, minimum 0.55
LH_s = Load height (m) with respect to shear response of web frame, smaller of b and (S-s)
LL_s = Load length (m) with respect to shear response of web frame = w (l – 0.25w) / l
L = Spacing of web frames, measured along the shell plate (m)
b = Height of design ice load patch as provided in Sec [8.2.5.1] / Sec [.2.5.2].
s = Longitudinal frame spacing (m)
S = Span (m) of web frame as provided in Sec [8.3.2.5].
w = Length (m) of load patch as provided in Sec [8.2.6.1], but is not to be taken larger than 2 l
η = Usage factor 0.90
σ_F = Minimum upper yield stress (N/mm^2) of the material
φ_w = Smallest angle (deg) between shell plate and web of the web frame, at middle of span.

The angle φ_w may be taken as 90 degrees provided the smallest angle is not less than 75 degrees.

The net elastic section modulus (cm^3) of web frames supporting longitudinal local frames, Z_{wf}, shall not be less than:

Z_{wf} = 100^3 (AF PPF_s P_{avg}) (LH_b LL_s) (S – 0.50LH_b) (1/[4 σ_F k_f sinφ_w]) – (Z_p k_{fl} S^2 / [16 a s k_f]) (cm^3)

Where,
a = Design span (m) of local frame as given in Sec [8.3.2.5]
LH_b = Load height (m) with respect to bending of web frame, smaller of b and S
k_f = End fixity parameter for the web frame
= 2.00, if fixed at both ends
= 1.50. if fixed at one end
= 1.00. if simply supported at both ends
k_{fl} = End fixity parameter for the local frames
= 2.00, if fixed at both ends
= 1.50, if fixed at one end
= 1.00, if simply supported at both ends
Z_p = Net plastic section modulus of fitted local ice frames as provided in Sec [8.3.2.9].

8.3.5.4 The effective net web area (cm^2), as defined in Pt 3, Ch 3, Sec 3.5, of web frames supporting load carrying stringers, A_{wf}, shall not be less than:

A_{wf} = $[100^2 (AF\ PPF_s\ P_{avg})\ wb\ (S – C)\ (l_{LCS} – 0.25\ w)\ (l – 0.25b)] / [0.577\ \sigma_F\ \eta\ S\ l_{LCS}\ l\ \sin\varphi_w]$ (cm^2)

Where,
AF = Hull Area Factor (Refer Table 8.2.3.)
PPF_s = Peak Pressure (MPa) Factor from Table 8.2.2.
P_{avg} = Mean pressure (MPa) within load patch as provided in Sec [8.2.6.1]
b = Height of design ice load patch as provided in Sec [8.2.5.1] / Sec [8.2.5.2].
C = Smallest distance (m) from considered load carrying stringer to web frame support
l_{LCS} = Distance between web frames (m), measured along the shell plate.
l = distance (m) from considered load carrying stringer to adjacent load carrying stringer or longitudinal support member, as applicable, measured along the shell plate
S = Span (m) of web frame as provided in Sec [8.3.2.5].
w = Length (m) of load patch as provided in Sec [8.2.6.1].
η = Usage factor 0.90
σ_F = Minimum upper yield stress (N/mm^2) of the material
φ_w = Smallest angle (deg) between shell plate and web of the web frame, measured at the load carrying stringer.

The net elastic section modulus (cm^3) of web frames supporting load carrying stringer, Z_{wf}, shall not be less than:

Z_{wf} = $[100^3(AF\ PPF_S\ P_{avg})\ wbC\ (S\text{-}C)(l_{LCS} – 0.25w)(l – 0.25b)] / [2\sigma_F\ k_f\ S\ l_{LCS}\ l\ \sin\varphi_w]$ (cm^3)

Where,

k_f = End fixity parameter for the web frame
= 2.00, if fixed at both ends
= 1.50. if fixed at one end
= 1.00. if simply supported at both ends

8.3.5.5 The effective net web area (cm^2) , as defined in Pt 3, Ch 3, Sec 3.5, of load bearing stringers, A_{lcs}, shall not be less than:

A_{lcs} = $17331\ (AF\ PPF_s\ P_{avg})\ LH_s\ LL_s\ (S – 0.5\ [LL_S + s]) / (\sigma_F\ \eta\ S\ \sin\varphi_w)$ (cm^2)

Where,
AF = Hull Area Factor (Refer Table 8.2.3.)
PPF_s = Peak Pressure (MPa) Factor from Table 8.2.2.
P_{avg} = Mean pressure (MPa) within load patch as provided in Sec 8.2.6.1
LH_s = Load height (m) with respect to shear response of stringer = b (l – 0.25b) / l
LL_s = Load length (m) with respect to shear response of stringer, smaller of w and (S-s)
l = Distance between transverse frame supports (m), measured along the shell plate
b = Height of design ice load (m) patch as given in Sec [8.2.6.1]
w = Length of load patch as given in Sec [8.2.6.1].
s = Spacing (m) of transverse frames
S = Span (m) of stringer as provided in Sec [8.3.2.5].
η = Usage factor 0.90

σ_F = Minimum upper yield stress (N/mm^2) of the material
φ_w = Smallest angle (deg) between shell plate and web of the stringer, measured at middle of span. The angle φ_w may be take s 90 degrees provided the smallest angle is not less than 75 degrees.

The net elastic section modulus (cm^3) of the stringer, Z_{lcs}, shall not be less than:

Z_{lcs} = [100^3 (AF PPF_s P_{avg}) b LL_b (S – 0.50w)] / (4 σ_F k_f sinφw)] – [(Z_p k_{fl} S^2) / (16 a s k_f)] (cm^3)
Where,
a = Design span (m) of local frame as given in Sec [8.3.2.5]
k_f = End fixity parameter for the load bearing stringer
= 2.00, if fixed at both ends
= 1.50. if fixed at one end
= 1.00. if simply supported at both ends
k_{fl} = End fixity parameter for the local frames
= 2.00, if fixed at both ends
= 1.50. if fixed at one end
= 1.00. if simply supported at both ends
LL_b = Load length (m) based on bending response of stringer, given as the smaller of w and S
Z_p = Net plastic section modulus of fitted local ice frames as provided in Sec [8.3.2.9].

8.3.5.6 The scantlings of web frames and load-carrying stringers shall meet the structural stability requirements of Sec [8.3.6].

8.3.6 Framing Structural Stability

8.3.6.1 To prevent local buckling of the web, the ratio of web height (h_w) to net web thickness (t_{wn}) of any framing member shall not exceed:

$h_w / t_{wn} \le 282 / (\sigma_F^{0.50})$, For flat bars

$h_w / t_{wn} \le 805 / (\sigma_F^{0.50})$, For bulb, tee and angle sections

Where,
h_w = Web height (m)
t_{wn} = Web thickness (m) net
σ_F = Minimum upper yield stress (N/mm^2) of material

8.3.6.2 Framing members for which it is not practicable to meet the requirements of Sec 8.3.6.1 (eg. load carrying stringers or deep web frames) are required to have their webs effectively stiffened. The scantlings of the web stiffeners shall ensure the structural stability of the framing member. The minimum net web thickness for these framing members is given by:

$t_{wn} = 0.00263\, c_1 (\sigma_F / (5.34 + 4.0 [c_1 / c_2]^2)^{0.50}$ (mm)

Where,
c_1 = h_w – 0.80 h (mm)
h_w = Web height (mm) of stringer / web frame (Refer Fig. 5)
h = Height of framing member (mm) penetrating the member under consideration, 0 if no such framing member. (Refer Fig. 5)
c_2 = Spacing (mm) between supporting structure oriented perpendicular to the member under consideration (Refer Fig. 5)
σ_F = Minimum upper yield stress (N/mm^2) of material

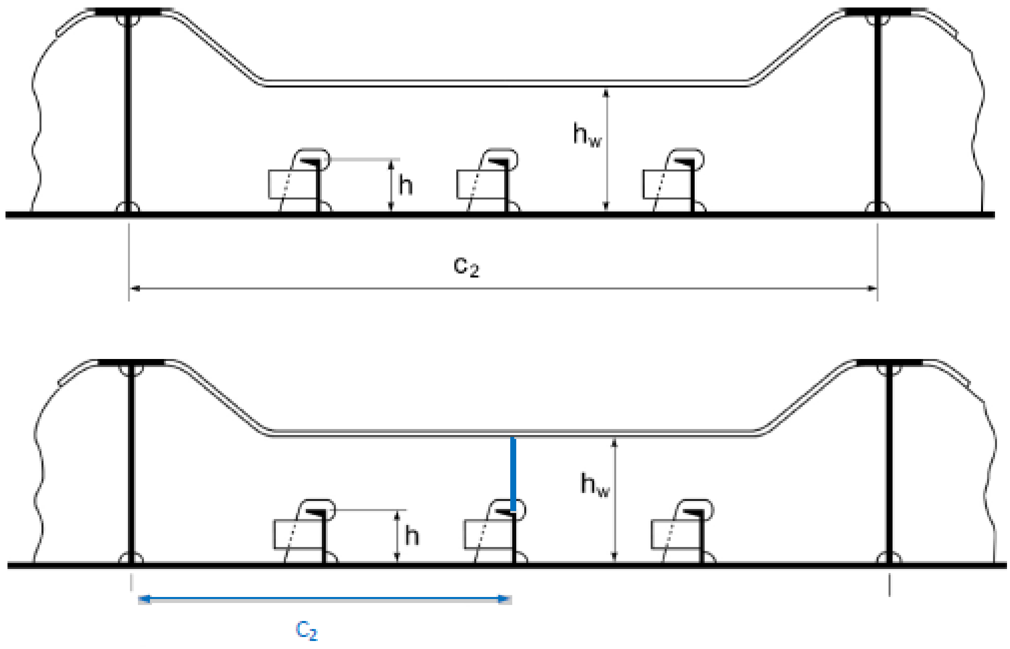


Fig. 5 Web Stiffening – Parameter Definition

8.3.6.3 In addition, the following shall be satisfied:

$t_{wn} \geq 0.35\ t_{pn}\ (\sigma_F / 235)^{0.50}$

Where,
σ_F = Minimum upper yield stress (N/mm^2) of shell plate in way of framing member
t_{wn} = Net thickness (mm) of the web
t_{pn} = Net thickness (mm) of the shell plate in way of the framing member

8.3.6.4 Local flange buckling of welded profiles shall be prevented if the following is satisfied:

(a) The flange width, b_f [mm], shall not be less than five times the net thickness of the web, t_{wn}.
(b) The flange outstand, bout [mm], shall meet the following requirement:

$b_{out} / t_{fn} \leq 155 / (\sigma_F)^{0.50}$

Where,
t_{fn} = Net thickness (mm) of flange
σ_F = Minimum upper yield (MPa) of the material

8.3.7 Plated Structures

8.3.7.1 Plated structures are those stiffened plate elements in contact with the shell and subject to ice loads. These requirements are applicable to an inboard extent which is the lesser of:

(i) Web height of adjacent parallel web frame or stringer; or
(ii) 2.5 times the depth of framing that intersects the plated structure.

8.3.7.2 The thickness of the plating and the scantlings of attached stiffeners shall be consistent with the end connection requirements for supported framing as given in Sec 8.3.9.

8.3.7.3 Plated structures subjected to direct ice loads, as defined in 3.2, shall be comply with he buckling requirements in Pt 3, Ch 14.

8.3.8 Stem and Stern Frames

8.3.8.1 The requirement of the Finnish- Swedish Ice Class Rules for the stem and stern, are to be additionally complied with for **PC-6/PC-7** vessels requiring **1A*/1A** equivalency.

8.3.8.2 When the vessel has a sharp edged stem, the thickness of the stem side plate within a breadth not less than 0.7 s, where s denotes the spacing of stiffening members, shall not be less than 1.2 t, where t denotes the required net shell plate thickness for the bow area, as provided in Sec [8.3.1].

8.3.8.3 Vessels intended to operate under harsh ice condition, and of type and size that may cause excessive beaching to occur, a forward ice knife may need to be installed. This requirement will be based on consideration of design speed, stability and freeboard.

8.3.9 End Connection for Framing Members

8.3.9.1 The end connection for framing members exposed to ice loads, to supports, such as stringers, web frames, decks or bulkheads, shall be related to the response of the member when subjected to ice loads. The connection area is generally obtained through support members such as collar plate, lugs, end brackets or web stiffener.

The total net connection area of support members shall be:

$$a = \sum_{n} 0.01\ k_\tau\ (t_i - t_s)\ h_i \quad (\text{cm}2)$$

Where,

k_τ = 1.0 for members which are shear critical
= 1.5 for members which are normal stress critical
t_i = Thickness of connection area #i
t_s = Minimum corrosion addition as provided in Sec [8.8.1.3].
h_i = Effective dimension of connection area of member #i

8.3.9.2 The net end connection area installed, a, is generally not to be less than a_o, provided below:

For longitudinal local frames:

$$a_0 = [100^2\ (AF\ PPF_s\ P_{avg})\ b_1\ (w\text{-}s)\ (a - 0.5w)] / [0.577\ \sigma_F\ \eta\ a\ \sin\varphi_w] \quad (\text{cm}^2)$$

For transverse local frames:

$$a_0 = [100^2\ (AF\ PPF_t\ P_{avg})\ sb\ (a - 0.5b - 0.5s)] / [0.577\ \sigma_F\ \eta\ a\ \sin\varphi_w] \quad (\text{cm}^2)$$

For load carrying stringers:

$$a_0 = [100^2\ (AF\ PPF_s\ P_{avg})\ b\ (w\text{-}s)\ (S - 0.5w)] / [0.577\ \sigma_F\ \eta\ S\ \sin\varphi_w] \quad (\text{cm}^2)$$

For transverse web frames supporting longitudinal local frames:

a_0 = $[100^2 (AF\ PPF_s\ P_{avg})\ wb\ (S - 0.5b - 0.5s)] / [0.577\ \sigma_F\ \eta\ S\ \sin\varphi_w]$ (cm^2)

Where,
AF = Hull Area Factor Refer Table 8.2.3
PPF_s = Peak Pressure (MPa) Factor from Table .8.2.2
P_{avg} = Mean pressure (MPa) within load patch as provided in Sec [8.2.6.1]
LH = Load height (m), smaller of b and (a – s)
LL = Load length (m), smaller of w and (a – s)
a, S = Span of member as given in Sec [8.3.2.5]. (m)
s = Spacing (m) of frames
b, w = Refer Sec [8.2.6.1]
b_1 = Refer Sec [8.3.4.2]
η = Usage factor 0.90
σ_F = Minimum upper yield stress (N/mm^2) of the material
φ_w = Smallest angle (deg) between shell plate and web of the stringer or web frame as applicable, measured at the intersection with the stiffener. The angle φ_w may be taken as 90 degrees provided the smallest angle is not less than 75 degrees.

8.3.9.3 For support members constituting the end connection, the throat thickness (mm) of double fillet welds for the attachment of the support member i, to the framing member and the support is provided as minimum of:
t_w = $\{[(t_i - t_c)\ a_0\ \sigma_F] / [450\ a\ f_w]\} + 0.5\ t_s$
= $0.50\ t_i$

Where,
a = As provided in Sec [8.3.9.2]
a_0 = As provided in Sec [8.3.9.2]
t_i = Thickness of connection member i (mm)
f_w = Refer Pt 3, Ch 11, Sec 3, [3.1.3]
t_s = Corrosion addition/ abrasion addition as given in Sec 8.[8.1.3].
The throat thickness shall not be less than that provided in Pt 3, Ch 11, Sec [3.2.2]

8.4 Longitudinal Strength

8.4.1 Application

8.4.1.1 Ice loads need only be combined with still water loads. The combined stresses shall be compared against permissible bending and shear stresses at different locations along the ship's length. In addition, sufficient local buckling strength is also to be confirmed.

8.4.2 Design Vertical Ice Force at the Bow

8.4.2.1 The design vertical ice force at the bow, F_{IB} shall be:

F_{IB} = Minimum of $F_{IB,1}$, $F_{IB,2}$ (MN)
Where,
$F_{IB,1}$ = $0.534\ K_I^{0.15} \sin^{0.2}(\gamma_{stem})\ (\Delta_{kt}\ K_h)^{0.5}\ CF_L$ (MN)
$F_{IB,2}$ = $1.20\ CF_F$ (MN)
K_I = Indentation Parameter = K_f / K_h

a) For vessels with blunt bow form:
K_f = $[2\ C\ B^{1-eb} / (1 + e_b)]^{0.9} \tan(\gamma_{stem})^{-0.9\ (1-eb)}$

b) For vessels with wedge bow form (α_{stem} < 80 deg), e_b =1.0;

K_f = [tan (α_{stem}) / tan^2 (γ_{stem})]$^{0.9}$
K_h = 0.01 A_{wp} (MN/m)

CF_L = Longitudinal Strength Class Factor from Table 8.2.1.
e_b = Bow shape exponent based on the water plane (Refer Fig. 6 and Fig. 7)
= 1.0 for simple wedge bow form
= 0.4 to 0.6 for a spoon bow form
= 0.0 for a landing craft bow form

An approximate e_b determined by a simple fit is acceptable.

γ_{stem} = Stem angle to be measured between the horizontal axis and the stem tangent at the upper ice waterline (deg) and buttock angle as in Fig. 2 measured at the centreline.
α_{stem} = Hull waterline angle (deg) to be measured at stem (centre line) at the UIWL, Refer Fig.2
C = 1 / [2 (L_B / B)^{eb}]
B = Breadth moulded (m)
L_B = Bow length (m) used in the equation y = B / 2 (x/L_B)^{eb}. (Refer Fig. 6 and Fig. 7)
Δ_{kt} = Ship displacement (kt) at UIWL, not to be taken less than 10 kt
A_{wp} = Ship water plae area (m^2)
CF_F = Flexural Failure Class Factor from Table 8.2.1.

Draught dependent quantities, wherever applicable, are to be determined at the waterline corresponding to the loading condition under consideration.

8.4.3 Design Vertical Shear Force

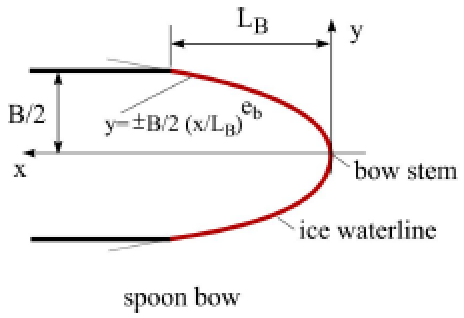
8.4.3.1 The design vertical ice shear force, FI, along the hull girder shall be:

F_I = C_f F_{IB} (MN)

Where,
C_f = Longitudinal distribution factor to be taken as follows:

i) Positive shear force
C_f = 0.0 between the aft end of L and 0.6L from aft
= 1.0 between 0.9L from aft and forward end of L

ii) Negative shear force
C_f = 0.0 at the aft end of L
= -0.5 between 0.2L and 0.6L from aft
= 0.0 between 0.8L from aft and the forward end of L
Intermediate values shall be determined by linear interpolation.



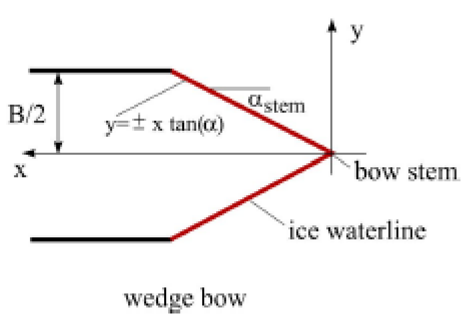


Fig. 6 Bow Shape Definition

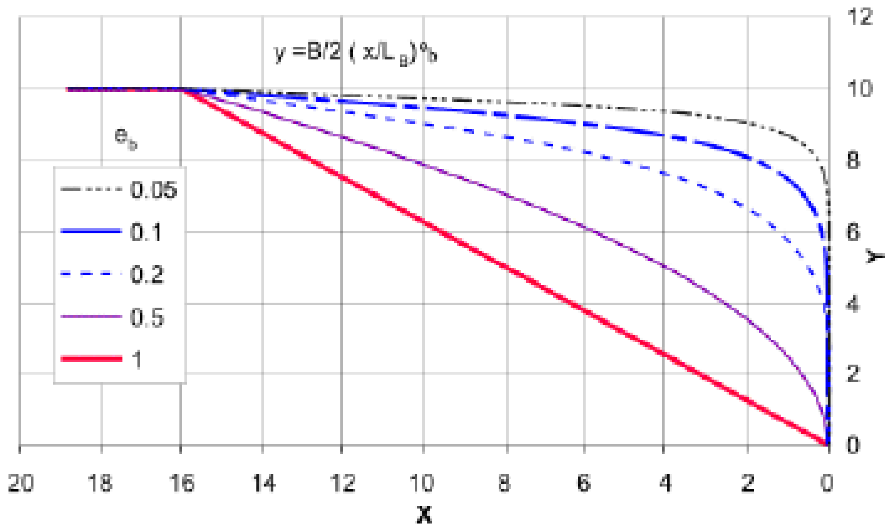


Fig. 7 e_b Effect on Bow Shape for B = 20 and L_B = 16

Table 8.4.1 Longitudinal Strength Criteria			
Failure Mode	**Applied Stress**	**Permissible stress when $\sigma_F/\sigma_U \le 0.7$**	**Permissible stress when $\sigma_F/\sigma_U > 0.7$**
Tension	σ_a	$\eta\ \sigma_f$	$0.41\ \eta\ (\sigma_u + \sigma_F)$
Shear	τ_a	$\eta\ \sigma_F$ / 1.732	$0.41\ \eta\ (\sigma_u + \sigma_F)$ / 1.732
Buckling	σ_a	σ_c for plating and for web plating of stiffeners σ_c /1.0 for stiffeners	
	τ_a	τ_c	

8.4.3.2 The applied vertical shear stress, τ_a, shall be determined along the hull girder in a similar manner as in Pt 3, Ch 5 by substituting the design vertical ice shear force for the design vertical wave shear force.

8.4.4 Design Vertical Ice Bending Moment

8.4.4.1 The design vertical ice bending moment, MI, along the hull girder shall be:

$$M_I = 0.10\ C_m\ L\ F_{IB}\ \sin^{-0.2}(\gamma_{stem}) \quad \text{(MNm)}$$

Where,

γ_{stem} = As provided in Sec [8.4.2]
F_{IB} = Design vertical ice force at the bow (MN)
C_m = Longitudinal distribution factor for design vertical ice bending moment
= 0.0 at the aft end of L
= 1.0 between 0.5L and 0.7L from aft
= 0.3 at 0.95L from aft
= 0.0 at the forward end of L
L = Ships length as defined in Pt 3, Ch 1, measured at the upper ice waterline UIWL (m)
Intermediate values shall be determined by linear interpolation.

Draught dependent quantities wherever applicable are, to be determined at the waterline corresponding to the loading condition under consideration.

8.4.4.2 The applied vertical bending stress, σa, shall be determined along the hull girder in a similar manner as in Pt 3, Ch 5, by substituting the design vertical ice bending moment for the design vertical wave bending moment. The ship still water bending moment shall be taken as the maximum sagging moment.

8.4.5 Longitudinal Strength Criteria

8.4.5.1 Strength criteria as detailed in Table 8.4.1 is to be complied with. The design stress shall not exceed the permissible stress.

Where,
σ_a = Applied vertical bending stress (N/mm^2)
τ_a = Applied vertical shear stress (N/mm^2)
σ_F = Minimum upper yield stress of the material (N/mm^2)
σ_u = Ultimate tensile strength of material (N/mm^2)
σ_c = Critical buckling stress in compression. Refer Pt 3, Ch 14. (N/mm^2)
τ_c = Critical buckling stress in shear. Refer Pt 3, Ch 14. (N/mm^2)

8.5 Appendages

8.5.1 General

8.5.1.1 All appendages shall be designed to withstand forces appropriate to the location of their attachment to the hull structure or their position within a hull area, as detailed below. For appendages of type or arrangement other than those considered below, the load definition and response criteria are subject to special consideration.

8.5.1.2 Stern frames, rudders, propeller nozzles are in general to be designed according to the rules given in Pt 4, Ch 2.

8.5.1.3 Bilge keels are not recommended in general and should preferably be substituted by roll-damping equipment. If bilge keels are fitted, it is required that the connection to the hull is so designed that in case the bilge keel is ripped off, the damage to the hull is minimized.

8.5.1.4 Additional requirements for ice reinforced vessels are given in the following. For vessels with rudders which are not located behind the propeller, special consideration will be made with respect to the longitudinal ice load.

8.5.2 Rudders

8.5.2.1 The rudder stock and upper edge of the rudder shall be effectively protected against ice pressure.

8.5.2.2 It is recommended to install ice horns abaft each rudder in such a manner that:

a. Ice is prevented from wedging between the top of the rudder and the vessel's hull.
b. The upper edge of the rudder is protected within two degrees to each side of the mid position when going astern

8.5.2.3 The vertical extend of ice horn shall be, minimum = 1.5 CF_D (m) below LIWL, where CF_D shall be taken as given in Table 8.2.1. Alternatively, an equivalent arrangement shall be provided.

8.5.2.4 Exposed seals for rudder stock are assumed to be designed for the given environmental conditions such as:

a. Specified design temperature
b. Ice formation

8.5.3 Ice Forces of Rudder

8.5.3.1 The ice force, F_U, acting on the uppermost part of the rudder, the ice horn etc. shall be assessed based on the Society's current practice, on a case to case basis.

The force F_U shall be divided between rudder and ice horn according to their support position. The force acting on the ice horn may generally be taken as:

$F_H = (F_U [X - X_F]) / (X_K - X_F)$ (kN)

Where,
X = Distance from leading edge or rudder to point of attack of the force F
= 0.50 l_r (m) minimum
= 0.67 l_r (m) maximum
l_r = Length (m) of rudder profile (including ice knife)
X_F = Longitudinal distance (m) from the leading edge of the rudder to the axis of the rudder stock
X_K = Distance (m) from leading edge of rudder to center of ice knife

For the above loading the stress response of the rudder, the ice horn and support structures for these shall not exceed σ_y, where σ_y denotes the minimum upper yield stress of the material.

8.5.3.2 The ice force, FR, acting on the rudder the distance LIWL below LIWL shall be assessed based on the Society's current practice, on a case to case basis.
The rudder force, F_R, gives rise to bending moments in the rudder, the rudder stock and the rudder horn, based on the arrangements. Alternative positions for the ice load area shall be considered so that maximum possible bending moment is considered in the design.

The bending moment, M_B, in way of the rudder section shall be:

$M_B = F_R h_s$ (kNm)
Where,
h_s = Vertical distance from the ice load area position to the rudder section considered

The rudder force, F_R, gives rise to a rudder torque (M_{TR}) and a bending moment in the rudder stock (M_B), where both will vary depending on the position of the assumed ice load area, and on the rudder type and arrangement considered.

In general, the load giving the most severe combination of F_R, M_{TR} and M_B with respect to the structure under consideration shall be applied in a direct calculation of the rudder structure.

The design value of M_{TR} is given by:
$M_{TR} = F_R (0.60 l_r - X_F)$ (kNm)
= 0.15 $F_r l_r$, minimum
Where,
X_F = Longitudinal distance (m) from the leading edge of the rudder to the axis of the rudder stock
l_r = Length of rudder profile (m)

8.5.4 Rudder Scantlings

8.5.4.1 Scantlings of rudder, rudder stock, rudder horn and rudder stoppers, as applicable, shall be calculated for the force, given in Sec 8.5.3.1 acting on the rudder and ice horn, with respect to bending and shear. The nominal equivalent stress shall not exceed σ_f, where σ_f denotes the minimum upper yield stress of the material (N/mm²).

8.5.4.2 The scantlings of rudders, rudder stocks and shafts, pintles, rudder horns and rudder actuators shall be calculated from the formulae given in Pt 4, Ch 2, inserting the rudder torque M_{TR}, bending moments M_B and rudder force F_R as provided in Sec [8.5.3.2].

8.5.4.3 Provided an effective torque relief arrangement is installed for the steering gear, and provided effective ice stoppers are fitted, the design rudder torque need not be taken greater than M_{TR}:

M_{TR} = M_{TRO}
Where
M_{TRO} = Steering gear relief torque (kNm)

8.5.4.4 For rudder plating the ice load thickness shall be calculated as given in, Sect[4.7.3.3]for the stern area or lower stern area as applicable.

8.5.5 Ice Loads on Propeller Nozzles

8.5.5.1 The transverse ice force, F_N, on propeller nozzles shall be calculated as provided in Sec 8.5.7.

8.5.5.2 The longitudinal ice force, F_L, acting on the nozzle shall be assessed on a case to case basis based on the Society's current practice.

8.5.5.3 For calculation of F_L, the following ie load areas, A, shall be considered:

a. An area on both sides of the nozzle at the propeller shaft level, with transverse width equal to the height (m) of the nozzle profile with height equal to 0.35 D. Both symmetric and asymmetric loading shall be checked.

b. An area positioned at the lower edge of the nozzle with width equal to 0.65 D and height equal to the height of the nozzle profile (m).

Where, D is the diameter of the nozzle (m)

8.5.6 Propeller Nozzle Scantlings

8.5.6.1 The scantlings of the propeller nozzle and its supports in the hull shall be calculated for the ice loads provided in Sec [8.5.5]. The nominal equivalent stress shall not exceed σ_y, where σ_y denotes the minimum upper yield stress of the material (N/mm²).

The ice load thickness for nozzle plating assessment shall be as provided in Sec [8.3.1], using the design ice pressure as given for the stern area, lower stern area as applicable.

8.5.7 Podded Propulsors and Azimuth Thrusters

8.5.7.1 Vessels operating in ice and equipped with podded propulsors or azimuth thrusters shall be designed according to operational mode and purpose stated in the design specification. If not provided, it shall be assumed that the vessel may operate longer periods in ice using astern running mode as part of its operational profile. When limitations are imposed, this information shall also be stated in the ship's documents.

8.5.7.2 The vessel is not anticipated to undergo astern ramming.

8.5.7.3 Documentation of both local and global strength capacity of the pod/thruster shall be submitted for class review and approval. Recognized structural idealization and calculation methods shall be applied.

8.5.7.4 Ice loads on pod/thruster body shall be assessed in line with the Society's current practice based on a case by case basis.

8.5.7.5 The nominal equivalent stress shall not exceed the minimum upper yield stress, σ_F, of the material (N/mm^2)

8.6 Direct Calculations

8.6.1 General

8.6.1.1 As an alternative to the analytical procedures prescribed for shell plating and local frames, direct calculations shall not be considered.

8.6.1.2 Where direct calculation is used to check the strength of structural systems, the load patch specified in Sec [8.2.5] with design pressure given as the product (AF P_{avg}) shall be applied at locations that maximize the shear and bending response of the relevant structure members for the analysis.

AF = As provided in Table 8.2.3
P_{avg} = As provided in Sec [8.2.6.1]

8.6.1.3 Direct calculations may be used for the scantling control of the support structures for local frames, including load-carrying stringers, web frames and plated structures in general. The extent of the structure model must be such that possible inaccuracies in the support definition will not affect the calculation results significantly. The stress response of webs and flanges of girder structures, when a usage factor = 0.9 is included, does not exceed yield or the buckling capacity. The documentation of direct strength analyses shall be in accordance with Pt 3, Ch 13, [1.3].

8.7 Welding

8.7.1 General

8.7.1.1 Continuity of strength shall be ensured at all structural connections.

8.7.1.2 All welding within ice-strengthened areas shall be of the double continuous type.

8.7.2 Minimum Weld Requirements

8.7.2.1 The weld connection of local frames and load carrying stringers and web frames supporting local frames to shell shall be as given in Pt 3, Ch 11, 3.1.3, with the weld factor C provided below:

C = 0.31 r_w, minimum 0.26, for middle 60% span
= 0.52 r_w, minimum 0.43, at ends

r_w = Ratio of required net web area over fitted net web area of member considered.
For transverse local frames, r_w minimum shall be:
r_w = $(100^2\ LL\ s\,[F\ PPF_s\ P_{avg}]\ [1 - 0.25s - 0.50LL_s]) / (0.577\ \sigma_F\ a\ A_w)$

Where,
LL_s = Length of the loaded portion of the span
= Lesser of a and (b – 0.5s) (m)
a = Frame span (m) as defined in Sec [8.3.2.5]
b = Height (m) of design ice load patch as provided in Sec [8.2.5]

s = Transverse frame spacing (m)
AF = Hull Area Factor from Table 8.2.3
PPF_t = Peak Pressure Factor from Table 8.2.2
P_{avg} = Average pressure (MPa) within load patch as provided in Sec [8.2.6.1].
σ_F = Minimum upper yield stress of material (N/mm^2)

8.8 Material and Corrosion Protection

8.8.1 Corrosion/abrasion Additions and Steel Renewal

8.8.1.1 For all Polar ships an effective protection against corrosion and ice-induced abrasion is recommended for all external surfaces of the shell plating.

8.8.1.2 The values of corrosion/abrasion additions, t_s, to be considered in determining the shell plate thickness for each Polar Class are listed in Table 8.8.1.

Table 8.8.1 Corrosion/ Abrasion Additions for Shell Plating

Hull Region	t_s (mm)					
	With Effective Protection			Without Effective Protection		
	PC-1 PC-2 PC-3	PC-4 PC-5	PC-6 PC-7	PC-1 PC-2 PC-3	PC-4 PC-5	PC-6 PC-7
Bow, Bow Intermediate Ice belt	3.5	2.5	2.0	7.0	5.0	4.0
Bow Intermediate Lower, Midbody and Stern Ice belt	2.5	2.0	2.0	5.0	4.0	3.0
Midbody and Stern Lower, Bottom	2.0	2.0	2.0	4	3	2.5

8.8.1.3 A minimum corrosion/abrasion addition of t_s = 1.0 mm applied to all internal structures within the ice-strengthened hull areas, including plated members adjacent to the shell, as well as stiffener webs and flanges for Polar ships. Additionally, the corrosion/abrasion addition, t_s, shall not be less than tk as given in Pt 3, Ch 2, Sec [4.2].

8.8.1.4 For ice strengthened structures, steel renewal is required when the gauged thickness is less than t_{net} + 0.5 mm.

8.8.2 Hull Materials

8.8.2.1 For hull structures the plating material shall be not less than those given in Tables 8.8.3 and Table 8.8.4 based on the as-built thickness of the material, the Polar Class notation assigned to the ship and the material class of structural members given in Sec [8.8.2.2].

8.8.2.2 Material classes specified in Pt 3, Ch 2, are applicable to Polar Class ships regardless of the ship's length. In addition, material classes for weather and sea exposed structural members and for members attached to the weather and sea exposed shell plating of Polar Class ships are given in Table 8.8.2. Where the material classes in Table 8.8.2 and those in Pt 3 Ch 2 differ, the higher material class shall be applied.

Table 8.8.2 Material Class for Structural Members of Polar Ships

Structural Members	Material Class
Shell plating within the bow and bow intermediate ice belt hull areas (B, BI_i)	III
All weather and sea exposed SECONDARY and PRIMARY, as defined in Pt 3, Ch 2, Sec 2, Table 2.2.2, structural members outside 0.4 L amidships	II

Plating materials for stem and stern frames, rudder horn, rudder, propeller nozzle, shaft brackets, ice skeg, ice knife and other appendages subject to ice impact loads	III
All inboard framing members attached to the weather and sea-exposed plating including any contiguous inboard member within 600 mm of the plating	II
Weather-exposed plating and attached framing in cargo holds of ships which by nature of their trade have their cargo hold hatches open during cold weather operations	II
All weather and sea exposed SPECIAL, as defined in Pt 3, Ch 2, Sec 2, Table 2.2.2, structural members within 0.2 L from FP	III

8.8.2.3 Steel grades for all plating and attached framing of hull structures and appendages situated below the level of 0.3 m below the lower waterline, as shown in Fig.8, shall be obtained from Pt 3, Ch 2, Sec 2, based on the Material Class for Structural Members in Table 8.8.2 above, regardless of Polar Class.

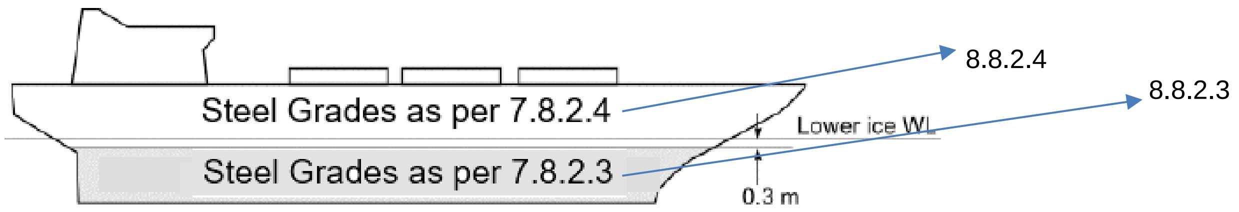


Fig. 8 Steel Grade Requirements for Submerged & Weather Exposed Shell Plating

Table 8.8.3 Steel Grades for Weather Exposed Plating

Thickness t (mm)	Material Class II				Material Class III				Material Class IV					
	PC-1 to PC-5		PC-6 PC-7		PC-1 to PC-5		PC-6 PC-7		PC-1 to PC-3		PC-4 PC-5		PC-6 PC-7	
	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT	MS	HT
t ≤ 10	B	AH	B	AH	B	AH	B	AH	E	EH	E	EH	B	AH
10 < t ≤ 15	B	AH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
15 < t ≤ 20	D	DH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
20 < t ≤ 25	D	DH	B	AH	D	DH	B	AH	E	EH	E	EH	D	DH
25 < t ≤ 30	D	DH	B	AH	E	EH(2)	D	DH	E	EH	E	EH	E	EH
30 < t ≤ 35	D	DH	B	AH	E	EH	D	DH	E	EH	E	EH	E	EH
35 < t ≤ 40	D	DH	D	DH	E	EH	D	DH	F	FH	E	EH	E	EH
40 < t ≤ 45	E	EH	D	DH	E	EH	D	DH	F	FH	E	EH	E	EH
45 < t ≤ 50	E	EH	D	DH	E	EH	D	DH	F	FH	F	FH	E	EH

Note:
(1) Includes weather-exposed plating of hull structures and appendages, as well as their outboard framing members, situated above a level of 0.3 m below the lowest ice waterline.
(2) Grades D, DH are allowed for a single strake of side shell plating not more than 1.8 m wide from 0.3 m below the lowest ice waterline.

Table 8.8.4 Steel Grades for Inboard Framing Members Attached to Weather Exposed Plating				
Thickness t (mm)	**PC-1 to PC-5**		**PC-6, PC-7**	
	MS	**HT**	**MS**	**HT**
t ≤ 20	B	AH	B	AH
20 < t ≤ 35	D	DH	B	AH
25 < t ≤ 45	D	DH	D	DH
45 < t ≤ 50	E	EH	D	DH

8.8.2.4 For all weather exposed plating of hull structures and appendages situated above the level of 0.3 m below the lower ice waterline, steel grades shall be as shown in Fig.8, shall be not less than given in Table 8.8.3.

8.8.2.5 For all inboard framing members attached to weather exposed plating, the steel grade shall be not less than given in Table 8.8.4. This applies to all inboard framing members as well as to other contiguous inboard members (e.g. bulkheads, decks) within 600 mm of the exposed plating.

8.8.2.6 Castings and forgings shall have specified properties consistent with the expected service temperature for the cast component. Forged or cast materials in structural members exposed to design temperatures lower than 10°C, shall fulfil requirements given in Sec [6.3.10.1]. The test temperature of components fully exposed to the ambient air shall, if the design temperature has not been specified, for notations **PC-1** to **PC-5** be taken as -20ºC and for notations **PC-6** and **PC-7** as -10ºC.

8.8.3 Materials for Machinery Components Exposed to Sea Water

8.8.3.1 Materials exposed to sea water, such as propeller blades, propeller hub, cast thrusters body shall have an elongation not less than 15% on a test specimen with a length which is five times the diameter of test specimen. Charpy V impact tests shall be carried out for materials other than bronze and austenitic steel. Average impact energy of 20 J taken from three Charpy V tests is to be obtained at minus 10ºC.

8.8.4 Materials for Machinery Components Exposed to Sea Water Temperatures

8.8.4.1 Materials exposed to sea water temperature shall be of steel or other approved ductile material. Charpy V impact tests shall be carried out for materials other than bronze and austenitic steel. An average impact energy value of 20 J taken from three tests shall be obtained at minus 10ºC. This requirement applies to blade bolts, CP-mechanisms, shaft bolts, strut-pod connecting bolts, etc. This does not apply to surface hardened components, such as bearings and gear teeth.

8.8.5 Materials for Machinery Components Exposed to Low Air Temperature

8.8.5.1 Materials of essential components exposed to low air temperature shall be of steel or other approved ductile material. An average impact energy value of 20 J taken from three Charpy V tests shall be obtained at 10ºC below the lowest design temperature. This does not apply to surface hardened components, such as bearings and gear teeth.

For definition of structural boundaries exposed to air temperature refer Sec [4.2.1].

8.9 Ice Interaction Loads- Machinery

8.9.1 Propeller ice interaction

8.9.1.1 Open and ducted type propellers situated at the stern of a vessel having controllable pitch or fixed pitch blades are covered in these rules. Ice loads on bow propellers and pulling type propellers shall receive special consideration. The given loads are expected, single occurrence, maximum values for the whole ships service life for normal operational conditions. These loads do not cover off-design operational conditions, for example when a stopped propeller is dragged through ice. These Rules cover loads due to propeller ice interaction also for azimuth and fixed thrusters with geared transmission or integrated electric motor ("geared and podded propulsors"). However, the load models of these Rules do not cover propeller/ice interaction loads when ice enters the propeller of a turned azimuthing thruster from the side (radially) or when ice block hits on the propeller hub of a pulling propeller/thruster.

8.9.1.2 The loads given in this section are total loads (unless otherwise stated) during ice interaction and shall be applied separately (unless otherwise stated) and are intended for component strength calculations only.

8.9.1.3 F_b is a force bending a propeller blade backwards when the propeller mills an ice block while rotating ahead. F_f is a force bending a propeller blade forwards when a propeller interacts with an ice block while rotating ahead.

8.9.2 Ice Class Factors

8.9.2.1 The design ice thickness and ice strength index to be used for the assessment of the propeller ice loads is provided in the table below.

Table 8.9.1 Ice Class Factors

Ice Class	H_{ice} (m)	S_{ice} (-)
PC-1	4.00	1.2
PC-2	3.50	1.1
PC-3	3.00	1.1
PC-4	2.50	1.1
PC-5	2.00	1.10
PC-6	1.75	1.00
PC-7	1.50	1.00

Where,
H_{ice} : Ice thickness for machinery strength design
S_{ice} : Ice strength index for blade ice force

8.9.3 Design Ice Loads for Open Propeller

8.9.3.1 Maximum backward blade force, Fb

When $D < D_{limit}$:

$$F_b = 27\, S_{ice}\, (n\, D)^{0.7}\, (EAR / Z)^{0.30}\, D^2 \text{ (kN)}$$

When $D \geq D_{limit}$:

$$F_b = 23\, S_{ice}\, (n\, D)^{0.7}\, (EAR / Z)^{0.3}\, (H_{ice})^{1.4}\, D \quad \text{(kN)}$$

$$D_{limit} = 0.85\, (H_{ice})^{1.4}$$

Where,
n = nominal rotational speed (at MCR free running condition) for CP-propeller and 85% of the nominal rotational speed (at MCR free running condition) for a FP-propeller (regardless driving engine type) (rps)
D = Propeller diameter (m)

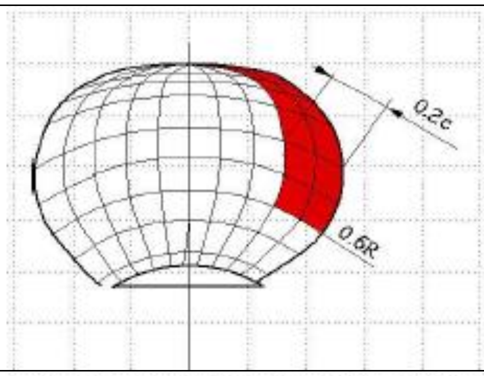
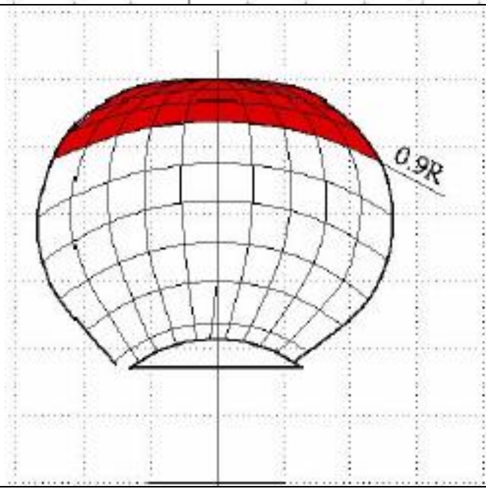
EAR = Expanded blade area ratio
Z = Number of propeller blades

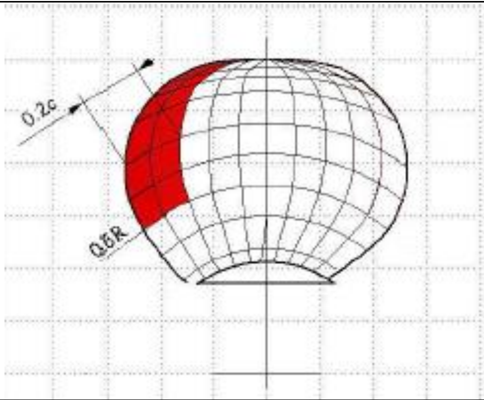
Fb shall be applied as a uniform pressure distribution to an area on the back (suction) side of the blade for the following load cases:

a) Load case 1:
From 0.6 R to the tip and from the blade leading edge to a value of 0.2 chord length
b) Load case 2:
A load equal to 50% of the F_b shall be applied on the propeller tip area outside 0.9 R

c) Load case 5:
For reversible propellers a load equal to 60% of the greater of Fb or Ff, shall be applied from 0.6 R to the tip and from the blade trailing edge to a value of 0.2 chord length.

Table 8.9.2

Load Case	Force	Loaded Area	Right handed propeller blade seen from back
Load case 1	F_b	Uniform pressure applied on the back of the blade (suction side) to an area from 0.6 R to the tip and from the leading edge to 0.2 times the chord length	
Load case 2	50% F_b	Uniform pressure applied on the back of the blade (suction side) on the propeller tip area outside of 0.9 R radius.	

Load case 5	Greater of 60% F_f (or) F_b	Uniform pressure applied on propeller face (pressure side) to an area from 0.6 R to the tip and from the trailing edge to 0.2 times the chord length	

8.9.3.2 Maximum forward blade Force, F_f

When $D < D_{limit}$:

$F_f = 250 \, (EAR / Z) \, D^2$ (kN)

When $D \geq D_{limit}$:

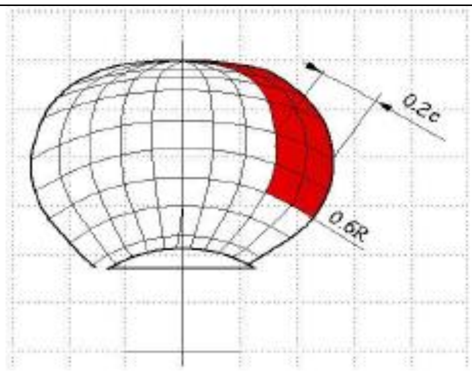
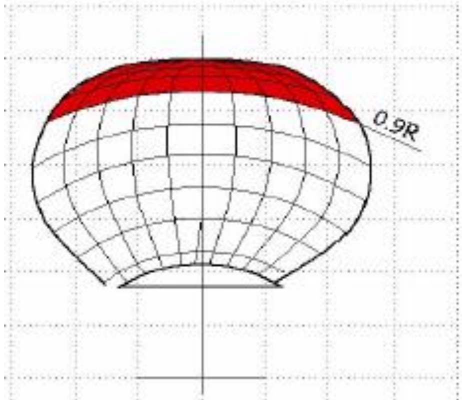
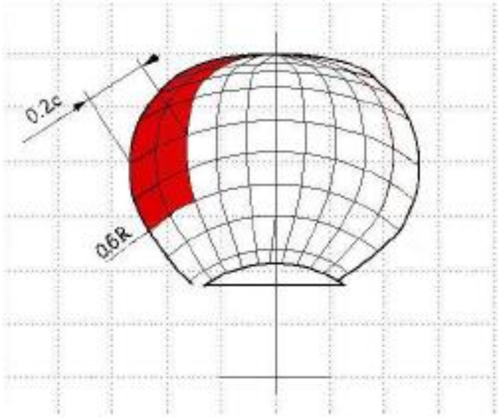
$F_f = 500 \, (EAR / Z) \, D \, H_{ice} \, (1 / [1 - d / D])$ (kN)
$D_{limit} = (2 / [1 - d/D]) \, H_{ice}$

Where,
d = Propeller hub diameter (m)
D = Propeller diameter (m)
EAR = Expanded blade area ratio
Z = Number of propeller blades

F_f shall be applied as a uniform pressure distribution to an area on the face (pressure) side of the blade for the following loads cases:

a) Load case 3:
From 0.6 R to the tip and from the blade leading edge to a value of 0.2 chord length
b) Load case 4:
A load equal to 50% of the F_f shall be applied on the propeller tip area outside 0.9 R
c) Load case 5:
For reversible propellers a load equal to 60% of the greater of F_f or F_b, shall be applied from 0.6 R to the tip and from the blade trailing edge to a value of 0.2 chord length.

Table 8.9.3			
Load Case	**Force**	**Loaded Area**	**Right handed propeller blade seen from back**

Load case 3	F_f	Uniform pressure applied on the blade face (pressure side) to an area from 0.6 R to the tip and from the leading edge to 0.2 times the chord length.	
Load case 4	50% F_f	Uniform pressure applied on propeller face (pressure side) on the propeller tip area outside of 0.9 R radius.	
Load case 5	Greater of 60% F_f (or) F_b	Uniform pressure applied on propeller face (pressure side) to an area from 0.6 R to the tip and from the trailing edge to 0.2 times the chord length	

8.9.3.3 Maximum Blade Spindle Torque, Q_{smax}

Spindle torque Q_{smax} around the spindle axis of the blade fitting shall be calculated both for the load cases described in Sec 8.9.3.1 and Sec 8.9.3.2 for F_b F_f. If these spindle torque values are less than the default value given below, the default minimum value shall be used.

Default Value $Q_{smax} = 0.25\ F\ c_{0.7}$ (kNm)

Where,

$c_{0.7}$ = Length of the blade chord at 0.7 R radius (m)

F = Greater absolute value of F_b or F_f

8.9.3.4 Maximum Propeller Ice Torque applied to the propeller:

When $D < D_{limit}$:

$T_{max} = k_{open}\ (1 – [d/D])\ (P_{0.7} / D)^{0.16}\ (n\ D)^{0.17}\ D^3$ (kNm)

Where

k_{open} = 14.70 for PC-1 to PC-5

k_{open} = 10.90 for PC-6, PC-7

When $D \geq D_{limit}$:
T_{max} = $(k_{open}/0.53)$ (1 – [d/D]) $(P_{0.7} / D)^{0.16}$ $(n\ D)^{0.17}$ $D^{1.9}$ $(Hice)^{1.1}$ (kNm)
D_{limit} = 1.8 H_{ice}

Where
$P_{0.7}$ = Propeller pitch at 0.7R (m)
n = Propeller speed (rps) at bollard condition. If not known, n is to be taken as below:

Table 8.9.4 Propeller Type and Speed	
Propeller Type	**n**
Controllable Pitch (CP) Propellers	n_n
Fixed Pitch (FP) Propellers driven by turbine or electric motor	n_n
Fixed Pitch (FP) Propellers driven by diesel engine	0.85 n_n
Note: Where n_n is the nominal rotational speed at MCR, free running condition.	

For CP propellers, propeller pitch, $P_{0.7}$ shall correspond to MCR in bollard condition. If not known, $P_{0.7}$ shall be taken as 0.7 $P_{0.7n}$, where $P_{0.7n}$ is propeller pitch at MCR free running condition.

8.9.3.5 Maximum Propeller Ice Thrust applied to the shaft

Th_f = 1.1 F_f (kN)
Th_b = 1.1 F_b (kN)

The load models of this requirement do not include propeller/ice interaction loads when ice block hits on the propeller hub of a pulling propeller.

8.9.4 Design Ice Loads for Ducted Propeller

8.9.4.1 Maximum Backward Blade Force, F_b

When $D < D_{limit}$:

F_b = 9.5 S_{ice} $(n\ D)^{0.7}$ $(EAR / Z)^{0.3}$ D^2 (kN)

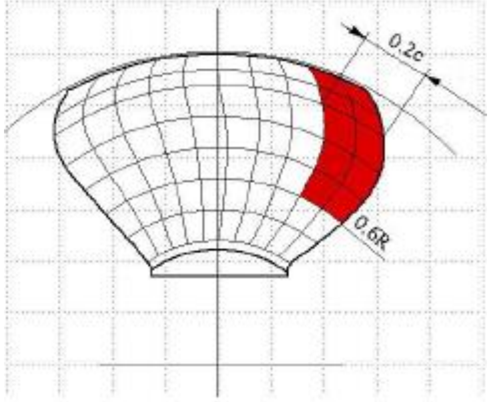
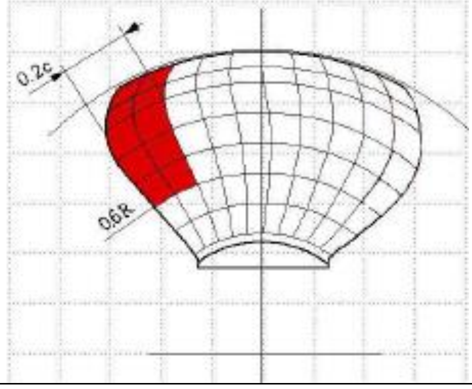
When $D \geq D_{limit}$:

F_b = 66 S_{ice} $(n\ D)^{0.7}$ $(EAR / Z)^{0.3}$ $(H_{ice})^{1.4}$ $D^{0.6}$ (kN)

Where
D_{limit} = 4 H_{ice}
n = Refer Sec [8.9.3.1]

F_b shall be applied as a uniform pressure distribution to an area on the back side for the following load cases:
a) Load Case 1:
On the back of the blade from 0.6 R to the tip and from the blade leading edge to a value of
0.2 chord length
b) Load Case 5:
For reversible rotation propellers a load equal to 60% of the greater of Fb or Ff is applied on the blade face from 0.6 R to the tip and from the blade trailing edge to a value of 0.2 chord length.

Table 8.9.5

Load Case	Force	Loaded Area	Right handed propeller blade seen from back
Load Case 1	F_b	Uniform pressure applied on the back of the blade (suction side) to an area from 0.6 R to the tip and from the leading edge to 0.2 times the chord length	
Load Case 5	Greater of 60% F_f (or) F_b	Uniform pressure applied on propeller face (pressure side) to an area from 0.6 R to the tip and from the trailing edge to 0.2 times the chord length	

8.9.4.2 Maximum Backward Blade Force, Ff

When $D < D_{limit}$:
$F_f \quad = 250\ (EAR / Z)\ D^2$ (kN)

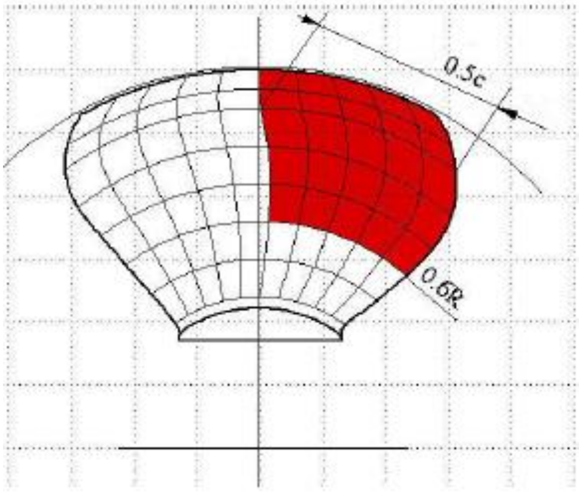
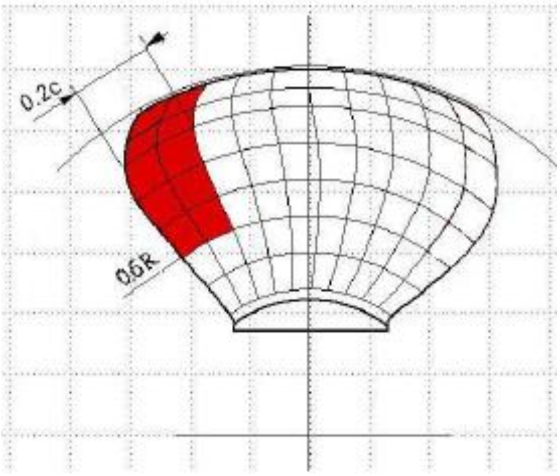
When $D \geq D_{limit}$:
$F_f \quad = 500\ (EAR / Z)\ D\ (1 / [1 - (d/D))\ H_{ice}$ (kN)

Where
$D_{limit} \quad = (2\ H_{ice}) / (1 - [d / D])$ (m)

F_f shall be applied as a uniform pressure distribution to an area on the face (pressure) side for the following load case:

a) Load case 3:
On the blade face from 0.6 R to the tip and from the blade leading edge to a value of 0.5 chord length.

b) Load case 5:
A load equal to 60% of the greater of F_f or F_b shall be applied from 0.6 R to the tip and from the blade leading edge to a value of 0.2 chord length.

Table 8.9.6			
Load Case	**Force**	**Loaded Area**	**Right handed propeller blade seen from back**
Load Case 3	F_f	Uniform pressure applied on the blade face (pressure side) to an area from 0.6 R to the tip and from the leading edge to 0.5 times the chord length.	
Load Case 5	Greater of 60% F_f (or) F_b	Uniform pressure applied on propeller face (pressure side) to an area from 0.6 R to the tip and from the trailing edge to 0.2 times the chord length	

8.9.4.3 Maximum Blade Spindle Torque for CP- Mechanism Design, Q_{smax}

Spindle torque Q_{smax} around the spindle axis of the blade fitting shall be calculated for the load case described in Sec [8.9.1]. If these spindle torque values are less than the default value given below, the default value shall be used.

Q_{smax} (default Value) $= 0.25\ F\ c_{0.7}$ (kNm)

Where c_{07} the length of the blade section at 0.7R radius and F is either F_b or F_f whichever hs the greater absolute value.

8.9.4.4 Maximum Propeller Ice Torque applied to the propeller
T_{max} is the maximum torque on a propeller due to ice- propeller interaction.

When $D \le D_{limit}$

$T_{max} = k_{ducted}\ (1 - [d/D]\ )\ (P_{0.7} / D)^{0.16}\ (n\ D)^{0.17}\ D^3$ (kNm)

Where
k_{ducted} = 10.40 for PC-1 to PC-5
k_{ducted} = 7.70 for PC-6, PC-7

When $D > D_{limit}$

T_{max} = 1.90 k_{ducted} (1 – [d/D]) $(H_{ice})^{1.1}$ $(P_{0.7} / D)^{0.16}$ $(n D)^{0.17}$ $D^{1.9}$ (kNm)
Where
D_{limit} = 1.80 H_{ice} (m)

Table 8.9.7 Propeller Type and Speed	
Propeller Type	**n**
Controllable Pitch (CP propellers	n_n
Fixed Pitch (FP) propellers driven by turbine or electric motor	n_n
Fixed Pitch (FP) propellers driven by diesel engine	0.85 n_n

Where n_n is the nominal rotational speed at MCR, at free running conditions.

For CP propeller, propeller pitch $P_{0.7}$ shall correspond to MCR in bollard condition. If not known, $P_{0.7}$ shall be taken as 0.7 P_{07n}, where $P_{0.7n}$ is propeller pitch at MCR free running condition.

8.9.4.5 Maximum Propeller Ice Thrust (applied to the shaft at the location of the propeller)

Th_f = 1.10 F_f (kN)
Th_b = 1.10 F_b (kN)

8.9.5 Propeller Blade Loads and Stresses for Fatigue Analysis

8.9.5.1 Blade Stresses

The blade stresses at various selected load levels for fatigue analysis are to be taken proportional to the stresses calculated for maximum loads given in sections Sec [8.9.3.1], Sec [8.9.3.2], Sec [8.9.4.1], Sec [8.9.4.2].

The peak stresses are those determined due to F_f and F_b. The peak stress range $\Delta\sigma_{max}$ and the maximum stress amplitude F_{Amax} are determined as below:

ΔF_{max} = 2 F_{Amax} = $|F_f| + |F_b|$

8.9.6 Design Ice Loads for Propulsion Line

8.9.6.1 Torque

The propeller ice torque excitation for shaft line dynamic analysis shall be described by a sequence of blade impacts which are of half sine shape and occur at the blade. The torque due to a single blade ice impact as a function of the propeller rotation angle is as below:

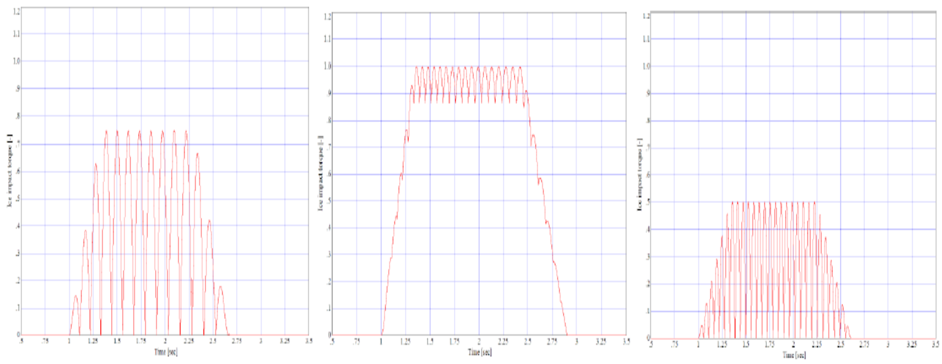
$T(\varphi)$ = C_q T_{max} $\sin(\varphi\ [\ 180 / \alpha_I\ ])$
When φ rotates from 0 to α_I plus integer revolutions,
$T(\varphi)$ = 0
When φ rotates from 0 to 360 plus integer revolutions
where C_q and α_i parameters are given in table below:

Table 8.9.8			
Torque Excitation	**Propeller Ice Interaction**	**C_q**	**α_i**
Case 1	Single ice block	0.75	90
Case 2	Single ice block	1.00	135
Case 3	Two ice blocks with 45 degree phase in rotation angle	0.50	45

The total ice torque is obtained by summing the torque of single blades taking into account the phase shift 360 deg/Z. The number of propeller revolutions during a milling sequence shall be obtained as below:

$N_Q = 2 H_{ice}$

Total number of impacts during one ice milling sequence is $Z N_T$.
The impacts are to ramp up over 270 degrees and subsequently ramp down over 270 degrees.
The total excitation torque from the 3 cases shall be as shown in Fig.9 below.
Time (sec) along X axis Vs Ice Impact Torque along Y axis.



Case 1 Case 2 Case 3

Fig. 9 Shape of Propeller Ice Torque Excitation for 90, 135 deg Single Blade Impact Sequences and 45 Degrees Double Blade Impact Sequence (Case 1 to 3 respectively apply for propeller with 4 blades)

Milling torque sequence duration is not valid for pulling bow propellers, which are subject to special consideration.

8.9.6.2 Response Torque in the Propulsion System

The response torque, $T_r(t)$ at any component in the propulsion system shall be analyzed by means of transient torsional vibration analysis considering the excitation torque at the propeller $T(\phi)$ as provided in [8.9.6.1], the actual available engine torque T_e, and the mass elastic system. Calculations have to be carried out for all excitation cases given in 8.9.6.1 and the excitation torque has to be applied on top of the mean hydrodynamic torque in bollard condition at considered propeller rotational speed. The worst phase angle between the ice interactions and any high torsional vibrations caused by engine excitations (e.g. 4th order engine excitation in direct coupled 2-stroke plants with 7-cyl. engine) should be considered in the analysis.

Note:
Transient torsional vibration calculations shall be carried out based on approved procedures/ methodologies in line with standard industrial practice.

The results of the 3 cases detailed above are to be used as mentioned below:

1) The highest peak torque (between the various lumped masses in the system) is in the following referred to as peak torque T_{peak}.

2) The highest torque amplitude during a sequence of impacts is to be determined as half of the range from max to min torque and is referred to as T_{Amax}.

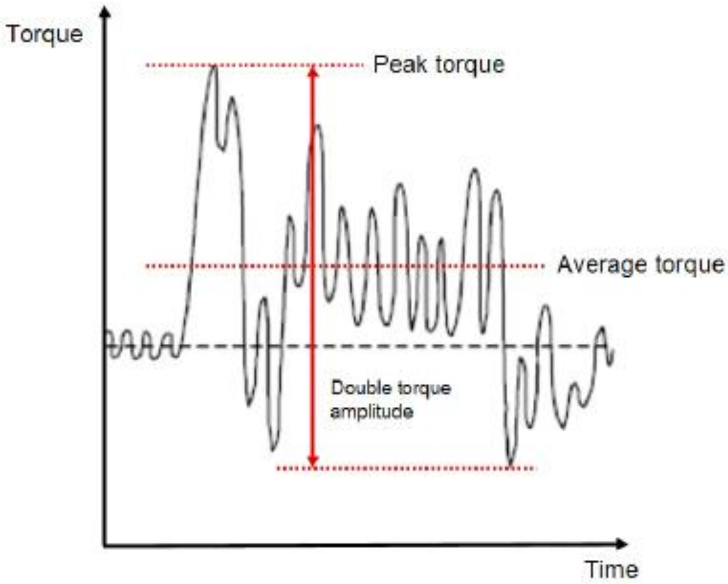


Fig. 10 Response Torque Over Time

8.9.6.3 Maximum Response Thrust

Maximum thrust along the propeller shaft line shall be calculated as detailed below. The factors 2.2 and 1.5 take into account the dynamic magnification due to axial vibration. Alternatively, the propeller thrust magnification factor may be calculated by dynamic analysis.

Maximum Shaft Thrust Forward, Th_r = $Th_n + 2.2\ Th_f$ (kN)
Maximum Shaft Thrust Backward, Th_r = $1.5\ Th_b$ (kN)
Where.
Th_n = Propeller bollard thrust (kN)
Th_f = Maximum forward propeller ice thrust (kN)
If hydrodynamic bollard thrust, Th_n is not known, refer the Table below:

Table 8.9.9 Propeller Type Vs Th_n	
Propeller Type	**Th_n**
Controllable pitch (CP) propeller (Open type)	1.25 Th
Controllable pitch (CP) propeller (Ducted)	1.10 Th
Fixed pitch (FP) propeller driven by turbine or electric motor	Th_f
Fixed pitch (FP) propeller driven by diesel engine (open)	0.85 Th
Fixed pitch (FP) propeller driven by diesel engine (ducted)	0.75 Th

Th = Nominal propeller thrust at MCR at free running open water conditions.

8.9.6.4 Blade Failure Load for Both Open and Nozzle Propeller

The force is acting at 0.8R in the weakest direction of the blade at the centre of the blade. For calculation of spindle torque the force is assumed to act at a spindle arm, 1/3 of the distance from the axis of blade rotation to the leading or the trailing edge, whichever is greater.

The blade failure load, F_{ex} is provided below:

$F_{ex} = (300\ c\ t^2\ \sigma_{ref}) / (0.8D - 2r)$ (kN)

Where,
σ_{ref} = $0.60\ \sigma_{0.2} + 0.40\ \sigma_u$
σ_u = Specified maximum ultimate tensile strength of blade material

$\sigma_{0.2}$ = Specified maximum yield or 0.2% proof strength of blade material

These values may either be obtained by means of tests, or commonly accepted "thickness correction factors" approved by the classification society. If not available, maximum specified values shall be used.

c = Actual chord length (m)
t = Thickness of the cylindrical root section (m)
D = Propeller diameter (m)
r = Radius (m)
The values of c, t, D and r above are those of the cylindrical root section of the blade at the weakest section outside root fillet and typically will be at the termination of the fillet into the blade profile.

The blade bending failure is considered to occur when equivalent stress reach σ_{ref1} times 1.5 in elastic model. Blade bending failure is observed to occur reasonably close to the root fillet end and normally not more 20% of R outside fillet.

Alternatively, the F_{ex}, can be determined by means of FEA of the actual blade.

8.9.7 Machinery Fastening Loading Conditions

8.9.7.1 Essential equipment and main propulsion machinery supports shall be suitable for the accelerations as indicated in as follows. Accelerations shall be considered acting independently.

8.9.7.2 Longitudinal Impact Acceleration
Maximum longitudinal impact acceleration (a_l) at any point along the hull girder,

$a_l = (F_{IB} / \Delta_{tk}) \, ([7H/L] + 1.10 \tan[\gamma + \varphi]) \quad (m/s^2)$

8.9.7.3 Vertical Acceleration
Combined vertical impact acceleration at any point along the hull girder,
$a_v = (F_{IB} / \Delta_{tk}) \, F_x \quad (m/s^2)$

F_x = 1.30 at FP
= 0.20 at Midship
= 0.40 at AP
= 1.30 at AP for vessels conducting ice breaking astern
Intermediate values to be interpolated linearly

8.9.7.4 Transverse Impact Acceleration
Combined transverse impact acceleration at any point along hull girder,
$a_t = 3 \, F_{Bow} \, (F_x / \Delta_{tk})$

F_x = 1.50 at FP
= 0.25 at Midship
= 0.50 at AP
= 1.50 at AP (For vessels carrying out ice breaking astern. Intermediate values to be obtained by linear interpolation)
Where,
ϕ = Maximum friction angle between steel and ice, normally taken as 10 degrees
γ = Bow stem angle at waterline (deg)
Δ_{tk} = Displacement at UIWL (kt)
L = Length between perpendiculars (m)\
H = Distance (m) from the waterline to the point being considered
F_{IB} = Vertical impact force as provided in Sec [8.4.2].
F_{Bow} = As defined in Sec [8.2.5.1].

8.10 Design - Machinery

8.10.1 Design Principles

8.10.1.1 Fatigue Design – General

The propeller and shaft line components are to be designed so as to prevent accumulated fatigue failure when considering the loads according to Sec [8.9.3], Sec [8.9.4], Sec [8.9.5], Sec [8.9.6] using the linear elastic Palmgren-Miner's rule.

$MDR = (n_1 / N_1) + (n_2 / N_2) + (n_3 / N_3) + \ldots\ldots + (n_k / N_k) \leq 1.00$

The long term ice load spectrum is approximated with two-parameter Weibull distribution.

8.10.1.2 Propeller Blades

The load spectrum for forward loads is normally expected to have a higher number of cycles than the load spectrum for backward loads. Taking this into account in a fatigue analysis introduces complications that are not justified considering all uncertainties involved.

The simplified and approximated blade stress amplitude distribution is as detailed below:

$\sigma_A (N) = \sigma_{Amax} \{ 1 – [\log (N) / \log (N_{ice})] \}^{(1/k)}$

Where,
k = Weibull shape parameter
= 0.75 for open propeller
= 1.00 for ducted propeller (or) propeller in nozzle

This is illustrated in the cumulative stress spectrum (stress exceedance diagram) in Fig. 11.

Number of load cycles N_{ice} in the load spectrum per blade is to be determined as provided below:

$N_{ice} = k_1 k_2 N_{class} n$

Where

N_{class} = Reference number of impacts per propeller rotation speed for each ice class (table)

Ice Class	PC-1	PC-2	PC-3	PC-4	PC-5	PC-6	PC-7
N_{class}	$21x10^6$	$17x10^6$	$15x10^6$	$13x10^6$	$11x10^6$	$9x10^6$	$6x10^6$

k_1 = 1 for center propeller
= 2 for wing propeller
= 3 for pulling propeller (center & wing)
= For pulling bow propellers number of load cycles is expected to increase in range of 10 times

k_2 = 0.80 – f, when f < 0
= 0.80 – 0.40f, when 0 ≤ f ≤ 1.00
= 0.60 – 0.20f, when 1 < f ≤ 2.50

= 0.10 when f > 2.50

Where the immersion function f provided below:

f = (2 [h_0 – H_{ice}] / D) – 1

Where

h_0 = Propeller center line depth at the maximum ballast waterline in ice (LIWL) of the vessel.

8.10.1.3 Applicable loads in propulsion line components

The strength of the propulsion line components shall be designed:

a) For maximum loads in Sec [8.9.3] and Sec [8.9.4] (for open and ducted propeller respectively)
b) Such that the plastic bending of a propeller blade shall not cause damages in other propulsion line components.
c) With fatigue strength as determined by the criteria in Sec [8.10.5] with the following ice load spectrum.

The Weibull shape parameter, k = 1.0 for both open and ducted propeller torque and bending forces. The load distribution is an accumulated load spectrum (load exceedance diagram).

$T_A (N) = T_{A\,max} (1 – [\log(N) / \log(Z\,N_{ice})])$

This is illustrated by the example below in Fig. 12.

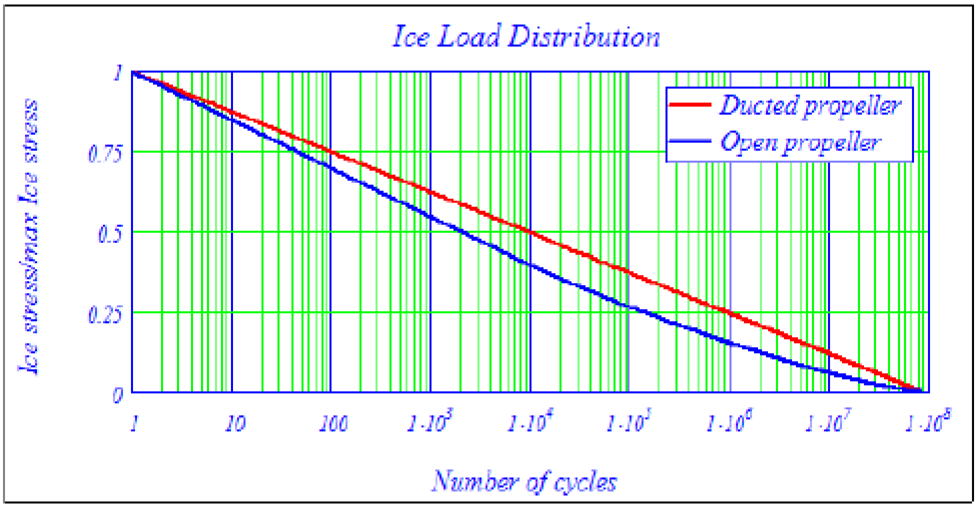


Fig. 11 Ice Load Distribution for Ducted and Open Propeller

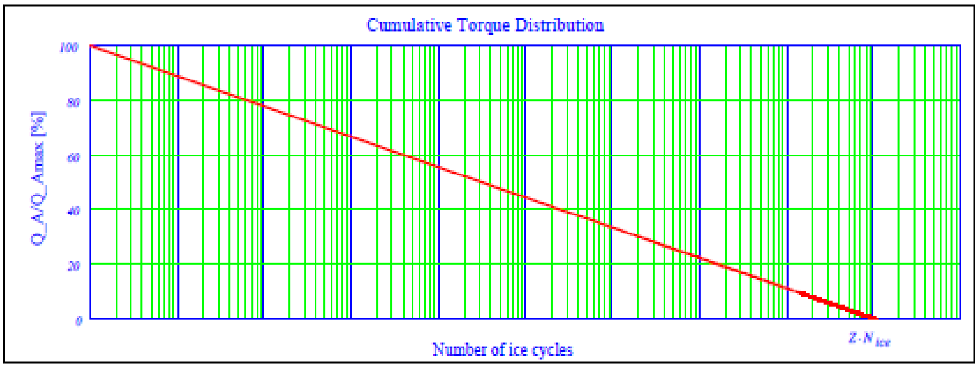


Fig. 12 Total Number of Load Cycles in the Load Spectrum (Determined as: Z Nice)

8.10.2 Propeller Blade Design

8.10.2.1 Maximum Blade Stresses

Equivalent and principal stresses at the blade shall be calculated using the backward and forward loads given in Sec [8.9.3] and Sec [8.9.4]. The stresses shall be calculated with recognized and well documented FE analysis.

The stresses on the blade shall not exceed the allowable stresses σ_{all} for the blade material given below. Calculated blade equivalent stress for maximum ice load shall comply with the following:

$\sigma_{calc} < \sigma_{all} = \sigma_{ref} / S$

Where
σ_{ref} = Reference Stress
= Lesser of ($0.70\ \sigma_u$, $0.60\ \sigma_{0.20} + 0.40\ \sigma_u$)
σ_u , $\sigma_{0.2}$ = Minimum specified values of blade material by manufacturer
S = 1.50

8.10.3 Fatigue Design of Propeller Blades

8.10.3.1 Propeller blades are to be designed so as to prevent accumulated fatigue when considering the loads according to Sec [8.10.1.2] and using the Miner's rule.

8.10.3.2 The S-N curve characteristics are based on two slopes, the first slope 4.5 is from 10^0 to 10^8 load cycles; the second slope 10 is above 10^8 load cycles.

- The fatigue strength $\sigma_{Fat\text{-}E7}$ is the fatigue limit at 10 million load cycles
- The maximum allowable stress is limited by σ_{ref} / S.

The geometrical size factor, K_{size}:
K_{size} =1 – a ln (t / 25)

Where
t = Actual blade thickness at considered section
a = Provided in Table 8.10.1

The mean stress effect K_{mean} is detailed below:
$K_{mean} = 1.00 - (1.4\ \sigma_{mean} / \sigma_u)^{0.75}$

The fatigue limit for 10 million load cycles is then:
$\sigma_{E7} = (\sigma_{Fat\text{-}E7} / S)\ K_{size}\ K_{mean}$
Where
S= 1.50

The SN curve is extended by using the first slope (4.5) to 100 million load cycles due to the variable loading effect (Stress interaction effect).

Table 8.10.1 Mean Fatigue Strength $\sigma_{Fat\text{-}E7}$ and Material Types			
Bronze and brass (a = 0.10)		Stainless steel (a = -.05)	
Mn-Bronze, CUI (high tensile brass)	80 MPa	Ferritic (12Cr 1Ni)	120 MPa
Mn-Ni-Bronze,CU2(high tensile brass	80 MPa	Martensitic (13Cr 4Ni/ 13Cr 6Ni)	150 MPa
Ni-Al-Bronze, CU3	120 MPa	Martensitic (16CR 5Ni)	165 MPa
Mn-Al-Bronze, CU4	105 MPa	Austenitic (19Cr 10Ni)	130 MPa

8.10.4 Blade Flange, Bolts and Propeller Hub and CP Mechanism

8.10.4.1 The blade bolts, the cp mechanism, the propeller boss, and the fitting of the propeller to the propeller shaft shall be designed to withstand the maximum and fatigue design loads, as defined in [8.9]. The safety factor against yielding shall be greater than 1.3 and that against fatigue greater than 1.5. In addition, the safety factor for loads resulting from loss of the propeller blade through plastic bending as defined in Sec [8.9.6.4] shall be greater than 1 against yielding.

8.10.4.2 Blade bolts shall withstand following bending moment considered around bolt pitch circle, or an other relevant axis for not circular joints, parallel to considered root section with a safety factor of 1.0:

$M_{bolt} = F_{ex} (0.4D – r_{bolt})$ (kNm)

Where

r_{bolt} = Radius to the bolt plan (m)

8.10.4.3 Blade bolt pre-tension shall be sufficient to avoid separation between mating surfaces with maximum forward and backward ice loads in Sec [8.9.3.1], Sec [8.9.3.2] and Sec [8.9.4.1], Sec [8.9.4.2] (open and ducted respectively).

8.10.4.4 Separate means using dowel pins, have to be provided in order to withstand a spindle torque resulting from blade failure (Sec 8.9.6.4) Qsex or ice interaction Qsmax (Sec 8.9.3.3), whichever is greater. A safety factor S of 1.0 is required. The minimum diameter of the pins is:

$d = 1000 (13.86 Q_s / [PCD\ i\ \pi\ \sigma_{0.20}])^{0.5}$ (mm)

Where,

Q_s = Maximum of ($Q_{smax\ or}\ Q_{sex}$) – Q_{fr1} – Q_{fr2} (kNm)

PCD = Pitch circle diameter (mm)

i = Number of pins

$\sigma_{0.2}$ = Yield strength of dovel pin material

$Q_{sex} = ([F_{ex} L_{ex}] / 3)$ (kNm)

Q_{fr1} = Friction torque in blade bearings caused by the reaction forces due to F_{ex}

Q_{fr2} = Friction between connected surfaces resulting from blade bolt pretension forces.

L_{ex} = Maximum of distance from spindle axis to the leading, or trailing edge at radius 0,8R

Coefficient of friction 0.15 may normally be applied in the calculation of Q_{fr1} and Q_{fr2}.

8.10.4.5 Components of Controllable Pitch (CP) mechanisms are to be designed to withstand the blade failure spindle torque Q_{sex} and maximum ice spindle torque.

Consequential damage should not occur due to the blade failure spindle torque Q_{sex}.

Fatigue strength is to be considered for parts transmitting the spindle torque from blades to a servo system considering ice spindle torque acting on one blade. The maximum amplitude is defined as:

$Q_{sa\ max} = 0.5 (Q_{sb} + Q_{sf})$ (kNm)

Provided that calculated stresses duly considering local stress concentrations are less than yield strength, or maximum 70% of σ_u of respective materials, detailed fatigue analysis is not required. In opposite case components shall be analyzed for cumulative fatigue.

8.10.4.6 Design pressure for servo system shall be taken as a pressure caused by Q_{smax} or Q_{sex} when not protected by relief valves, reduced by relevant friction losses in bearings caused by the respective ice loads. Design pressure shall in any case be less than relief valve set pressure.

8.10.5 Propulsion Line Components

8.10.5.1 Propeller Fitting to the Shaft

a) Key Mounting
Key mounting is not acceptable.

b) Keyless Cone Mounting
The friction capacity (at 0ºC) shall be at least 2.0 times the highest peak torque T_{peak} (kNm) as determined in Sec [8.9.6] without exceeding the permissible hub stresses.

The required surface pressure can be determined as below:

$P_{0^oc} = (2.20\ T_{peak}) / (1000\ \pi\ \mu\ D_s^2\ L)$

Where
μ = 0.13 for steel to bronze
= 0.14 for steel to steel
D_s = Shrinkage diameter at the mid length of the taper (m)
L = Effective length of taper (m)
Above friction coefficients may be increased by 0.04 if glycerine is used in wet mounting

c) Flange Mounting
The flange mounting shall comply with the following:

1. Flange thickness is to be at least 25% of the shaft diameter.
2. Any additional stress raisers such as recesses for bolt heads shall not interfere with the flange fillet unless the flange thickness is increased correspondingly.
3. The flange fillet radius is to be at least 10% of the shaft diameter.
4. The diameter of ream fitted (light press fit) bolts shall be chosen so that the peak torque does not cause shear stresses beyond 30% of the yield strength of the bolts.
5. The bolts are to be designed so that the blade failure load F_{ex} ,Sec [8.9.6.4] does not cause yielding.

8.10.5.2 Propeller Shaft

The propeller shaft is to be designed to comply with the following:

A. The blade failure load Fex [Sec 8.9.6.4] applied parallel to the shaft (forward or backwards) shall not cause yielding. Bending moment need not to be combined with any other loads. The diameter d in way of the aft stern tube bearing shall not be less than:

$d = 160\ \{ [F_{ex}\ D] / [\sigma_y\ [1 - (d_i / d)^4]\ \}^{1/3}$ (mm)

Where
d = Shaft diameter (mm)
di = Shaft inner diameter (mm)
σy = Minimum specified yield or 0.2% proof strength of the material of the propeller shaft (MPa)

Forward from the aft stern tube bearing the diameter may be reduced based on direct calculation of actual bending moments, or by the assumption that the bending moment caused by F_{ex} is linearly reduced to 50% at the next bearing and in front of this linearly to zero at third bearing.

Bending due to maximum blade forces F_b and F_f have been disregarded since the resulting stress levels are much below the stresses due to the blade failure load.

B. The stresses due to the peak torque Tpeak [kNm] shall have a minimum safety factor of 1.5 against yielding in plain sections and 1.0 in way of stress concentrations in order to avoid bent shafts.

Minimum diameter of Plain Shaft:
$d = 237 \{T_{peak} / (\sigma_y [1 - (d_i / d)^4])\}^{1/3}$ (mm)

Minimum diameter of Notched Shaft:
$d = 207 \{(T_{peak} \alpha_t) / (\sigma_y [1 - (d_i / d)^4])\}^{1/3}$ (mm)

Where
α_t = Local stress concentration factor in torsion.
Notched shaft diameter shall in any case not be less than the required plain shaft diameter.

C. The torque amplitudes with the foreseen number of cycles shall be used in an accumulated fatigue evaluation with the safety factors as defined below.

D. For plants with reversing direction of rotation the stress range $\Delta\tau \alpha_t$ resulting from forward T_{peakf} to astern T_{peakb} shall not exceed twice the yield strength (in order to avoid stress- strain hysteresis loop) with a safety factor of 1.5.

$\Delta\tau \alpha_t \le [2 \sigma_y] / [(3)^{0.5} 1.5]$ (MPa)

The fatigue strength σ_F and τ_F (3 million cycles) of shaft materials may be assessed on the basis of the material's yield or 0.2% proof strength, as below:

$\sigma_F = 0.436 \sigma_y + 77$ (MPa)
$= \tau_F 3^{0.5}$ (MPa)
This is valid for small polished specimens (no notch) and revered stresses.

The high cycle fatigue (HCF) is to be assessed based on the above fatigue strengths, notch factors (ie geometrical stress concentration factors and notch sensitivity), size factors, mean stress influence and the required factor of safety of 1.50.

The low cycle fatigue (LCF) representing 10^3 cycles is to be based on the lower value of either half of the stress range criterion (Refer D above) or the smaller value of yield or 0.7 of tensile strength/$\sqrt{3}$. Both criteria shall have a factor of safety of 1.50.

The LCF and HCF as given above represent the upper and lower knees in a stress-cycle diagram. Since the required safety factors are included in these values, a Miner sum of unity is acceptable.

8.10.5.3 Intermediate Shafts

Intermediate shafts are to be designed to comply with the following:

A. The stresses due to the peak torque T_{peak} (kNm) shall have a minimum safety factor of 1.5 against yielding in plain sections and 1.0 in way of stress concentrations in order to avoid bent shafts.

Minimum diameter of plain shaft, $d = 237\ T_{peak}^{(1/3)} / (\sigma_y\ [1 - (d_i^4 / d^4)])^{1/3}$ (mm)

Minimum diameter of plain shaft, $d = 207\ (\alpha_t\ T_{peak})^{(1/3)} / (\sigma_y\ [1 - (d_i^4 / d^4)])^{1/3}$ (mm)

where α_t is the local stress concentration factor in torsion. Notched shaft diameter shall in any case not be less than the required plain shaft diameter.

B. The torque amplitudes with the foreseen number of cycles shall be used in an accumulated fatigue evaluation with the safety factors as defined below.

C. For plants with reversing direction of rotation the stress range $\Delta\tau\ \alpha_t$ (MPa) resulting from forward T_{peakf} to astern T_{peakb} shall not exceed twice the yield strength (in order to avoid hysteresis) with a factor of safety of 1.50.

$\Delta\tau\ \alpha_t \leq 2\ \sigma_y / 2.60$ (MPa)

The fatigue strengths σ_F and τ_F (3 million cycles) of shaft materials may be assessed on the basis of the material's yield or 0.2% proof strength as detailed below:

$\sigma_F = 0.436\ \sigma_y + 77$ (MPa)
$= 3^{0.5}\ \tau_F$ (MPa)

This is valid for small polished specimens (no notch) and reversed stresses.

The high cycle fatigue (HCF) is to be assessed based on the above fatigue strengths, notch factors (mainly geometrical stress concentration factors and notch sensitivity), size factors, mean stress influence and the required factor of safety of 1.5.

The low cycle fatigue (LCF) representing 10^3 cycles is to based on the lower value of either half of the stress range criterion (Refer C) or the smaller value of yield or 0.7 of tensile strength/√3. Both criteria utilise a factor of safety of 1.5.

The LCF and HCF as given above represent the upper and lower knees in a stress-cycle diagram. Since the required safety factors are included in these values, a Miner sum of unity is acceptable.

8.10.5.4 Shaft Connections

A. Shrink fit couplings (keyless)
The friction capacity shall be at least 1.8 times the highest peak torque T_{peak} as determined in [8.9.6.2] without exceeding the permissible hub stresses.

The necessary surface pressure can be determined by:

$P = 3.6\ T_{peak} / (1000\ \pi\ \mu\ D_s^2\ L)$ (MPa)

Where,
$\mu = 0.14$ (Friction coefficient for steel to steel with oil injection)
$= 0.18$ (Friction coefficient for steel to steel with glycerine injection)

D_s = Shrinkage diameter at mid-length of taper (m)
L = Effective length of taper (m)

B. Key mounting
Key mounting is not permitted.

C. Flange Mounting
The following shall be considered for flange mounting:
1. Flange thickness is to be at least 20% of shaft diameter
2. Flange fillet radius is to be at least 8% of shaft diameter
3. Any additional stress raisers such as recesses for bolt heads shall not interfere with the flange fillet unless the flange thickness is increased correspondingly.
4. The diameter of ream fitted (light press fit) bolts or pins shall be chosen so that the peak torque does not cause shear stresses beyond 30% of the yield strength of the bolts or pins.
5. The bolts are to be designed so that the blade failure load Sec [8.9.6.4] in backwards direction does not cause yielding.

8.10.5.5 Gear Transmissions

A. Shafts
Shafts in gear transmissions shall meet the same safety level as intermediate shafts, but where relevant, bending stresses and torsional stresses shall be combined (by von Mises).

B. Gearing
The following acceptance criteria is to be complied with:
1) Tooth root fracture
2) Pitting of flanks
3) Scuffing
In addition to the above criteria, subsurface fatigue may need to be considered.

Common for all criteria is the influence of load distribution over the face width. All relevant parameters are to be considered, such as elastic deflections (of mesh, shafts and gear bodies), accuracy tolerances, helix modifications, and working positions in bearings (especially for twin input single output gears).

The load spectrum , Refer Sec [8.10.1.3], may be applied in such a way that the numbers of load cycles for the output wheel are multiplied by a factor of (number of pinions on the wheel / number of propeller blades Z). For pinions and wheels with higher speed the numbers of load cycles are found by multiplication with the gear ratios. The peak torque (T_{peak}) is also to be considered.

Tooth root safety shall be assessed against the peak torque, torque amplitudes (with the pertinent average torque) as well as the ordinary loads (free water running) by means of accumulated fatigue analyses. The resulting factor of safety is to be at least 1.50.

The safety against pitting shall be assessed in the same way as tooth root stresses, but with a minimum resulting safety factor of 1.20.

The scuffing safety (flash temperature method) based on the peak torque shall be at least 1.20 when the FZG class of the oil is assumed one stage below specification.

The safety against subsurface fatigue of flanks for surface hardened gears (oblique fracture from active flank to opposite root) shall be assessed at the discretion of each society.

C. Bearings
Refer Sec [8.10.5.9].

8.10.5.6 Clutches

Clutches shall have a static friction torque of at least 1.3 times the peak torque and dynamic friction torque of 2/ 3 of the static.

Emergency operation of clutch after failure of say operating pressure shall be made possible within reasonably short time. If this is arranged by bolts, it shall be on the engine side of the clutch in order to ensure access to all bolts by turning the engine.

8.10.5.7 Elastic couplings

There shall be a separation margin of at least 20% between the peak torque and the torque where any twist limitation is reached.

The torque amplitude (or range Δ) shall not lead to fatigue cracking, i.e. exceeding the permissible vibratory torque. The permissible torque may be determined by interpolation in a log-log torque-cycle diagram where T_{Kmax1} respectively ΔT_{Kmax} refer to 50,000 cycles and T_{KV} refer to 10^6 cycles. Refer illustration in Fig. 13, 14 and 15.

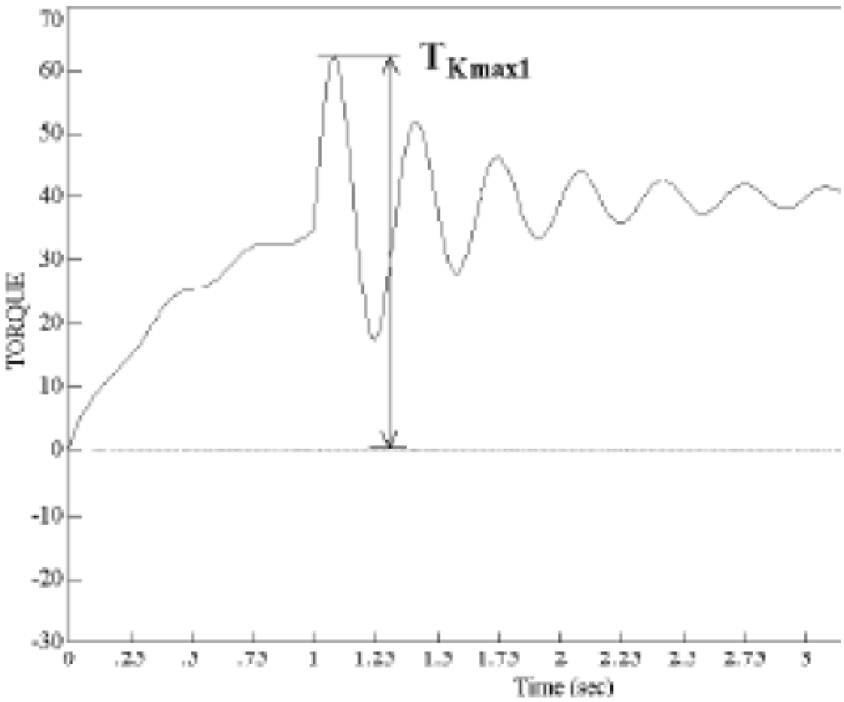


Fig. 13

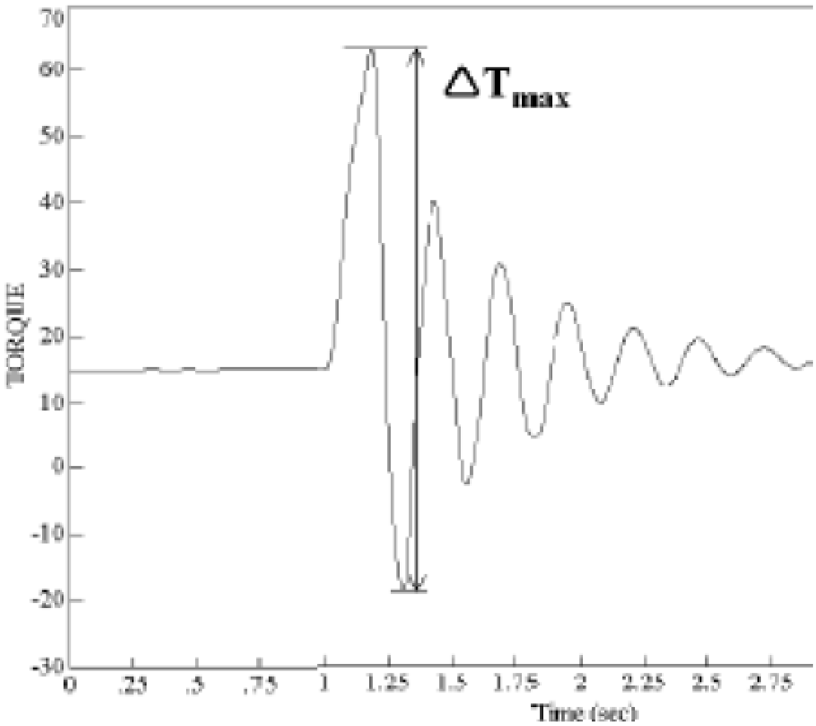


Fig. 14

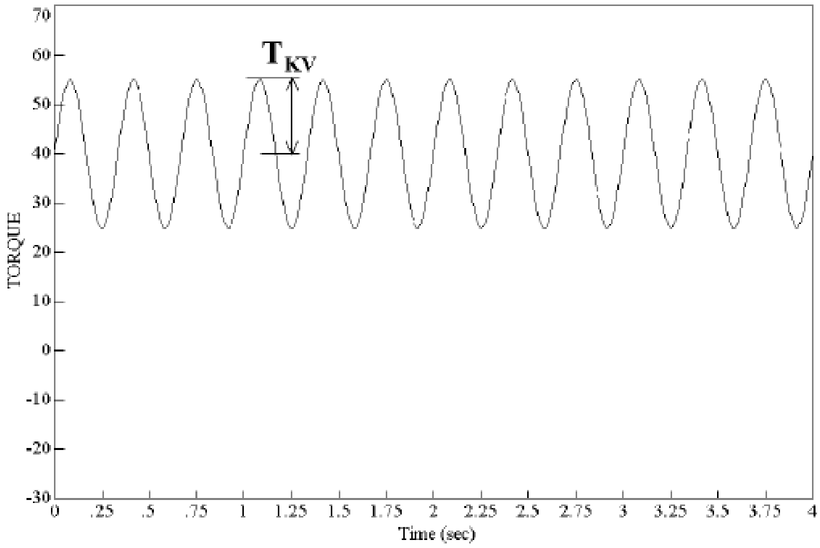


Fig. 15

8.10.5.8 Crankshafts

For plants with large inertia (flywheel, tuning wheel, power take off etc) in the non-driving end of the engine, special consideration is to be applied.

8.10.5.9 Bearings

All shaft bearings are to be designed to withstand the propeller blade ice interaction loads as provided in Sec [8.9.3] and Sec [8.9.4]. For the purpose of calculation, the shafts are assumed to rotate at rated speed. Reaction forces due to the response torque (gear transmissions etc) are to be considered.

Additionally, the aft stern tube bearing as well as the next shaft-line bearing are to withstand F_{ex} as given in Sec 8.9.6, in such a way that the ship can maintain operational capability.

Rolling bearings are to have a L_{10a} lifetime of at least 40 000 hours according to ISO-281.

Thrust bearings and their housings are to be designed to withstand maximum response thrust Sec 8.9.6 and the force resulting from the blade failure force F_{ex}. For the purpose of calculation except for F_{ex} the shafts are assumed to rotate at rated speed. For pulling propellers special consideration is to be given to loads from ice interaction on propeller hub.

8.10.5.10 Seals

Basic requirements for seals:

A. Seal are to be of a proven design or type approved.

B. Seals are to prevent egress of pollutants, and be suitable for the operating temperatures. Contingency plans for preventing the egress of pollutants under failure conditions are to be documented.

8.10.6 Azimuthing main propulsion

8.10.6.1 Special consideration shall be given to those loading cases which are extraordinary for propulsion units when compared with conventional propellers, in addition to the above requirements. The estimation of loading cases has to reflect the way of operation of the ship and the thrusters. In this respect, for example, the loads caused by the impacts of ice blocks on the propeller hub of a pulling propeller have to be considered. Furthermore, loads resulting from the thrusters operating at an oblique angle to the flow have to be considered. The steering mechanism, the fitting of the unit, and the body of the thruster shall be designed to withstand the loss of a blade without damage. The loss of a blade shall be considered for the propeller blade orientation which causes the maximum load on the component being studied. Typically, top-down blade orientation places the maximum bending loads on the thruster body.

8.10.6.2 Azimuth thrusters shall also be designed for estimated loads due to thruster body/ice interaction as per Sec [8.5]. The thruster body has to stand the loads obtained when the maximum ice blocks, which are given in Sec [8.9.2.1], strike the thruster body when the ship is at a typical ice operating speed. In addition, the design situation in which an ice sheet glides along the ship's hull and presses against the thruster body should be considered. The thickness of the sheet should be taken as the thickness of the maximum ice block entering the propeller, as defined in Sec [8.9.2].

8.10.6.3 Design criteria for azimuth propulsors
Loads as defined below shall be considered in the design of azimuth propulsors:

1) Ice pressure on strut based on defined location area of the strut / ice interaction as per Sec [8.5].
2) Ice pressure on pod based on defined location area of thruster body / ice interaction as per Sec [8.5].
3) Plastic bending of one propeller blade in the worst position (typically top-down) without consequential damages to any other part.
4) Steering gear design torque T_{SG} shall be minimum 60% of steering torque expected at propeller ice milling condition defined as T_{max}.

$$T_{SG} = 0.6(T_{max} / 0.8R)\ l \qquad \text{(kNm)}$$

Where,
l is distance from the propeller plane to steering (azimuth) axis (m)

5) Steering gear shall be protected by effective means limiting excessive torque caused by:

a) Torque caused by plastic bending of one propeller blade in the worse position (related to steering gear) and leading to rotation of the unit.
b) Ice milling torque exceeding design torque and leading to rotation of unit

6) Steering gear shall be ready for operation after the above load 5(a) and 5(b) cease to exist.

8.10.7 Steering System

8.10.7.1 Rudder stoppers are to be provided. The design ice force on rudder shall be transmitted to the rudder stoppers without damage to the steering system.

8.10.7.2 Ice knife shall in general be fitted to protect the rudder in centre position. The ice knife shall extend below BWL. Design forces shall be determined according to the subsection [8.5].

8.10.7.3 The effective holding torque of the rudder actuator, at safety valve set pressure, is obtained by multiplying the open water requirement at design speed (maximum 18 knots) by following factors:

Ice Class	**PC-1**	**PC-2**	**PC-3**	**PC-4**	**PC-5**	**PC-6**	**PC-7**
Factor	5.0	5.0	3.0	3.0	3.0	2.0	1.5

The holding torque shall be limited to the actual twisting capacity of the rudder stock calculated at its yield strength (Refer Pt 4 Ch 2)

8.10.7.4 The rudder actuator shall be protected by torque relief mechanism, assuming the following turning speeds (deg/s) without undue rise in pressure (Refer Pt 4 Ch 2 for undue pressure rise):

Ice Class	**PC-1, PC-2**	**PC-3, PC-4, PC-5**	**PC-6, PC-7**
Turning speed (deg/s)	8.0	6.0	4.0

8.10.7.5 Additional fast acting torque relief arrangements (acting at 15% higher pressure than set pressure of safety valves in Sec [8.10.7.4] shall provide effective protection of the rudder actuator in case of the rudder is pushed rapidly hard over against the stops assuming following turning speeds (deg/s).

Ice Class	**PC-1, PC-2**	**PC-3, PC-4, PC-5**	**PC-6, PC-7**
Turning speed (deg/s)	40.0	20.0	10.0

8.10.7.6 The arrangement shall be so that the steering capacity can be fast regained.

8.10.8 Prime Movers

8.10.8.1 Prime movers (main engines etc) shall be capable of being started and running the propeller in bollard condition.

8.10.8.2 Propulsion plants with controllable pitch (CP) propeller shall be capable being operated even in case with the controllable pitch system in full pitch as limited by mechanical stoppers.

8.10.8.3 Heating arrangements shall be provided to ensure ready starting of the cold emergency power units at an ambient temperature applicable to the Polar class of the ship.

8.10.8.4 Power units for emergency purpose shall be equipped with starting devices with a stored energy capability of at least three consecutive starts at the design temperature in Sec [8.9.1] above The source of stored energy shall be protected to preclude critical depletion by the automatic starting system, unless a second independent means of starting is provided. A second source of energy shall be provided for an additional three starts within 30 minutes, unless manual starting can be demonstrated to be effective.

8.10.9 Auxiliary Systems

8.10.9.1 Machinery shall be protected from the harmful effects of ingestion or accumulation of ice or snow. Where continuous operation is necessary, means should be provided to purge the system of accumulated ice or snow.

8.10.9.2 Means shall be provided to prevent damage due to freezing, to tanks containing liquids.

8.10.9.3 Intake and discharge pipes, vent pipes and associated systems shall be designed to prevent blockage due to freezing or ice and snow accumulation.

8.10.10 Sea Inlets, Cooling Water Systems and Ballast Tanks

8.10.10.1 Cooling water systems for machinery that are essential for the propulsion and safety of the vessel, including sea chests inlets, shall be designed for the environmental conditions applicable to the ice class.

8.10.10.2 At least two sea chests shall be arranged as ice boxes for class PC-1 to PC-5 inclusive where. The calculated volume for each of the ice boxes shall be at least 1 m3 for every 750 kW of the total installed power. For PC-6 and PC-7 there shall be at least one ice box located preferably near center line.

8.10.10.3 Ice boxes shall be designed for an effective separation of ice and venting of air.

8.10.10.4 Sea inlet valves shall be secured directly to the ice boxes. The valve shall be a full bore type.

8.10.10.5 Sea bays and ice boxes shall have vent pipes and shall have shut off valves connected direct to the shell.

8.10.10.6 Means shall be provided to prevent freezing of sea bays, ice boxes, ship side valves and fittings above the load water line.

8.10.10.7 Efficient means shall be provided to re-circulate cooling seawater to the ice box. Total sectional area of the circulating pipes shall not be less than the area of the cooling water discharge pipe.

8.10.10.8 Ice boxes shall be provided with detachable gratings or manholes shall be provided. Manholes shall be located above the deepest load line. Access shall be provided to the ice box from above.

8.10.10.9 Openings in ship sides for ice boxes shall be fitted with gratings, or holes or slots in shell plates. The net area through these openings shall be not less than 5 times the area of the inlet pipe. The diameter of holes and width of slot in shell plating shall be not less than 20 mm. Gratings of the ice boxes shall be provided with a means of clearing. Clearing pipes shall be provided with screw-down type non return valves.

8.10.11 Ballast Tanks

8.10.11.1 Efficient means shall be provided to prevent freezing in fore and after peak tanks and wing tanks located above the water line and where otherwise found necessary.

8.10.12 Ventilation Systems

8.10.12.1 The air intakes for machinery and accommodation ventilation shall be located on both sides of the ship.

8.10.12.2 Accommodation and ventilation air intakes shall be provided with means of heating.

8.10.12.3 The temperature of inlet air provided to machinery from the air intakes shall be suitable for the safe operation of the machinery.

8.10.13 Alternative Design

8.10.13.1 As an alternative, a comprehensive design study may be submitted and may be requested to be validated by an agreed test program.

8.11 Stability and Watertight Integrity

8.11.1 General

8.11.1.1 The stability requirements according to Sec [4.12] apply except as stated in Sec [8.11.1.2].

8.11.1.2 For ships of Polar Classes (PC) 6 and 7 not carrying any polluting or hazardous cargoes, damage may be assumed to be confined between watertight bulkheads, except where such bulkheads are spaced at less than the damage dimension.

CHAPTER 2 PASSENGER AND DRY CARGO SHIPS

CONTENTS

SECTION 1 GENERAL REQUIREMENTS

Contents

1.1 Classification

1.1.1 Application

1.1.1.1 This chapter is applicable to ships intended for passengers an or carriage of various dry cargoes. The requirements detailed herein shall be regarded as supplementary to those given for the assignment of main class.

1.1.2 Class Notation

1.1.2.1 Vessels complying with relevant additional requirements of this chapter will be assigned one of the following class notations as detailed below:

Table 2.1.1 Class Notation

Class Notation	Reference
Passenger Ship	Refer Sec 2
Car Ferry A (or B)	Refer Sec 3
Train Ferry A (or B)	Refer Sec 3
Car and Train Ferry A (or N)	Refer Sec 4
General Cargo Carrier (RO/RO)	Refer Sec 4
Bulk Carrier ESP (CSR, BC-A, BC-B, BC-C)	Refer Sec 5
Bulk Carrier (HC-A, HC-B, HC-C, HC-B*, HC-M)	Refer Sec 5
Ore Carrier ESP	Refer Sec 12
Container Carrier	Refer Sec 6
Car Carrier	Refer Sec 7
X Carrier	Refer Sec 9

1.1.2.2 The notations:
The notations below may be added to the class notation provided in Sec [2.1.2.1] as relevant.

PWDK:
Permanent decks for wheel loading (Refer Sec 4)
CONTAINER:
Arranged for carriage of containers (Refer Sec 6)
MCDK:
Arranged for movable car decks (Refer Sec 7)
PET:
Arranged for lift on/ lift off cargo handling and arranged for carriage of vehicles.
…..TEU:
Number of twenty foot containers (Refer Sec 6)
SAFE LASH:
Safe access to containers (Refer Sec 6)
WIV:
Wave induced vibration ie. springing and whipping (Refer Sec 6)

Ships arranged with movable car decks shall satisfy relevant design requirements regardless of the assignment of class notation.

1.1.2.3 The notations below are primarily applicable to general cargo carriers and bulk carriers respectively as indicated in [2.1.2.1], but may be added to other class notations after special consideration.

RO/RO :
Arranged for roll on / roll off cargo handling
BC-A :
Designed to carry dry bulk cargoes of cargo density 1.0 t/m^3 and above with specified holds empty, at maximum draught in addition to **BC-B** conditions.
BC-B:

Designed to carry dry bulk cargoes of cargo density 1.0 t/m^3 and above with all cargo holds loaded in addition BC-C conditions.
BC-C:
Designed to carry dry bulk cargoes of cargo density less than 1.0 t/m^3.
HC-A:
Designed to carry dry bulk cargoes of cargo density 1.0 t/m3 and above with specified holds empty, at maximum draught in addition to **HC-B** conditions.
HC-B:
Designed to carry dry bulk cargoes of cargo density 1.0 t/m3 and above with all holds loaded in addition to **HC-C** conditions.
HC-C:
Designed to carry dry bulk cargoes of cargo density less than 1.0 t/m^3
HC-B*:
Designed to carry dry bulk cargoes of cargo density 1.0 t/m3 and above with any holds empty at maximum draught, applicable for double hull vessels and general cargo carriers.
HC-M:
Designed to carry dry bulk cargoes, applicable for vessels not in compliance with **HC-A**, **HC-B**, **HC-C**, or **HC-B***.
Holds a,b.. may be empty:
Combination of holds that are empty (a, b,..etc)
No MP:
Not strengthened for multiport loading, i.e. not designed to carry maximum allowable cargo hold design mass at reduced draught
Max Cargo Density x.y (t/m^3):
Designed for a cargo density less than x.y t/m3
Block Loading:
Ships intended to operate in alternate block load condition.

1.2 Definitions

1.2.1 Symbols

1.2.1.1 General

L = Rule length (m) (*)
B = Rule breadth (m) (*)
D = Rule depth (m) (*)
T = Rule draught (m) (*)
k_m = Material factor (*)
= 1.00 for Grade A,B,D,E
= 0.78 for Grade AH32, DH32, EH32, FH32
= 0.72 for Grade AH36, DH36, EH36, FH36
= 0.68 for Grade AH40, DH40, EH40, FH40
= $(\sigma_f / 235)^{-a}$ for steel forging and castings
a = 0.75 for $\sigma_f > 235$
= 1.00 for $\sigma_f < 235$
σ_f = Minimum upper yield stress (N/mm^2) not to be taken greater than 70% off Ultimate tensile strength. If not specified on the drawings, σ_f is taken as 50% of the ultimate tensile strength.
f_2 = Stress factor (*)
= 1.00 when midship hull girder strength is in accordance with minimum section modulus.
t_k = Corrosion addition (mm) (*)
w_k = Section modulus corrosion addition (cm^3)(*)
L_1 = L but not to be taken greater than 300m
s = Stiffener spacing (m) measured along plating
l = Stiffener span (m) measure along the top flange of the stifferner
z_n = Vertical distance (m) from baseline or deck line to the neutral axis of the hull girder as relevant
z_a =Vertical distance (m) from the baseline or deck to the point under consideration below or above the neutral axis respectively.
(*) Refer Pt 3, Ch 1, Sec 2.1.1 for details.

1.3 Documentation

1.3.1 General

1.3.1.1 Details on additional classes regarding design, arrangement and strength are in general to be included in the plans specified for the main class.

1.3.1.2 Additional documentation not covered by the main class are specified in appropriate sections of this chapter.

SECTION 2 PASSENGER SHIPS

Contents

2.1 General

2.1.1 Classification

2.1.1.1 The requirements in this section apply to all ships intended for transport or accommodation of passengers. Ships arranged for transport of more than 12 passengers shall be built in compliance with the relevant requirements in this section, and will be assigned one of the mandatory service and type notations **Passenger Ship**, **Car Ferry A** (or **B**), **Train Ferry A** (or **B**) or **Car and Train Ferry A** (or **B**). Refer also Sec 3.

2.1.2 Definitions

2.1.2.1 Strength deck:
As defined in Pt 3, Ch 1, Sec [2.2.5]. If the ship's sides are arranged with rows of windows which will significantly reduce the shear strength, the strength deck may be defined as a lower deck than defined in Pt 3, Ch 1, Sec [2.2.5]. For passenger ships with large discontinuities and reduced effective shipside, the term strength deck will normally not be relevant.

2.1.3 Documentation Requirements

2.1.3.1 Documents as detailed in Table 2.1.1 shall be submitted as required.

Table 2.1.1 Documentation Requirements

Applicability	Documentation Type	Additional Description	(A)/(I)
Decks exposed to vehicles	Design load plan		(I)
Glass roofs	Calculation report	Strength calculations	(I)
Longitudinal and transverse bulkheads	Detailed drawing	Connection between door frames and bulkheads	(I)
Propulsion and steering	Failure mode description	Report shall be submitted prior to approval of detail design plans. Refer IACS UR M69	(I)
Note: (A): For Approval; (I): For Information			

2.1.3.2 For full definition of the documentation types, refer Part 1 relevant Sect

2.1.3.3 When direct stress analyses are submitted for information, such analyses shall be supported by documentation satisfactory for verifying results obtained from the analyses as described in the Pt 3, Ch 13, Sec 1.

2.2 Hull Arrangement and Strength

2.2.1 General

2.2.1.1 Si0de and end bulkheads of the superstructure shall be effectively supported. Adequate transition arrangements shall be provided at the ends of effective continuous longitudinal strength members in the deck and bottom structures.

2.2.2 Global Strength

2.2.2.1 In order to determine the effectiveness of the superstructure and the normal and shear stress response of the hull girder, direct strength calculations using a finite element method may have to be carried out. For passenger ships it is often necessary to utilize the effective load carrying capacity of the superstructure for longitudinal strength purpose.

2.2.2.2 For passenger ships of unusual form or structural arrangements, special consideration and calculations may be required as deemed necessary.

2.2.2.3 When direct strength calculations are carried out, the maximum stillwater shear force and bending moment are normally to be based on the actual loading conditions provided by the designer and may be less than the values specified in Pt 3, Ch 5, Sec [2.1]. The maximum values from all loading conditions, calculated at each position along the ship, shall be used to define the stillwater shear force and bending moment envelope limit curves.

Note:
It is recommended that the envelope limit curves includes a margin of 5% to 8% to provided allowance for possible changes in the design.

2.2.2.4 The design stillwater shear force in areas with large opening or discontinuities in the midship region will be specially considered. The factor ksq, as deigned in Pt 3, Ch 5, Sec [2.1.8] shall not be taken less than 0.5 between 0.4L and 0.6L from AP. Direct strength analyses, where the design shear force envelope limit curve is applied together with the wave shear force distribution, may be required.

2.2.2.5 If documented that the vessel will never be in a stillwater sagging condition, the maximum design sagging stillwater moment may be taken as the minimum actual hogging bending moment.

2.2.2.6 The limiting curve envelope used as basis for the design shall be included in the loading manual and loading computer system as permissible limits for the vessel.

2.2.2.7 The allowable longitudinal stresses shall be as given in Pt 3, Ch 5. When no strength deck is defined, the following longitudinal stress factor applies for bottom and deck respectively:

$f_{2b} = \sigma_l / 175$
$f_{2d} = \sigma_l / 175$

Where
f_{2b} = Stress factor at a position below the neutral axis of the hull girder
f_{2d} = Stress factor at a position above the neutral axis of the hull girder
σ_l = Actual longitudinal stress at the position considered, taken from the global finite element analysis.

2.2.3 Deck Structure

2.2.3.1 Decks subjected to trolleys used in the handling of luggage shall satisfy the requirements given in Sec [4.3.3] and Sec [4.3.4]. The design pressure may be calculated as in Sec 4.3.2, where the trolleys will be regarded as cargo handling vehicles in harbour condition. If the plating or stiffener is subjected to more than one load area, the scantling shall be specially considered.

2.2.3.2 When the lateral and torsional buckling modes in Pt 3, Ch 14, Sec 3 are satisfied, the minimum thickness of deck longitudinals (local stiffeners) according to Pt 3, Ch 8, Sec [3.3.3], may be accepted for normal welded panels with adjustment to the nearest mm. The thickness need not exceed the actual thickness of the deck plating.

2.2.3.3 Deck plating acting as top flange for girders shall be specially checked for buckling, refer Pt 3, Ch 14, Sec 3.

Transverse buckling:
The usage factor for plating acting as transverse girder flange shall not be greater than

$\eta = \sigma_t / \sigma_c \leq 0.87$

Longitudinal buckling:
The usage factor for plating acting as longitudinal girder flange is given by:

$\eta = (\sigma_{MS} + \sigma_{MW} + \sigma_L) / \sigma_c \leq 1.00$

or

$\eta = (\sigma_{MS} + 0.59\ \sigma_{MW} + \sigma_L) / \sigma_c \leq 0.87$

Where
σ_{MS}, σ_{MW} : As defined in Pt 3, Ch 5.
σ_l = Longitudinal stress at deck

2.2.4 Pillars

2.2.4.1 While carrying out direct strength calculations, the axial load component from global bending shall be taken into consideration when determining the nominal axial force in pillars.

2.2.4.2 Pillars subjected to compressive loads shall be checked against the critical buckling load calculated from the Rules Pt 3, Ch 14, Sec 3.

2.2.4.3 When the axial load component from global bending is taken into consideration in combination with local deck forces as described in Pt 3, Ch 14, Sec [3.2], k may be taken as 0.9.

2.2.4.4 The allowable axial stress for pillars subjected to tensile load shall be

$\sigma = 160 / k_m$ (MPa)

2.2.4.5 The local support of tension exposed pillars shall be specially considered. Full penetration welds shall normally be arranged at the ends.

2.2.4.6 Direct stress analyses of deck and bottom structure in way of pillars may be necessary.

2.2.5 Cofferdam Structure

2.2.5.1 Diaphragm plates in cofferdams surrounding tanks shall be specially checked for buckling. All applicable local loads in tank boundaries are given in Pt 3, Ch 9, Sec [2.1.1]. However, the formula taking into account the air pipe height shall be replaced by the following formula for buckling check:

$p = \rho\ g_0\ h_p + \Delta\ p_{dyn}$

Note:
The shear buckling capacity of the diaphragms in the cofferdam structure is often critical for these structures, and details like openings need special consideration. The requirement is based on observations on cofferdams surrounding fuel oil and fresh water tanks.

2.2.5.2 The thickness of plating in diaphragm structure shall satisfy the buckling strength requirements given in Pt 3, Ch 14, Sec 3, taking into account also combination of shear and compressive in-plane stresses as applicable.

2.2.6 Movable Glass Roofs

2.2.6.1 The glass roof and the supporting structure shall be designed for a minimum force, normally be taken as detailed below:

Vertical force:

p_v = q (g_0 + 0.5 a_v) (kN/m^2)
P_v = p A_v
q = minimum 0.15 t/m^2 + self weight of glass roof
a_v = Vertical acceleration according to Pt 3, Ch 4.
A_v = Vertical projection of glass roof

Transverse force on side walls:
p_T = 2.5 kN/m^2
P_T = p A_T
A_T = Vertical projection of glass roof.

Loads at horizontal stoppers:

Combine P_{VC} (= q g_0 A_v) with P_T

2.2.6.2 Allowable nominal stresses shall be as below:
σ = 160 / k_m (MPa)
τ = 90 / k_m (MPa)

2.2.6.3 The roof shall not be opened when the wind speed exceeds 30 knots (15 m/sec). This restriction shall be stated in the operation manual for the vessel.

2.2.6.4 The locking devices/ stoppers shall be provided such that in the event of failure of the hydraulic system the roof will remain in position.

2.2.7 Windows and Glass Structure

2.2.7.1 For windows and glass structure the design load shall be in accordance with the rules as given in Pt 3, Ch 10 Sec 3.1. Design pressure on windows located at front bulkheads above navigation bridge is taken as minimum 7.5 kN/m2, provided that the location is above 4th tier.

2.2.7.2 Required glass thickness is calculated according to Pt 4, Ch 6, Sec [12.2]. Minimum glass thickness given in item 2) may be especially considered for glass doors and walls located in protected areas at sides and aft ends, 1.7 C_w (m) or more above SWL.

2.2.8 Fatigue

2.2.8.1 For ro-pax vessels, which are mainly intended for transport of cargo and with limited numbers of passengers, the racking strength and corresponding fatigue evaluation shall be considered.

2.2.8.2 Fatigue strength assessment of structural details shall be carried out with proper care and attention. Details resulting in high stress concentrations due to longitudinal or racking transverse stresses shall be specially assessed with respect to fatigue.

2.2.8.3 In order to minimize stress concentration and to maintain stress concentration at acceptable levels, increased radius, sufficient edge reinforcements and inserts with increased plate thickness may have to be provided.

Note:
Openings in ship side, longitudinal bulkheads and upper decks are normally to be considered for fatigue assessment.

2.2.8.4 In order to minimize stress concentration and to maintain stress concentration at acceptable levels; increased radius, sufficient edge reinforcements and inserts with increased plate thickness may have to be provided.

2.2.8.5 Welding shall in general be avoided in way of corner regions of opening for doors and windows. If welding in these areas cannot be avoided completely, the details need special consideration as the maximum allowable peak stress due to fatigue reduces considerably.

2.3 Machinery and Systems

2.3.1 General

2.3.1.1 For ships with class notation Passenger Ship the machinery and systems are in to be as required by the main class.

Note:.
Requirements for bilge pumping in passenger ships are provided in SOLAS Ref II-1/21.2.

2.3.1.2 Electrical distribution systems shall be arranged such that fire in any main vertical zone, as defined in Pt 6,Ch 6,sect [4.14], will not interfere with essential services for safety in any other such zone. This requirement will be met if main and emergency feeders passing through any such zone are separated both vertically and horizontally as widely as is practicable.

2.4 Emergency Source of Electrical Power and Emergency Installations

2.4.1 General

2.4.1.1 Statutory text that has been adopted in the rules will be written in normal rule text font (not italics) with a reference to the corresponding statutory regulation. Adopting statutory requirements by reference alone will not be used. Statutory requirements that are outside the scope of class but important to consider in association with the rules shall in some cases be referred to in the notes.

2.4.1.2 An emergency source of electric power which is self-contained shall be provided.

2.4.1.3 The emergency source of electric power, and its associated equipment (transformers etc.) if any, transitional source of emergency power, emergency switchboard, emergency lighting switchboard shall be located above the uppermost continuous deck and shall be readily accessible from the open deck. They shall not be located forward of the collision bulkhead.

2.4.1.4 The location of the emergency source of electrical power and its associated equipment (transformers etc.), if any, the transitional source of emergency power, the emergency switchboard and the emergency electric lighting switchboards in relation to the main source of electrical power, and its associated equipment (transformers etc.), if any, and the main switchboard shall be such as to ensure to the satisfaction of the Administration that a fire or other casualty in spaces containing the main source of electrical power, and its associated equipment (transformers etc.), if any, and the main switchboard or in any machinery space of category A will not interfere with the supply, control and distribution of emergency electrical power. As far as practicable, the space containing the emergency source of electrical power, and its associated equipment (transformers etc.), if any, the transitional source of emergency electrical power and the emergency switchboard shall not be contiguous to the boundaries of machinery spaces of category A or those spaces containing the main source of electrical power, and its associated equipment (transformers etc.), if any, or the main switchboard.

2.4.1.5 Non-essential domestic supplies should not be directly connected to the emergency switchboard.

Provided that suitable measures are considered for safeguarding independent emergency operations under all circumstances, the emergency generator may be used exceptionally, and for short periods to supply non- emergency circuits.

2.4.2 Services to be Offered

2.4.2.1 The electrical power available shall be sufficient to supply all those services that are essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously. The emergency source of electrical power shall be capable (having regard to starting currents and the transitory nature of certain loads) of supplying simultaneously at least the following services for the periods specified hereinafter, if they depend upon an electrical source for their operation, as stated in the following items in Sec [2.4.2.2] to Sec [2.4.2.7].

2.4.2.2 Emergency lighting for a period of 36 hours to be provided as detailed below:

a. At the fire pump, the sprinkler pump and the emergency bilge pump referred to in Sec [2.4.2.4] and at the starting position of their motors;
b. At the steering gear;
c. At all the stowage locations of firemen's outfit;
d. At all control stations, machinery control rooms, and at each main and emergency switchboard;
e. In the machinery spaces and main generator stations including their control positions;
f. In all service and accommodation alleyways, stairways, exists and personnel lift cars;
g. In alleyways, stairways and exits giving access to the muster and embarkation stations, as required by SOLAS regulation III/11.5;
h. At every muster and embarkation station and over the sides as required by SOLAS regulations III/11.4 and III/16.7

2.4.2.3 Emergency power for a period of 36 hours for the following systems:

a. The VHF radio installation required by SOLAS regulation IV/7.1.1 and IV/7.1.2; and, if applicable:
   - 2.1 the MF radio installation required by SOLAS regulations IV/12.1.1, IV/12.1.2, IV/10.1.2 and IV/10.1.3;
   - 2.2 the ship earth station required by SOLAS regulation IV/10.1.1.; and
   - 2.3 the MF/HF radio installation required by SOLAS regulations IV/10.2.1, IV/10.2.2 and IV/11.1.

b. The navigation lights and other lights required by the International Regulations for Preventing Collisions at Sea in force

2.4.2.4 Emergency power for a period of 36 hours for the following systems:

a. For intermittent operation of the daylight signaling lamp, the ship's whistle, the manually operated call points and all internal signals that are required in an emergency;
b. The fire detection and fire alarm system, and the ire door holding and release system;
c. The shipborne navigational equipment as required by SOLAS regulation V/12;
d. All internal communication equipment required in an emergency shall include:
   - The means of communication which is provided between the navigating bridge and the steering gear compartment.
   - The means of communication which is provided between the navigating bridge and the position in the machinery space or control room from which the engines are normally controlled.
   - The means of communication which is provided between the bridge and the radio telegraph or radio telephone stations.
   - The means of communication which is provided between the officer of the watch and the person responsible for closing any watertight door which is not capable of being closed from a central control station.

- The public address system or other effective means of communication which is provided throughout the accommodation, public and service spaces.
- The means of communication which is provided between the navigating bridge and the main fire control station;

Unless such services have and independent supply for the period of 36 hours from an accumulator battery suitably located for use in an emergency.

2.4.2.5 Emergency power for a period of 36 hours for the following systems:

a. The emergency bilge pump, and all the equipment essential for the operation of electrically powered remote controlled bilge valves.
b. The automatic sprinkler system, if any
c. One of the fire pumps required by SOLAS regulation II-2/4.3.1 and 4.3.3.

2.4.2.6 For the period of time required by Pt 6,Ch5,Sect [3.9.1] the steering gear if required to be so supplied by that subsection.

2.4.2.7 For a period of half an hour:

a. The emergency arrangements to bring the lift cars to deck level for the escape of persons. The passenger lift cars may be brought to deck level sequentially in an emergency.
b. Any watertight doors required by SOLAS Reg. II-1/16 to be power operated together with their indicators and warning signals.

2.4.2.8 In a ship engaged regularly on voyages of short duration, the Administration if satisfied that an adequate standard of safety would be attained may accept a lesser period than the 36 hour period specified in items [2.4.2.2] to [2.4.2.6] but not less than 12 hours.

2.4.3 Arrangement of Emergency Source(s) of Power

2.4.3.1 The emergency source of electrical power may be either a generator or an accumulator battery, which shall comply with the following:

2.4.3.2 Where the emergency source of electrical power is a generator, it shall be capable of:

a. Started automatically upon failure of the electrical supply from the main source of electrical power and shall be automatically connected to the emergency switchboard; those services referred to in Sec [2.4.4] shall then be transferred automatically to the emergency generating set. The automatic starting system and the characteristic of the prime-mover shall be such as to permit the emergency generator to carry its full rated load as quickly as is safe and practicable, subject to a maximum of 45 seconds; unless a second independent means of starting the emergency generating set is provided, the single source of stored energy shall be protected to preclude its complete depletion by the automatic starting system; and

b. Provided with a transitional source of emergency electrical power according to Sec [2.4.4].

c. Driven by a suitable prime-mover with an independent supply of fuel having a flashpoint (closed cup test) of not less than 43°C;

2.4.3.3 Where the emergency source of electrical power is an accumulator battery, it shall be capable of:

a. Immediately supplying at least those services specified in Sec [2.4.4].
b. Automatically connecting to the emergency switchboard in the event of failure of the main source of electrical power

c. Carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12 per cent above or below its nominal voltage;

2.4.4 Transitional Source of Emergency Power

2.4.4.1 The transitional source of emergency electrical power supply as required by item 2.4.3.2 b, shall comprise of an accumulator battery suitably located for use in an emergency which shall operate without recharging while maintaining the voltage of the battery throughout the discharge period within 12 per cent above or below its nominal voltage and be of sufficient capacity and so arranged as to supply automatically in the event of failure of either the main or emergency source of electrical power at least the following services, if they depend upon an electrical source for their operation:

2.4.4.2 For half an hour:

a. Lighting as required by [2.4.2.2] and [2.4.2.3] b.
b. All services required by items [2.4.2.4] a, [2.4.2.4] b, [2.4.2.4] d.

2.4.4.3 Power to operate the watertight doors, as required by SOLAS Reg. II-1/16, but not necessarily all of them simultaneously, unless an independent temporary source of stored energy is provided. Power to the control, indication and alarm circuits as required by SOLAS Reg. II-1/16, for half an hour.

2.4.5 Low-location lighting

2.4.5.1 Low-location lighting (LLL) complying with IMO Res. A.752(18) shall be provided for passenger ships.

2.4.6 Supplementary Lighting

2.4.6.1 Supplementary lighting shall be provided in al cabins in passenger ships, to clearly indicate the exit, so that occupant will be able to find their way to the door. Such lighting connected to an emergency source of power or have a self-contained source of electrical power in each cabin, shall automatically illuminate when power to the normal cabin lighting is lost and remain on for a minimum of 30 minutes. (SOLAS Reg. II-1/41.6)

2.4.6.2 For ro-ro passenger ships (SOLAS Reg. 11-1/42-1), in addition to the emergency lighting required by regulation 42.2 (Sec 2.4.2), on every passenger ship with ro-ro cargo spaces or special category spaces as defined in regulation (Sec 2.6):

1. All passenger public spaces and alleyways shall be provided with supplementary electric lighting that can operate for at least three hours when all other sources of electric power have failed and under any condition of heel. The illumination provided shall be such that the approach to the means of escape can be readily seen. The source of power for the supplementary lighting shall consist of accumulator batteries located within the lighting units that are continuously charged, where practicable, from the emergency switchboard. Alternatively, any other means of lighting which is at least as effective may be accepted by the Administration. The supplementary lighting shall be such that any failure of the lamp will be immediately apparent. Any accumulator battery provided shall be replaced at intervals having regard to the specified service life in the ambient conditions that they are subject to in service; and

2. A portable rechargeable battery operated lamp shall be provided in every crew space alleyway, recreational space and every working space which is normally occupied unless supplementary emergency lighting, as required by sub paragraph.1, is provided.

2.4.7 Location of Emergency Switchboard, distribution

2.4.7.1 Emergency switchboard shall be installed as near as is practicable to the emergency source of electrical power.

2.4.7.2 Where the emergency source of electrical power is a generator, the emergency switchboard shall be located in the same space unless the operation of the emergency switchboard would thereby be impaired.

2.4.7.3 No accumulator battery fitted in accordance with this Regulation shall be installed in the same space as the emergency switchboard. An indicator shall be mounted in a suitable place on the main switchboard or in the machinery control room to indicate when the batteries constituting either the emergency source of electrical power or the transitional source of emergency electrical power referred to in item Sect [2.4.3.2] (b) or [2.4.4] are being discharged.

2.4.7.4 The emergency switchboard shall be supplied during normal operation from the main switchboard by an interconnector feeder which shall be adequately protected at the main switchboard against overload and short circuit and which shall be disconnected automatically at the emergency switchboard upon failure of the main source of electrical power. Where the system is arranged for feedback operation, the interconnector feeder is also to be protected at the emergency switchboard at least against short circuit.

2.4.7.5 To ensure ready availability of the emergency source of electrical power, arrangements shall be made where necessary to disconnect automatically non-emergency circuits from the emergency switchboard to ensure that power shall be available to the emergency circuits.

2.4.7.6 The arrangement of the emergency electric lighting system shall be such that a fire or other casualty in spaces containing the emergency source of electrical power, associated transforming equipment, if any, the emergency switchboard and the emergency lighting switchboard will not render the main electric lighting system required by this regulation inoperative. Refer- Pt 6,Ch 2,Sect [3.1.7]

2.4.8 Inclination/ List and Trim of Ship

2.4.8.1 The emergency generator and its prime-mover and any emergency accumulator battery shall be so designed and arranged as to ensure that they will function at full rated power when the ship is upright and when inclined at any angle of list up to 22.5° or when inclined up to 10° either in the fore or aft direction, or is in any combination of angles within those limits.

2.4.9 Periodical Testing

2.4.9.1 Provision shall be made for the periodic testing of the complete emergency system and shall include the testing of automatic starting arrangements.

2.4.10 Starting Arrangements for Emergency Generating Sets

2.4.10.1 Starting arrangements for emergency generating sets shall comply with the requirements given for cargo ships in Pt 6,Ch 2,Sect [3.2]

2.5 Fire Safety Measures for Passenger Ships

2.5.1 Application

2.5.1.1 The requirements for fire protection in this section apply to any ship which carries more than twelve passengers.

2.5.2 Rule References and Definitions

2.5.2.1 These requirements are given in addition to those applicable for the main class, as given in.Pt 6 Ch7 Sect [4.8]

2.5.2.2 For fire technical and space definitions, refer Pt 6 Ch7 Sect [4.8]

2.5.3 Documentation

2.5.3.1 The following plans and particulars shall be submitted for approval:

- General arrangement plan showing main vertical zone arrangement including steps and recesses, stairways and doors
- Arrangement of means of escape from different compartments and escape calculations.

2.5.4 Main vertical zones and horizontal zones (SOLAS Reg. II-2/9.2.2.1)

2.5.4.1 In ships carrying more than 36 passengers, the hull, superstructure and deckhouses shall be subdivided into main vertical zones by “A-60” class divisions. Steps and recesses shall be kept to a minimum but where they are necessary, they shall also be “A-60” class divisions. Open deck spaces, sanitary or similar spaces, tanks, voids and auxiliary machinery spaces having little or no fire risk on one side or where fuel oil tanks are on both sides of the division the standard may be reduced to “A-0”.

2.5.4.2 In ships carrying not more than 36 passengers, the hull, superstructure and deckhouses in way of accommodation and service spaces shall be subdivided into main vertical zones by “A” class divisions.

2.5.4.3 Bulkheads forming the boundaries of the main vertical zones above the bulkhead deck shall be in line with watertight subdivision bulkheads situated immediately below the bulkhead deck, as far as practicable. The length and width of main vertical zones may be extended to a maximum of 48 m in order to bring the ends of main vertical zones to coincide with watertight subdivision bulkheads or in order to accommodate a large public space extending for the whole length of the main vertical zone provided that the total area of the main vertical zone is not greater than 1 600 m2 on any deck. The length or width of a main vertical zone is the maximum distance between the furthermost points of the bulkheads bounding it.

2.5.4.4 Such bulkheads shall extend from deck to deck and to the shell or other boundaries.

2.5.4.5 Where a main vertical zone is subdivided by horizontal “A” class divisions into horizontal zones for the purpose of providing an appropriate barrier between a zone with sprinklers and a zone without sprinklers, the divisions shall extend between adjacent main vertical zone bulkheads and to the shell or exterior boundaries of the ship.

2.5.4.6 Those special purpose ships designed for, automobile or railroad car ferries, where the provision of main vertical zone bulkheads would defeat the purpose for which the ship is intended, equivalent means for controlling and limiting a fire shall be substituted and specifically approved by the Society. Service spaces and ship stores shall not be located on ro-ro decks unless protected in accordance with the applicable requirements.

2.5.4.7 However, ships with special category spaces, any such space shall comply with the applicable requirements to such spaces and where such compliance would be inconsistent with other requirements for passenger ships specified in this Part, the requirements for special category spaces shall prevail.

2.5.4.8 The basic principle underlying the provisions of this paragraph is that the main vertical zoning required by Sec 2.5.4.1 and Sec 2.5.4.2 may not be practicable in vehicle spaces of passenger ships and, therefore, equivalent protection shall be obtained in such spaces on the basis of a horizontal zone concept and by the provision of an efficient fixed fire-extinguishing system. Based on this concept, a horizontal zone may include special category spaces on more than one deck provided that the total overall clear height for vehicles does not exceed 10 m. (SOLAS Reg. II-2/20.2.2.1)

2.5.4.9 The basic principle underlying the provisions of Sec [2.5.4.8] is also applicable to ro-ro spaces. (SOLAS Reg. II-2/20.2.2.2)

2.5.5 Stairways and Lift Protection in Accommodation Area (SOLAS Reg. II-2/9.2.2.5)

2.5.5.1 Stairways shall be within enclosures formed of “A” class divisions, with positive means of closure at all openings, except that:

1. A stairway connecting only two decks need not be enclosed, provided the integrity of the deck is maintained by proper bulkheads or self-closing doors in one 'tween-deck space. When a stairway is closed in one 'tween-deck space, the stairway enclosure shall be protected in accordance with the requirements for decks; and
2. Stairways may be fitted in the open in a public space, provided they lie wholly within the public space.

2.5.5.2 Lift trunks shall be so fitted as to prevent the passage of smoke and flame from one ‘tween-deck to another and shall be provided with means of closing so as to permit the control of draught and smoke. Machinery for lifts located within stairway enclosures shall be arranged in a separate room, surrounded by steel boundaries, except that small passages for lift cables are permitted. Lifts which open into spaces other than corridors, public spaces, special category spaces, stairways and external areas shall not open into stairways included in the means of escape.

2.5.6 Means of Escape from Accommodation Spaces, Service Spaces and Control Stations (SOLAS Reg. II-2/13.3.2.1 - 13.3.2.4)

2.5.6.1 Two means of escape below the bulkhead deck, at least one of which shall be independent of watertight doors, shall be provided from each watertight compartment or similarly restricted space or group of spaces. Exceptionally, the Society may dispense with one of the means of escape for crew spaces that are entered only occasionally, if the required escape route is independent of watertight doors.

2.5.6.2 Where the Society has granted dispensation under the provisions of [2.5.6.1], this sole means of escape shall provide safe escape. However, stairways shall not be less than 800 mm in clear width with handrails on both sides.

2.5.6.3 There shall be at least two means of escape above the bulkhead deck, from each main vertical zone or similarly restricted space or group of spaces at least one of which shall give access to a stairway forming a vertical escape.

2.5.6.4 Stairway enclosures in accommodation and service spaces shall have direct access from the corridors and be of a sufficient area to prevent congestion, having in view the number of persons likely to use them in an emergency. Within the perimeter of such stairway enclosures, only public toilets, lockers of non-combustible material providing storage for non-hazardous safety equipment and open information counters are permitted. Only public spaces, corridors, lifts, public toilets, special category spaces and open ro-ro spaces to which any passengers carried can have access, other escape stairways required by [2.5.6.5] and external areas are permitted to have direct access to these stairway enclosures. Small corridors or “lobbies” used to separate an enclosed stairway from galleys or main laundries may have direct access to the stairway provided they have a minimum deck area of 4.5 m^2, a width of no less than 900 mm and contain a fire hose station.

2.5.6.5 At least one of the means of escape required by [2.5.6.1] and [2.5.6.3] shall consist of a readily accessible enclosed stairway, which shall provide continuous fire shelter from the level of its origin to the appropriate lifeboat and liferaft embarkation decks, or to the uppermost weather deck if the embarkation deck does not extend to the main vertical zone being considered. In the latter case, direct access to the embarkation deck by way of external open stairways and passageways shall be provided and shall have emergency lighting and slip-free surfaces underfoot. Boundaries facing external open stairways and passageways forming part of an escape route and boundaries in such a position that their failure during a fire would impede escape to the embarkation deck shall have fire integrity, including insulation values, in accordance with appropriate requirements.

2.5.6.6 Protection of access from the stairway enclosures to the lifeboat and liferaft embarkation areas shall be provided either directly or through protected internal routes which have fire integrity and insulation values as required for stairway enclosures.

2.5.6.7 Stairways serving only a space and a balcony in that space shall not be considered as forming one of the required means of escape.

2.5.6.8 Each level within an atrium shall have two means of escape, one of which shall give direct access to an enclosed vertical means of escape meeting the requirements of [2.5.6.5].

2.5.6.9 The widths, number and continuity of escapes shall be in accordance with the requirements in the Fire Safety Systems Code.

2.5.7 Means of Escape from Machinery Spaces (SOLAS Reg. II-2/13.4.1)

2.5.7.1 Where the space is below the bulkhead deck the two means of escape shall consist of either:

1. Two sets of steel ladders as widely separated as possible, leading to doors in the upper part of the space similarly separated and from which access is provided to the appropriate lifeboat and liferaft embarkation decks. One of these ladders shall be located within a protected enclosure from the lower part of the space it serves to a safe position outside the space. Self-closing fire doors of the same fire integrity standards shall be fitted in the enclosure. The ladder shall be fixed in such a way that heat is not transferred into the enclosure through non-insulated fixing points. The protected enclosure shall have minimum internal dimensions of at least 800 mm × 800 mm, and shall have emergency lighting provisions; or

2. One steel ladder leading to a door in the upper part of the space from which access is provided to the embarkation deck and additionally, in the lower part of the space and in a position well separated from the ladder referred to, a steel door capable of being operated from each side and which provides access to a safe escape route from the lower part of the space to the embarkation deck.

2.5.7.2 Where the space is above the bulkhead deck, the two means of escape shall be as widely separated as possible and the doors leading from such means of escape shall be in a position from which access is provided to the appropriate lifeboat and liferaft embarkation decks. Where such means of escape require the use of ladders, these shall be of steel.

2.5.7.3 For ships below 1 000 gross tonnage, the Society may dispense with one of the means of escape, due regard being paid to the width and disposition of the upper part of the space. In a ship of 1 000 gross tonnage and above, the Society may dispense with one means of escape from any such space, including a normally unattended auxiliary machinery space, so long as either a door or a steel ladder provides a safe escape route to the embarkation deck, due regard being paid to the nature and location of the space and whether persons are normally employed in that space. In the steering gear space, a second means of escape shall be provided when the emergency steering position is located in that space unless there is direct access to the open deck.

2.5.7.4 From a machinery control room located within a machinery space, two means of escape shall be provided, at least one of which shall provide continuous fire shelter to a safe position outside the machinery space.

2.5.8 Means of Escape from Special Category and Open Ro-Ro Spaces to which any Passengers Carried Can Have Access (SOLAS Reg. II-2/13.5)

2.5.8.1 In special category and open ro-ro spaces to which any passengers carried can have access, the number and locations of the means of escape both below and above the bulkhead deck shall be to the satisfaction of the Society and, in general, the safety of access to the embarkation deck shall be at least equivalent to that provided for under [2.5.6.1], [2.5.6.3], [2.5.6.5] and [2.5.6.6]. Such spaces shall be provided with designated walkways to the means of escape with a breadth of at least 600 mm. The parking arrangements for the vehicles shall maintain the walkways clear at all times.

2.5.8.2 One of the escape routes from the machinery spaces where the crew is normally employed shall avoid direct access to any special category space.

2.5.9 Additional Requirements to Means of Escape for Ro-Ro Passenger Ships

2.5.9.1 Escape routes shall be provided from every normally occupied space on the ship to an assembly station. These escape routes shall be arranged so as to provide the most direct route possible to the assembly station, and shall be marked with symbols. (SOLAS Reg. II-2/13.7.1.1)

Note:
Refer to “Symbols related to life-saving appliances and arrangements” adopted by IMO by Res. A. 760 (18).

2.5.9.2 Escape routes from cabins to stairway enclosures shall be as direct as possible, with a minimum number of changes in direction. It shall not be necessary to cross from one side of the ship to the other to reach an escape route. It shall not be necessary to climb more than two decks up or down in order to reach an assembly station or open deck from any passenger space. (SOLAS Reg. II-2/13.7.1.2)

2.5.9.3 External routes shall be provided from open decks, as referred to in 902, to the survival craft embarkation stations. (SOLAS Reg. II-2/13.7.1.3)

2.5.9.4 Where enclosed spaces adjoin an open deck, openings from the enclosed space to the open deck are, where practicable, to be capable of being used as emergency exits. (SOLAS Reg. II-2/13.7.1.4)

2.5.9.5 Escape routes shall not be obstructed by furniture and other obstructions. With the exception of tables and Chairs which may be cleared to provide open space, cabinets and other heavy furnishings in public spaces and along escape routes shall be secured in place to prevent shifting if the ship rolls or lists. Floor coverings are also to be secured in place. When the ship is underway, escape routes shall be kept clear of obstructions such as cleaning carts, bedding, luggage and boxes of goods. (SOLAS Reg. II-2/13.7.1.5)

2.5.9.6 Escape routes shall be evaluated by an evacuation analysis early in the design process. The analysis shall be used to identify and eliminate, as far as practicable, congestion which may develop during an abandonment, due to normal movement of passengers and crew along escape routes, including the possibility that crew may need to move along these routes in a direction opposite the movement of passengers. In addition, the analysis shall be used to demonstrate that escape arrangements are sufficiently flexible to provide for the possibility that certain escape routes, assembly stations, embarkation stations or survival craft may not be available as a result of a casualty. (SOLAS Reg. II-2/13.7.4)

Note:
Refer to the "Interim Guidelines for a Simplified Evacuation Analysis on Ro-Ro Passenger Ships" developed by IMO (MSC/Circ.909).

2.6 Stability and Watertight Integrity

2.6.1 Application

2.6.1.1 Ships with class notation **Passenger Ship** shall comply with the requirements according to [2.6.2].

2.6.1.2 For ships in domestic trade and with service restrictions, alternative stability requirements may be accepted after considerations in each separate case.

2.6.2 Intact Stability

2.6.2.1 Passenger ships shall comply with Pt 8, with the supplementing requirements as given in Sec [2.6.2.2] to Sec [2.6.2.4].

2.6.2.2 Loading Conditions:
The following standard loading conditions shall be included:

- Ship in the fully loaded departure condition with full cargo, stores and fuel and the full number of passengers and their luggage
- Ship with full stores and fuel and the full number of passengers and their luggage, but without cargo
- Ship in the fully loaded arrival condition, with full cargo and the full number of passengers and their luggage but with only 10% stores and fuel remaining
- Ship with only 10% stores and fuel and the full number of passengers and their luggage, but without cargo.

2.6.2.3 Additional Criteria:
- The angle of hell due to crowding of passengers to one side shall not exceed 10 degrees.
- The angle of hell due to turning should not exceed 10 degrees when calculated using the following formulae:

$$MR = 0.02\, V_0^2\, D\, (KG - 0.5d) / L$$

Where
MR = Heeling moment (tm)
V_0 = Service speed (m/s)
L = Length of ship (m) at waterline
D = Displacement (t)
d = Draught (m)
KG = Vertical centre of gravity, above keel (m)

2.6.2.4 When applying the additional criteria in [2.6.2.3], the following shall be assumed:

1. For each passenger, a mass of 75 kg shall be considered, except that this value may be reduced to not less than 60 kg where this can be justified. In addition, the mass and distribution of the luggage shall be taken into account.

2. The vertical center of gravity for the passengers shall be assumed as below, for standing and seated case:

- For passengers standing upright:
  1.0 m above deck level (camber and sheer to be taken into account)

- For passengers that are seated:
  0.3 m above the seat (camber and sheer to be taken into account)

3. Passengers without luggage shall be considered as distributed to produce the most unfavorable combination of passenger heeling moment and or initial metacentric height, which may be obtained in practice. A value of not less than 4 persons per square meter shall be applied.

SECTION 3 FERRIES

Contents

3.1 General

3.1.1 Classification

3.1.1.1 Requirements provided in this section apply to ships intended for regular transport of passengers and vehicles. The requirements for passenger ships given in Sec 2 are also to be complied with.

3.1.1.2 Ships designed and arranged for carriage of vehicles on enclosed decks and built in compliance with relevant requirements specified in the following will be given one of the class notations **Car Ferry A**, **Train Ferry A** or **Car and Train Ferry A** whichever is applicable.

3.1.1.3 Ships designed and arranged for carriage of vehicles on weather deck only and built in compliance with relevant requirements specified in the following will be given one of the class notations **Car Ferry B**, **Train Ferry B** or **Car and Train Ferry B** whichever is applicable.

3.1.2 Assumptions

3.1.2.1 The requirements for the class notation **B** are based on the assumption that service restriction notation **R2** or stricter are included in the main class.

3.1.3 Documentation

3.1.3.1 The following plans and particulars shall be submitted for approval:

a. Bow, stern, side shell doors (inner and outer) including force carrying structures of door cleat and support devices and their supporting structure of the hull.
b. Closing arrangement for doors and system for operation.
c. Arrangement of access from the ro-ro deck (bulkhead deck) to spaces below (showing all doors, ramps, hatches etc)
d. Operating and maintenance manual for bow doors, side shell doors and stern doors

The operating and maintenance manual shall be provided on board and shall include the following:

Main particulars and design drawings:
- Details of vessel, class
- Equipment and design loading (for ramps)
- Key plan of equipment (doors and ramps)
- Special safety precautions
- Manufactures recommended testing for equipment
- Description of equipment for:
- Bow doors
- Inner bow doors
- Bow ramps/ doors
- Side doors
- Stern doors
- Central power pack
- Bridge panel
- Engine control room panel

Service Conditions:
- Limiting hell and trim of ship for loading/ unloading
- Limiting heel and trim for door operations
- Doors/ ramps operating instructions
- Doors/ ramps emergency operating instructions

Maintenance:
− Manufacturers maintenance procedures.
− Schedule and extent of maintenance
− Trouble shooting
− Acceptance/ rejection criteria, acceptable clearances

Register of inspections including:
− Inspection of locking, securing and supporting devices.
− -Repairs and renewals

The operating and maintenance manual, together with the items listed above, shall be submitted for approval. In addition, the inclusion of the necessary information with regard to inspections, trouble-shooting and acceptance/rejection criteria in the maintenance part shall be verified.

Note:
Recorded inspections of the door supporting and securing devices be carried out by the ships staff at monthly interval or following incidents that could result in damage, including heavy weather or contact in the region of the shell doors. Any damage recorded during such inspections shall be reported to the Class. This is also to be stated in the operating and maintenance manual.

Reference is also made to the safety management system described in the ISM code.

3.1.3.2 The following plans and particulars shall be submitted for information:

a. An arrangement plan showing the position of watertight doors in the stern, sides, bow and collision bulkhead in relation to the watertight subdivision of the hull.
b. Arrangement of doors including hydraulic and mechanical supporting, cleating and locking arrangements as relevant. For doors with clear opening >12 m^2, the design support forces considered and or determined for each support shall be stated on the arrangement drawing and submitted together with design calculations carried out. For bow doors the longitudinal, transverse and vertical projections shall be shown.
c. Arrangements of air intakes, ventilators etc.
d. Arrangement of doors from vehicle deck.
e. Drainage openings and or freeing ports for vehicle deck and space between outer and inner bow door.
f. Arrangement of wheels and axles or bogies for heavy vehicles, stating maximum axle and or bogie load.
g. Fastening and securing appliances of vehicles to the hull structure.
h. Types of locking arrangements used on cleats and support devices on doors with clear opening > 12 m^2 Refer Sec [3.4.12.1]

3.1.3.3 Documentation for the following indication, control and monitoring systems shall be submitted for approval:

− Bow door monitoring system
− Water leakage monitoring system
For requirements on documentation types, refer Pt.4 Ch.9 (..Machinery and systems??).

3.1.4 Definitions

3.1.4.1 Symbols:

k_m = Material factor (*)
= 1.00 Grade A,B,D,E
= 0.78 for Grade AH32, DH32, EH32, FH32

= 0.72 for Grade AH36, DH36, EH36, FH36
= 0.68 Grade AH40, DH40, EH40, FH40
(*) For details of k_m refer Pt 3, Ch 2, Sec 2.2.

t = Rule thickness (mm) of plating
Z = Rule section modulus (cm^3) of stiffeners and simple girders
s = Stiffener spacing (m) measured along the plating
l = Stiffener span (m) measured along the top flange of the member. For definition of span point, refer Pt 3, Ch 3, Sec 3.1. For curved stiffeners l may be taken as the cord length.
S = Girder span (m). For definition of span point, refer Pt 3, Ch 3, Sec 3.1.
b = Loading breadth (m) for girders

3.1.4.2 The load point where the design pressure shall be calculated is defined for various strength members as follows:

a. For plates:
Midpoint of horizontally stiffened plate field.
Half of the stiffener spacing above the lower support of vertically stiffened plate field or at lower edge of plate when the thickness is changed within the plate field.

b. For stiffeners:
Midpoint of span.
When the pressure does not vary linearly over the span, the design pressure shall be taken as the greater of:
p_m and $0.50(p_a + p_b)$

Where
p_m, p_a and p_b are calculated pressures at the midpoint and each end respectively.

c. For girders:
Midpoint of load area

3.1.4.3 Ro-Ro Passenger Ships
Ro-Ro passenger ships are passenger ships with ro-ro spaces or special category spaces.

3.1.4.4 Ro-Ro spaces
Ro-ro spaces are spaces not normally subdivided in any way and normally extending to either a substantial length or the entire length of the ship in which motor vehicles with fuel in their tanks for their own propulsion and/ or goods (packaged or in bulk, in or on rail or road cars, vehicles (including road or rail tankers), trailers, containers, pallets, demountable tanks or in or on similar stowage units or other receptacles) can be loaded and unloaded normally in a horizontal direction.

3.1.4.5 Special Category Spaces

Special category spaces are those enclosed spaces above or below the bulkhead deck into and from which vehicles can be driven and to which passenger have access. Special category spaces may be accommodated on more than one deck provided that the total overall clear height for vehicles does not exceed 10 m.

3.1.5 Internal Communication

3.1.5.1 Requirement for documentation of general alarm and public address systems is given in INTLREG rules Part 06.

3.1.6 Bow Doors Monitoring System Certification

The bow doors monitoring system shall be certified .

3.2 Hull Arrangement and Strength

3.2.1 Vehicle Decks, Ramps and Lifts

3.2.1.1 Plating with supporting stiffeners and girders for direct wheel loads shall satisfy the requirements for the class notation **PWDK** given in Sec 4.3. Decks where the free height exceed 2.5 m, shall be designed for an axle load not less than 10 t.

3.2.1.2 If movable car decks are fitted, shall satisfy relevant requirements given in Sec 7.

3.2.1.3 Lift platforms, external ramps and internal ramps are to satisfy the requirements provided in Sec 4.2.

3.2.1.4 Scantlings of lifts, decks and ramps etc. for railway carriages shall be considered on a case by case basis.

3.2.2 Securing of Vehicles

3.2.2.1 Effective means for securing of road vehicles and railway carriages shall be provided. Strength and fastening of the securing points shall satisfy the requirements given in Sec 4.2.12.

3.2.2.2 For ships with restricted service notation **R3**, **R4** or **RE**, the requirements with respect to securing appliances may be reduced or discarded based upon special consideration of the intended service area.

3.2.3 Transverse Strength

3.2.3.1 A sufficient number of vertical side girders and/or transverse bulkheads in casing(s) shall be fitted between the vehicle deck(s) and the superstructure above. Transverse and longitudinal bulkheads shall be effectively supported below the vehicle deck(s). Calculations necessary to demonstrate that the stresses are acceptable, shall be carried out for the ship also in heeled conditions. Design loads, calculation methods and allowable stresses shall be as given for complex girder systems in Pt 3, Ch 14.

3.3 Opening and Closing Appliances

3.3.1 Doors

3.3.1.1 Arrangements and scantlings of doors in ship's side and ends are in general to satisfy the requirements given in the main class, with relevant additions as given in Sec 3.3.1.2 to…….

3.3.1.2 The bow door arrangement, scantlings and securing are provided in Sec 3.4.

3.3.1.3 The side and stern doors arrangement, scantlings and securing are provided in Pt 4, Ch 6.

3.3.1.4 For ferries with the class notation B, openings in sides and ends leading to the vehicle deck need not have closing appliances.

3.3.1.5 Doors also used as driving ramps for vehicles shall satisfy relevant requirements given in Sec 4.2 and Sec 4.3.

3.3.2 Access Openings

3.3.2.1 Sill heights, doors re in general to satisfy the requirements given in the main class rules.

3.3.2.2 Doors leading from vehicle deck to engine room shall have sill heights not less than 380 mm. Other doors leading from vehicle deck within a closed superstructure to spaces below freeboard deck, are in no case to have sill heights less than 230 mm.

3.3.3 Watertight Integrity from the Ro-Ro Deck (Bulkhead Deck) to Spaces Below

3.3.3.1 Subject to the provisions of 3.3.3.2 and 3.3.3.3 all accesses that lead to spaces below the bulkhead deck shall have a lowest point which is not less than 2.5 m above the bulkhead deck. (SOLAS Reg. II-1/20-2.1)

3.3.3.2 Where vehicle ramps are installed to give access to spaces below the bulkhead deck, their openings shall be able to be closed weathertight to prevent ingress of water below, alarmed and indicated to the navigation bridge. Signboard marked “To be closed at sea” to be fitted. (SOLAS Reg. II-1/20-2.1)

3.3.3.3 The Society may permit the fitting of particular accesses to spaces below the bulkhead deck provided they are necessary for the essential working of the ship, eg. the movement of machinery and stores, subject to such accesses being made watertight, alarmed and indicated to the navigation bridge. Signboard marked “To be closed at sea” to be fitted. (SOLAS Reg. II-1/20-2.1)

3.3.3.4 Subject to the approval by flag-state, the Society may accept equivalent solutions to the requirements specified in Sec 3.3.3.1 and Sec 3.3.3.3.

3.4 Bow Doors

3.4.1 Application and Definitions

3.4.1.1 The requirements given below are applicable for bow doors in ships with unrestricted service. For possible reduced bow impact loads for ships with service area restriction, refer Sec 3.4.4.2. Conditions established in this respect shall be presented in the Operating and Maintenance Manual.

3.4.1.2 For outer bow doors, the requirements apply to the following two types of doors:

a. Visor doors opened by rotating upwards on the horizontal axis through hinges located near the top of the door and connected to the primary structure of the door by longitudinally arranged lifting arms.

b. Side hinged doors opened by rotating outwards on a vertical axis through two or more hinges located near the outboard edges. It is anticipated that side hinged doors are arranged by pairs.

Other types of outer door will be specially considered in association with the applicable requirements given below.

The closing arrangement for bow doors shall include the following:

- Doors
- Ramps
- Packing/ seals
- Hinges
- Cleats
- Supports

– Locking arrangement

3.4.1.3 Definitions

Bow doors:
Collective term for the outer and the inner bow door normally leading to a complete or long forward enclosed superstructure.

Cleats:
Devices for pre-compression of packings and steel to steel contact (not load carrying devices).

Supports:
Load carrying devices designed for transfer of acting forces from door- to hull structures. These may include hinges, welded supports, bolts / eye plates etc.

Locking Arrangement:
Preventive measures ensuring that cleats and supports as applicable always remain in position when engaged.

3.4.2 Arrangement

3.4.2.1 The bow doors shall be situated above the freeboard deck of the vessel. A watertight recess in the freeboard deck located forward of the collision bulkhead and above the deepest waterline fitted for arrangements of ramps or other related mechanical devices may be regarded as a part of the freeboard deck for the purpose of this requirement.

3.4.2.2 When bow doors lead to a complete or long forward enclosed superstructure, an inner door shall be fitted. The inner door shall be part of the collision bulkhead. The inner door needs not to be fitted directly above the bulkhead below, provided the requirements concerning the position of the collision bulkhead are complied with, refer Sec 2.2. A vehicle ramp may be arranged to serve the purpose of an inner door, provided no part of the ramp protrudes forward of the location range of the collision bulkhead.

3.4.2.3 The outer doors shall be installed to ensure tightness consistent with operational conditions and to give effective protection to inner doors. Inner doors forming part of the collision bulkhead shall be weather tight over the full height of the cargo space and shall be arranged with supports on the aft side of the doors.

3.4.2.4 Bow doors shall be arranged so as to avoid the possibility of the outer door causing structural damage to the collision bulkhead and the inner door in the case of damage to or detachment of the door.

Note:
In order to comply with requirements given in Sec 3.4.2.4 it is advised that the hinges of the outer bow door should not be attached to structural elements being part of the collision bulkhead or to the upper deck at a position aft of the collision bulkhead at the point of attachment. If the above mentioned solution is not possible, due attention should be given to the design of the hingepin (axle) and fastening of this to ensure this is the weak link compared to the fastening/support of the hinge-plate (lug) to the ship structure. This shall ensure that any possible damage occurs in the hingepin or in way of this, and not the hinge-plate fastening/support or adjacent ship structure which in turn may lead to damage of the collision bulkhead. Furthermore, no part of the inner door (or combined inner door/ramp) should protrude forward of the adjacent hull structures.

3.4.2.5 The whole steel construction between the outer and inner door, ie. deck construction, the sides and bulkheads forming the space between the outer and inner door, shall be capable of sustaining the sea loads as given in Sec 3.4.4.3 for the inner door.

3.4.3 Materials

3.4.3.1 Materials for bow door structure shall satisfy the requirements given for hull materials.

3.4.3.2 Steel forgings or castings used in the closing arrangement and maneuvering components shall be of approved ductile materials, tested in accordance with the requirements in Pt 2, Ch 2. The material factor k_m for forgings (including rolled round bars) and castings may be taken as:

k_m = $(\sigma_F / 235)^{-0.75}$

Where,
σ_F = Minimum upper yield stress (N/mm^2), not to be taken greater than 70% of the ultimate tensile strength.
Material factor k_m shall not be taken less than 0.72 unless a direct fatigue analysis is carried out.

3.4.4 Design Loads

3.4.4.1 Design sea pressure for ordinary outer doors:
p_e = Refer p_2 in Pt 3, Ch 5, Sec 3.

3.4.4.2 Design bow impact pressure for outer doors:
p_{se} = Refer p_{sl} in Pt.3 Ch.1 Sec.7 E with $\gamma = 0$

For ships with service area restrictions R2 to RE the wave coefficient, Cw, may be reduced as follows for calculations of bow door impact pressure:
- Service area notation R2: 10%
- Service area notation R2: 20%
- Service area notation R2: 30%
- Service area notation R2: 40%

3.4.4.2 For inner doors including surrounding structures forming part of the collision bulkhead above the freeboard deck, the design sea pressure shall be taken as the greater of:

p_e = 0.60 L (kN/m^2)
Or
p_h = 10 h_b (kN/m^2)

Where
L = Ships length (m) as provided in Pt.3 Ch.1 Sec.1 B, need not be taken greater than 200m.
h_b = Vertical distance (m) from load point to top of cargo space

3.4.4.3 For bow doors the internal design pressure shall not be taken less than:
p_i = 25 kN/m^2

3.4.4.3 The design load (kN) on each half of the outer door for support devices, including supporting structural members and surrounding structures, are given by (Ref Fig. 1):

External loads:
- Total longitudinal load, F_x = Greater of 0.375 p_{se} A_x (or) 1.30 p_e A_x
- Total transverse load, F_y = Greater of 0.375 p_{se} A_y (or) 1.30 p_e A_y

– Total vertical load, F_y = Greater of 0.375 p_{se} A_z (or) 1.30 p_e A_z

The vertical force shall not be taken less than 3.3 b l h, where b, l and h are breadth, length and height, respectively, of the outer door in m as given in Fig. 1.

A_x = Area (m^2) of the transverse vertical projection of the outer door at one side of the centre line, between the levels of the bottom of the door and the top of the upper deck bulwark, or between the bottom of the door and the top of the door, including the bulwark, where it is part of the door, whichever is lesser. Where the flare angle of the bulwark is at least 15 degrees less than the flare angle of the adjacent shell plating, the height from the bottom of the door may be measured to the upper deck or to the top of the door, whichever is lesser. In determining the height from the bottom of the door to the upper deck or to the top of the door, the bulwark shall be excluded.

Ay = Area (m^2) of the longitudinal vertical projection of the outer door between the levels of the bottom of the door and the top of the upper deck bulwark, or between the bottom of the door and the top of the door, including the bulwark, where it is part of the door, whichever is lesser. Where the flare angle of the bulwark is at least 15 degrees less than the flare angle of the adjacent shell plating, the height from the bottom of the door may be measured to the upper deck or to the top of the door, whichever is lesser.

Az = Area (m^2) of the horizontal projection of the outer door at one side of the centre line, between the bottom of the door and the top of the upper deck bulwark, or between the bottom of the door and the top of the door, including the bulwark, where it is part of the door, whichever is lesser. Where the flare angle of the bulwark is at least 15 degrees less than the flare angle of the adjacent shell plating, the height from the bottom of the door may be measured to the upper deck or to the top of the door, whichever is lesser.

The design pressures shall be calculated at the position h/2 above the bottom of the door and l/2 aft of the stem line.

For outer doors, including bulwark, of unusual form or proportions, the areas and angles used for determination of the design values of external forces may require special consideration.

Internal loads:

Total longitudinal load, F_{xi} = p_i A_x

Total transverse load, F_{yi} = p_i Ay

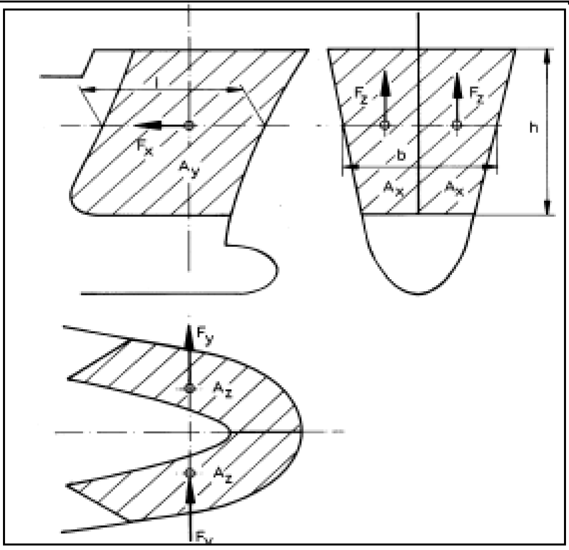


Fig 1 Bow Doors

3.4.4.4 The design force (kN) on the inner door for support devices, including supporting structural members and surrounding structures, is given by:

External force:
Total longitudinal load, F_x = Maximum of $p_e A_x$ or $p_h A_x$

Internal force:
Total longitudinal load, F_{xi} = $p_i A_x$

Where
A_x = Inner door area (m^2)

3.4.5 Strength Criteria

3.4.5.1 Based on the direct strength calculations as detailed in Sec 3.4.9.3. scantlings of primary members and supports of bow doors shall be determined to withstand the design pressures based on the following allowable stresses:

Table 3.4.1 Allowable Stresses, Outer Doors

Design Pressure	Shear Stress	Bending or Normal stress	Equivalent Stress
p (N/mm²)	**τ (N/mm²)**	**σ (N/mm²)**	**σ_e (N/mm²)**
p_e or p_i	80 / k_m	120 / k_m	150 / k_m
0.375 p_{se}	105 / k_m	160 / k_m	200 / k_m

Table 3.4.2 Allowable Stresses, Inner Doors

Design Pressure	Shear Stress	Bending or Normal stress	Equivalent Stress
p (N/mm²)	**τ (N/mm²)**	**σ (N/mm²)**	**σ_e (N/mm²)**
p_e, p_h or p_i	105 / k_m	160 / k_m	200 / k_m

3.4.5.2 In support devices and supporting member and surrounding structure, the allowable stresses shall be as provided below:

Table 3.4.3 Allowable Stresses, Outer Doors

Design Pressure	Shear Stress	Bending or Normal stress	Equivalent Stress
p (N/mm²)	**τ (N/mm²)**	**σ (N/mm²)**	**σ_e (N/mm²)**
0.375 p_{se}, 1.3 p_e, or 1.3 p_i	105 / k_m	160 / k_m	200 / k_m

Table 3.4.4 Allowable Stresses, Inner Doors

Design Pressure	Shear Stress	Bending or Normal stress	Equivalent Stress
p (N/mm^2)	**τ (N/mm^2)**	**σ (N/mm^2)**	**σ_e (N/mm^2)**
p_e, p_h or p_i	$105 / k_m$	$160 / k_m$	$200 / k_m$

3.4.5.3 For threads of bolts not carrying support forces the nominal tension in way of the threads shall not exceed $125 / k_m$ (N/ mm^2).

3.4.5.4 Nominal bearing pressure, determined by dividing the design force by the projected bearing area, shall not exceed $0.8\ \sigma_F$ (N/mm2) for steel material where σ_F is the yield stress for the bearing material. For other bearing materials the nominal bearing pressure will be specially considered.

3.4.6 Structural Arrangement

3.4.6.1 The bow doors shall be adequately stiffened, and arrangements shall be provided to prevent lateral or vertical movement of the doors when closed. For outer doors of the visor type adequate strength shall be provided in the connections of lifting arms to the door and the ship structure.

3.4.6.2 The structural arrangement and the member scantlings for outer doors shall comply with the requirements for bow impact in Pt 3, Ch 7, Sec 5 and associated requirements given under Sec 3.4.7 to Sec 3.4.9.

3.4.7 Plating

3.4.7.1 The bow door plating thickness requirement corresponding to lateral pressure is given by the greater of the following:

- Inner and outer doors:

$t_1 = 1.58\ k_a\ s\ (p_e\ k_m)^{0.5}$ (mm)
For calculating t1 for inner doors, p_e to be taken as the greatest of p_e, p_h or p_i.

$t_2 = 13.8\ k_a\ s\ (p_{sl} / \sigma_f)^{0.5}$ (mm)
- Outer doors:

Where
p_{sl} = As provided in Pt 3, Ch 7, Sec 5.
k_a = Correction factor for aspect ratio of the plate field
= $(1.10 – 0.25\ s/l)^2$
= maximum of 1.00 for s/l = 0.40
= maximum of 0.72 for s/l = 1.00
The thickness of the inner door shall not be less than the minimum thickness for the collision bulkhead as given in Pt 3, Ch 9, Sec 3.

3.4.8 Stiffeners

3.4.8.1 The horizontal or vertical stiffener's elastic/plastic section modulus shall not be less than the greater of the following:

- Inner and Outer doors: The elastic section modulus, Z_1 shall not be less than,
  $Z_1 = 0.80\ s\ p_e\ l^2\ k_m$ (cm^3)

  For calculation of Z_1 for inner doors, p_e to be taken as the greatest of p_e, p_h or p_i

- Outer doors: The plastic section modulus of shell stiffeners, ZP, as defined in Pt 3, Ch 3, Sec 3 shall not be less than as given in Pt 3, Ch 7, Sec 5 with $t_k = 0$.

3.4.8.2 The net sectional area of the stiffener web plate at the ends shall area not less than the greater of the following:

- Inner and Outer doors:
  $A_1 = 0.08\ s\ l\ p_e\ k_m$ (cm^2)
  For calculation of A_1 for inner doors, p_e to be taken as the greatest of p_e, p_h or p_i

- Outer doors:
  $A_2 = A$, as provided for shell stiffeners in Pt 3, Ch 7, Sec 5 with $t_k = 0$.

3.4.9 Girders

3.4.9.1 The section modulus of single girders shall not be less than the greater of the following:

- Outer doors:

$Z_1 = 1.05\ S^2\ b\ p_e\ k_m$ (cm^3)

- Inner doors:

$Z_1 = 0.80\ S^2\ b\ p_e\ k_m$ (cm^3)

For calculation of Z_1 for inner doors, p_e to be taken as the greatest of p_e, p_h or p_i.

- Outer doors:

$Z_2 = Z$, as provided in Pt.3 Ch.1 Sec.7 E with $w_k = 1.0$ for primary members supporting shell stiffeners.

3.4.9.2 The web area requirement (after deduction of cutouts) at the girder ends is provided by the greater of the following:

- Inner and Outer doors:

$A_1 = 0.08\ S\ b\ p_e\ k_m$ (cm^2)

For calculation of A_1 for inner doors, p_e to be taken as the greatest of p_e, p_h or p_i.

- Outer doors:

$A_2 = A$, as provided in Pt 3, Ch 7, Sec 5 with $t_k = 1.00$ for primary members supporting shell stiffeners.

3.4.9.2 For large doors with a complex girder system a direct stress analysis of the door structure including supports may be required. Allowable stresses are given in Sec 3.4.5.1 and Sec 3.4.5.2.

3.4.9.3 For the primary structural members, the buckling strength needs to be verified as being adequate.

3.4.9.4 The arrangement, scantlings and stiffening of girders and diaphragms supporting shell frames of outer bow doors shall comply with requirements given in Pt 3, Ch 7, Sec 5..

3.4.9.5 The girder system shall be given sufficient stiffness to ensure integrity of the boundary support of the door. The stiffness of the edge girders shall be related to the distance between supports and to the loads from the main door girders.

3.4.9.6 Wheel loads shall be considered where inner doors serve as vehicle ramps as provided in Sec 3.2.3.

3.4.10 Closing Arrangement, General

3.4.10.1 Based on the strength and stiffness of the surrounding structure, adequate provisions shall be arranged for closing of bow doors.

3.4.10.2 Mechanism for closing of bow doors shall be easily accessible and simple to operate.

3.4.10.3 The operation and control panel for remotely controlled bow doors shall be inaccessible for unauthorized persons. Closing arrangement for bow doors shall be provided with devices arranged for remote control form a convenient position above the freeboard deck.

3.4.10.4 Display notice plates, providing instructions that bow doors shall be closed and all devices provided for closing are closed and locked before leaving quay-side (or terminal) shall be placed at the navigation bridge and at the operating panel.

3.4.10.5 For side-hinged type outer doors, the thrust bearings shall be provided in way of girder ends at the closing of the two leaves to prevent one leaf shifting towards the other one under the effect of asymmetrical forces (Refer sample Fig. 2). The two parts shall be kept together by means of cleats. Any other arrangement serving the same purpose may be considered.

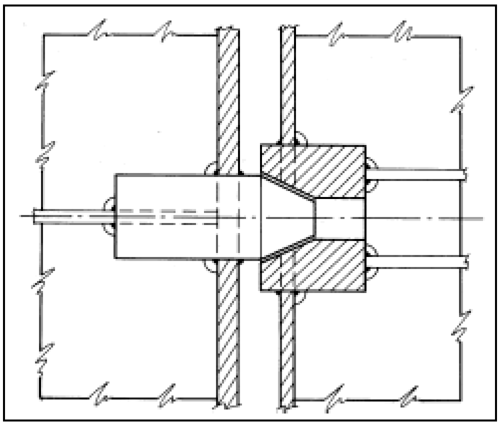


Fig 2 Thrust Bearing (Bow Door Leaves)

3.4.10.6 For outer doors of the visor type, the hinge arrangement is generally to be such that the door is effectively self closing under external loads as below:

$\alpha = (F_x a - F_z b) / [(F_x^2 + F_z^2)^{0.5} (a^2 + b^2)] \geq 0.10$

Where,
a = Vertical distance (m) from visor hinge to position h/2
b = Horizontal distance (m) from visor hinge to position l/2
F_x, F_z, h and l as provided in Sec 3.4.4.5.

3.4.10.7 Effective mechanisms shall be arranged for the bow doors to be secured in open position. Bow doors of the visor type shall be mechanically secured in open position.

3.4.10.8 Where packing is required the packing material shall be of a comparatively soft type, and the supporting forces shall be carried by the steel structure only. Other types of packing may be considered. Flat bars or similar fastening devices for packing shall have scantlings and welds determined with ample consideration to wear and tear.

3.4.10.9 Documented operating procedures for closing and securing the bow doors shall be kept on board and posted at the appropriate places.

3.4.11 Closing Arrangement Strength

3.4.11.1 Only supports having an effective stiffness in a given direction shall be included in calculation of the load carrying capacity of the devices. The distribution of the total forces acting on the supports may, for doors with a complex closing arrangement, be required calculated by a direct calculation taking into account the flexibility of the door and surrounding hull structure and the position of the supports. The number of supports is generally to be the minimum practical taking into account the requirements for redundant provision as given in Sec 3.4.11.3 and the available space for adequate support in the surrounding hull structure which may limit the size of each device. Maximum design clearance for effective supports should normally not exceed 3 mm. Design clearances shall be included in the Operating and Maintenance Manual as given in Sec 3.1.3.1.

3.4.11.2 The maximum forces acting on the supports shall be established on the basis of the external and internal forces as given in Sec 3.4.4.5 and Sec 3.4.4.6. The following cases shall be considered:

1. For outer doors of the visor type the forces acting on the supports shall be determined for the following combination of simultaneous design forces:
   a) 2 F_x and 2 F_z
   b) 1.4 F_x, 0.70 F_y and 1.40 F_z with 0.7 F_y acting alternatively from either side.
2. For outer doors of the side hinged type the forces acting on the supports shall be determined for the following combination of simultaneous design forces:
   a) F_x, F_y, and F_z with each force acting on both doors
   b) 0.70 F_x, 0.70 F_y and 0.70 F_z, acting on each door separately

Note:
The support forces as determined according to 1 a) and 2 a) shall in general give rise to a zero moment in the longitudinal vertical plane about the transverse axis at h/2 and l/2.

3.4.11.3 For outer doors effective supports including surrounding door and hull structural members are, in the case of failure of any single support, to have sufficient capacity to withstand the total design forces. In this case the allowable stresses given in Table 3.4.3 in Sec 3.4.5.2 may be increased by 20%.

3.4.11.4 For visor type outer doors, at least two securing devices shall be provided at the bottom of the door, each capable of providing the full reaction force required to prevent opening of the door within the allowable stresses given in Table 3.4.3. The opening moment to be balanced by the said reaction force shall not be taken less than the following:

$M_0 = 1.30\,(10\,W\,d + 5\,A_x\,a)$ (kN.m)

Where,

W = Mass of door (t)

a = Vertical distance (m) from visor hinge to the centroid of the vertical projected area of the bow visor.

d = vertical distance (m) from hinge axis to the centre of gravity of the door.

A_x As defined in Sec 3.4.4.5.

3.4.11.5 All load bearing members in the design load path, from the door through supports into the ship structure, including welded connections, shall be to the same strength standard as required for the supports.

3.4.11.6 The lifting arms of a visor type outer door and its connections to the door and hull structure shall be dimensioned for the static and dynamic loads applied during lifting and lowering operations. A minimum wind pressure of 0.0015 N/mm^2 shall be taken into account.

3.4.12 Closing arrangement, Operation, Indication and Monitoring

3.4.12.1 Locking mechanisms shall be provided for cleats and support devices (self locking or separate arrangement) or shall be of the gravity type.

Note:
Alternative locking arrangements may be accepted depending on the location and reliability of the arrangement.

3.4.12.2 Where hydraulic systems are utilized, cleats and support devices shall remain locked in the closed position in case of failure in the hydraulic system.

3.4.12.3 Mechanisms for operation of cleats and support devices and, where applicable, for locking arrangement shall be interlocked in such a way that they can only operate in the proper sequence. Hydraulic systems shall be isolated from other circuits and shall be inhibited when doors and closing arrangement are in the closed or locked position.

3.4.12.4 Indication of the open or closed position of any of the bow doors and indication that cleats, support and locking devices, as applicable, are properly positioned shall be provided at the operating panel for remote control. The indication panel shall be provided with a lamp test function. When a mechanical lock is placed inside the hydraulic cylinder operating a cleat or support, indication of the open or closed position of the cleat or support shall be made on the lock inside the cylinder.

3.4.12.5 Separate audible alarms and indicator lights shall be installed on the navigation bridge to show and monitor that each of the bow doors is properly closed and that cleats, support and locking devices as applicable are properly positioned. The indicator system shall show by visual indication if any of the bow doors are not fully closed and not fully locked, and by audible alarms if securing devices become open or locking devices become unsecured.

3.4.12.6 Alarm and indication panel on the navigation bridge shall be equipped with a mode selection function “harbor /sea voyage” so arranged that audible alarm is activated on the navigation bridge if the vessel departs the quay side (or terminal) with any of the bow doors not properly closed or any of the cleats, support and locking devices not properly positioned.

3.4.12.7 The indicator and alarm systems on the navigation bridge mentioned under Sec 3.4.12 shall be designed on the fail-to-safe principle in compliance with the following:

1) The indication panel shall be provided with the following:
   - Earth failure alarm
   - Lamp test device
   - Separate indication for door closed / not closed or door locked/ not locked
   - Power failure alarm provided from both power sources
   - Dimmer (it shall not be possible to turn off the indicator lights completely.)
2) The electrical circuits used for indicating door position shall be normally closed when the door is completely closed and completely open. When more limit switches are provided for each door they may be connected in series.

3) The electrical circuit used for indicating securing arrangements position shall be normally closed when the securing arrangements are completely locked and completely un-locked. When more limit switches are provided for each door they may be connected in series.

4) Separate circuits shall be arranged for indication of door position (closed/not closed) and for securing arrangements position (locked/not locked). Multicore cable is permitted.

5) In case of dislocation of limit switches, this shall be indicated by not closed/not locked/securing arrangement not in place - as appropriate.

3.4.12.8 The power supply for indicator and alarm systems for operating and closing doors shall be independent of the power supply for the operating and closing arrangements and shall be provided with a backup power supply from the emergency source of power or other secure power supply, Eg. UPS (Uninterrupted Power Supply) with a minimum capacity of 30 minutes.

3.4.12.9 All sensors for the indicator system shall be protected from water, ice formation and mechanical damage.

3.4.12.10 A water leakage detection system with audible alarm and television surveillance shall be arranged to provide an indication to the navigation bridge and to the engine control room of the leakage through the inner door.

3.4.12.11 In the space between the outer and the inner doors a television surveillance system shall be arranged with monitors on the navigation bridge and in the engine control room. The system shall monitor the position of the doors and a sufficient number of devices for the closing arrangement. Special consideration shall be given for the lighting and contrasting color of objects under surveillance.

3.4.12.12 A drainage system shall be arranged in the space between the bow door and ramp, or where no ramp is fitted, between the bow door and inner door. The system shall be equipped with an audible alarm function to the navigation bridge being set off when the water levels in these areas exceed 0.5 m or the high water level alarm, whichever is lesser.

3.4.12.13 Special category spaces and ro-ro spaces shall be continuously patrolled or monitored by effective means, such as television surveillance, so that any movement of vehicles in adverse weather conditions and unauthorized access by passengers thereto can be detected whilst the ship is underway.
Note:
Section 3.4.12.4 to 3.4.12.12 apply to shell doors, loading doors and other closing appliances for all passenger ships with ro-ro spaces or special category spaces as defined in A400 which, if left open or not properly closed and locked, could lead to a major flooding of such spaces.

3.5 Inlets and Drainage Arrangement

3.5.1 Air intakes, Ventilators etc.

3.5.1.1 Location of air intake for engines shall be considered in each case.

3.5.1.2 In ships with class notation A, the following shall be applicable:

a) If air intakes for engines are led through superstructure sides, the distance from the lower side of the opening to the freeboard deck shall not be less than 4.5 m, and a drainage box shall be fitted between the ship's side and the engine room, draining directly overboard.

b) If ventilators, etc. without weather tight closing appliances are led through superstructure sides, the distance from the lower side of the ventilator opening to the freeboard deck shall not be less than 4.5 m.

3.5.2 Drainage of Vehicle Deck (class notation A)

3.5.2.1 Drainage of vehicle decks within superstructures shall comply with the requirements , in addition to the requirements in Sec 3.5.2.2 and Sec 3.5.2.3.

3.5.2.2 If the drainage openings in the vehicle deck is lower than the waterline when the ship loaded to summer freeboard has a list of 5°, the outlets shall be led down to a separate tank.

3.5.2.3 Each scupper shall have an automatic non-return valve with a positive means of closing it from a position above the freeboard deck. However, the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds 0.01 L, the discharge may have two automatic non-return valves without positive means of closing, provided that the inboard valve is always accessible for examination under service conditions. The means for operating the positive action valve shall be readily accessible and provided with an indicator showing whether the valve is open or closed.

3.5.3 Freeing Ports (class notation B)

3.5.3.1 The freeing port area at vehicle deck shall not be less than required for an open freeboard deck according to Pt 4, Ch 6, Sec 13.

3.6 Stability

3.6.1 General

3.6.1.1 Ships with class notation **Car Ferry**, **Train Ferry** or **Car** and **Train Ferry** shall comply with the requirements of Pt 8 as well as the requirements of Pt 4, Ch 3, Sec 6 for **Passenger Ships**.

3.6.1.2 For ships in domestic trade and with service restrictions, alternative stability requirements may be accepted on a case by case basis.

3.7 Life Saving Appliances and Arrangements

3.7.1 Application

3.7.1.1 Ships with class notation **Car Ferry**, **Train Ferry** or **Car and Train Ferry** shall comply with the requirements of Sec 3.6.

3.7.2 Additional Requirements for Ro-Ro Passenger Ships (Regulation III/26)

1. This regulation is applicable to all ro-ro passenger ships constructed on or after 1 July 1998 and shall comply with the requirements of paragraphs 2.3, 2.4, 3.1, 3.2, 3.3, 4 and 5.

2. Liferafts

   2.3 Every liferaft on ro-ro passenger ships shall be of a type fitted with a boarding ramp complying with the requirements of paragraph 4.2.4.1 or 4.3.4.1 of the Code, as appropriate.

   2.4 Every liferaft on ro-ro passenger ships shall either be automatically self-righting or be a canopied reversible liferaft which is stable in a seaway and is capable of operating safely whichever way up it is floating. Alternatively, the ship shall carry automatically self-righting liferafts or canopied reversible liferafts, in addition to its normal complement of liferafts, of such aggregate capacity as will accommodate at least 50% of the persons not accommodated in lifeboats. This additional liferaft capacity shall be determined on the basis of the difference between the total number of persons on board and the number of persons accommodated in lifeboats. Every such liferaft shall be approved by the Administration having regard to the recommendations adopted by the Organization.(*)

3. Fast Rescue Boats

3.1 At least one of the rescue boats on a ro-ro passenger ship shall be a fast rescue boat approved by the Administration having regard to the recommendations adopted by the Organization.(* *)

3.2 Each fast rescue boat shall be served by a suitable launching appliance approved by the Administration. When approving such launching appliances, the Administration shall take into account that the fast rescue boat is intended to be launched and retrieved even under severe adverse weather conditions, and also shall have regard to the recommendations adopted by the Organization.(* *)

3.3 At least two crews of each fast rescue boat shall be trained and drilled regularly having regard to the Seafarers Training, Certification and Watchkeeping (STCW) Code and recommendations adopted by the Organization,(***) including all aspects of rescue, handling, manoeuvring, operating these craft in various conditions, and righting them after capsize.

4. Means of Rescue

4.1 Each ro-ro passenger ship shall be equipped with efficient means for rapidly recovering survivors from the water and transferring survivors from rescue units or survival craft to the ship.

4.2 The means of transfer of survivors to the ship may be part of a marine evacuation system, or may be part of a system designed for rescue purposes.

4.3 If the slide of a marine evacuation system is intended to provide the means of transfer of survivors to the deck of the ship, the slide shall be equipped with handlines or ladders to aid in climbing up the slide.

5. Life Jackets

5.1 Notwithstanding the requirements of regulations 7.2 and 22.2, a sufficient number of life jackets shall be stowed in the vicinity of the muster stations so that passengers do not have to return to their cabins to collect their life jackets.

5.2 In ro-ro passenger ships, each lifejacket shall be fitted with a light complying with the requirements of paragraph 2.2.3 of the Code.

(*) Refer to the requirements for automatically self-righting liferafts and canopied reversible liferafts, MSC/Circ.809.
(**) Refer to recommendations to be adopted by the Organization.
(***) Refer to the Recommendation on training requirements for crews of fast rescue boats, adopted by the Organization by resolution A.771(18) and section A-VI/2, table A-VI/2-2 “Specification of the minimum standard of competence in fast rescue boats” of the Seafarers' Training, Certification and Watch keeping (STCW) Code. (SOLAS Reg. III/26).

SECTION 4 GENERAL CARGO CARRIERS

Contents

4.1 General

4.1.1 Classification

4.1.1.1 Requirements provided in this section apply to ships intended for carriage of general dry cargoes.

4.1.1.2 Ships deigned and arranged for general cargo handling and built in compliance with relevant requirements specified in the following may be given the class notation **General Cargo Carrier.**

4.1.1.3 Ships designed and arranged for roll on/roll off cargo handling and built in compliance with relevant requirements specified in the following may be given the class notation **General Cargo Carrier RO/RO.**

4.1.1.4 Ships designed and arranged for general cargo handling and where the decks and inner bottom are built in compliance with relevant requirements in Sec 4.3, will be given the additional class notation **PWDK.**

4.1.1.5 Ships designed and arranged for general cargo handling and also arranged for carriage of vehicles with fuel in their tanks shall comply with requirements given in SOLAS Reg. II-2/20 and Reg. II-2/20-1, and will, when in compliance, be given the class notation **PET**. For further information regarding SOLAS requirements.

4.1.1.6 Ships designed and arranged for roll on/roll off cargo handling (class notation General Cargo Carrier RO/RO) shall have decks, inner bottom, ramps and lifts fulfilling the strength requirement in Sec 4.3. Additionally, the requirements for class notation **PET** (Refer Sec 4.1.1.5.) shall be complied with.

4.1.1.7 Ships intended for carriage of dry bulk and built in compliance with the requirements given in Sec.5 will be given the class notation **General Cargo Carrier HC-A** (or **HC-B**, **HC-C**, **HC-B*, HC-M**).

4.1.2 Documentation

4.1.2.1 The following plans shall be submitted for approval of deck structure for General Cargo Carrier:

- Plans as detailed in Sec 4.1.2.3 as relevant.
- Uniform deck load
- Type of cargo handling vehicles including maximum axle load and details of wheel and/or foot print arrangement.

4.1.2.2 The following information shall be submitted for the approval of structures subjected to wheel loading (**PWDK**):

- Stowage and securing arrangement for all vehicles to be carried. Stowage plan shall include the most unfavourable combination of vehicles that may be positioned on deck
- Uniform deck load
- Type of cargo handling vehicles including maximum axle load and details of wheel and/or foot print arrangement
- Plans for supporting structure for lashing points, if relevant.
- Maximum axle load and axle arrangement for all vehicles (cars, trucks, dumpers, road trailers, MAFI trailers, busses, etc.) shall be carried onboard. Details of wheel and/or foot print should be included.

4.1.2.3 The following information shall be submitted for approval of internal ramps and ramps for shore connections:

- Maximum number of vehicles with and or the most unfavourable combination of vehicles which may be situated on the ramp

- Hoisting and securing arrangement in working and stowed position
- Maximum lifting force and hinge forces, including force direction
- Tightening arrangement against water penetration, if relevant
- Detailed procedure for functional testing
- Schematic diagrams of hydraulic systems, electrical systems and pneumatic systems
- Braking/ locking mechanism
- Plans and supplementary documentation giving pertinent particulars of the hoisting/lowering mechanical gear arrangement
- Plans showing scantling and layout of supporting structure for hinges, release hook, cleats, operating winches, king post and other relevant RO/RO equipment.

4.1.2.4 The following information shall be submitted for approval of securing points for rod vehicles and cars.

- Maximum axle load and number of axles of vehicles
- Stowage and securing arrangement for all vehicles to be carried
- Securing points for lashing with data regarding position, type, design of fittings and Maximum Securing Load (MSL)

4.1.2.5 The following plans and particulars shall be submitted for approval for ships built for carriage of vehicles with fuel in their tanks (**PET**).

- Plan(s) as specified iwith reference to SOLAS 2000 Amend. Ch.II-2 Reg.20.
- Arrangement plan(s) as specified in Pt.6 showing all electrical equipment in spaces where vehicles are carried, with specification of make, type and rating of all such equipment and of cable types.

4.1.2.6 The following plans and particulars shall be submitted for approval for ships built in compliance with the requirement for class notation (**General Cargo Carrier RO/ RO**)

- Plans as detailed in Sec 4.1.2.1, Sec 4.1.2.2, Sec 4.1.2.4, Sec 4.1.2.5 above.

4.1.2.7 If water ingress detection is provided necessary documentation as specified in Sec 5.1.6.4 shall be submitted for approval.

4.2 Hull Arrangement and Strength

4.2.1 General

4.2.1.1 Where direct stress analysis is required in the following, the design loads, calculation methods and allowable stresses are in general to be as given for complex girder systems in Pt 3, Ch 13.

4.2.1.2 For ships with class notation General Cargo Carrier RO/RO strength / buckling analysis of racking constraining structure, girder system and pillars to be carried out considering hull girder loads as well as local loads as relevant.

4.2.1.3 In ships with cargo hatchways the upper deck and 'tween deck(s) are normally supported by deck transverses (hatch side cantilevers) extending from a side vertical to the hatch side coaming. The scantlings shall be dimensioned as given in Sec 4.2.6..

4.2.1.4 For ships that are open type, with weather deck hatch openings in one transverse section of substantial breadth and length, the combined effects of hull girder bending and torsion related to possible local bending and shear may have to be specially considered.

4.2.1.5 Wherever movable card deck are installed, it shall comply with relevant requirements provided in Sec 7.3.

4.2.1.6 Where cargo decks are supported by pillars, the pillars shall normally extend to the bottom structure or a supporting bulkhead. Direct stress analysis of deck structure and bottom structure in way of pillars may be necessary.

4.2.1.7 For pillars the supports shall be designed so as to withstand tensile forces as relevant.

4.2.1.8 Pillars shall be designed for the worst case loads of the decks or structure to which it is connected.

4.2.1.9 Double bottom in ships with decks supported by pillars on the double bottom shall be investigated for relevant seagoing draught including maximum ballast draught, minimum 0.6 T, with no loads on decks above. Counteracting forces due to ballast in double bottom may be taken into account in the analysis.

4.2.1.10 If the double bottoms are not supported by pillars or vertical pillar bulkheads shall be investigated for relevant draught, normally maximum draught, with no load on the inner bottom.

4.2.1.11 Double bottom structure may have to be specially considered for the docking condition with relevant acceptance criteria according to Pt 3.

4.2.1.12 Deck girder structure shall be checked for the uniform deck load (UDL) at relevant seagoing condition draught and applied as evenly and unevenly distributed on the deck.

4.2.1.13 The deck girder structure shall be checked for the most severe axle position for load handling vehicles and vehicles to be carried.

4.2.1.14 The hull structure shall be assessed for damage condition with acceptance criteria according to Pt 3, Ch 13.

4.2.1.15 Special care is to be taken for fatigue of structural details. Refer to Sec 4.2.5 for further details.

4.2.1.16 Strength of decks intended for carrying trailers or other vehicles carrying more than one tier of containers, shall be specially considered in a heeled condition.

4.2.2 Degree of Strength Analysis

4.2.2.1 The hull structure for General Cargo Carrier RO/RO and Car Carrier (see Sec.7)

4.2.2.2 The hull structure for **General Cargo Carrier RO/RO** and **Car Carrier** (Refer Sec.7) that are also analysed will be given the additional class notation

4.2.2.3 The hull structure for **General Cargo Carrier RO/RO** and **Car Carrier** (Sec.7) t

4.2.3 Longitudinal Strength

4.2.3.1 Longitudinal strength shall be checked for relevant loading conditions as described in Pt 3, Ch 5, Sec 2.. Due attention should be put to the sagging and hogging bending moments for non-homogenous loading conditions.

4.2.3.2 Still water sagging moment below the minimum Rule sagging moment may only be accepted provided the strength can be documented for a non-homogenous loading with maximum realistic load concentration within 0.4 L amidships.

4.2.4 Transverse Strength

4.2.4.1 For vessels with a limited number of effective transverse strength structures for racking (class notation **General Cargo Carrier RO/RO**) shall be subject to a direct strength analysis to demonstrate that the stresses are acceptable in a heeled condition.

4.2.4.2 For ships with limited hull depth (class notation **General Cargo Carrier RO/RO**), the transverse strength is usually secured by having self supporting side verticals. A simplified racking assessment using beam models will then be accepted for documentation of the transverse strength.

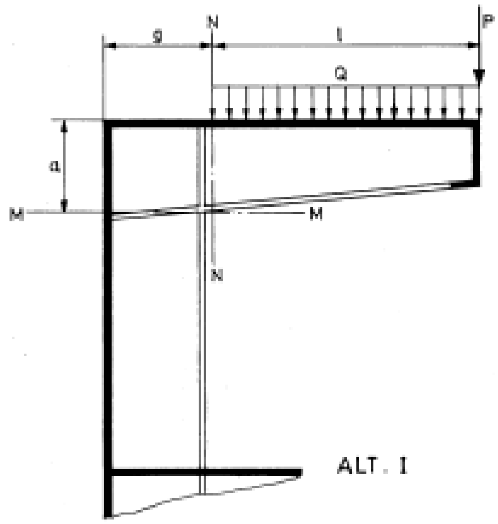
4.2.5 Fatigue

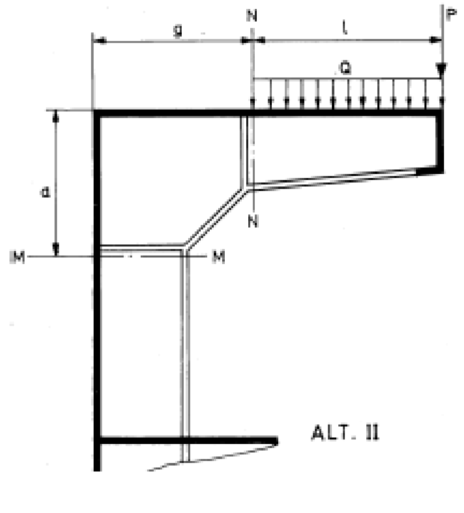
4.2.5.1 Structural details subjected to racking loads shall be specially considered to ensure a proper resistance against fatigue.

4.2.5.2 For ships with limited hull depth (class notation General Cargo Carrier RO/RO), the side verticals are usually designed self supporting with respect to racking. In such case, a proper fatigue life can be ensured by controlling the general stress level in the support areas of the side verticals.

4.2.6 Hatch Side Cantilevers

4.2.6.1 Hatch side cantilevers and side verticals are shown in Fig. 1.





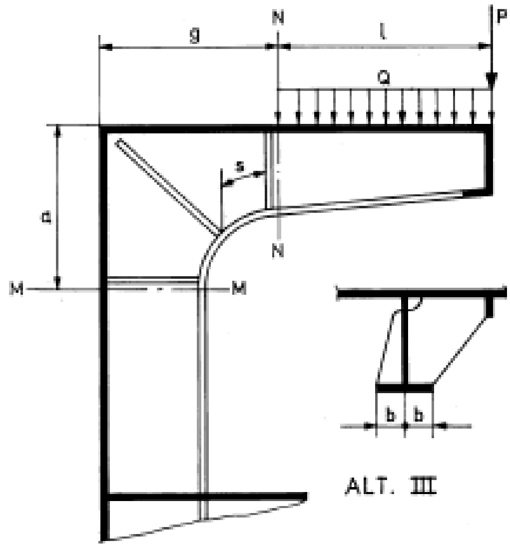


Fig 1 Hatch Side Cantilevers

4.2.6.2 When the cantilever may be considered as a simple girder the section modulus in sections M-M and NN shall not be less than:

$Z = 6\, l\, (P + 0.5\, Q)\, k_m$ (cm^3)

Where,
l = As shown in Fig 1 (m)
P = Point load (kN) at side coaming (from cargo on hatch cover and transversely stiffened deck)
Q = Distributed load (kN) from cargo on longitudinally stiffened deck

The design pressure from cargo loads shall be calculation as provided in Pt 3.

4.2.6.3 For rounded corners shown in Fig 1 (Alt. III), the effective width of the face plate shall be taken as given in Pt 3, Ch 3, Sec 3.4.

For corner designs according to Fig. 1 (Alt. I or Alt. II), the effective width of the face plate shall be taken equal to the actual width.

4.2.6.4 The total effective width of the attached area of deck and shell plating may be taken as 0.4 l. The width is, however, not to be taken greater than the cantilever spacing or the distance g in Fig. 1.

4.2.6.5 The net web area of the cantilever shall not be less than:

$A = (P + [Q\, x / l\,])\, (k_m / [8.33]\,)$ (cm^2)

Where,
x = Distance (m) from end of cantilever
P = As provided in Sec 4.2.6.2
Q = As provided in Sec 4.2.6.2

4.2.6.6The thickness of the corner plate between the sections M-M and N-N shall not be less than:

$t = (P + 0.5\, Q)\, (l / a\, g)\, (1 / [83.33 / k_m]\,)$ (mm)

The corner plate in Fig 1 (Alt I and Alt II) shall be additionally stiffened if a and g is greater than 70 t.

P = As provided in Sec 4.2.6.2
Q = As provided in Sec 4.2.6.2
l = As shown in Fig 1
a = As shown in Fig 1
g = As shown in Fig 1

4.2.7 External Vehicle Ramps

4.2.7.1 Vehicle ramps for shore connection are normally to be built with a grillage system of girders, and local stiffeners in the vehicle's moving direction. The ramps shall have sufficient strength for the specified design working loads and maximum loads during hoisting operation. After end ramps shall have sufficient flexibility for resting on the quay during loading/unloading operations with a minimum list of 3 degrees. A direct stress analysis may have to be carried out to demonstrate that stresses and flexibility/ deflections are within acceptable limits.

4.2.7.2 Plates and stiffeners shall comply with the strength requirements provided in Sec 4.3.

4.2.7.3 For ramps acting as a watertight door, relevant requirements given for the main class shall be satisfied.

4.2.7.4 The support structure for large ramps in stowed position will have to be specially considered based on design loads as given for heavy units in Pt 3, Ch 4, Sec 3. A direct stress analysis might need to be carried out considering these loads.

4.2.7.5 Functional tests shall be carried out the satisfaction of the attending Surveyor.

4.2.7.6 Provision shall be made to lock handles in the neutral position when the operating gear is unattended. Control handles for winches or operation devices shall be so arranged that they quickly revert to the neutral (stop/ brake) position when released.

4.2.8 Internal Ramps and Lifts

4.2.8.1 Sufficient strength shall be ensured for the internal ramps and lift platforms for the specified design working load. For hoist able ramps and lifts also the maximum loads during hoisting conditions shall be considered.

4.2.8.2 Plates and stiffeners shall satisfy the strength requirements given in Sec 4.3 for permanent decks for wheel loading.

4.2.8.3 Ramps or lift platforms acting as covers for deck opening shall comply with the relevant requirements to the deck according to Pt 3.

4.2.8.4 Functional tests shall be carried out the satisfaction of the attending Surveyor.

4.2.9 Ceilings and Cargo Battens

4.2.9.1 Limber boards shall be arranged to provide easy access for inspection of the bottom structures. Ships with single bottom in cargo holds shall be fitted with ceiling on top of floors, extending to the upper part of the bilges.

4.2.9.2 Any wooden ceiling on inner bottom shall be fitted either directly in a layer of tightening and preserving composition or on battens of thickness at least 12.5 mm. The thickness of wooden ceiling shall not be less than 63 mm. In way of the bilges removable ceiling shall be fitted. Deck composition as mentioned in Sec 4.2.9.4 instead of wooden ceiling shall be satisfactory strengthened. There shall be effective drain to the bilges.

4.2.9.3 In spaces for general dry cargo, battens are normally to be fitted on ship's sides from upper turn of bilge (or from deck in between deck spaces and superstructures) up to the underside of beam knees. The clear space between adjacent rows of battens shall not exceed 300 mm. The thickness of wooden battens shall not be less than 50 mm.

4.2.9.4 Deck compositions are subject to approval by the Society. Refer "Register of Type Approved Products No.3: Containers, Cargo Handling, Lifting Appliances and Miscellaneous Equipment".

4.2.10 Cargo Protection

4.2.10.1 It is assumed that adequate precautions are taken when necessary to prevent hazards from cargoes which are subject to gassing, oxidation, self-heating or spontaneous combustion in connection with heating, moisture or other detrimental affecting of the cargo. The above mentioned assumption will be stated in the appendix to the classification certificate for the ship.

4.2.11 Support of Cargo Handling Equipment

4.2.11.1 Masts and posts shall be efficiently supported and connected to at least two decks or to one deck and a mast house top above. If the latter arrangement is adopted, the mast house top shall be of sufficient size and adequately stiffened. A winch house of usual size and scantlings is not considered to meet the requirements.

4.2.11.2 In way of fastenings for standing rigging and for guys and topping lifts, the deck shall be securely stiffened and reinforced for the additional loading.

4.2.11.3 Supports for other lifting arrangement will be specially considered.

4.2.12 Securing Points for Lashing

4.2.12.1 Decks intended for carriage of vehicles shall be equipped with a satisfactory number of securing points (cargo securing device) for lashing of the vehicles. The arrangement of securing is left to the discretion of the owner, subject to compliance with the requirements of 4.2.12.2 through 4.2.12.8.

4.2.12.2 Each lashing point shall have a Maximum Securing Load (MSL) of not less than the value below, unless otherwise specified:

MSL $= k\,Q\,g_0$
$= 100$ kN (minimum in decks for road vehicles)
$= 15$ kN (minimum in decks for cars only)
k $= n / r$
(k to be increased by 10% if r is different from 1)
r = Number of effective lashing points at each side of the vehicle for the number n of axles in the group.
Q = Maximum axle load (t)

For road trailers, Q can be calculated as the total weight with n = 1 and r = total number of lashings at each side.

4.2.12.3 Maximum securing loads in securing points shall not exceed:
MSL $= 0.50\,P_m$

P_m = Minimum breaking load (kN) of the cargo securing device

4.2.12.4 If the securing point is designed to accommodate more than one lashing, the magnitude and direction of the lashing loads shall be taken into account when determining the total MSL of the securing point.

4.2.12.5 Strengthening of deck plating is not normally required for Lashing points intended for a maximum working load of 15 kN.

4.2.12.6 For lashing points intended for a maximum working load of more than 15 kN , document structural analysis for complying with strength requirement or mock up test is to be carried out.

4.2.12.7 Fixed cargo securing devices shall be certified according to the requirements in Standard for Certificaion Portable cargo securing devices shall be of a certified type..

4.2.12.8 Nominal normal and shear stresses in local structures of hull structural steel, supporting sockets for lashing shall not exceed:

$\sigma = 210 / k_m$ (N/mm^2)
$\tau = 120 / k_m$ (N/mm^2)

In structures also subjected to longitudinal stresses (eg. deck longitudinal and girders) in combination with such stresses as given in Pt 3, Ch 8, the allowable bending stresses in Pt 3, Ch 8, Table 8.3.3 and Pt 3, Ch 8, Table 8.3.4 shall be increased by 30%.

4.2.13 Steel Coils

4.2.13.1 The inner bottom plating and inner bottom longitudinals will be especially considered for vessels intended to carry steel coils.

4.2.13.2 Recommended calculation procedure is provided

4.3 Permanent Decks for Wheel Loading

4.3.1 General

4.3.1.1 Ships strengthened in accordance with the following requirements may have the additional class notation **PWDK.**

4.3.1.2 Requirements include wheel loads from cargo handling vehicles and from cargo transporting vehicles onboard and supported on their wheels when the ship is at sea. Vehicles supported by crutches, horses etc. will be specially considered.

4.3.1.3 Stiffener scantlings on decks intended for carrying trailers or other vehicles carrying more than one tier of container, shall be specially considered in a heeled condition.

4.3.1.4 The strength requirements are based on the assumption that the considered plating or stiffener is subjected to one load area only, and that the element is continuous in both directions across several evenly spaced supports. Requirements for other loads and or boundary conditions will be specially considered.

4.3.1.5 The maximum permissible axle load, the maximum tyre pressure of pneumatic tyre wheels, wheel arrangement on axles, and specially approved vehicles shall be indicated in a sign board and fitted in suitable positions onboard. Detailed information of the basis for approval will be stated in the appendix to the classification certificate.

4.3.1.6 Any other types and combinations of car decks and materials may be approved after special considerations on a case by case basis.

4.3.2 **Design Loads**

4.3.2.1 Vehicles with specified arrangement and dimensions of footprints, the design pressure in general is to be considered as provided below:

p = (Q / [n_0 a b]) (9.81 + [a_v / 2]) (kN/m^2)

Where,
Q = Maximum axle load (t)
n_0 = Number of load areas on the axle
a = Extend of load area parallel to the stiffeners (m). Refer Fig 2
b = Extend of load area perpendicular to the stiffeners (m) Refer Fig 2
a_v = 6 / $Q^{0.5}$ for moving cargo handling vehicles in harbour conditions.
= Vertical acceleration as defined in Pt 3, Ch 5, Sec 2.

The load area as indicated in Fig 2 is defined as:
- The footprint area of individual wheels
- The rectangular enveloped area of footprints of a wheel group

In general, the scantlings shall be checked according to both definitions. If, however, the distance e between individual footprints is less than the breadth b1 of the prints, the load area may normally be calculated for the group of wheels only.

4.3.2.2 In case the arrangement and dimensions of footprints are not available for vehicles with pneumatic tyres, the design pressure may normally be taken as:

p = (p_0 [9.81 + 0.5 a_v]) / (9.81 w) (kN/m^2)

Where,
p_0 = Maximum tyre pressure (kN/m^2)
= 1000, for cargo handling vehicles unless specified otherwise
= 120 $(Q + 3)^{0.50}$ for road transporters unless specified otherwise
w = 1.20 for double wheels
= 1.27 for triple wheels
= 1.00 in general otherwise
a_v = Provided in Sec 4.3.2.1

The load area dimensions are in general to be considered as below:

a = $(k A)^{0.5}$ (m)
b = $(A / k)^{0.5}$ (m)

Where
k = k_1, in general
= k_2, for plating when $k_2 < k_1$ and
$wQ / n_0 s^2 > \sim 100$
k_1 = 2.00 for single wheel
= 2.00 for multiple wheels with axles parallel to stiffeners
= 0.80 for double wheels with axles perpendicular to stiffeners
= 0.50 for triple wheels with axle perpendicular to stiffeners

k_2 =([0.50 $A^{0.50}$] / s)

A = 9.81 w Q / n_0 p_0

Where,
Q = As defined in Sec 4.3.2.1
n_0 = As defined in Sec 4.3.2.1
= 2 Unless specified otherwise

4.3.2.3 Where the stowing and lashing arrangement may significantly affect the load distribution at sea due to heavy vehicles, the design pressure for individual load areas will be specially considered.

4.3.2.4 Deck areas for wheel loads from cargo handling vehicles, which are frequently operating in all directions, shall be checked for design loads with axle parallel and perpendicular to stiffeners.

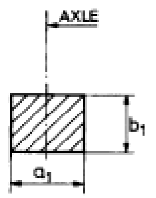
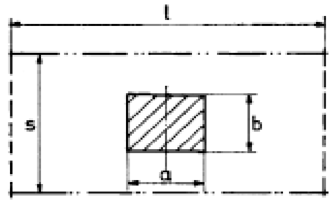
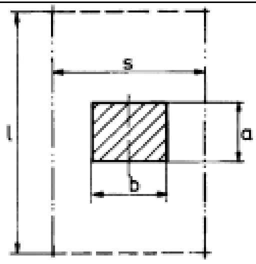
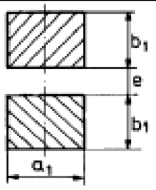
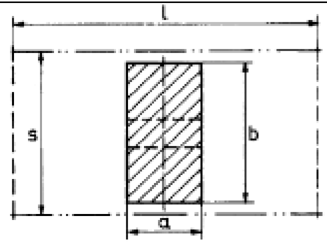
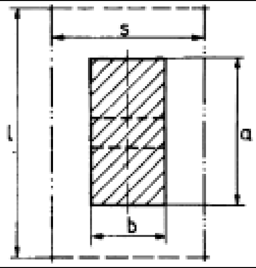
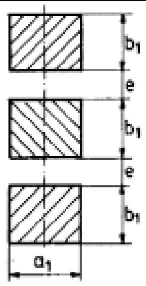
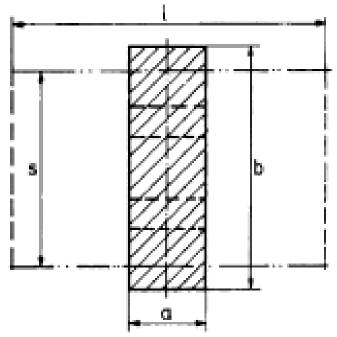
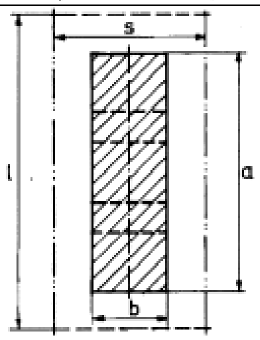
1	2	3	4
Number of wheels in group	**Footprint dimensions (real contact areas between tyre and deck)**	**Design load area for axle perpendicular to stiffeners**	**Design load area for axle parallel to stiffeners**
Single Wheel			
Double Wheels			
Triple Wheels			

Fig 2 Load Area Definitions

4.3.3 Plating

4.3.3.1 The thickness of deck plating subjected to wheel loading shall not be less than that provided below:

$t = (77.40\ k_a\ [k_w\ c\ s\ p]^{0.50} / [m\ \sigma]^{0.5}) + t_k$ (mm)

Where,

k_a = 1.10 – 0.25 (s / l)
= Maximum 1.00 for s / l = 0.4
= Maximum 0.85 for s / l = 1.0

k_w = 1.30 – { 4.20 / ([a/s] + 1.80)^2 }
= Maximum 1.0 for a ≥ 1.94 s

c = b for b < s
= s for b > s

p = As provided in 4.3.2.1

a = As provided in 4.3.2.1
b = As provided in 4.3.2.1

m = (38 / [(b / s)^2 – 4.70 (b / s) + 6.5]) for b / s ≤ 1.00
= 13.57 for b / s > 1.00

Between specified values of b/s the m value may be linearly interpolated. The value of m may be obtained from Fig 3.

σ = 320 / k_m (N/mm^2) maximum in general for seagoing condition
= 370 / k_m (N/mm^2) maximum in general for harbour condition
= As provided in Table 4.3.1, but not exceeding the above general maximum values, for upper deck within 0.4 L amidships. For upper deck between 0.4L amidships and 0.1L from the perpendiculars, σ shall be varied linearly.

For "tween deck σ shall be linearly interpolated between upper deck value and general maximum value taken at the neutral axis.

Table 4.3.1 Allowable Bending Stress for Upper Deck Plating Within 0.4L Amidships

Arrangement	Condition	σ (N/mm$^{2)}$
Longitudinally stiffened	Seagoing	(280 / k_m) + 60 ([1 / k_m] – f_2)
Longitudinally stiffened	Harbour	(355 / k_m) + 20 ([1 / k_m] – f_2)
Transversely Stiffened	Seagoing	(185 / k_m) + 135 ([1 / k_m] – f_2)
Transversely Stiffened	Harbour	(285 / k_m) + 85 ([1 / k_m] – f_2)

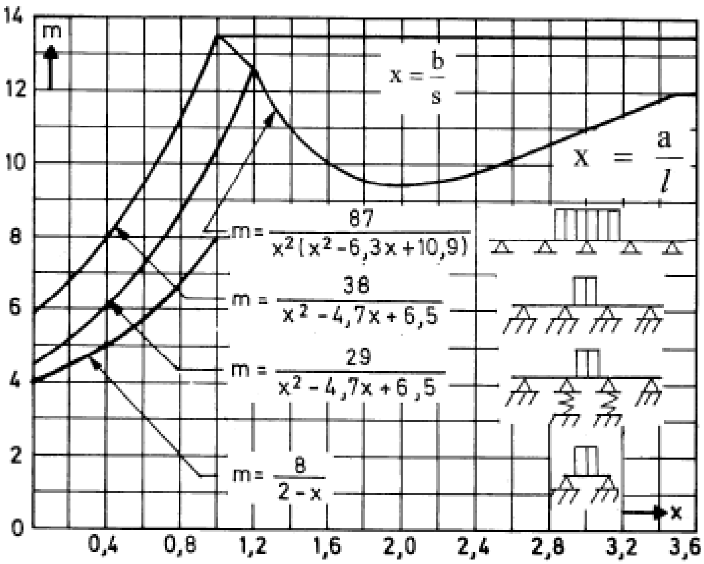


Fig 3 Bending Moment Factor (m Values)

Where,
x = b / s nor greater than 1.00 for plating
x = a / l for stiffeners

4.3.3.2The general thickness requirements of deck plating subjected to various wheel loading from pneumatic tyres are provided in Fig 4a. The following parameter values have been assumed:

- Corrosion addition, t_k = 0.0 mm
- Allowable stress, σ = 370 N/mm^2

- Aspect ratio of plate field, $l / s \geq 2.50$
- Tyre pressure, p_0 = 800 kN/mm²

4.3.3.3 The minimum deck plate thickness in dry cargo spaces can be taken as 5.0 mm for vessels with more than two continuous decks above 0.7 D from the base line and provided the deck is kept coated and free from corrosion. (Refer also Pt 3, Ch 8, Sec 3.1)

4.3.4 Stiffeners

4.3.4.1 The section modulus for deck beams and longitudinals subjected to wheel loading shall not be less than:

$Z = (1000\ k_z\ l\ c\ d\ p\ w_k) / (m\ \sigma)$ (cm³)

Where

k_z = 1.0 for b/s < 0.60 and b/s > 3.4
= (1.15 – [0.25 b/s]) for 0.60 < b/s < 1.0
= (1.15 – [0.25 b/s]) (b/s) for 1.0 < b/s < 3.4

c = As provided in Sec 4.3.3.1
d = a for a < l
= l for a > l
a = As provided in Sec 4.3.2
b = As provided in Sec 4.3.2
p = As provided in Sec 4.3.2

m = $r / ([a/l]^2 – 4.7 [a/l] + 6.50)$; for $a/l \leq 1.00$
= $87 / ([a/l]^2 [(a/l)^2 – 6.3 (a/l) + 10.90])$; for $1.20 < a/l \leq 2.50$
= 12; for $a/l \geq 3.50$

r = 29 (Factor depending on the rigidity of girders supporting continuous stiffeners), unless better support conditions are ensured and demonstrated.
= 38 When continuous stiffener may be considered as rigidly supported at each girder.
For intermediate values of a/l the m value may be linearly interpolated. The m value may also be obtained from Fig 3.

σ = $160 / k_m$ (N/mm²) maximum in general for seagoing conditions
= $180 / k_m$ (N/mm²) maximum in general for harbour conditions
= As provided in Table 4.3.2, but not exceeding the general maximum values, for longitudinals within 0.4L amidships.

For longitudinals between 0.4 L amidships and 0.1 L from the perpendiculars σ may be linearly interpolated. For longitudinals in tween decks σ may be found by interpolation as given for plating in Sec 4.3.3.1.

Table 4.3.2 Allowable Bending Stress for Deck Longitudinals	
Condition	**σ (N/mm²)**
Seagoing	$(225 / k_m) – 130\ f_2 ([z_n – z_a] / z_n)$
Harbour	$(225 / k_m) – 85\ f_2 ([z_n – z_a] / z_n)$

4.3.4.2 If more than one load area can be positioned simultaneously on the same stiffener span or adjacent spans, the sections modulus will be specially considered, based on direct stress analysis.

4.3.5 Girders

4.3.5.1 The scantlings of girders will be specially considered based on the most severe condition of moving or stowed vehicles. Allowable stresses are as given in Pt 3, Ch 13 Sec 2.4.

The vehicle loads shall be taken as forces

P_v = Q_w (9.81 + 0.5 a_v) (kN)

Where,

a_v = Vertical acceleration as provided in Sec 4.3.2.1.

Q_w= load (t) on wheel group or single wheel. For more than one axles in group, the strength of the girder system shall be specially considered.

4.3.5.2 For class notation **General Cargo Carrier RO/RO**, the scantlings of girders being part of a complex system shall normally be based on a direct stress analysis

4.3.5.3 The girder shall be based on the most severe of the uniform deck load, UDL (evenly and unevenly distributed) and the vehicle axle load (cargo handling vehicle and vehicles to be carried). The position of the vehicles shall be taken as the most unfavourable for the girder strength.

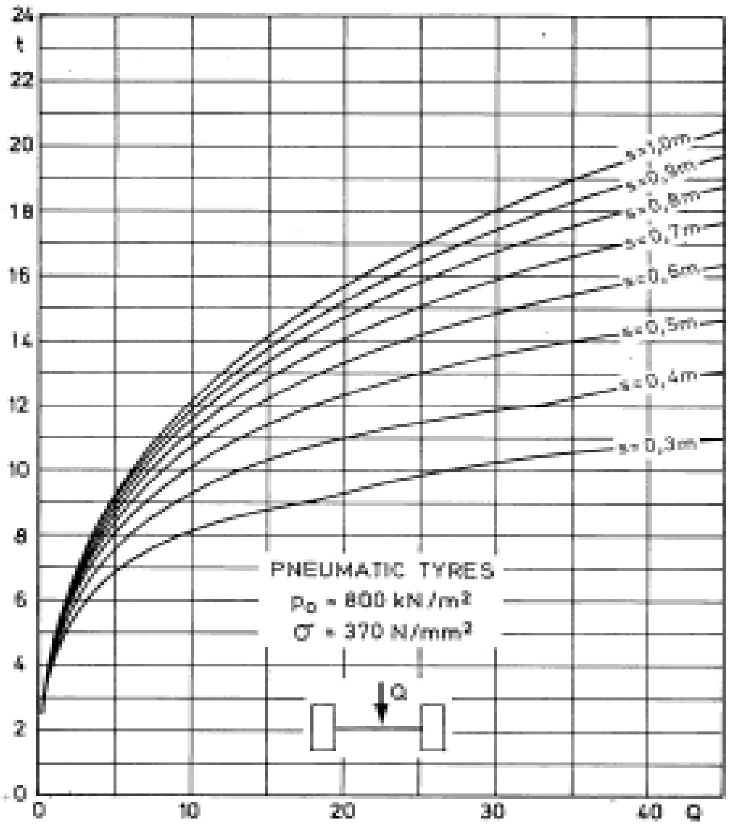
4.3.5.4 The scantlings of girders shall also be considered based on the most severe condition of cargo handling or stowed vehicles. Unless otherwise specified, the girder system shall be designed for a condition were the axles of several trailers side by side are acting on the same transverse girder.

4.3.6 Structural Details

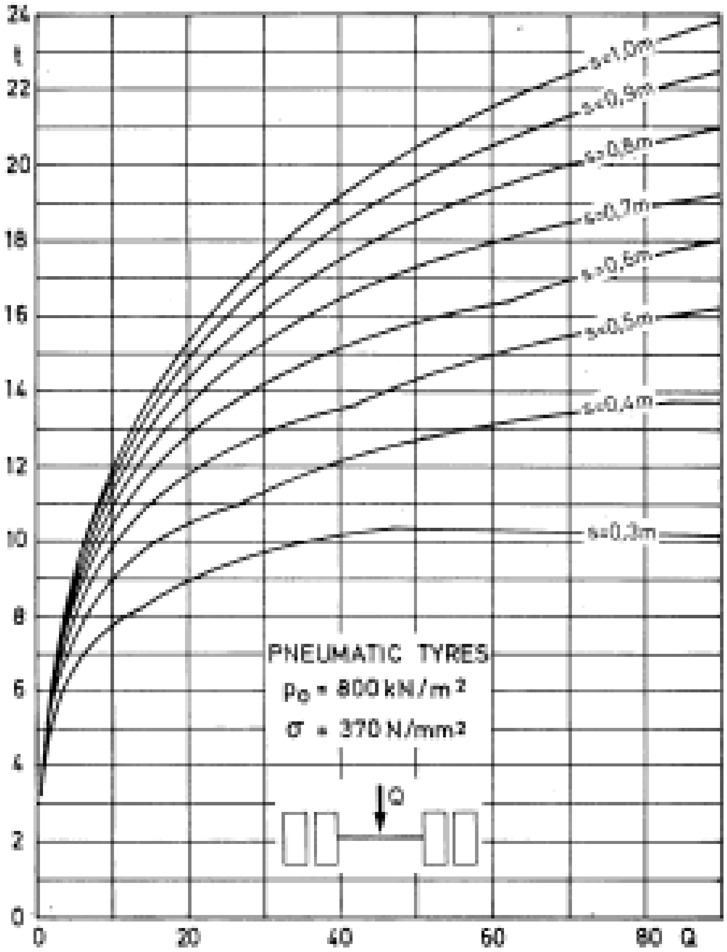
4.3.6.1 Lap joints between deck plates intended for cars only are generally not acceptable, however shall be specially considered with due attention to fatigue.

4.3.6.2 Double continuous fillet welds are normally to be used between the plating and the strength member. Chain welds may be accepted after special consideration when vehicles are fitted with pneumatic or solid rubber tyres. Girders and stiffeners shall not be scalloped. However, small size scallops in block joint will be accepted.

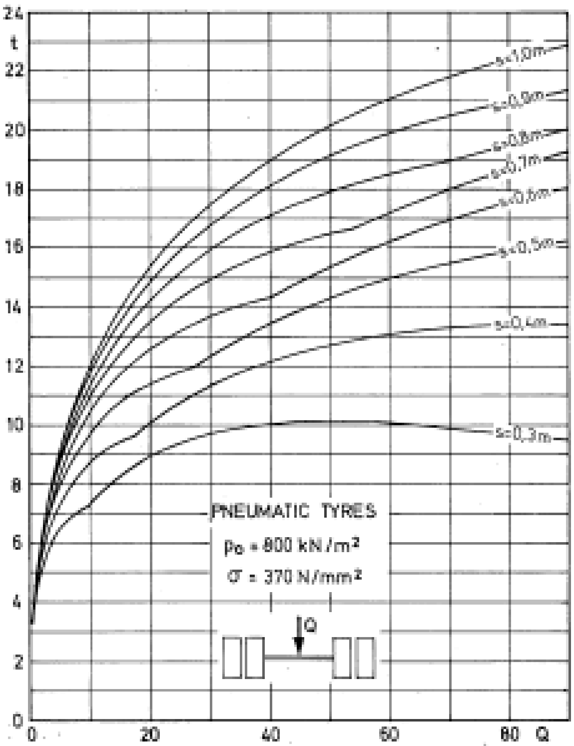
4.3.6.3 The necessary connection areas between stiffeners and girders will be specially considered. The shear stresses shall not exceed 100 N/mm^2 in the members to be joined and 115 N/mm^2 in the weld material.



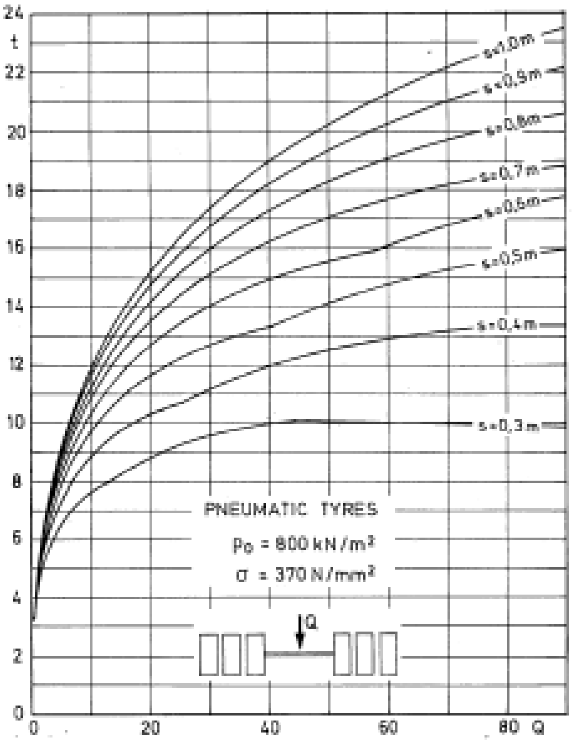
(a) Single Wheel
(General)



(b) Double Wheels
(Axle Parallel to Stiffeners)



(c) Double Wheels
(Axle Perpendicular to Stiffeners)



(d) Triple Wheels
(Axle parallel to stiffeners)

Fig 4 Plate Thickness for Wheel Loadings

4.4 Detection of Water Ingress in Single Hold Cargo Ships

4.4.1 Performance Requirements

4.4.1.1 Water level detectors giving audible and visual alarms on the navigation bridge shall be installed on single hold cargo ships:

1. When the water level above the inner bottom in the cargo hold reaches a height of not less than 0.3 m
2. And another when such level reaches not more than 15% of the mean depth of the cargo hold
   (SOLAS II-I/23-3)

4.4.1.2 Water ingress detector equipment shall be type tested in accordance with MSC.188 (79) “Performance Standards for Water Level Detectors on Bulk Carriers and Single Hold Cargo Ships other than Bulk Carriers”, and be suitable for the intended cargoes.

Note:
The appendix to the Classification Certificate will contain information as to which cargoes the systems are approved for.

4.4.2 Installation

4.4.2.1 Sensors shall be located in a protected area that is in communication with the aft part of the cargo hold or above its lowest point in such ships having an inner bottom not parallel to the designed waterline.

These sensors shall be located:
- At both the port and starboard side
- Either as close to the centre line as practically possible.

4.4.2.2 The detector installation shall not adversely affect the use or functioning of any sounding pipe or other water level gauging device for cargo holds or other spaces.

4.4.2.3 Detectors and equipment shall be installed where they are accessible for survey, maintenance and repair.

4.4.2.4 Filters of any kind fitted to detectors shall be capable of being cleaned before loading.

4.4.2.5 Electrical cables and any associated equipment installed in cargo holds shall be protected from damage by cargoes or mechanical handling equipment, associated with bulk carrier operations, such as in tubes of robust construction or in similar protected locations.

4.4.2.6 The part of the electrical system which has circuitry in the cargo area shall be arranged intrinsically safe.

4.4.2.7 Power supply shall be in accordance with Pt.6

4.4.3 Survey On Board

4.4.3.1 After installation the sensors and the system is subject to survey consisting of the following:
- Alarm panel function test
- Alarm loop test
- Detector testing and demonstration
- Filter cleaning demonstration
- Inspection of the installation

SECTION 5 BULK CARRIERS

Contents

5.1 General

5.1.1 Classification

5.1.1.1 This section applies to ships intended for carriage of solid bulk cargoes. Ships intended for carriage of solid bulk cargoes shall be given one of ship type notations in 5.1.1.3 and 5.1.1.4, or Sec 12.1.1.3. Relevant requirements for general cargo ships given in Sec 4 are also to be complied with.

5.1.1.2 Double side skin implies a configuration for all cargo holds where,

- Each ship side is constructed by the side shell and a longitudinal bulkhead connecting the double bottom and the strength deck. Hopper side tanks and top wing tanks may, where fitted, be integral parts of the double-side skin configuration; and

- The breadth of the double side measured perpendicular to the shell from the top of double bottom to the strength deck at any location within the length of the hold shall not be less than 1000 mm.

Single side skin means a configuration other than double side skin.

5.1.1.3 The mandatory ship type notation **Bulk Carrier ESP** shall be assigned to ships built in compliance with the requirements in this section with the following characteristics:

- Typical cargo hold cross-sections are given in Fig 1.

- Single deck ships that are seagoing with cargo holds of single and or double side skin construction, with a double bottom, hopper side tanks and top-wing tanks fitted below the upper deck, and intended for the carriage of solid bulk cargoes.

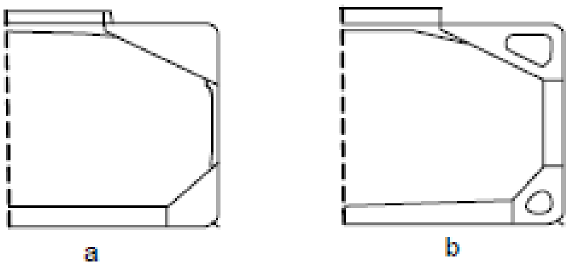


Fig 1 Typical Hold Cross Sections
(a: Single side skin bulk carrier b: Double side skin bulk carrier)

The notation **Bulk Carrier** may be given to ships built in compliance with the requirements in this section, with structural arrangement different from that defined above.

5.1.1.4 For ships with notation **General Cargo Carrier** and intended for carriage of solid bulk cargoes, followings are required:

1. Ships with double side skin construction:
   - Freeboard of type B without reduced freeboard

2. Ships with single side skin construction:
   - Freeboard of type B without reduced freeboard and
   - Freeboard length L_F (refer Pt 3, Ch 1, Sec 2.1.1) < 100m

Such ships shall be built in compliance with the requirements in this section. One of **HC** notations shall be assigned (Refer Sec 5.1.1.8).

5.1.1.5 The additional notation CSR is mandatory for ships when:

- The notation **Bulk Carrier ESP** is mandatory as defined in Sec 5.1.1.3 and
- Length L ≥ 90 m

The **CSR** notation describes that the newbuilding is designed and built according to IACS Common Structural Rules for Bulk Carriers and Oil Tankers as described in Sec 5.1.3, where application of Rule requirements are further specified.

5.1.1.6 The requirements for additional notations **BC-A**, **BC-B**, **BC-C, HC-A**, **HC-B**, **HC-C**, **HC-B***, **HC-M**, **No MP**, **Maximum Cargo Density x.y t/m3**, **Holds a, b,…may be empty**, and **Block loadin**g are described in Sec 5.1.2. The combination with ship type notations is specified in Sec 5.1.1.8..

5.1.1.7 Additional notation **GBS (Newbuilding)** is described in Pt.3 Ch.1 Sec.15 (….Special requirments- Additional class- NAUTICUS, CSR) and comprises extended fatigue and direct strength calculations.

The additional notation **IB-X** is described in Pt 3, Ch 6, Sec 8.5, and comprises requirements for strengthening for grab loading and discharging.

The additional notation **DG-B** is described in Ch.11 (…"Carriage of Dangersous Goods" not in PHASE 2) and comprises requirements for carriage of dangerous goods.

The additional notation **EC** is described in Sec 5.4 and comprises requirements for easy cleaning of cargo holds. The combinations with ship type notations are specified in Sec 5.1.1.8..

5.1.1.8 For each ship, only one of notations **BC-A**, **BC-B**, BC-C, **HC-A**, **HC-B**, **HC-C**, **HC-B*** and **HC-M** may be applied. For each ship, one of the above notations is required. Otherwise notations may be combined voluntarily unless specified clearly in Table 5.1.1.

Table 5.1.1 Combination of Notations

Notations	**Bulk Carrier ESP and L< 90 m**	**Bulk Carrier**	**General Cargo Carrier**	
BC-A or **BC-B** or **BC-C**	X	-	-	-
HC-A or **HC-B** or **HC-C** or **HC-B*** or **HC-M**	-	X(1)	X	X(1)
IB-1 or **IB-2** or **IB-3**	X(2)	X(3)	X(3)	X
NAUTICUS (New building)	X(2)	X(4)	X(4)	X
DG-B	X	X	X	X
EC	X(5)	X(5)		

X : Mandatory
- : Not applicable

(1) HC-B is not applicable for single side skin ships
(2) Not applicable for ships with **CSR**. Refer Sec 5.1.3.

(3) **IB-3** is mandatory for ships of freeboard length L_F ≥ 150m (Pt 3, Ch 1, Sec 2.1.1) and loading density of 1.0 t/m^3. For ships with **HC-M**, **IB-1** or **IB-2** may be applied instead.

(4) Mandatory for ships with **HC-B** or **HC-C** of length L > 190m and for ships with **HC-A** or **HC-B*** of length L > 170m
(5) **EC** notation is not applicable for single side skin ships

5.1.2 Notations Related to Design Loading Conditions

5.1.2.1 Notations **HC-A**, **HC-B**, and **HC-C** correspond to the notations **BC-A**, **BC-B** and **BC-C** respectively, exempting requirements as given in Sec 5.1.2.4 item 7 and Sec 5.1.2.5.

Notation **HC-B*** implies that the vessel is designed to carry dry cargo in bulk of any density with any hold empty at maximum draught. This notation requires design loading conditions in addition to those required for **HC-B**.

For ships with notation **HC-M**, in addition to the requirements in Pt 3, Ch 5, requirements in this section shall be applied exempting those as given in Sec 5.1.2.4 to Sec 5.1.2.6, Sec 5.1.2.8 to Sec 5.1.2.12.

5.1.2.2 The loading conditions listed in Sec 5.1.2.3 to Sec 5.1.2.6 shall be used for the checking of Rules criteria regarding longitudinal strength, as required by Pt 3, Ch 5 and Sec 5.1.4, local strength, capacity and disposition of ballast tanks and stability.

5.1.2.3 General requirements for additional notations **BC-A**, **BC-B**, **BC-C**, **Maximum Cargo Density x.y t/m3**, **Holds a, b … may be empty**, **GRAB[X],** and **Block loading** are described in CSR Pt.1 Ch.1. Sec.1 [3.2].

The additional notation **No MP** shall be assigned to vessels, which have not been designed for loading and unloading in multiple ports. I.e. the vessel is not designed to carry maximum allowable cargo hold design mass at reduced draughts.

5.1.2.4 The vessel shall have a normal ballast (no cargo) condition where:

1. The longitudinal strength requirements shall be met with all ballast tanks 100% full.
2. The structures of bottom forward shall be strengthened in accordance with Pt 3, Ch 6 against slamming for the condition listed above at the lightest forward draught.
3. The trim shall be by the stern and shall not exceed 0.015 L.
4. The propeller shall be fully immersed.
5. Any cargo hold or holds adapted for the carriage of water ballast at sea shall be empty.
6. The ballast tanks may be full, partially full or empty. Where partially full option is exercised, the conditions in Pt 3, Ch 5, Sec 2.1.3 shall be complied with.
7. The longitudinal strength requirements shall be met for the conditions listed above.

5.1.2.5 The vessel shall have a heavy ballast (no cargo) condition where:

1. The ballast tanks may be full, partially full or empty. Where partially full option is exercised, the conditions in Pt 3, Ch 5, Sec 2.1.3 shall be complied with.

2. At least one cargo hold adapted for carriage of water ballast at sea, where required or provided, shall be 100% full.

3. The propeller immersion I/D shall be at least 60%. (where I = distance from propeller centre line to the water line; D = Propeller diameter)

4. The trim shall be by the stern and shall not exceed 0.015L.

5. The moulded forward draught in the heavy ballast condition shall not be less than the smaller of 0.03 L or 8 m.

6. The longitudinal strength requirements shall be met for the conditions above.

7. The longitudinal strength requirements shall be met under a condition with all ballast tanks 100% full and one cargo hold adapted and designated for

the carriage of water ballast at sea, where provided, 100% full.

8. Where more than one hold is adapted and designated for the carriage of water ballast at sea, it will not be required that two or more holds be assumed 100% full simultaneously in the longitudinal strength assessment, unless such conditions are expected in the heavy ballast condition. Unless each hold is individually investigated, the designated heavy ballast hold and any/all restrictions for the use of other ballast hold(s) shall be indicated in the loading manual.

5.1.2.6 The loading conditions given in 5.1.2.3 to 5.1.2.5 shall be included in the loading manual and shall be separated into one departure and one arrival condition, where:

- Arrival conditions with 10% consumables
- Departure condition with bunker tanks not less than 95% full and other consumables 100%.

5.1.2.7 The following design loading conditions apply for consideration of local strength as given in Sec 5.3, where:

M_H = Actual cargo mass in a cargo hold corresponding to a homogeneously loaded condition at maximum draught.

M_{FULL} = Cargo mass in a cargo hold corresponding to cargo with virtual density (homogeneous mass/hold cubic capacity, minimum 1.0 t/m3) filled to the top of the hatch coaming, M_{FULL} shall not be less than M_H

M_{HD} = Maximum cargo mass allowed to be carried in a cargo hold according to design loading condition(s) with specified holds empty at maximum draught.

5.1.2.8 General conditions applicable for all notations are specified in **CSR** Pt.1 Ch.4 Sec.8 [4.2.1].

5.1.2.9 Conditions applicable for all notations, except when notation **No MP** is assigned, are specified in **CSR** Pt.1 Ch.4 Sec.8 [4.2.2].

5.1.2.10 Additional conditions applicable for **BC-A** notation only are specified in CSR Pt.1 Ch.4 Sec.8 [4.2.3].

5.1.2.11 Conditions applicable for notation **HC-B*** only:

- Any cargo hold shall be capable of carrying 1.2 M_{FULL}, with fuel oil tanks in double bottom in way of the cargo hold, if any, being 100% full and ballast water tanks in the double bottom being empty in way of the cargo hold, both at 67% of maximum draught
- Any cargo hold shall be capable of being empty with all double bottom tanks in way of the cargo hold also being empty, at maximum draught
- Any two adjacent cargo holds shall be capable of carrying 1.1 MFULL, with fuel oil tanks in the double bottom in way of the cargo hold, if any being 100% full and ballast water tanks in the double bottom in way of the cargo hold being empty, at 67% of the maximum draught.
- Any two adjacent cargo holds shall be capable of being empty, with all double bottom tanks in way of the cargo hold being empty, at 75% of maximum draught.

5.1.2.12 Additional conditions applicable during loading and unloading in harbour only are specified in CSR Pt.1 Ch.4 Sec.8 [4.2.5].

5.1.2.13 Additional conditions applicable during loading and unloading in harbour for notation **HC-M** only:

- At reduced draught during loading and unloading in harbour, the maximum allowable mass in a cargo hold may be increased by 15% of the maximum mass allowed at the maximum draught in sea-going condition, but shall not exceed the mass allowed at maximum draught in the sea-going condition. The minimum required mass may be reduced by the same amount.

5.1.2.14 Additional conditions applicable for ballast holds if any are specified in **CSR** Pt.1 Ch.4 Sec.8 [4.2.4].

5.1.3 Common Structural Rules

5.1.3.1 Application of the mandatory class notation CSR is described in CSR Pt.1.

5.1.3.2 The requirements in CSR Pt.1 and Pt.2 shall apply to CSR ships, for which building contract is placed on or after 1 July 2015.

5.1.3.3 For vessels with **CSR** notation the following chapters and sections are not applicable, since they are covered by **CSR** Pt.1 and Pt.2:

Pt.3 Except as described in Sec 5.1.3.5.

Pt 4, Ch 2 Except subsection 9
Pt 4, Ch 3
Pt 4, Ch 6
Pt 4, Ch 7
Pt 7B Sec 5.2 and Sec 5.3
Pt 7B Sec 8

5.1.3.4 For vessels with **CSR** notation Pt.6 Ch.9 is applicable for approval of Loading Computer Systems, in addition to the relevant sections of CSR Pt.1 and Pt.2.

5.1.3.5 For regions of the structure for which CSR Pt.1 and Pt.2 does not apply, the appropriate classification rules shall be applied. In cases where CSR Pt.1 and Pt.2 does not address certain aspects of the ship's design, the applicable classification rules shall be applied.

5.1.3.6 Optional design feature notations described in Pt 3 may be given to vessels with **CSR** notation. The additional notations **NAUTICUS(Newbuilding)** and **IB-X** are not applicable to ships with **CSR** notation.

5.1.3.7 Access to and within spaces in, and forward of, the cargo area shall comply with SOLAS Regulation II-1/3-6 and IACS UI SC191, for ships of gross tonnage ≥ 20 000 with notation **CSR**.

5.1.3.8 Vessels with CSR notation constructed between 1 July 2015 and 30 June 2016 shall comply with IACS Common Structural Rules for Bulk Carriers for rudders, sole pieces and rudder horns.

5.1.4 SOLAS Regulations for Hull Strength and Arrangement

5.1.4.1 Requirements reflecting SOLAS Regulations for hull strength and arrangement are listed in Table 5.1.2 with reference with INTLREG Rules as shown in Table 5.1.3.

Table 5.1.2 SOLAS Regulations for Hull Strength and Arrangement Based on Class Notation

SOLAS Regulations	Bulk Carrier ESP L < 90m	Bulk Carrier	General Cargo Carrier	
			DS[1]	SS[2]
II-I/3-2 (Protective coatings of dedicated sea water ballast tanks in all types of ships and double-side skin spaces of bulk carriers)	X	X	X[3]	X
II-I/3-6 (Access to and within spaces in, and forward of, the cargo area of oil tankers and bulk carriers)	-	-	-	-
XII/5 (Additional safety measures for bulk carriers: Structural strength)[4]	-	X	-	-
XII/6 (Additional safety measures for bulk carriers: Structural and other requirements)[5]	-	X	X	-
XII/11 (Additional safety measures for bulk carriers: Loading instrument)[5]	-	X	X	X
XII/12 (Additional safety measures for bulk carriers: Hold, ballast and dry space water ingress alarms)	X	X	X	X
XII/13(Additional safety measures for bulk carriers: Availability of drainage forward spaces)	X	X	X	X

X : Mandatory
- : Not applicable
[1] DS= Double side skin construction
[2] SS= Single side skin construction
[3] Double side skin void space shall be treated as for ships with **Bulk Carrier** notation.
[4] Mandatory only for ships intended to carry bulk cargo having a density ≥ 1.0 t/m3 with freeboard length L_F (Refer Pt 3 Ch 1 Sec 2.1) ≥ 150 m, and single side; or
double side if any part of longitudinal bulkhead in any cargo hold is located within B/5 or 11.5 m, whichever is less, inboard from the ship's side at right angle to the centreline at the assigned summer load line. Only cargo holds in way of the double side-skin space of which does not meet the criteria need to be considered flooded.
[5] Mandatory only for freeboard length LF (Refer Pt 3 Ch 1 Sec 2.1) ≥ 150 m

Table 5.1.3 SOLAS Regulations for Hull Strength and Arrangement.

SOLAS Regulations	Reference Rules
II-1/3-2 (Protective coatings of dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers)	Pt 5A
XII/5 (Additional safety measures for bulk carriers: Structural strength)[1]	Pt 3, Ch 9 and Pt 3, Ch 8, Sec 3/ Sec 4 / Sec 5
XII/6 (Additional safety measures for bulk carriers: Structural and other requirements)	Sec 8.9.3
XII/11 (Additional safety measures for bulk carriers: Loading instrument)	Sec 8.1
XII/12 (Additional safety measures for bulk carriers: Hold, ballast and dry space water ingress alarms)	Sec 8.9.4, Sec 8.9.5, Sec 8.9.6
XII/13(Additional safety measures for bulk carriers: Availability of drainage forward spaces)	Sec 8.9.7

[1] Only the cargo holds and transverse bulkhead subject to flooding needs to be considered flooded

5.1.5 IACS Unified Requirements for Hull Strength and Arrangement

5.1.5.1 IACS Unified Requirements for hull strength and arrangement are listed in Table 5.1.4 with reference to INTLREG Rules as shown in Table 5.1.5.

Table 5.1.4 IACS Unified Requirements for Hull Strength & Arrangement, Depending on Class Notation

IACS Unified Requirements	Bulk Carrier ESP L < 90 m	Bulk Carrier	General Cargo Carriers	
			DS[1]	SS[2]
UR S1A (Additional requirements for loading conditions, loading manuals and loading instruments)[3]	-	X	X	X
UR S12 (Side structure)	X[4]	-	-	-
UR S21 (Scantlings of hatch covers)	X	-	-	-
UR S28 (Fitting of forecastle)	X	-	-	-
UR Z9 Corrosion protection coatings for cargo hold spaces on bulk carriers	X	-	-	-

X : Mandatory
- : Not applicable
[1] DS: Double side skin construction
[2] SS: Sing side skin construction
[3] Mandatory only for hips with length L ≥ 150m
[4] Applicable only for ships of single side construction

Table 5.1.5 IACS Unified Requirements for Hull Strength & Arrangement, with Reference to INTLREG Rules

IACS Unified Requirements	Reference Rule
UR S1A (Additional requirements for loading conditions, loading manuals and loading instruments)	Sec 8.1
UR S21 (Scantlings of hatch covers)	Sec 8.6
UR S28 (Fitting of forecastle)	Sec 8.7
UR Z9 Corrosion protection coatings for cargo hold spaces on bulk carriers	Sec 8.8.3

5.1.6 Documentation

5.1.6.1 For ships with class notations **BC-A**, **BC-B**, **BC-C**, **HC-A**, **HC-B**, **HC-C**, **HC-M** and **HC-B***, the loading conditions (separated into one departure and one arrival condition, refer Sec 5.1.2.6) shall be submitted for approval. The associated strength calculations shall be submitted as required by Pt 3, Ch 1, Sec 3.2.1 and Table 1.3.1 and together with possible special stillwater bending moment limit (hogging and sagging). Refer Sec 5.3.3.

5.1.6.2 Design loads as applicable shall be submitted for information in accordance with Pt 3, Ch 1, Sec 3.2.1 as follows:

- Design load (t) for holds in terms of cargo mass (M_H, M_{FULL} and M_{HD}) in hold.
- Design pressure (kN/m2) load for inner bottom.
- Design pressure (kN/m2) load for deck and hatch cover.
- Design steel coil loads (tons) in terms of weight, length (m), tiers and dunnage numbers.
  Load limitations for tanks as applicable.

5.1.6.3 Based on the design loading criteria for local strength as given in 5.1.2.7 to 5.1.2.13, on submitted information given in accordance with Sec 5.1.6 and on the direct calculations as required in Sec 5.3.4, hold mass curves shall be included in the loading manual and the loading instrument (Refer Pt 3, Ch 5).

The curves shall provide:
- Maximum allowable and minimum required mass as a function of draught, still water bending moment limit etc., in sea-going condition as well as during loading and unloading in harbour.
- Hold mass curves for each single hold, as well as for any two adjacent holds, shall be included.

5.1.6.4 If water ingress detection is arranged the following documentation shall be submitted for approval:

- Single line diagrams
- Power supply arrangement
- Location of alarm panel
- Location of water ingress detectors
- Specification of cargo types for which the ship is intended
- Functional description of the alarm system unless type approved by INTLREG
- Type approval test reports unless type approved by INTLREG

Manuals provided on board shall contain the following information and operational instructions:

1) A description of the equipment for detection and alarm arrangements together with a listing of procedures for checking that as far as practicable, each item of equipment is working properly during any stage of ship operation.
2) Documented evidence that the equipment has been type tested to the requirements in the performance standard.
3) Line diagrams of the detection and alarm system showing the positions of equipment.
4) Installation instructions for orientation, setting, securing, protecting and testing.
5) List of cargoes for which the detector is suitable for operating in a 50% seawater slurry mixture.
6) In the event equipment not functioning correctly detailed procedure to be followed.
7) Maintenance requirements for equipment and system.

5.1.6.5 For ships with the special feature notation **EC**, the following shall be submitted for information:
- Cleaning equipment and mucking pump as applicable
- Supply lines and discharge lines for each cargo hold

5.1.6.6 For ships with the special feature notation **EC**, the following shall be submitted for approval:
- Hold wash water holding/water ballast tank(s) arrangement.

5.1.7 Structural Leak Testing

5.1.7.1 Structural leak testing shall be in accordance with Pt.3

5.2 Design Loads

5.2.1 Design Cargo Density and Angle of Repose

5.2.1.1 Design load for cargo hold shall be based on the largest cargo mass, M_H, M_{FULL} or M_{HD} (as defined in Sec 5.1.2.7), according to the submitted loading conditions, refer Sec 5.1.6, for the hold considered, except as specified in Sec 5.2.1.3 to Sec 5.2.1.5.

5.2.1.2 The design angle of repose, δ, of bulk cargo is generally not to be taken greater than:

Cement cargo:	δ = 25 degrees (cargo density 1.3 t/m3)
Light bulk cargo (grain etc.):	δ = 20 degrees
Heavy bulk cargo:	δ = 35 degrees (cargo density ≥ 1.78 t/m3)
In general:	δ = 30 degrees

5.2.1.3 For the calculation of plates and stiffeners the cargo density of any hold shall be taken as:

For **BC-A** (ore hold):
In general: $\rho = (M_{HD} + 0.1\ M_H) / V_H$ (t/m^3)
For Sec 8.4: $\rho = (M_{HD} / V_H$ (t/m^3)

For **BC-A** (empty hold), **BC-B** and **BC-C**:
In general $\rho = M_{FULL} / V_H$ (t/m^3)

For **HC-B*:**
In general $\rho = 1.20\ M_{FULL} / V_H$ (t/m^3)

For **HC-M**:
In general $\rho = M_H / V_H$ (t/m^3)
For ore loading $\rho = M_{HD} / V_H$ (t/m^3)

5.2.1.4 For the direct calculation of girder structures, the design cargo density of any hold shall be taken as the greater of:

For **BC-A** (ore hold):
In general $\rho = (M_{HD} + 0.1\ M_H) / V$ (t/m^3)

For **BC-A** (empty hold), **BC-B** and **BC-C**:
In general $\rho = M_{FULL} / V$ (t/m^3)

For **HC-B*:**
In general $\rho = 1.20\ M_{FULL} / V$ (t/m^3)

For **HC-M**:
In general $\rho = M_H / V$ (t/m^3)
For ore loading $\rho = M_{HD} / V$ (t/m^3)

Where
V = V_H for calculation of cargo bulkhead structures, plates and stiffeners.
= V_{HR} for calculation of hold girder structure other than cargo bulkheads
V_{HR} = bulk carrier hold volume below a level 0.3 H + 0.14 bf within 60% of the middle width/length of the hold, and linearly reduced to a level 0.3 H at hold sides and to 0.3 H + 0.07 b_f at transverse bulkheads.
H = Height of hold (m) from inner bottom to top of coaming
b_f = Breadth of hold (m) at level 0.30H above inner bottom at hold midlength

5.2.1.5 Inner bottom design pressure or tank top uniform load for any cargo hold shall be determined by,

P = ρ H (t/m^2)
ρ = Cargo density of hold (t/m^3) as provided in Sec 5.2.1.3
H = Height of hold (m) from inner bottom to top of coaming

If larger design pressure (P_{design}, t/m^2) is specified in midship drawing for enhanced local strength for general cargo loading, inner bottom plating and stiffeners shall be designed based on the cargo density,

$\rho = P_{design} / H$ (t/m^3)

In such a case, maximum cargo mass in the hold shall not exceed the design cargo mass in Sec 5.2.1.3 and Sec 5.2.1.4.

5.2.2 Lateral Pressure Loads

5.2.2.1 The design pressures for local elements (i.e. plates and stiffeners) shall be determined as given in Pt 3, Ch 4 using parameters given in Sec 5.2.1.

5.2.2.2 For direct calculation of girder structures, design pressures shall be determined as given in Pt 3, Ch 13 using parameters given in Sec 5.2.1.

5.2.2.3 For bulkhead structures, the combination of cargo density, angle of repose shall be such to give the largest nominal lateral pressure on the bulkhead. A combination of a cargo density of 0.88 t/m^3 and an angle of repose of 20 degrees, loaded to top of hatch coaming shall be considered to give the minimum lateral pressure.

When cement is not the design cargo, it is not necessary to consider the lateral pressure due to cement. However, if cement is a design cargo, such kind of information shall be clearly specified in the midship drawing and in loading manual and the lateral pressure due to cement shall be considered for bulkhead structures.

5.2.2.4 For vessels intended to carry steel coils the inner bottom plating and inner bottom longitudinals will be especially considered.

An acceptable calculation method is given in Classification Note No. 31.1.

5.3 Bulk Carriers (Full Breadth Holds)

5.3.1 Arrangement of Hull

5.3.1.1 The ship shall have a double bottom in way of the cargo holds, and is in general arranged with a single deck.

5.3.1.2 Strength requirements are provided for cargo holds extending over the full breadth of the ship (or between double side structures).

5.3.1.3 A longitudinal stiffening system is assumed applied for the bottom- and inner bottom panels within the cargo region.

5.3.2 Longitudinal strength

5.3.2.1 The longitudinal strength shall be determined as given in Pt 3, Ch 5.

5.3.2.2 In the region between fore bulkhead in after cargo hold and after bulkhead in fore cargo hold, the side plating thickness shall not be less than that provided below:

$t = 0.0036 (L_1 \; k_m) (LB)^{1/3}$ (mm)

The thickness t may be taken to represent the combined thickness of the side and the inner side plating in way of double side skin regions.

The side plating thickness will be specially considered, if the ratio between the cargo hold length and ship's breadth exceeds 1.0.

Outside the region mentioned above, the side plating thickness can be varied linearly to give the shear area required by the main class at fore end of machinery spaces and after end of fore peak or adjacent deep tank.

5.3.3 Plating and Stiffeners

5.3.3.1 Cross sectional properties and thickness are in general to be calculated as given for the main class using design pressure according to Sec 5.2.2 where applicable.

Note:
For ships when the timber load line is intended to be marked, the draught corresponding to the design summer timber freeboard should be included in midship drawing. The local hull strength for bottom/side shell plating and stiffeners should be ensured under the sea pressure based on this draught.

The above is based on the assumption that the ship is homogeneously loaded in all cargo holds in the intended timber loading condition. When the actual timber loading condition deviates from this, the hull strength should be specially considered.

5.3.3.2 For the design of structural members of the double bottom, the stress factor f_{2B} (in hogging and sagging) as given in Pt 3, Ch 6, Sec 1 may for the loading conditions with specified holds empty on full draught be based on reduced stillwater bending moment limits. The limits are defined by the maximum moments in hogging and sagging (= 0.5 Mso as given in Pt 3, Ch 5, Sec 2.1 and Pt 3, Ch 5, Sec 2.2, minimum occurring for these loading conditions, unless higher limits are specified to be used.

5.3.3.3 The thickness of inner bottom plating between hopper or side tanks shall not be less than as required in Pt 3, Ch 6, Sec 3.4.

The thickness is in no case to be less than that detailed below:
$t = 9.0 + [\,0.03\,L_1\,(k_m^{0.5})\,] + t_k$ (mm)

5.3.3.4The section modulus of bottom longitudinals (except in way of hopper and side tanks) for sea pressure loads in ore loading conditions shall not be less than according to the requirements given in Pt 3 Ch 6 with:

$\sigma = (245 / k_m) - 40\,f_{2BH} - 0.70\,\sigma_{gh}$ (in empty holds)
$= (245 / k_m) - 40\,f_{2BS} - 0.70\,\sigma_{gh}$ (in ore loaded holds)
$= 160$ / km Maximum

Where
k_m = Material factor as provided in Sec 1.2.1 with respect to bottom longitudinal
σ_{gh} = 190 / k_{mB}, but need not be taken larger than σ_{DB} + 130 f_{2BH}
σ_{gs} = 190 / k_{mB}, but need not be taken larger than σ_{DB} + 130 f_{2BS}
f_{1B} = Material factor k_m as provided in Sec 1.2.1 with respect to bottom plating.
σ_{DB} = Longitudinal double bottom girder stress at middle of hold in N/mm2 with respect to the bottom plating .

f_{2BH} = f_{2B} as provided in Pt 3, Ch 6, Sec 1 with respect to hogging still water bending moment (Refer also Sec 5.3.3.2)
f_{2BS} = f2B as given in Pt 3, Ch 6, Sec 1 with respect to sagging still water bending moment (Refer also Sec 5.3.3.2).

5.3.3.5 The section modulus of inner bottom longitudinals shall for ore pressure loads not be less than according to the requirement given in Pt 3, Ch 6 with:

σ = (265 / k_m) – 30 f_{2BH} – 0.70 σ_g
= (160 / k_m) Maximum

Where

k_m = Material factor as provided in Sec 1.2.1 with respect to the inner bottom longitudinal

σ_g = 190 / k_{mIB}, but not be taken greater than σ_{DB} + 100 f_{2BH}

f_{1IB} = Material factor k_m as given in Sec 1.2.1 with respect to the inner bottom plating

σ_{DB} = longitudinal double bottom girder stress at middle of hold in N/mm^2 with respect to the inner bottom plating according to direct calculation .

f_{2BH} = As provided in Sec 5.3.3.4.

5.3.4 Girder systems

5.3.4.1 For girders which are parts of a complex 2- or 3-dimensional structural system, a complete structural analysis may have to be carried out to demonstrate that the stresses are acceptable when the structure is loaded as described in Sec 5.3.4.3..

5.3.4.2 Calculations as detailed in 401 are applicable for:

- Deck ad cargo hold structure in open type ships
- Transverse web frame structures in ships with a small number of transverse bulkheads
- Transverse bulkhead structure in bulk cargo holds
- Top wing tank, side and hopper tank structure in long bulk cargo holds
- Double bottom structures in way of full breadth holds/ tanks intended for ballast or liquid cargo
- Other structures as required elsewhere in the rules or otherwise when deemed necessary by the Society.

5.3.4.3 The following load cases are generally to be considered.

For vessels with the class notation **HC-M**, the design cargo mass and the design draught shall be determined according to Table 5.1.6. Any special loading conditions included in the vessel's Loading Manual shall also be considered.

a) Heavy cargo in hold (with adjacent hold empty), Refer Sec 5.1.2, with respect to strength of double bottom of the loaded and adjacent empty holds. Generally only condition(s) with untrimmed ore cargo filling the volume V_{HR} (as given in Sec 5.2.1.4) of the hold need be considered, refer Fig.2. The mass and draught varies depending on the class notation.

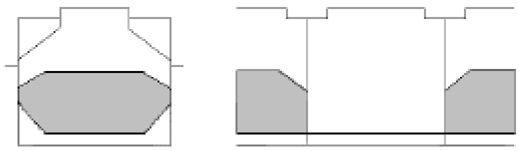


Fig 2 Heavy Cargo in Hold

b) Heavy cargo filling the volume V_{HR} (as given in Sec 5.2.1.4) of two adjacent holds, refer Sec 5.1.2, with respect to cross-deck and bulkhead shear strength, refer Fig.3. The mass and draught varies depending on the class notation.

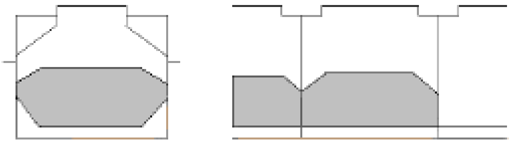


Fig 3 Heavy Cargo Adjacent Holds

c) Heavy cargo as given in Sect 5.1.2 filling the entire cargo hold with respect to cargo bulkhead strength for lateral load. Refer Fig.4. The mass and draught varies depending on the class notation.

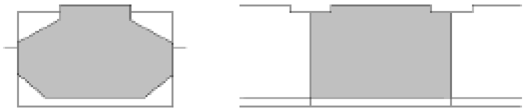


Fig 4 Bulkhead Loading

d) Ballast in ballast hold (with adjacent holds empty), with all double bottom tanks in way of cargo hold being 100% full, at ballast draught, T_{HB}, and with respect to double bottom, transverse bulkhead and top wing tank/ship side strength. It shall also be strength wise acceptable that ballast holds are filled when the topside wing, hopper and double bottom tanks are empty. For the top wing tank and side structures also the heeled condition shall be considered. Refer also Fig.5.

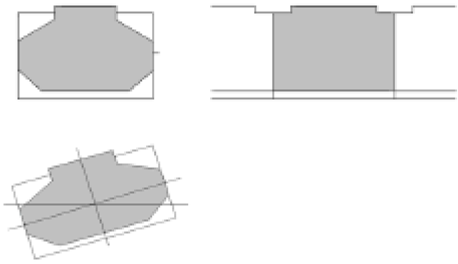


Fig 5 Ballast Hold

e) Ballast in top wing tank with respect to top wing tank strength in the upright and heled conditions, Refer Fig 6.

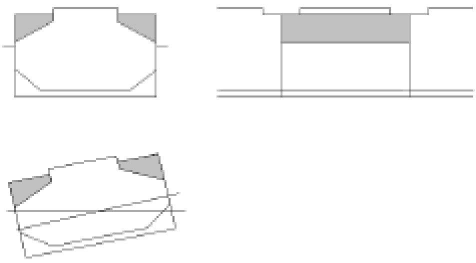


Fig 6 Ballast in Top Wing Tank

f) Cargo on deck (as specified) and external sea pressure on deck (in particular forward holds) with respect to deck (and top wing tank) strength, refer Fig.7.

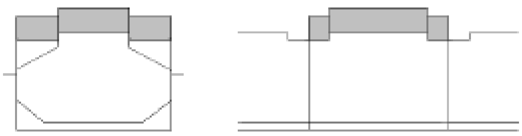


Fig 7 Cargo on Deck

Table 5.1.6 Loading Conditions for HC-M			
Conditions	**Cargo Mass**	**Design Draft**	**Remark**
Homogenous cargo in hold	M_H	T	Refer Sec 5.1.2.7
Homogenous cargo filled up hold	M_H	T	Refer Sec 5.1.2.7
Slack hold	$0.5M_H^{(1)}$	T	Refer Sec 5.1.2.7
Empty hold	Nil	$T_B^{(2)}$	Refer Sec 5.1.2.7
Heavy cargo in two adjacent holds	Highest of M_{HD} and M_H	$T_A^{(3)}$	
Heavy cargo in alternate loading	M_{HD}	T	Applicable when the loading condition is included in the vessels Loading Manual
Empty hold in alternate loading	Nil	T	
Ballast in hold (harbour)	Nil	T/3	
Ballast in hold (seagoing)	Nil	$T_{HB}^{(4)}$	
Ballast in hold (heeled)	Nil	$T_{HB}^{(4)}$	

(1) For ships with special cargo hold arrangement, cargo mass for slack hold may be specially considered.
(2) T_B : Deepest draught of any cargo loading or ballast conditions
(3) T_A: Design minimum draught of the loading condition in the vessels loading manual.
(4) T_{HB}: Heavy ballast draught

5.3.4.4 If any fuel oil tanks in double bottom, shall be assumed full when this is unfavourable. Water ballast tanks in the double bottom are generally to be assumed empty.

5.3.4.5 Harbour conditions need, unless the notation **No MP** is added, normally not be specially considered provided the minimum draught in harbour with filled cargo hold is not less than two thirds of the draught in the associated approved seagoing condition.

5.3.4.6 The allowable stresses are generally to be taken as given in Pt 3, Ch 13. For double bottom longitudinal girders, the girder bending stresses shall not exceed the following limits:

- Bottom plate at middle of empty hold (and at transverse bulkhead of loaded or ballast hold):

$$\sigma_{DB} = (190 / k_{mB}) - 130\ f_{2BH}$$

- Inner bottom plate at middle of loaded holds (and at transverse bulkhead of empty hold):

$$\sigma_{DB} = (190 / k_{mB}) - 100\ f_{2BH}$$

- Bottom plate at middle of loaded or ballasted hold (and at transverse bulkhead of empty hold):

$$\sigma_{DB} = (190 / k_{mB}) - 100\ f_{2BS}$$

- Inner bottom plate at middle of empty hold (and at transverse bulkhead of loaded or ballasted hold):

$$\sigma_{DB} = (190 / k_{mIB}) - 100\ f_{2BS}$$

Where,
k_{mB} = As provided in Sec 5.3.3.4
k_{mIB} = As provided in Sec 5.3.3.5
f_{2BH} = As provided in Sec 5.3.3.4
f_{2BS} = As provided in Sec 5.3.3.4

5.4 Optional Class Notation EC

5.4.1 Optional Class Notation EC

5.4.1.1 The vessel shall be built with double-side skin construction as provided in Sec 5.1.1.2. In addition, hatch covers which are not accessible for cleaning in open position shall be of double side skin construction.

5.4.1.2 Combined or separate hold wash water holding/water ballast tank(s) of adequate size and capacity for temporary storage shall be fitted. The tank(s) shall be filled by common wash water discharge line on deck, connected to individual hold branch lines, and discharged directly overboard by drop surface valve(s). At the aft of each cargo hold a valve for connection of flexible hose shall be fitted at the end of the individual hold discharge line branched down. Similar arrangement may be accepted.

Small hatch with coaming, giving unobstructed access to the holding tank, for internal cleaning, shall be fitted on upper deck. Close to access hatch air and water supply for internal cleaning shall be provided.

Provision shall be made so that deck washings can be collected and guided into the storage tank(s).

5.4.1.3 Air and water supply lines shall be provided in all cargo holds at protected but easily accessible locations. In addition, the water and air supply lines shall be fitted with hose connection valves at lower end and isolation valves at deck.

The hold discharge line shall be provided from the bottom of hold to upper deck with hose connection valves at both ends.

5.4.1.4 Portable or fixed cleaning system shall be provided.

The general service pump and the service air compressor shall have adequate capacity and pressure for simultaneous operation of at least two cleaning guns, and one air-driven mucking pump. If fixed cleaning system, the general service pump and service air compressor shall have adequate capacity to operate the system.

Note:
Portable cleaning guns of the jet type (air and water powered) are recommended due to poor experience and need of substantial maintenance of fixed guns while handling dusty cargoes.

5.4.1.5 Davit for handing air-driven mucking pump and cargo residue shall be provided. Small hatch with coaming, giving unobstructed access to the inner bottom for removal of cargo residue shall be fitted on upper deck at the cross deck at the aft end of each cargo hold with air outlet close by.

5.4.1.6 Cargo holds shall be coated with abrasive resistant painting.

5.4.1.7 Ladders in cargo holds shall be located in separate trunks.

SECTION 6 CONTAINER CARRIERS

Contents

6.1 General

6.1.1 Introduction

6.1.1.1 Objective:

This section provides applicable requirements to hull strength in addition to those for main class for ships intended for carriage of standard freight containers and securing of such containers.

6.1.1.2 Scope

This section describes requirements to arrangements and hull strength in addition to the requirements as described in Pt 3. This includes the following:

- Optional class notation **WIV**
- Optional class notation **SafeLash**
- Strength evaluation of container securing arrangements
- Arrangements for stowing and lashing of containers in holds and on weather deck
- Longitudinal and local strength, and requirements to girder systems in cellular container holds.

6.1.1.3 Application

These rules shall be applicable to ships exclusively intended for the carriage of containers and arranged with cell guides in holds. Ships complying with this section will be assigned the mandatory ship type class notation **Container Carrier**.

Those ships intended also for other purposes, while arranged, equipped and strengthened for carriage of containers on deck and/or in holds and built in compliance with Sec 6.1.5, Sec 6.4 and Sec 6.5 may be given the optional class notation related to cargo **CONTAINER** in addition to optional ship type class notations (eg **General Cargo Carrier CONTAINER**).

Other ship types with container transportation capability in holds, e.g. open hatch bulk carriers, shall comply with the structural requirements given in C as applicable in addition to the requirements of the ship type and additional class notations to be assigned to the vessel (e.g. **General Cargo Carrier HC-A**). For such ships, maximum mass of container stacks and total mass of containers in hold(s) shall be taken into account when establishing cargo mass limits (eg hold mass curves) for the respective hold(s).

Subsection elements Sec 6.2.1 to Sec 6.2.6 need in general not be considered for ships with length L < 100 m.

Ships fitted with a wave breaker shall comply with the requirements given in Sec 6.2.7.

For ships assigned the class notation **Container Carrier** and incorporating steel plates with thickness over 50 mm, of steel grades NV 36 and NV 40, the procedures as outlined in Sec 6.9 shall be followed.

For ships assigned the class notation **Container Carrier** and incorporating steel plates with thickness over 50 mm, of steel grade NV 47, the procedures as outlined in Sec 6.9 and Sec 6.10 shall be followed.

6.1.1.4 Additional class notations and their applications as defined in Table 6.1.1 and Table 6.1.2 may be assigned to vessels complying with the associated requirements for design, construction and testing.

Table 6.1.1 Additional Class Notation Relevant for Container Carrier

Class Notation	Description	Application	Requirements
NAUTICUS (Newbuilding)	Requirements to extended fatigue and direct strength calculations	Mandatory for vessels with length L, greater than 190 m	
…TEU	Number of twenty-foot containers	Optional Class Notation	
SafeLash	Requirements providing safe working area when engaged in container lashing	Optional Class Notation	H
WIV	Extended assessment of the hull girder ultimate strength and fatigue strength considering the effect of wave induced hull girder vibration.	Optional Class Notation	**K**

Table 6.1.2 Additional Class Notations Relevant for CONTAINER

Class Notation	Description	Application	Requirements
…TEU	Number of twenty-foot containers	Optional Class Notation	
SafeLash	Requirements providing safe working area when engaged in container lashing	Optional Class Notation	**H**
WIV	Extended assessment of the hull girder ultimate strength and fatigue strength considering the effect of wave induced hull girder vibration.	Optional Class Notation	**K**

6.1.1.5 Relation to other INTLREG documents

Further to the requirements in this section, applicable calculation methods are described in the following:

IACS S11A Longitudinal Strength Standard for Container Ships

IACS S33 Requirements for Use of Extremely Thick Steel Plates in Container Ships

IACS S34 Functional Requirements on Load Cases for Strength Assessment of Container Ships by Finite Element Analysis

6.1.1.6 For ships assigned the class notation **Container Carrier**, the required calculation scope and calculation methods depend on vessel size and structural complexity. For ships assigned the class notations **Container Carrier** or **CONTAINER**, the procedures for certification of container securing devices as outlined in Standard for Certification No. 2.23 shall be followed.

6.1.2 References

6.1.2.1 Definitions

Container: Freight container according to ISO Standard, or other specially approved container.

Container stack: Containers which are stacked vertically and secured horizontally by stackers, lashings etc., refer Fig. 1.

Container block: A number of container stacks interconnected and secured horizontally by bridge stackers or double stacking cones, refer Fig. 2.

Container securing devices: Loose and fixed equipment and support fittings used for securing and supporting of containers.

Container securing equipment: Loose and fixed securing devices which do not form an integral part of the ship.

Container support fittings: Fittings welded into tank tops, decks, bulkheads or hatch covers, ie. fittings that form an integral part of the ship structure.

Rigid securing arrangements: Securing arrangements where the stiffness of the containers does not influence support forces and internal forces in the containers, eg. cellular containment arrangements.
Non-rigid securing arrangements: Securing arrangements where the stiffness of containers influences support forces and internal forces in the containers, eg lashing arrangements including lashing bridges and container stanchions.

Cell guides:
An arrangement in holds or on deck of fixed vertical guide rails for support of containers.

Container free end:
Free end of 20’ containers stowed in 40’ cell guides.

Maximum securing load, MSL:
The maximum allowable load in container securing devices, based on testing or calculations.

Minimum breaking load:
The tested minimum breaking strength of a container securing device.

Working areas:
Spaces used by stevedores or vessel crew when operating container securing equipment, eg. lashing bridges and platforms.

Transit areas:
Passage ways, Stairs, decks and other areas used for moving about the ship.

Fencing:
Guardrails, safety rails, toe boards, safety barriers and similar structures that provide protection against the fall of persons.

Ladder stringers:
The uprights or sides of a ladder.

Rungs:
The bars that form the steps of a ladder.

Lashing computer system:
Computer based system for calculation and control of container securing arrangements for compliance with applicable strength requirements.

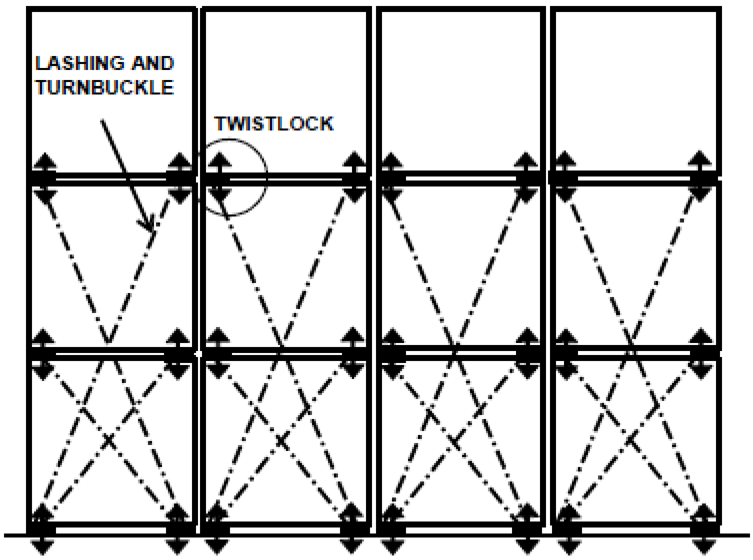


Fig 1 Individual Container Stacks with Lashings

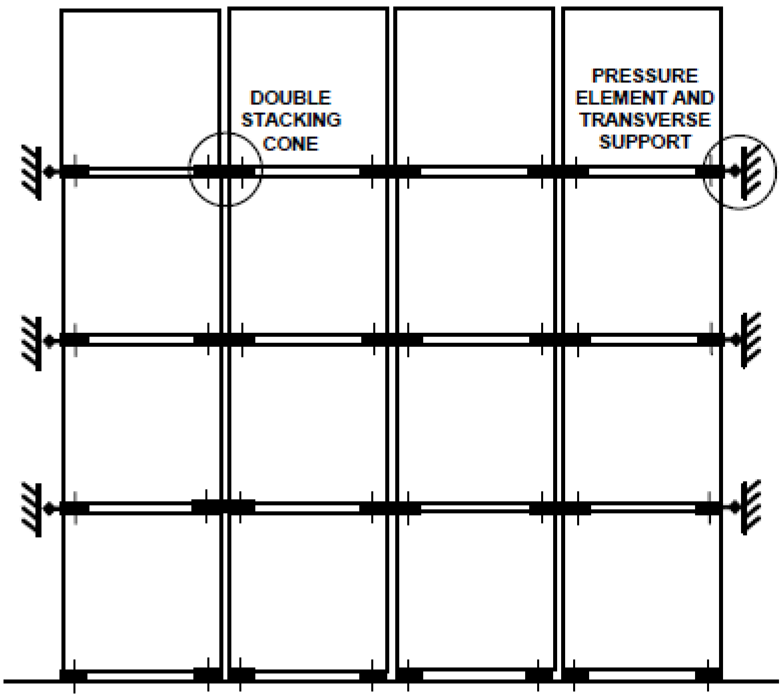


Fig 2 Example of Container Block in a System Capable of Transferring Pressure Loads

6.1.3 Certification Requirements

6.1.3.1 For class notation **Container Carrier** or **CONTAINER** components shall be certified as required by Table 6.1.3.

Table 6.1.3 Certification Requirements- Class Notation Container Carrier or CONTAINER			
Object	**Certificate Type**		**Additional Description**
Cell guide	INTLREG-M	INTLREG Material Certificate	-
Lashing bridge	INTLREG-M	INTLREG Material Certificate	-
Container Stanchion	INTLREG-M	INTLREG Material Certificate	-
Container Securing Equipment	INTLREG W-M	Works Material Certificate	-
Container Support Fitting	INTLREG-M	INTLREG Material Certificate	-
Container Securing Equipment	INTLREG-P	INTLREG Material Certificate	-
Container Support fitting	INTLREG-P	INTLREG Material Certificate	-

6.1.4 Documentation Requirements

6.1.4.1 For class notation **Container Carrier** or **CONTAINER** documentation shall be submitted as required in Pt 3, Ch 1. In addition, documentation as given in Table 5.5.4 shall be submitted.

Table 6.1.4 Documentation Requirements- Class Notation Container Carrier or CONTAINER			
Object	**Documentation Type**	**Additional Description**	**(A)/(I)**
Ship hull	Midship section drawing	Including stack weights of 20’ and 40’ containers in holds and on deck. Minimum mass in one typical 40’ bay on scantling draught, if relevant.	(A)
	Loading Manual	Including maximum hull girder still water torsional moment, and unsymmetrical design loading conditions, if applicable.	(A)
	Container stowage and securing manual		(A)
Cell guides	Detailed drawing	Including nominal cell guide/container clearances and specified building tolerances of container cell guides.	(A)
Supporting structures of fixed container securing devices	Detailed drawing		(A)
Note: (A): For Approval; (I): For Information			

6.1.4.2 For class notation **Container Carrier** with class notation **NAUTICUS (Newbuilding)** documentation shall be submitted as required by Table 6.1.5.

Table 6.1.5 Documentation Requirements- Class Notation NAUTICUS (Newbuilding)			
Object	**Documentation Type**	**Additional Description**	**(A)/(I)**
Ship hull structure	Strength Analysis	3D Finite element analysis of primary supporting members in midship area.	(I)
	Strength Analysis	Local structure analysis of longitudinal stiffeners in way of transverse bulkheads in midship area.	(I)
	Strength Analysis	Fatigue assessment for end structures of longitudinals in cargo area, including effect of relative deformations.	(I)
Note: (A): For Approval; (I): For Information			

6.1.4.3 For ships with class notation **Container Carrier** having a breadth B > 52 m documentation shall be submitted as required by Table 6.1.6.

Table 6.1.6 Documentation Requirements- Ships with Class Notation Container Carrier (B > 52 m)			
Object	**Documentation Type**	**Additional Description**	**(A)/(I)**
Ship hull structure	Global strength analysis		(I)
	Wave load analysis		(I)
	Fatigue analysis		(I)
Note: (A): For Approval; (I): For Information			

6.1.4.4 For class notation **SafeLash** documentation shall be submitted as required by Table 6.1.7.

Table 6.1.7 Documentation Requirements- Class Notation SafeLash			
Object	**Documentation Type**	**Additional Description**	**(A)/(I)**
Protection of the crew	Container safe access plan		(A)
Lightning arrangement	Lightning description	Showing container working areas and transit areas, including light intensity levels.	(A)
Electrical power systems	System arrangement plan	Including location and details of reefer container power outlets and adjacent working areas.	(A)
Note: (A): For Approval; (I): For Information			

6.1.4.5 For general requirements to documentation, including definitions of the Info codes,

6.1.5 Container Stowage for Ships Assigned the Class Notation Container Carrier or CONTAINER

6.1.5.1 Whenever the ships is assigned to carry containers the loose container securing devices is to be carried on board.

6.1.5.2 Containers carried on deck or in holds shall be secured by an approved method.

The "Container Stowage and Securing Manual" shall be approved in accordance with Sec 6.1.5.3 to Sec 6.1.5.5 and shall be kept onboard.

6.1.5.3 Requirements to arrangements of stowage and lashing of containers are given in Sec 6.4.

6.1.5.4 Calculations of maximum forces and stresses in container supports, cell guides, lashings, containers etc. shall be carried out in accordance with Sec 6.5

6.1.5.5 Approval of the container stowage is based on the following assumptions:

- Approved “Container Stowage and Securing Manual” is kept available on board for the stowage and securing of the container cargo.
- All required equipment for the securing of containers is certified by the Society for its purpose.
- Containers are stowed and secured in accordance with the approved “Container Stowage and Securing Manual” or checked for compliance with requirements given in Sec 6.5 by a lashing computer system installed on board certified by INTLREG.
- All container securing devices is properly maintained and repaired.
- Damaged equipment is replaced by equipment which is type approved and of at least the same strength rating.
- The above assumptions shall be stated in the approved “Container Stowage and Securing Manual” onboard.

6.2 Longitudinal and Local Strength

6.2.1 Definitions

6.2.1.1 Symbols

k_m = Material factor as given in Sec. 1B for the considered member.
= 0.66 for steel for vessels assigned the notation **Container Carrier**
= 0.62 for for vessels assigned the notation **Container Carrier**

f^*_2 = Longitudinal stress parameter, applicable for transversely stiffened plates and longitudinal stiffeners of the hull cross-section, given by:
= 5.70 (M_s + M_w) / Z

f^*_{2B} = f^*_2 with respect to the hull girder section modulus at bottom. To be taken as the greater of f^*_{2BH} and f^*_{2BS}

f^*_{2D} = f^*_2 with respect to the hull girder section modulus at deck

f^*_{2BH} = f^*_{2B} considering hogging moment

f^*_{2BS} = f^*_{2B} considering sagging moment

k_l = parameter for determination of allowable stress for laterally loaded plates
= 3.50 (1 – [f^*_2 k_m]), k_l not to be taken larger than 5 (x/L) – 1

x = Distance (m) from L/2 to considered position
= 0.20 L minimum
=0.40 L maximum

k_{lD} = k_l with respect to f^*_{2D}

k_{lB} = k_l with respect to f^*_{2B}

Z = Z_B = Section modulus at bottom (cm^3) of hull girder as built at section considered
= Z_D = Section modulus at deck (cm^3) of hull girder as built at section considered

M_s = Design still water bending moment (kNm) at considered section

k_{sm} M_{SO} = As provided in Pt 3, Ch 5, Sec 2.1.

M_W = Rule wave bending moment (kNm) at considered section given in Pt 3, Ch 5, Sec 2. Hogging or sagging moment shall be chosen in relation to the applied still water moment.

6.2.2 Longitudinal Strength due to Vertical Hull Girder Loads

6.2.2.1 The longitudinal strength due to vertical hull girder loads shall be determined in accordance with Pt 3, Ch 5 and Pt 3, Ch 14 and Sec 5.6.1.1. and Sec 5.6.2.2-5.6.2.4.

6.2.2.2 The design still water bending moments, M_S, and still water shear forces, Q_s, may be based on the envelope curve representing all relevant full and part load cargo and ballast conditions as given in Pt 3, Ch 5, Sec 2.1.1.

6.2.2.3 The requirement for section modulus of the hull girder about the transverse axis is for any section to be taken as given in Pt 3, Ch 5, Sec 3.3 with $\sigma_l = 175 / k_m$ [N/mm^2].

6.2.2.4 The extent of high strength steel shall be as given in Pt 3, Ch 5, Sec 3.2, replacing f_2 with f_2*.

6.2.2.5 Ships with the mandatory ship type class notation Container Carrier shall have sufficient global hull girder hogging bending strength to resist the defined Rule extreme design loads as given in Sec 6.2.2.8 without suffering hull girder collapse, ductile plate fracture and compartment flooding.

After the extreme design wave loading, the vessel shall stay afloat and maintain its overall integrity. Permanent sets and buckles in limited areas are accepted, as long as the global hull girder strength and stiffness is not violated.

6.2.2.6 The longitudinal strength requirements as given in Sec 6.2.2.1 and Sec 6.2.2.5 apply over the entire length of the ship.

6.2.2.7 The moment M to be used in the criteria given in Sec 6.2.2.8 should be evaluated at the mid-position between two neighbouring transverse girders in the cross-section considered.

6.2.2.8 The vertical hogging bending moment criterion shall be as below:

$\gamma_s^M M_s + \gamma_w^M M_w \leq M_U / \gamma_m$

Where,

γ_S^M = Load factor for still water hogging bending moment
= 1.00

γ_w^M = Load factor for wave hogging bending moment
= 1.25 forward of 0.65L from AP
= 1.50 aft of 0.58L from AP
= Intermediate values may be obtained from linear interpolation

γ_m^M = Factor for ultimate moment capacity
= 1.00

M_s = Still water hogging bending moment (kNm) as provided in Sec 6.2.2.2 in the considered hull section.

M_w = Wave hogging bending moment (kNm) as provided in Pt 3, Ch 5, Sec 2.2.2 in the considered hull section without adjustments to k_{wm}.

M_U = Ultimate hull girder strength capacity in hogging bending moment for the considered section in a pure vertical bending modus as given in Sec 6.2.2.9.

6.2.2.9 The ultimate hull girder strength capacity, M_U, is calculated by summing up the longitudinal loads carried by each element in the considered section at hull girder collapse. The M_U shall be calculated using as built scantlings.

$$M_u = \sum_{i=1}^{K} P_i z_i = \sum (EA)_{eff\text{-}i} \varepsilon_i z_i \quad \text{(kNm)}$$

P_i = Axial load in element number i at hull girder collapse
= $(EA)_{eff\text{-}i} \varepsilon_i^{g\text{-}collapse}$

z_i = distance from hull-section neutral axis to centre of area of element number i at hull girder collapse. The neutral axis position shall be shifted due to local buckling and collapse of individual elements in the hull-section.

$(EA)_{eff\text{-}I}$ = Axial stiffness of element number i accounting for buckling of plating and stiffeners (pre-collapse stiffness)

K = Total number of assumed element in hull section (typical stiffened panels, girders etc.)

ε_i = Axial strain of centre of area of element number i at hull girder collapse ($\varepsilon_i = \varepsilon_i^{g\text{-}collapse}$). The collapse strain for each element follows the displacement hypothesis assumed for the hull section.

σ = Axial stress in hull section

z = Vertical co-ordinate in hull section measured from neutral axis

Note:
Panel ultimate strength assessment is to be carried out for individual element ultimate capacity and stiffness assessments. Standard industry software tools acceptable to Intleg may be used in the assessment.

6.2.3 Longitudinal Strength Due to Vertical Hull Girder Loads in Combination with Horizontal and Torsional Hull Girder Loads

6.2.3.1 Combined nominal stress due to vertical hull girder loads in combination with horizontal and torsional hull girder loads shall be as below:

$$\sigma_l = (\sigma_S + \sigma_{WR}) + \sigma_{WH} + (\sigma_{ST,w} + \sigma_{WT,w}) + (\sigma_{ST,dl} + \sigma_{WT,dl}) \quad (N/mm^2)$$

Where,

σ_s = Hull girder stress due to design still water hogging bending moment as provided in Sec 5.6.2.2.

σ_{WR} = Hull girder stress due to reduced vertical wave hogging bending moment

= 0.45 M_W, in general

σ_{WH} = Hull girder stress due to horizontal wave bending moment as provided in Pt 3, Ch 5, Sec 2.2.5.

$\sigma_{ST,w}$ = Warping stress due to still water torsional moment as given in Sec 5.6.3.2

$\sigma_{WT,w}$ = Warping stress due to wave torsional moment as given in Pt 3, Ch 5, Sec 2.2.7.

$\sigma_{ST,dl}$ = Bending stress in upper deck and hatch coaming due to warping deformation of cross deck induced by still water torsional moment

= 0, for longitudinal structural members below the transverse neutral axis.

$\sigma_{WT,dl}$ = Bending stress in upper deck and hatch coaming due to warping deformation of cross deck induced by wave torsional moment

= 0, for longitudinal structural members below the transverse neutral axis.

Note:
The still water and wave induced warping stress and stress due to warping deformations of cross decks may be determined based on prismatic beam or global coarse mesh finite element calculations.

6.2.3.2 The still water torsional moment shall not be taken less than 0.30 LB^2 (kNm).

To calculate the still water torsional stress, a still water torsional distribution equal to the wave torsional distribution may be assumed.

Note:
The permissible still water torsional moment curve in the loading manual need not have a shape similar to the wave torsion distribution curve, but can be given as constant value over the entire ship length.

6.2.3.3 The combined nominal stress as given in Sec 5.6.3.1 applies to upper deck, hatch coaming and longitudinal structures below the transverse neutral axis within the cargo hold area where the hatchway opening size remains unchanged.

6.2.3.4 The combined nominal stress as given in Sec 5.6.3.1 shall in general not exceed 195 / k_m [N/mm²]. For upper deck and hatch coaming where $\sigma_{ST,dl}$ and $\sigma_{WT,dl}$ are applicable, the combined nominal stress shall not exceed 225 / k_m [N/mm²].

6.2.3.5 The buckling strength of longitudinal structures below the transverse neutral axis, such as bilge and stool bench area, shall be determined as given in for plating and stiffeners, replacing σ_{al} as given in Pt 3, Ch 14 Sec 2.2.5 and Sec 2.2.6 with the combined nominal stress as given in Sec 5.6.3.1.

6.2.3.6 The combined hot spot stress in way of hatchway corners on upper deck and hatch coaming shall be taken as:

$$\sigma_{hs} = K_v\,(\sigma_S + \sigma_{WR}) + K_h\,\sigma_{WH} + K_{tw}\,(\sigma_{ST,w} + \sigma_{WT,w}) + K_{td}\,(\sigma_{ST,dt} + \sigma_{WT,dt}) \quad \text{(N/mm}^2\text{)}$$

Where,

σ_S, σ_{WR} = As provided in Sec 5.6.3.1.

σ_{WH} = As provided in Sec 5.6.3.1.

$\sigma_{ST,w}$, $\sigma_{WT,w}$ = As provided in Sec 5.6.3.1.

$\sigma_{ST,dt}$ = Bending stress in cross decks due to warping deformation induced by still water torsional moment

$\sigma_{WT,dt}$ = Bending stress in cross decks due to warping deformation induced by wave torsional moment.

K_v = Stress concentration factor in way of hatchway corners from vertical bending

K_h = Stress concentration factor in way of hatchway corners from horizontal bending

K_{tw} = Stress concentration factor in way of hatchway corners from warping

K_{td} = Stress concentration factor in way of hatchway corners from bending stress due to warping deformation of cross decks.

6.2.3.7 The combined hot spot stress as given in Sec 5.6.3.6 applies to hatchway corners on upper deck and hatch coaming within the cargo hold area where the hatchway opening size remains unchanged.

6.2.3.8 The combined hot spot stress (N/mm2) as given in Sec 5.6.3.6 shall not exceed 400 / k_m.

6.2.4 Fatigue Assessment of Hatchway Corners

6.2.4.1 Combined global stress range due to horizontal and vertical hull girder bending and torsion in way of hatchway corners on upper deck and hatch coaming shall be calculated as below:

$$\Delta\sigma_g = \left(\Delta\sigma_v^2 + \Delta\,[\sigma_{hg} + \sigma_{wt}]^2 + 2\,\rho_{vh}\,\Delta\sigma_v\,\Delta[\sigma_{hg} + \sigma_{wt}] \right)^{1/2} \quad \text{(N/mm}^2\text{)}$$

Where,

$\Delta\sigma_v$ = Stress range due to vertical wave bending moment

$\Delta\,(\sigma_{hg}+\sigma_{wt})$= Stress range due to horizontal wave bending moment and wave torsional moment

ρ_{vh} = Correlation coefficient

6.2.4.2 The fatigue strength evaluation applies to hatchway corners on upper deck and hatch coaming within the cargo hold area where the hatchway opening size remains unchanged applying calculation methods according to Pt 3, Ch 15, Sec 1.5 with combined global stress range as given in Sec 5.6.4.1.

6.2.4.3 The fatigue assessment shall comply with the design criteria given in Pt 3, Ch 15, Sec 1.4.

6.2.5 Reinforcement and Shape of Hatchway Corners and Stringer Corners

6.2.5.1 Requirements detailed in Sec 5.6.5.2 to 5.6.5.5 below may be waived provided that more extensive calculations in accordance with Sec 5.6.3 and Sec 5.6.4 are carried out documenting acceptable nominal combined stress, combined hot spot stress and fatigue life in way of hatchway corners and stringer corners.

6.2.5.2 The curvature of streamlined hatch corners at side at the aft end of the open deck region shall be as given in Pt 3, Ch 5, Sec 5.5 with transverse extension not less than:

$a = 0.020\ B\ (1 / k_m)^{0.50}$ (m)

Where

k_m = As detailed in Sec 6.2.1.1 for deck plating in area considered.

Alternatively, double (or single) curvature corner shapes may be accepted provided the radius of curvature at the hatch side is not less than 1.8 a (m).

For extent of local reinforcement of deck plating at hatch corners, refer Pt 3, Ch 8, Sec 1.4.5.

6.2.5.3 The radius of rounded corners shall not be less than the following, for cross deck in way of upper deck and hatch coaming:

$r = k\ (w + 0.80)\ (1 / k_m)^{0.50}$ (m)

Where,

k = 0.16 for hatch corners at side
= 0.10 for hatch corners for longitudinal deck girders

k_m = k_m, as provided in Sec 5.6.1.1 for deck plating in area considered.

w = Width of cross deck (m)

A reduction of the inside radius may be considered, when a corner with double curvature is desired.

6.2.5.4 Cross decks in way of stringer corners, the radius of rounded corners shall not be less than 200 mm.

6.2.5.5 For cross decks in way of upper deck, hatch coaming and stringer corners in forward cargo holds area, the thickness shall not be less than:

$t_{insert} = c_1\ c_2\ c_3\ c_4\ [\ t_{min} + (L / [150\ (1 / k_m)\ ]\ )^2\ ]$ (mm)

The above should not be taken less than the adjacent deck/ stringer thickness.

t_{min} = As provided in Pt.3 Ch.1 Sec.8 applying k = 0.02
c_1 = 0.50 (1 + 2 [z / D]), not to be taken less than 1.00
z = Vertical distance (m) from baseline to considered portion
c_2 = 0.75 + [b / (2B)], not to be taken less than 1.00
b = Breadth (m) of the opening in way of the insert plate
c_3 = 1.20 in way of transverse bulkheads (supporting or watertight)
= 1.00 otherwise
c_4 = $(R_0 / R)^{0.25}$
R_0 = 200 mm
R = Actual radius (mm)

For the extend of local reinforcement, if any, in way of cross deck, refer Pt 3, Ch 8, Sec 1.4.5.

6.2.6 Plating and Stiffeners

6.2.6.1 Double bottom plating and double bottom stiffeners shall be designed as provided in Pt 3, Ch 6 with allowable stress for applicable rule items taken as below:

Bottom and bilge plating:
$\sigma = (175 + 40\ k_{IB})\ (1 / k_m) - 120\ f^*_{2B}$,
$= (120 + 40\ k_{IB})\ (1 / k_m)$ maximum, where transversely stiffened
$= (120 + 40\ k_{IB})\ (1 / k_m)$ where longitudinally stiffened

Inner bottom plating:
$\sigma = (200 + 20\ k_{IB})\ (1 / k_m) - 110\ f^*_{2B,}$
$= (140 + 20\ k_{IB})\ (1 / k_m)$ maximum, where transversely stiffened
$= (140 + 20\ k_{IB})\ (1 / k_m)$ where longitudinally stiffened
$= 220\ (1 / k_m)$ for flooded condition

Double bottom floor and longitudinal girder plating:
$\sigma = (190 + 30\ k_{IB})\ (1 / k_m) - 120\ f^*_{2B}$
$= (130 + 30\ k_{IB})\ (1 / k_m)$ maximum where transversely stiffened
$= (130 + 30\ k_{IB})\ (1 / k_m)$ where longitudinally stiffened
$= 160\ (1 / k_m)$ for floors
$= 220\ (1 / k_m)$ for flooded condition

Bottom longitudinals
$\sigma = 225\ (1 / k_m) - 130\ f^*_{2B}\ (z_n - z_a) / z_n$
$= 160\ (1 / k_m)$ maximum for single bottom longitudinals
$= 115\ (1 / k_m) - 130\ f^*_{2B} - 0.70\ \sigma_{db}$
$= 160\ (1 / k_m)$ maximum for double bottom longitudinals
= As provided in Sec 5.6.8.8 for bottom longitudinals of double bottom in cellular container holds.

Inner bottom longitudinals
$\sigma = 225\ (1 / k_m) - 100\ f^*_{2B} - 0.70\ \sigma_{db}$
$= 160\ (1 / k_m)$ maximum
$= 220\ (1 / k_m)$ for flooded condition

For inner bottom longitudinals exposed to tank pressure on the stiffener side only, the allowable stress shall be taken as the lesser of:

$\sigma = 2\ (225\ [\ 1/ k_m\ ] - 100\ f^*_{2BH} - 0.70\ \sigma_{db})$
$= 160\ [\ 1/ k_m\ ]$ maximum at middle of stiffener span
$= (225\ [\ 1/ k_m\ ] - 100\ f^*_{2BH} - 0.70\ \sigma_{db})$
$= 160\ [\ 1/ k_m\ ]$ maximum at end of stiffener span
$= 220\ [\ 1/ k_m\ ]$ for flooded condition

6.2.6.2 Side longitudinals shall be designed as detailed in Pt 3, Ch 7, Sec 3.3.1 with allowable stress taken as follows:

$\sigma = 225\ [\ 1/ k_m\ ] - 130\ f^*_2\ (z_n - z_a) / z_n$
$= 160\ [\ 1/ k_m\ ]$ maximum
$= 160\ [\ 1/ k_m\ ]$ for longitudnals in any case in combination with heeled condition pressures.

6.2.6.3 Deck plating and stiffeners shall be designed as given in Pt 3, Ch 8 with allowable stress for applicable rule items taken as below:

Strength deck plating:
$\sigma = (175 + 40\ k_{ID})\ [\ 1/ k_m\ ] - 120\ f^*_{2D}$
$= (120 + 40\ k_{ID})\ [\ 1/ k_m\ ]$ maximum, where transversely stiffened
$= (120 + 40\ k_{ID})\ [\ 1/ k_m\ ]$ where longitudinally stiffened

Deck longitudinals:
$\sigma = 225\ [\ 1/k_m\ ] - 130\ f^*_{2D}$
$= 160\ [\ 1/k_m\ ]$ maximum or strength deck and ong superstructures and effective deck house above strength deck

$= 225\ [1/k_m] - 130\ f^*_{2D}\ (z_n - z_a) / z_n$
$= 160\ [1/k_m]$ maximum for continuous decks below strength deck

For deck longitudinals below the neutral axis exposed to tank pressure on the stiffener side only, the allowable stress shall be taken as the lesser of:

$\sigma = 2\ (225\ [1\ k_m] - 130\ f^*_{2BH}\ (z_n - z_a) / z_n)$
$= 160\ [1/k_m]$ maximum at middle of stiffener span
$= (225\ [1/k_m] - 130\ f^*_{2BH}\ (z_n - z_a) / z_n)$
$= 160\ [1/k_m]$ maximum at end of stiffener span
$= 160[1/k_m]$ in any case in combination with heeled condition pressures

6.2.6.4 For ship with length > 100 m the arrangement of longitudinal stiffeners of the strength deck shall be taken as given in Pt 3, Ch 8, Sec 1.5.3 with longitudinals arranged to be continuous within the complete open cargo hold length.

6.2.6.5 Bulkhead plating and stiffeners shall be designed as given in Pt 3, Ch 7 with allowable stress for applicable rule items taken as below:

Bulkhead longitudinals

$\sigma = 225\ [1/k_m] - 130\ f^*_2\ (z_n - z_a) / z_n$
$= 160\ [1/k_m]$ maximum

For bulkhead longitudinals below the neutral axis exposed to tank pressure on the stiffener side only, the allowable stress shall be taken as the lesser of:

$\sigma = 2\ (225\ [1/k_m] - 130\ f^*_{2BH}\ (z_n - z_a) / z_n)$
$= 160\ [1/k_m]$ maximum at middle of stiffener span
$= (225\ [1/k_m] - 130\ f^*_{2BH}\ (z_n - z_a) / z_n)$
$= 160\ [1/k_m]$ maximum at end of stiffener span
$= 160\ [1/k_m]$ in any case in combination with heeled condition pressures.

Simple girders shall be designed as provided in Pt.3 Ch.1 with allowable stress for applicable rule items considered as below:

Ch 8, Sec 4.2.1 and Ch 9, Sec 4.2.1:
$\sigma = 190\ [1/k_m] - 130\ f^*_2\ (z_n - z_a) / z_n$
$= 160\ [1/k_m]$ maximum for continuous longitudinal girders
$= 160\ [1/k_m]$ for other girders
$= 160[1/k_m]$ for longitudinal girders in combination with heeled condition pressure

6.2.7 Strength Evaluation of Wave Breaker and Supporting Structure

6.2.7.1 Where a wave breaker is fitted in the forward part of the ship protecting the containers from damage due to green sea on deck, the scantlings of plating, stiffeners and girders, and the supporting deck structure shall be evaluated based on requirements given in the following.

6.2.7.2 The design load on the wave breaker structure shall be taken in accordance with the design load for unprotected front bulkhead of superstructure as given in Pt 3, Ch 10, Table 10.3.1.

6.2.7.3 Plating and stiffeners shall be designed as given in Pt 3, Ch 10, Sec 4.1 with allowable stress as given in Table 5.6.1.

6.2.7.4 Wave breaker girder system and its supporting structure shall be designed based on a direct calculation taking into account the efficiency of the provided deck support below the wave breaker.
Allowable stress shall be as provided in Table 5.6.1 below:

Table 5.6.1 Allowable Stresses	
-	**Wave breaker and supporting structure**
σ	160 [1/ k_m]
τ	90 [1/ k_m]

6.2.7.5 Where relevant, the plating of the wave breaker shall satisfy the buckling strength requirements given in Pt 3, Ch 14, Sec 2 applying usage factors:

Table 5.6.2 Usage Factors (Buckling)	
Panel Description	**Usage factor η**
Plate panels in uni axial compression	0.80
Plate panels in bi axial compression	0.85
Plate panels in shear	0.85

6.2.8 Special Requirements for Ships with Container Carrier Notation

6.2.8.1 Thickness and cross-section properties are to be as given for the main class with the exceptions as detailed in Sec 5.6.8.2 to Sec 5.6.8.8.

6.2.8.2 The minimum thickness of web and flange of stiffeners of ballast tanks shall be taken as provided in Pt 3, Ch 6, Sec 3.6.3; Pt 3, Ch 6, Sec 3.7.3; Pt 3, Ch 6, Sec 3.8.2; Pt 3, Ch 7, Sec 3.3.2; Pt 3, Ch 7, Sec 3.3.3 and Pt 3, Ch9, Sec 3.2.2 with k = 0.01 L1, and the minimum thickness relating to web height for flat bar profiles shall be taken as below:

$t = (h_w / 20) + t_k$ (mm)

Where,

h_w = Web height (mm)

For seachest boundaries (including top and partial bulkheads) refer Pt 3, Ch 6, Sec 3.5 and Pt 3, Ch 6, Sec 3.9.

6.2.8.3 The thickness of webs, flanges and brackets of girders of double bottom tanks shall be taken as given in Pt 3, Ch 6, Sec 3.5.2 with:

k = 0.030 L_1; for center girder up to 2 m above keel plate
= 0.015 L_1; for other girders and remaining part of center girder.
= 0.050 L_1; for sea chest boundaries (including top and partial bulkheads)

6.2.8.4 Thickness of stiffeners and girders including webs, flanges and brackets of ballast tanks of the side and bulkhead structures of the cargo region as otherwise provided by the requirements in Pt 3, Ch 7, Sec 4.1.1 and Pt 3, Ch 9, Sec 4.1.1 shall not be less than:

$t = [k / ([1/ k_m]^{0.5})] + t_k + 5$ (mm)

Where

$k = 0.01 L_1$

6.2.8.5 The inner shell plating thickness shall be as provided in Pt 3, Ch 9 Sec 3.1.2 with k = 0.01, and the requirement of Sec 5.7.1.4 disregarded.

6.2.8.6 Minimum plate thickness of transverse bulkheads which are required for gas tightness only, shall be taken as provided in Pt 3, Ch 9, Sec 3.1.2 with k = 0.

6.2.8.7 Minimum thickness of the side plating shall be as given in Pt 3, Ch 7, Sec 3.1.3 with k = 0.037 and Pt 3, Ch 7, Sec 3.1.2 with $T = T_d$ = design draught.

6.2.8.8 The section modulus of bottom longitudinals within the width of the double bottom shall not be less than according to the requirements given in Pt 3, Ch 6 considering the following:

$\sigma = 245 [1/ k_m] - 40 f^*_{2BH} - 0.70 \sigma_g$

Where
k_m = Material factor as provided in Ch 2, Sec 1.2 for bottom longitudinal
σ_g = 190 (1/ k_{mB}) , but not greater than σ_{DB} + 130 f^*_{2BH}
k_{mB} = Material factor k_m as provided in Ch 2, Sec 1.2 for the bottom plating
σ_{DB} = longitudinal double bottom stress at middle of hold with respect to the bottom plating, according to direct calculation of girder system in accordance with Sec 5.7
f^*_{2BH} = f^*_{2B} as provided in 101 with respect to the hogging still water bending moment.

Note:
In case a direct double bottom calculation has not been carried out and the bottotm longitudinal section modulus requirement based on the standard rule formulation provided in Pt 3, Ch 6, Sec 3.7.1 has not been complied with, the nottom longitudinal profile as proposed may still be accepted provided the calculated longitudinal double bottom stress σ_{db}, of the bottom plating in the mid part of the hold does not exceed the following limit:

σ_{db} = 350 (1 / k_m) – 1.43 (σ + 130 f^*_{2BH}) (N/mm^2)

Where
σ = ([83 l^2 s p w_k] / Z)
Z = *Section modulus (cm^3) of proposed bottom longitudinal.*
l2 s p wk = *As provided in Pt 3, Ch 6.*
In addition, it is assumed that the σ_{db} based on the direct calculation shall not exceed the following:

σ_{db} = 190 (1 / k_m) –130 f^*_{2BH} (N/mm^2)

6.2.8.9 For container carriers with the **NAUTICUS(Newbuilding)** notation, local structure analysis is mandatory for stiffeners subject to large deformations in way of transverse bulkheads. The designer shall demonstrate compliance with the principles given in Pt 3, Ch 13.

6.2.8.10 For container carriers with the **NAUTICUS(Newbuilding)** notation, fatigue assessment for end structures of longitudinals in the cargo hold area is mandatory.

6.2.8.11 At support of stiffeners, the net shear connection area ($a_{0,S}$) and the net connection area of the web stiffener ($a_{0,N}$) shall not be less than:

Required net shear area between lug(s) or collar plate and stiffener:
$a_{0,S}$ = c_S k (l – 0.5 s) s p (cm^2)

Required net connection area between the stiffener and the web stiffener welded to the flange of the stiffener.
$a_{0,N}$ = c_N k (l – 0.5 s) s p (cm^2)

k, l, s, p = As defined in Pt 3, Ch 11, Sec 3.4.2

c_S = c (A_{shear} / [K_{ws} A_{ws} + A_{shear}])

c_N = (c / $3^{0.5}$) (1 – [A_{shear} / (K_{ws} A_{ws} + A_{shear})])

Where,
c = Refer Pt 3, Ch 11, Table 11.3.4
A_{shear} = Net shear areas of the lug (s)/ collar plates in the connection
A_{ws} = Net area of the web stiffener on the flange of the stiffener
K_{ws} = Stress distribution factor as provided in Table 5.6.3 related to profile of the stiffener

Table 5.6.3 Values of K_{WS}

Connection Type	Asymmetrical profile (L, HP)	Symmetrical Profile (T, FB)
Type a(1)	1.4	1.8
Type b(1)	1.3	1.8
Type c(1)	1.2	1.8

(1) Connection types referring to Pt 3, Ch 11, Fig 11.3.1

Corrosion addition as specified in Pt 3, Ch 2, Sec 4 is not included in the formulae for $a_{0,S}$ and $a_{0,N}$, and shall be added where relevant.

The weld area, a_S and a_N, of the connections shall be minimum as below:

a_S = ([1.15 $a_{0,S}$ (1 / k_m) $^{0.5}$] / f_w) + a_k (cm^2)

a_N = ([1.40 $a_{0,N}$ (1 / k_m)$^{0.5}$] / f_w) + a_k (cm^2)

Where,

a_S = Required weld area between lug(s) or collar plate and longitudinal

a_N = Required weld area between stiffener and the web stiffener welded to the flange of the stiffener.

k_m = For a_S, material factor for the lug(s) or collar plate
= For a_N, material factor for the web stiffener

f_w = For a_S, material factor of weld deposit for the lug(s) or collar plate
= For a_N, material factor of weld deposit for the web stiffener

a_k = Corrosion addition corresponding to t_k

6.3 Cellular Container Hold Structures

6.3.1 Girder Systems

6.3.1.1 Typical primary structural members such as girders, floors in double bottom, transverse webs, stringers in bulkhead structures in the midship area, the scantlings are to be determined based on direct strength analysis as outlined in Pt 3, Ch 13.

6.3.1.2 Based on finite element methods cargo hold analysis for the midship region are mandatory for container carriers with the **NAUTICUS(Newbuilding)** notation. The designer shall demonstrate compliance with the principles given in Pt 3, Ch 13.
The girder systems of cellular container holds shall be strengthened for the design load cases provided in Sec 5.7.1.5- Sec 5.7.1.12. If more severe container loading conditions are specified in the loading manual, the girder systems shall be strengthened accordingly for such loading.

6.3.1.3 For container carriers with the **NAUTICUS(Newbuilding)** notation the effect of relative deformation of stiffener end connections in way of transverse bulkhead shall be taken into account in the fatigue assessment. Additional fatigue load cases as given in Pt 3, Ch 15 shall be applied to the midship cargo hold model.

6.3.1.4 LC1: Homogenous heavy 20’ containers in holds and maximum 20’ stack weights on deck in upright seagoing condition on scantling draught.

The weight of each 20’ container in holds shall be taken according to the most severe loading condition described the loading manual, not to be taken less than 15 t.

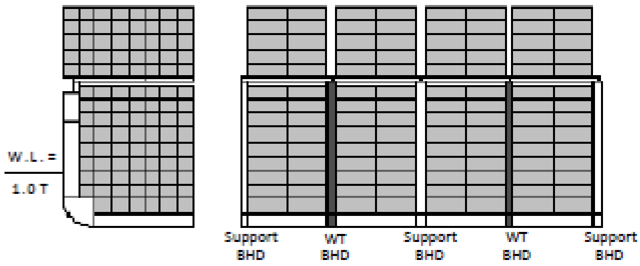


Fig 3 Load Case 1

6.3.1.5 LC2: One 40’ bay in hold and deck above empty in upright seagoing condition on scantling draught. All bays in hold and on deck not being empty shall be filled with maximum stack weights of 40’ container.

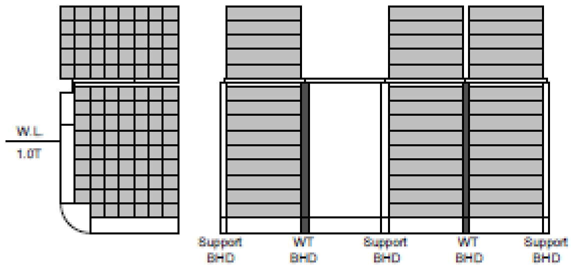


Fig 4 Load Case 2

6.3.1.6 LC3: Homogenous heavy 20’ containers in hold and maximum 20’ stack weights on deck in heeled condition on scantling draught.

The weight of each 20’ container in holds shall be taken according to the most severe loading condition described the loading manual, not to be taken less than 15 t.
The transverse acceleration shall be taken as given in Sec 5.7.1.1 and shall be combined with the vertical acceleration of gravity.

The hull girder stress for yield check and buckling control may in general be calculated as given in Pt 3, Ch 5, applying relevant combinations of hogging and sagging stress, and with reduced wave bending moments:

M_{WR} = 0.60 M_W
M_W = As provided in Pt 3, Ch 5, Sec 2.2.2

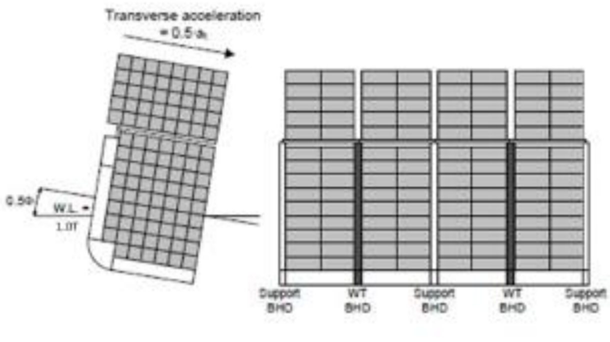


Fig 5 Load Case 3

6.3.1.7 LC4: One 40’ bay in hold and deck above empty in heeled condition on scantling draught.

All bays in hold and on deck not being empty shall be filled with maximum stack weighs of 40’ containers. The transverse acceleration shall be taken as given in 116 and shall be combined with the vertical acceleration of gravity.

The hull girder stress for yield check and buckling control may in general be calculated as given in Pt 3, Ch 5, applying relevant combinations of hogging and sagging stress, and with reduced wave bending moments:

M_{WR} = 0.60 M_W
M_W = As provided in Pt 3, Ch 5, Sec 2.2.2

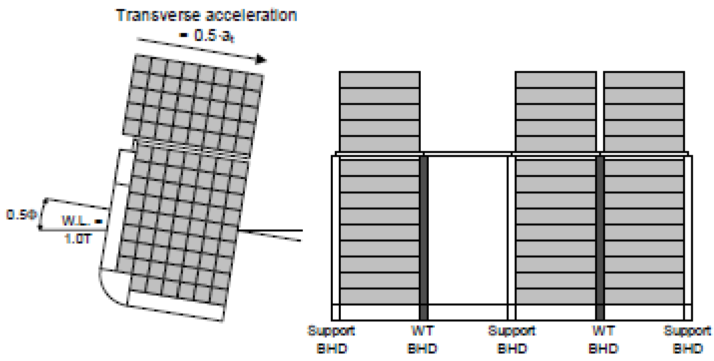


Fig 6 Load Case 4

6.3.1.8 LC5: Homogenous heavy 40’ containers in holds and on deck in upright seagoing condition on scantling draught combined with dynamic longitudinal acceleration.

All bays in holds and on deck shall be filled with maximum stack weighs of 40’ containers. The longitudinal acceleration shall be taken as given in 117 and shall be combined with the vertical acceleration of gravity.

The hull girder stresses for yield check and buckling control may in general be calculated as given in Pt 3, Ch 5, applying only still water sagging bending moment (or minimum still water hogging bending moment), M_S, as given in Sec 5.6.2.2 combined with wave sagging bending moment as given in Pt 3, Ch 5, Sec 2.2.2.

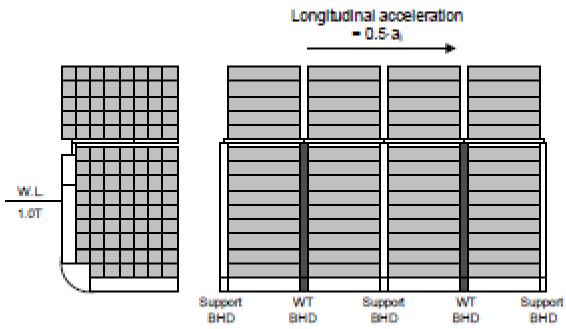


Fig 7 Load Case 5

6.3.1.9 LC6: One 40’ bay in hold empty in upright seagoing condition on scantling draught. All bays in hold not being empty and all bays on deck shall be filled with maximum stack weighs of 40’ containers.

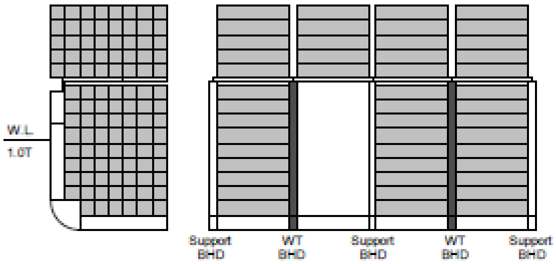


Fig 8 Load Case 6

6.3.1.10 LC7: Flooded damage condition for dimensioning of watertight bulkhead. The centre cargo hold is flooded. The flooding calculations shall be based on the deepest equilibrium waterline in damaged condition. However, if not available in early design, a flooding height up to the freeboard deck level may be assumed.

6.3.1.11 LC8: Homogenous light 40' containers in hold between adjacent watertight bulkheads in upright seagoing condition on scantling draught. The weight of each 40' container in the centre hold shall be taken according to the less severe loading condition described the loading manual, not to be taken more than 15 t.

The weight of each 20' container in the adjacent bays shall be taken according to the most severe loading condition described the loading manual, not to be taken less than 15 t.

All bays on deck shall be filled with maximum stack weighs of 40' containers.

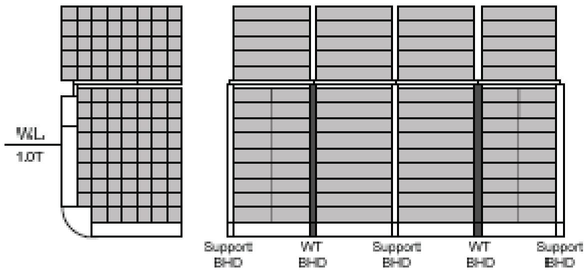


Fig 9 Load Case 8

6.3.1.12 For the load cases given in Sec 5.7.1.5 to 5.7.1.12 , water ballast tanks are in general to be assumed empty. However, for the design load cases on scantling draught with one 40' bay empty as specified in Sec 5.7.1.6 , Sec 5.7.1.8 and Sec 5.7.1.10 the double bottom water ballast tanks below empty bay may be assumed filled.

If such a condition is applied to the design, it shall be stated in the loading manual and the Appendix to the Classification certificate that the design is only strengthened for one 40' bay empty under the condition that the double bottom water ballast tank below empty bay is filled.

6.3.1.13 For the design load cases specified in 106, 108 and 110 with one 40' bay empty, a minimum specified stack weight may be applied to the empty 40' bay.

If such a condition is applied to the design, it shall be stated in the loading manual and the Appendix to the Classification certificate that the design is not strengthened for one 40' bay empty. The minimum stack weight applied as design condition is to be specified in the loading manual and the Appendix to the Classification certificate.

6.3.1.14 The sea pressure in upright seagoing condition shall be taken as given in Pt 3, Ch 14, Sec 2.3.

The sea pressure in heeled conditions shall be taken as:

p = 10 (TA – Z) + 10 y tan (0.5 ϕ) (kN/m^2) at submerged side
= 10 (TA – Z) - 10 y tan (0.5 ϕ) (kN/m^2) at emerged side
= 0 minimum

Where

y = Transverse distance (m) from center line
z = Vertical distance (m) from base line to the considered position
ϕ = As provided in Pt 3, Ch 4, Sec 2

6.3.1.15 The transverse acceleration shall be taken = 0.5 a_t

Where:

a_t = Dynamic transverse acceleration
= 0.40 a_y + g_0 sin ϕ + a_{ry} (m/s^2)

Where:

a_y a_{ry} ϕ = As provided in Pt 3, Ch 4 with RR taken with the negative sign for positions below the centre of rolling.

6.3.1.16 The longitudinal acceleration shall be taken = 0.50 al

Where:

a_t = Dynamic transverse acceleration
= 0.60 a_x + g_0 sin θ+ a_{px} (m/s^2)

Where:

a_x a_{px} θ = As provided in Pt 3, Ch 4 with RP taken with the negative sign for positions below the centre of rolling. The centre is generally not to be taken at a higher level than the considered draught.

6.3.1.17 Unless a special stack weight distribution is given in the design documentation, the container stack weight is assumed uniformly distributed over the height of the stack.

6.4 Arrangements for Stowing and Lashing of Containers

6.4.1 General

6.4.1.1 Containers shall be effectively supported by the ship structure and stowed longitudinally or transversely.

6.4.1.2 The containers shall be effectively prevented from tilting, sliding or lifting by a system of fixed supports or detachable lashing equipment.

6.4.1.3 The support fittings and securing equipment shall withstand the loads specified in Sec 5.9, and shall be arranged and dimensioned in such a way that the supporting forces and internal forces in the containers are within the minimum capabilities of the containers to be used.

6.4.2 Container in Cell Guides

6.4.2.1 Cell guide structures in the holds or weather decks are either to be permanently fastened (welded) to the hull structure or detachable (screwed on).

6.4.2.2 The vertical guide rails are normally to consist of equal angles with thickness not less than 12 mm. On top of the rails strong and efficient guide heads shall be fitted. The guide rail angles are preferably to be connected by web plates at the levels of the container corners.

6.4.2.3 The vertical guide rails are in general to be supported by a system of transverse and/or longitudinal ties transferring the transverse and longitudinal forces to the hull structure, if possible at the level of the container corners.

6.4.2.4 The total clearance between containers and cell guides shall not exceed 40 mm and 25 mm in the longitudinal and transverse directions, respectively.

Note:
The building tolerance of cell guides is taken into consideration, the limits above may be increased by 5 mm in the transverse and longitudinal directions.

6.4.2.5 The net clearance between cell guides and containers, building tolerances and deformations imposed by the still water torsional loading etc. of the ship deducted, is generally to be larger than the minimum value specified for operational purpose.

6.4.2.6 For 20’ containers stacked on top of each other in 40’ cell guides, the 20’ containers shall be secured together by a minimum of two stacking cones with at least one stacking cone fitted in the free end, to prevent sliding in transverse and longitudinal direction.

6.4.2.7 For the lowermost 20’ container in 40’ cell guides, the corners in the cell guide end shall be secured with welding cones, to prevent sliding in transverse and longitudinal direction. The corners in the free end shall be secured with stackers preventing the container against sliding in transverse direction.

6.4.2.8 In a mixed stowage of 20’ and 40’ containers in 40’ cell guides, the 40’ containers are to be put on top of the 20’ containers. The lowermost 40’ container shall be secured to the uppermost 20’ container by two stacking cones in each cell guide end, to prevent sliding in longitudinal and transverse direction.

6.4.2.9 For stowage as given in Sec 5.8.2.6 to 5.8.2.9 where the combined vertical acceleration as given in Sec 5.9.3 exceeds the acceleration of gravity, the 20’ containers shall be secured against lifting.

6.4.3 Containers on Deck

6.4.3.1 For containers on weather deck a combination of stacking cones (to prevent sliding), locking cones or twist locks (to prevent tilting or lifting) and lashing shall be applied. For one or two tiers of containers, twist locks alone are normally sufficient. When more tiers are required, lashings may have to be provided in addition. Due to buoyancy forces from shipped water, all containers not secured by lashings shall be secured by twist locks.

6.4.3.2 For container positions with supports which may move relative to each other, the supports are, as found necessary, to be arranged so that the relative movement does not lead to permanent deformation of the containers.

6.5 Strength Evaluation of Container Securing Arrangements

6.5.1 General

6.5.1.1 Container securing arrangements shall be based on analysis of support and lashing forces for the most severe realistic static load conditions in combination with extreme dynamic loads.

6.5.1.2 When the container securing arrangement is such that significant forces are generated in the containers or the securing devices by variations in container dimension etc., in accordance with the tolerances stipulated by the ISO Standard, such forces shall be taken into consideration in the evaluation of the securing arrangement.

6.5.2 Static Loads

6.5.2.1 The static conditions which give the largest support forces, lashing forces and the largest internal forces in the container structure shall be considered.

6.5.2.2 Reduction of forces due to friction between container tiers shall not be considered in any of the analysis, calculation of forces etc.

6.5.2.3 Unless otherwise specified, the maximum mass of 20' and 40' ISO containers in any given location shall be taken as 30 480 kg.

6.5.2.4 Pre-stressing of lashings should normally be kept as small as possible. If pre-stressing is an integral part of a securing system, this will be subject to special consideration.

6.5.3 Dynamic Loads

6.5.3.1 For container arrangements on deck and in holds the combined transverse acceleration shall be taken as:

$a_t = a_y + g_0 \sin\phi + a_{ry}$ (m/s^2)

Where,

a_y = As provided in Pt 3, Ch 4, Sec 2.5.2

ϕ = As provided in Pt 3, Ch 4, Sec 2.3.1 considering

k = 1.2

T = As provided in Pt 3, Ch 4, Sec 2.3.2 but not greater than 35 s.

GM = As specified by designer, not to be taken less than 1.0 m

a_{ry} = Transverse component of the roll acceleration as provided in Pt 3, Ch 4, Sec 2.3.3

ϕ = As provided above

R_{ry} = vertical distance (m) from the centre of container mass to the roll axis of rotation with a negative sign for positions below the centre of rolling.

6.5.3.2 For container arrangements on deck and in holds the combined vertical accelerations shall be as below:

$a_v = (a_{pz}^2 + a_z^2)^{0.5}$ (m/s^2)

Where

a_z = As provided in Pt 3, Ch1, Sec 2.5.3

a_{pz} = Vertical component of the pitch acceleration given in Pt 3, Ch 4, Sec 2.5.1 with:

θ = 0.20 (a_0 / C_b)

T_p = 2.10 $(L / g_0)^{0.5}$

R_{pz} = longitudinal distance in m from the centre of container mass to the pitch axis of rotation. The pitch axis of rotation shall be taken 0.4 L from A.P.

6.5.3.3 The combined longitudinal acceleration for container arrangements on deck and in holds shall be taken as:

$a_l = 0.60\, a_x + g_0 \sin\theta + a_{px}$ (m/s^2)

Where,

a_x = As provided in Pt 3, Ch 5, sec 2.5.1

θ = As provided in Sec 5.9.3.2

a_{px} = longitudinal component of the pitch acceleration given in Pt 3, Ch 4, Sec 2.4.3 with:

θ T_p = As provided in Sec 5.9.3.2

R_{px} = Vertical distance (m) from the pitching centre with a negative sign for positions below the centre of pitching. The pitch axis of rotation shall be taken D + T from B.L.

6.5.3.4 The accelerations given in Sec 5.9.3.1 to 5.9.3.4 may be obtained from a direct wave load analysis.

The North Atlantic wave scatter diagram shall in general be used for determination of long-term response. Upon owner's request, additional area dependent accelerations applying route specific wave scatter diagrams may be used.

6.5.3.5 For container side walls or end walls exposed to wind in upright condition the wind force is given by:

$P_{W,\ upright} = 0.5\ \rho\ A\ V^2_{wind}\ 10^{-3}$ (kN)

Where,
ρ = 1.42 kg/m^3
A = Container side wall area (m^2) or end wall area exposed wind
V_{wind} = Wind speed (m/s)
= $35\ (h / 10)^{0.12}$
h = z – T, not to be taken less than 0
z = Vertical centre of each container above baseline (m)

6.5.3.6 For container side walls or end walls exposed to wind in heeled condition the wind force is given by:
$P_{W,\ roll} = 0.5\ \rho\ A\ V^2_{wind} \cos^2(\phi)\ 10^{-3}$ (kN)

Where,
ρ A V_{wind} = As provided in Sec 5.9.3.5
h = (z – T) cos(ϕ) + 0.5B Sin(ϕ), but not less than 0
ϕ = As provided in Sec 5.9.3.1

6.5.4 Design Load Cases

6.5.4.1 LC1: Containers in a stack or a group of stacks exposed to transverse acceleration as given in Sec 5.9.3.1 in upright condition.

6.5.4.2 LC2: Containers in a stack or a group of stacks exposed to acceleration of gravity in combination with a uniform vertical acceleration as given in Sec 5.9.3.2 in upright condition.

6.5.4.3 LC3: Containers in a stack or a group of stacks exposed to transverse acceleration as given in Sec 5.9.3.1 in heeled condition.

6.5.4.4 LC4: Containers in a stack or a group of stacks exposed to longitudinal acceleration as given in Sec 5.9.3.3 in upright condition.

6.5.4.5 For non-rigid securing arrangements, design load cases as given in Sec 5.9.4.1, 5.9.4.3, and 5.9.4.4 shall be combined with the acceleration of gravity acting downwards.

6.5.4.6 For containers in a stack or a group of stacks exposed to wind in upright condition, LC1 as provided in Sec 5.9.4.1 is to be combined with wind force as given in Sec 5.9.3.5.

For containers in a stack or a group of stacks exposed to wind in upright condition, LC4 as provided in Sec 5.9.4.4 is to be combined with wind force as given in Sec 5.9.3.5.

For containers in a stack or a group of stacks exposed to wind in heeled condition, LC3 as given in Sec 5.9.4.3 is to be combined with wind force as given in Sec 5.9.3.6.

6.5.5 Strength Analysis of Rigid Securing Arrangements

6.5.5.1 The racking stiffness of the containers may be disregarded in the analysis of the overall response of the structures in rigid securing arrangements.

6.5.5.2 Generally cell guides structures are considered as rigid securing arrangements.

6.5.5.3 Freed ends of mixed container stowage shall be considered as non-rigid securing arrangements.

6.5.5.4 The analysis shall consider the following:

- While applying design load cases as in Sec 5.9.4.2 the vertical support loads to be determined and considered.
- While applying design load cases as in Sec 5.9.4.2 the internal vertical forces in containers to be determined and considered.

Stress calculations in cell guide structures and cell guide supporting structures shall be based on load cases given in Sec 5.9.4.1 and Sec 5.9.4.4 applying acceptance criteria given in Sec 6.5.8.

6.5.6 Strength Analysis of Non-rigid Securing Arrangements

6.5.6.1 The analysis in non-rigid securing arrangements shall take due account of the flexibilities of containers and of the securing members as well as possible deflections in the supporting structure.

6.5.6.2 Lashings and other securing arrangements and other flexible securing members may normally be considered as non-rigid containment arrangements.

6.5.6.3 The likely effects of clearances between stacks of containers and between containers and supports shall be considered.

6.5.6.4 Analysis shall consider design load cases specified in Sec 5.9.4 and determine the following:

- Internal loads in containers
- Loads in lashings and other securing members
- Vertical and horizontal support loads

Supporting Structure of Fixed Container Securing Devices

6.5.6.5 The strength of supporting structures of fixed container securing devices is generally to be based on the MSL or the maximum support forces as determined in Sec 5.9.5.4 and Sec 5.9.6.4 applying combined accelerations in accordance with Sec 5.9.3.1 to 5.9.3.3.

6.5.6.6 The supporting structures shall comply with acceptance criteria as provided in Sec 6.5.8 with respect to strength requirements.

6.5.7 Acceptance Criteria

6.5.7.1 The calculated internal reactions forces in containers and external forces on the container structure shall not exceed the tested minimum capabilities stated in the appropriate ISO- Standard for freight containers.

Note:
Container strength ratings according to the relevant ISO Standard are to be considered.

6.5.7.2 Maximum Securing Load in container securing devices shall not exceed as detailed below:

MSL $= 0.50\ P_m$

Where,

P_m = Minimum breaking load of the considered equipment/ item

Possible influence on the breaking load of fixed equipment by welding to the underlying structure shall be taken into account.

6.5.7.3 The nominal normal stress in cell guide structures including cell guide supporting structures, and container securing devices including supporting structures of fixed container securing devices in hull structural steel, or as steel forgings or castings shall not exceed as detailed below:

$\sigma = 210\ (1 / k_m)$ (N/mm^2)

6.5.7.4 The nominal shear stress in cell guide structures including cell guide supporting structures, and container securing devices including supporting structures of fixed container securing devices in hull structural steel, or as steel forgings or castings shall not exceed as detailed below:

$\tau = 120\ (1 / k_m)$ (N/mm^2)

6.5.7.5 For supporting structures subjected to longitudinal stress (eg deck longitudinals, girders etc.) combination with such stress as provided in Pt 3, Ch 8 is to be performed for vertical container loads (excluding rolling) as provided in Sec 5.9.4.2. Allowable bending stresses as provided in Pt 3, Ch 8 may be increased by 30%.

6.5.7.6 Structures subjected to compressive stresses shall be checked for buckling in accordance with Pt 3, Ch 14.

6.5.7.7 Corrosion additions for supporting members being part of hull structures (in tanks) shall be in accordance with requirements given in Pt 3, Ch2.

6.5.7.8 The compressive dynamic stress in cell guide supporting structures shall be in general to be considered with respect to the lateral buckling mode according to Pt 3, Ch 14, Sec 3.2.3 and considering factor k =1.00.

6.6 Signboards

6.6.1 General

6.6.1.1 Stowage and securing plans indicating typical arrangement and providing further reference to the “Stowage and Securing Manual” shall be posted at suitable locations in each cargo space and in the deck office.

6.7 Non-weathertight Arrangement for Weather Deck Hatch Covers

6.7.1 General

6.7.1.1 Those ships intended exclusively for the carriage of containers in cargo holds with non-weathertight arrangement of hatch covers in accordance with Pt 4, Ch 6, Sec 1 the requirements given under Pt 4, Ch 6, Sec 7 shall be complied with.

6.7.1.2 Wave breaker shall be arranged for the protection of the forward non-weathertight hatch covers. Alternatively, the wave breaker may be omitted if the hatch covers forward of, or partly forward of, 0.15 L from FP are weathertight.

Note:
The height of the wave breaker should normally be 5 m above the hatch cover top plate to cover two tiers of standard containers. A reduced height may be satisfactory in cases of large freeboard, i.e. when the top of the hatch cover plate is more than three standard superstructure heights (see ICLL Reg. 33) as calculated in Sec 5.11.1.3.

6.7.1.3 Non-weathertight hatch covers may be fitted to hatchways located on weather decks, which shall be at least two standard superstructure heights above an actual freeboard deck, or an assumed freeboard deck, from which a freeboard can be calculated. The calculated freeboard shall result in a draught of not less than that corresponding to the actual freeboard assigned. Where any part of a hatchway is forward of a point located one quarter of the ship's length (0.25 L) from the forward perpendicular, then that hatchway shall be located on a weather deck, at least three standard superstructure heights above the actual or assumed freeboard deck. It shall be understood that the assumed freeboard deck is used only for the purpose of measuring the height of the deck on which the hatchways are situated. The assumed freeboard deck may be an imaginary or virtual deck and shall not be used for the actual assignment of the freeboard. The vessel's freeboard shall be assigned from an actual deck, designated as the freeboard deck, which shall be determined in accordance with the ICLL.

6.7.1.4 Hatch coaming height shall not be less than 600 mm.

6.7.1.5 Non-weathertight joints of hatch covers shall be designed to minimise the possible rate of water ingress by the arranging of labyrinths, gutter bars or equivalent.

6.7.1.6 Cargo holds for containers, with no-weathertight arrangement of hatch covers shall be positioned on doublers plates or equivalent fitted on the inner bottom (or deck) with a height normally not less than 25 mm.

6.7.2 Bilge Level Alarms

6.7.2.1 For the bilge wells of container holds with non-weathertight hatch covers, high water level alarms shall be installed. The volume of each bilge well shall not be less than 1 m^3.. The volume of each bilge well shall not be less than 1 m^3.

6.8 Safe Access to Containers

6.8.1 Scope

6.8.1.1 The notation **SafeLash** is to provide stevedores and vessel crew with a safe working area when engaged in container lashing and similar tasks.

6.8.1.2 The following are covered by the above notation:

- Illumination of working areas and transit areas
- Design and arrangement of working areas
- Container top working
- Fencing and fall protection
- Markings of obstacles and openings
- Design of walkways, ladders steps and other means of access
- Design and arrangement of power supplied for reefer containers

6.8.2 General

6.8.2.1 Risk assessments should be carried out at the design stage, to ensure that securing operations can be carried out safely for all intended container stowage configurations. The assessment should address the following as minimum.

- Falls from height

- Slips, trips and falls
- Being struck by falling securing equipment or other objects
- Injuries while manually handling container securing equipment
- Injuries resulting from container loading and unloading operations
- Adjacent electrical risks
- Proper access to all areas necessary to safely perform container securing operations.
- Lashing equipment ergonomics
- Implication of lashing high-cube container and mixed stow of 40’ and 45’ containers

6.8.3 Working Areas

6.8.3.1 Working areas shall be designed to provide a clear space which is unencumbered by obstructions such as deck piping, storage bins and guides to reposition hatch covers.

6.8.3.2 For lashing of containers, the securing points shall as far as practicable be positioned so as to eliminate the use of three tier cross lashings, and shall be located in close proximity to securing equipment storage areas.

6.8.3.3 The horizontal distance from the lashing securing points to the containers shall not exceed 1100 mm, and not be less than 220 mm for lashing bridges and 130 mm for other positions.

6.8.3.4 The working areas shall have a width of not less than 750 mm. In addition, the width of permanent lashing bridges shall provide a clear distance of 600 mm between stowage racks, lashing cleats and other obstructions.

6.8.3.5 To ensure safe lashing of outboard containers, platforms shall be provided.

6.8.3.6 Working areas and platforms at the outboard at the ends of hatches shall as far as practicable be at the same level as the top of the hatch cover.

6.8.3.7 Between the container bays, the working areas shall provided the following:

- Space between securing point for lashing bars sufficient to allow tightening of turnbuckles.
- Spaces sufficient to permit stowage of securing equipment without causing a tripping hazard.
- Good visibility of twist lock handles and space for easy manipulation of lashing equipment.
- Working surface shall be firm and at a proper level.

6.8.3.8 Removable sections in the working areas shall be capable of being temporarily secured.

6.8.3.9 Safe means of access shall be provided if working on the top of containers is inevitable. However working on top of containers may be avoided as far as practicable, eg. by using semi-automatic or fully automatic twist locks etc.

6.8.4 Transit Areas

6.8.4.1 Access ladders and walkways shall be free of permanent obstructions and designed so that workers do not have to climb over piping, as fare as practicable.

6.8.4.2 Transit areas shall have a vertical clearance of minimum 2.0m and a clear width of 600 mm minimum.

6.8.4.3 Anti-slip surfaces shall be provided at all passageways, Stairs and relevant deck areas used for moving about in the ship.

6.8.4.4 Cleats, ribs, brackets and such protrusion posing a tripping hazard in access ways shall be highlighted/painted using contrasting colours for easy identification.

6.8.5 Fall Protection

6.8.5.1 Working platforms, lashing bridges and other working areas from which persons may fall 2.0 m or more shall be provided with fencing satisfying the requirements given in Sec 5.12.5.6.

6.8.5.2 Removable fencing shall be fitted where openings in safety barriers are necessary to allow for container crane movements.

6.8.5.3 Cargo securing walkways (generally located athwartships) with unprotected edges when hatch cover is removed it shall be protected by guardrails satisfying the requirements provided in Sec 5.12.5.6.

6.8.5.4 Suitable closing mechanism shall be provided for openings likely to cause a potential fall of 2.0 m or more.

6.8.5.5 Openings with a potential fall of less than 2.0 m which cannot be fenced or temporarily closed shall be identified by yellow paint or black and yellow stripe hazard marking.

6.8.5.6 A minimum of three railings/ courses shall be provided for guard rails. The height of the uppermost course shall be at least 1.0 m measured from the base. The opening below the lowest course of guard rails shall not exceed 230 mm. The other courses shall not be more than 380 mm.

6.8.5.7 Gaps without fencing shall be less than 300 mm in length.

6.8.5.8 Toe boards of 150 mm in height shall be provided around the sides of elevated working areas, to prevent securing equipment from falling and injuring people. In the case where toe board obstructs the loading of containers, the height of toe board may be reduced to 100 mm.

6.8.6 Manholes and Openings

6.8.6.1 In any part of the working areas unprotected openings shall not be provided. Access opening shall be protected by handrails or access covers which can be locked in closed position.

6.8.6.2 Manholes shall not be situated in transit areas, as far as practicable. if fitted fencing shall be fitted in accordance with Sec 6.8.5.6.

6.8.6.3 Manhole openings at different levels of lashing bridges shall not be located directly below one another.

6.8.7 Ladders

6.8.7.1 Where fixed ladders provide access to the outside of a working area, the stringers shall be connected at their extremities to the guardrails of the working area, irrespective of whether the ladder is sloping or vertical.

6.8.7.2 Where fixed ladders provide access to a working area through an opening in the platform, the opening shall be protected by fencing or a grate which can be locked in closed position. Handgrabs extending at least 1.0 m above the platform or landing accessed by the ladder shall be provided, to ensure safe access through the opening.

6.8.7.3 Where fixed ladders provide access to a working area from the outside of the platform, the stringers of the ladder shall be opened above the platform level to give a clear width of 700 mm.

6.8.7.4 Fixed ladders shall not slope more than 25° from vertical. Where the slope of a ladder exceeds 15° from vertical, the ladder shall be provided with handrails positioned not more than 540 mm from the stringers, measured horizontally.

6.8.7.5 Fixed ladders with a vertical height exceeding 3.0 m, and any fixed ladders from which a person may fall into the cargo hold, shall be fitted with a safety cage satisfying the requirements given in Sec 5.12.7.6 and Sec 5.12.7.7.

6.8.7.6 The distance between the rungs and the back of the safety cage shall not exceed 750 mm. Safety cage hoops shall be uniformly spaced at intervals not exceeding 900 mm and be connected by vertical bars uniformly spaced around the circumference of the hoops.

6.8.7.7 The stringers shall be extended at least 1.0 m above the floor level of the platform, and the ends of the stringers shall be given lateral support. The top step or rung shall be level with the floor of the platform unless rungs or steps are fitted up to the end of the stringers.

6.8.8 **Power Supply**

6.8.8.1 Power outlets for reefer shall be watertight electrical connection.

6.8.8.2 All reefers shall be fitted with heavy-duty, interlocked and circuit-breaker protected electrical power outlets. This in order to ensure that the outlet cannot be switched on until a plug is fully engaged and the actuator rod is pushed to the “on” position. Pulling the actuator rod to the “off” position shall manually de energise the circuit.

6.8.8.3 Power outlets for reefer shall de-energise automatically if the plug is accidentally withdrawn while in the “on” position. Furthermore, the interlock mechanism shall break the circuit while the pin and sleeve contacts are still engaged.

6.8.8.4 Power outlets for reefer shall be positioned and designed so as not to require the operator to stand directly in front of the socket when switching takes place.

6.8.8.5 The location of reefer power outlets shall allow for flexible cabling to be laid out without causing a tripping hazard.

6.8.8.6 Inoperative or defective reefer power sockets shall be provided with means to prevent connection of plugs and local indication when the socket is out of service.

6.8.9 Lighting

6.8.9.1 Transit areas and working areas shall be provided with proper lighting.

6.8.9.2 The lighting fixtures shall as far as possible be designed as a permanent installation adequately guarded against breakage.

6.8.9.3 A minimum light intensity level of 10 lux for passage ways and 50 lux for working areas shall be ensured.

6.9 Application of Extremely Thick Steel Plates

6.9.1 Application

6.9.1.1 This section is applicable only to container carriers incorporating extremely thick steel plates with thickness over 50 mm, of steel

6.9.1.2 The application of the measures specified in Sec 6.9.2 and Sec 6.9.3 shall be in accordance with Sec 6.9.4. (IACS UR S33.1)

6.9.1.3 The material selection shall be in accordance with “Material classes” as for high strength steel material.

6.9.1.4 Welding procedures (WPS) shall be qualified through welding procedure qualification test (WPQT) as described in Pt.2.

6.9.2 NDT During Construction

6.9.2.1 The NDT requirements provided in Sec 6.9.2 are in addition to the general requirements for NDT

6.9.2.2 Where NDT during construction is required in accordance with Sec 6.9.4, NDT shall be carried out in accordance with Sec 6.9.2. Enhanced NDT as specified in Sec 6.9.3.5 (5) shall be carried out in accordance with an appropriate standard and a procedure approved by the Society.

Note:
Time of flight diffraction (TOFD) technique using stricter defect acceptance in lieu of standard Ultrasonic testing (UT) technique may be considered as acceptable enhanced NDT.

6.9.2.3 On all block-to-block butt joints of all upper hull longitudinal structural members in the cargo hold region, ultrasonic testing (UT) shall be carried out. Upper hull longitudinal structural members include the uppermost strakes of longitudinal bulkhead, sheer strake, main deck, hatch side coaming, and all attached longitudinals. Refer Fig.10 for details.

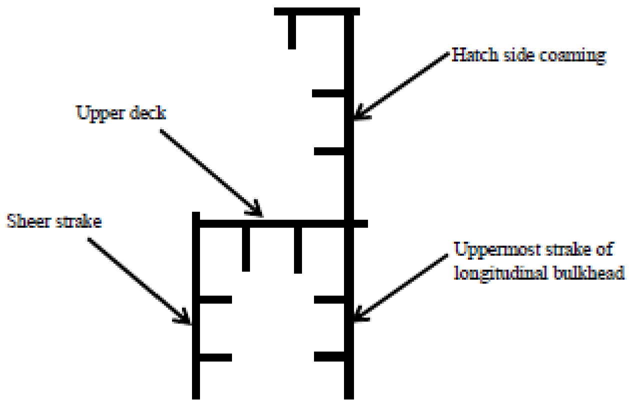


Fig 10 Upper Hull Longitudinal Structural Members

6.9.3 Brittle Crack Arrest Design

6.9.3.1 Suitable means for prevention of brittle crack propagation, which is same as brittle crack arrest (BCA) design, shall be considered within the cargo hold region.

6.9.3.2 The methodology provided in this sub section generally applies to the block-to-block joints, but it should be noted that cracks can initiate and propagate away from such joints. Therefore, appropriate measures shall be considered in accordance with Sec 5.13.3.4. (2).

6.9.3.3 BCA steel is defined as steel plate with measured crack arrest properties as given in Pt.2

6.9.3.4 The purpose of BCA design is aimed at arresting propagation of a crack at a proper position and to prevent large scale fracture of the hull girder.

The point of a brittle crack initiation shall be considered in the block-to-block butt joints both of hatch side coaming and upper deck.

The following cases shall be considered:

(1) Where the brittle crack runs straight along the butt joint
(2) Where the brittle crack initiates or deviates away form the butt joint and runs into base metal

6.9.3.5 Acceptable examples of BCA design are detailed below. The detail design arrangements shall be submitted for approval by the Society. Other concept designs may be considered and accepted by the Society.

BCA design for Sec 5.13.3.4 (2):

(1) The BCA steel shall be used for the upper deck along the cargo hold region in a way suitable to arrest a brittle crack initiating from the coaming and propagating into the structure below.

BCA design for Sec 5.13.3.4 (1):

(2) Where the block to block butt welds of the hatch side coaming and those of the upper deck are shifted, this shift shall be greater than or equal to 300 mm. BCA steel shall be provided for the hatch side coaming plating.

(3) Where crack arrest holes are provided in way of the block-to-block butt welds at the region where hatch side coaming weld meets the deck weld, the fatigue strength of the lower end of the butt weld shall be assessed. Additional countermeasures shall be taken for the possibility that a running brittle crack may deviate from the weld line into upper deck or hatch side coaming. These countermeasures shall include the application of BCA steel in hatch side coaming plating.

(4) Where Arrest Insert Plates of BCA steel or Weld Metal Inserts with high crack arrest toughness properties are provided in way of the block-to-block butt welds at the region where hatch side coaming weld meets the deck weld, additional countermeasures shall be taken for the possibility that a running brittle crack may deviate from the weld line into upper deck or hatch side coaming. These countermeasures shall include the application of BCA steel in hatch side coaming plating.

(5) The application of enhanced NDT as given in Sec 5.13.2.2 in lieu of standard UT technique can be an alternative to (2), (3) and (4).

(IACS UR S33.4)

6.9.4 Measure for Extremely Thick Steel Plates

6.9.4.1 Thickness and the yield strength shown in the Table 5.13.1 refer to the hatch coaming structure, and are the controlling parameters for the application of measures.

If the as built thickness of the hatch coaming structure is below the values as given in the table, measures are not necessary regardless of the thickness and yield strength of the upper deck.

Table 5.13.1 Measures Based on Thickness and Yield of Hatch Coaming

Steel Group	Thickness (mm)	Measures		
		1	2	3
NV 36	50 < t ≤ 85	-	-	-
	85 < t	X	-	-
NV 40	50 < t ≤ 85	X	-	-
	85 < t	X	X	X
NV 47	50 < t	X	X	X

X : Mandatory
-: Not Applicable
Measures:

1) NDT other than visual inspection on all target block joints during construction (Refer Sec 6.9.2)
2) BCA design against straight propogation of brittle crack along weld line (during construction)
3) BCA design against deviation of brittle crack from weld line and against propagation of cracks from other weld areas such as fillets and attachment welds (during construction).

(IACS UR S33 Annex 1)

6.10 Additional Requirements for Steel Grade

6.10.1 Application

6.10.1.1 This subsection shall be applied to container carriers incorporating extremely thick steel plates with thickness over 50 mm, of steel

6.10.1.2 Minimum quality of steel material grade shall be EH.

6.10.1.3 Additional requirements for fabrication and welding of grade in Part 2

6.10.2 Fatigue

6.10.2.1 For the upper hull structure built with Part 2 material, additional requirements with respect to the fatigue strength are described in Sec 6.10.2.2 to Sec 6.10.2.7,

6.10.2.2 In way of the hatch side coaming top and side plates, butt welded joints shall be shifted from the butt welded joints of upper deck structures by a minimum distance of 300 mm in ship's longitudinal direction.

6.10.2.3 The requirement for the shift in Sec 5.14.2.2 may be waived for block joints, provided that the upper hull longitudinal structural members as given in Sec 6.9.2.3 are inspected by NDT during construction stage according to Table 5.14.1, regardless of steel material grade and strength group applied in the upper hull longitudinal structural members.

6.10.2.4 The butt welded joints in the hatch side coaming and in the upper deck shall be kept away from hatch corners as far as practical. The distance between such a butt weld joint to the termination point of hatch corner curvature shall be at least 500 mm in the ship's longitudinal and transverse directions respectively.
Note:
A distance less than the required minimum value of 500 mm may be specially considered based on global FE analysis.

In way of the hatch side coaming butt welded joints top plate shall be analysed to show sufficient fatigue strength in accordance with Pt 3, Ch 15, Sec 1.4. The hull girder loads due to vertical wave bending moment, horizontal wave bending moment and wave torsion moment shall be considered. The stress range shall be calculated

Near the butt welded joints in the hatch side coaming and in the upper deck, between 500 mm aft and 500 mm forward in ship's longitudinal direction, the weld connection of hatch side coaming to upper deck and longitudinal bulkhead to upper deck shall be at least of partial penetration type with a maximum root face of 1/3 of the abutting plate gross thickness.

6.10.2.5 Hatch corner in the hatch side coaming top plate and in the upper deck shall be analysed to show sufficient fatigue strength. The stress range shall be calculated in accordance with CN 31.7. The hot spot stress at the hatch corner shall be obtained by finite element analysis according to the procedure required for Level 2 or Level 3 analysis as described in CN 31.7.

6.10.2.6 At the hatch side coaming the free edge top plate shall not have any defects such as notches.

6.10.2.7 The upper and lower edges of the hatch side coaming top plate in way of the butt welded joints and the hatch corners shall be ground smooth with a radius of 2 ~ 5 mm. The grinding shall be to the minimum extent of 100 mm forward and aft of the butt welded joints. For hatch corners, the grinding shall be applied to whole hatch cover curvature and shall be extended to a point minimum 100 mm away from termination point of hatch corner curvature.

Remaining upper and lower edges of the hatch side coaming top plate shall be ground smooth, with a radius of 2 mm as minimum.

Butt welded joint edges at upper and lower sides of the hatch side coaming top plate shall be ground smooth.

For stiffeners on the hatch side coaming top plate, the grinding shall be carried out similarly as described above.

6.10.2.8 For weld connections of smaller outfitting such as holders to hatch side coaming, if the welding is in a rectangular or polygonal or similar shape where good workmanship is difficult to achieve in the corners, circular doubling plates are required in order to achieve good workmanship. The doubling plate should be in a dimension and with a thickness as small as practical. The thickness shall be limited to 10 mm as a maximum value. The material grade of doubling plates shall be at least AH32.

For hatch cover pads welded to hatch coaming top plate, when the thickness of pads exceeds 25 mm, a taper not exceeding 1:3 shall be applied in order to reduce the stress concentration on hatch coaming top plate.

Welding for fixing outfitting items to the hatch coaming top plate shall be avoided in the area close to hatch corner to the extent 500 mm away from the termination point of hatch corner curvature, in the ship's longitudinal and transverse directions respectively. This may be achieved by applying flexible hatch cover pads without attachments to the hatch coaming top plate. However such a welding may be accepted, provided that the weld profile is ground smooth or treated in alternative equivalent means accepted by the Society.

6.10.3 **Non Destructive Testing**

6.10.3.1 The requirements in Sec 6.10.3 are applicable to welded joints for structural members of the upper hull of container ships made of steel grade only, with the exception as described in Sec 6.10.2.

Final inspection and NDT shall not be carried out before 48 hours after completion.

Non Destructive Testing procedures for testing of welded joints during periodical surveys have to reflect the surface condition. If the specified sensitivity requirements cannot be obtained, the painting has to be removed. Normally for ultrasonic testing (UT), the paint may be not removed if the condition of paint is satisfactory. The loss of sensitivity has to be compensated by performing transfer correction.

Magnetic particle testing (MT) may be replaced by eddy current (ET).

6.10.3.2 During construction stage, extent of NDT on welds of steel grade NV 47 shall be at least as specified in Table 5.14.1.

Table 5.14.1 Extend of NDT During Construction Stage

Testing Method	Type of Connection	Extend
Visual Inspection (VT)	All welded joints	100%
Magnetic Particle Testing (MT)	Weld joints transversely or vertically orientated, butt , and T-joint, full penetration, partial penetration and fillet welds	100%
	Weld joints longitudinally orientated	20%
Ultrsonic Testing (UT)	Butt and T-Joints of full penetration	100%

6.11 Wave Induced Vibration- Springing & Whipping

6.11.1 General

6.11.1.1 **WIV** notation implies that an extended verification of the hull girder ultimate strength and fatigue strength has been carried out, accounting for the effect of wave induced vibration of the hull girder, ie. springing and whipping.

6.11.1.2 Factors accounting for the effect of wave induced vibration for fatigue strength, vibration factor f_{vib} and for ultimate strength, partial safety factor γ_{WH},

6.11.1.3 For ships with bow flare angle α_{wiv} (provided in Sec 6.11.1.4) ≥ 55°, or Vwiv (given in Sec 6.11.1.5) ≥ 25 knots, or L ≥ 330 m or B ≥ 47 m, the factors f_{vib} and γ_{WH} may be required by the Society to be calculated applying a more ship specific alternative method (eg, numerical analysis or model tests) described and thereby replace factors given in Sec 6.11.1.2.

6.11.1.4 Bow flare angle α_{wiv} in degrees shall be taken as:

α_{wiv} = arctan {(a_1 + a_2) / (D –T)} and to be ≥ 0^0 and ≤ 90^0

a_1 + a_2 = Distance (m) between water line at D and T, measured through the line perpendicular to the waterline 0.50(D+T) at 0.00L aft of FP. Refer also fig 11 for details.

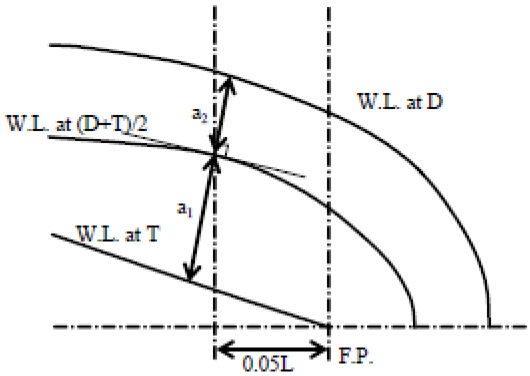


Fig 11 Measurement of a_1 + a_2

6.11.1.5 The V_{wiv} is the design speed in knots at design draft at 85% MCR with 15% sea margin. If the design speed V_{design} is provided at design draft but at x% MCR with y% sea margin, V_{wiv} may be converted from V_{design} with the simplified formula below:

V_{wiv} = 0.904 V_{design} [(1 + 0.01y) / (0.01 x)]$^{1/3}$

6.11.2 Hull Girder Ultimate Strength

6.11.2.1 The utilisation factor for vertical hogging and sagging bending moments over the entire length of the ship shall satisfy the following:

$$\eta = [\gamma_s M_{sw} + M_{wv} (\gamma_w + (\gamma_{WH} - \gamma_W) \gamma_{Du})] / [M_U / \gamma_R] \leq 1.00$$

Where,

γ_{WH} = Partial safety factor provided in Sec 6.11.1.2 or Sec 6.11.1.3
M_{SW} = vertical wave bending moment as given in Pt 3, Ch 5, Sec 2.2.2 at considered cross section with adjustment to k_{wm}.
γ_S, γ_W = Partial safety factors
γ_{dU}, γ_R = Partial safety factors
M_U = vertical hull girder ultimate bending capacity, in hogging and sagging conditions at the considered cross section. M_U shall be calculated in accordance with Sec 5.6.2.9.

6.11.3 Fatigue Strength

6.11.3.1 Fatigue strength shall be verified considering the effect from wave induced vibration, for end connections of longitudinals to web frames or transverse bulkheads in the cargo hold area, and for hatchway corners on upper deck and hatch coaming.

6.11.3.2 The combined global stress range, $\Delta\sigma_g$, due to horizontal hull girder bending, vertical hull girder bending and hull girder torsion including the effect of wave induced vibration shall be considered as below:

$$\Delta\sigma_g = [\Delta\sigma^2_{v,wiv} + \Delta (\sigma_{hg} + \sigma_{wt})^2 + 2 \rho_{vh} \Delta\sigma_{v,wiv} \Delta(\sigma_{hg} + \sigma_{wt})]^{0.5} \text{ (N/mm}^2\text{)}$$

Where,
$\Delta\sigma_{v,wiv}$ = Stress range due to vertical wave bending moment including the effect of wave induced vibration
= $f_{vib} \Delta\sigma_v$
f_{vib} = Vibration factor as provided in Sec 5.15.1.2 or Sec 5.15.1.3
Other parameters as detailed in Sec 5.6.4.1.

SECTION 7 CAR CARRIERS

Contents

7.1 General

7.1.1 Classification

7.1.1.1 This section is applicable to ships intended for carriage of cars.

7.1.1.2 Ships built in compliance with relevant requirements for class notation General Cargo Carrier RO/ RO (provided in Sec 4) and built in compliance with relevant requirement specified in the following, will be given the class notation Car Carrier.

7.1.1.3 Ships arranged with movable car decks or deck pontoons shall be built in compliance with relevant requirements in C and D. Such ships may be given the class notation **MCDK**.

7.1.2 Documentation

7.1.2.1 For ships with movable car decks (**MCDK**) the following plans and particulars shall be submitted for information:

- Uniform deck loading
- Maximum axle load including details of wheel and or foot print arrangement for all vehicles
- Proposed procedure for function testing

The following plans and particulars shall be submitted for approval:
- Car deck pontoons and their weights
- Supports or suspensions
- Connections to hull structure with information regarding reaction forces from hoisting devices
- Stowing arrangements for deck pontoons when not in use

7.2 Hull Strength

7.2.1 General

7.2.1.1 The requirements detailed below are to be complied with.

7.2.2 Transverse Strength

7.2.2.1 Vessels with strength limited by transverse racking constraining structure shall be subject to a direct strength analysis to demonstrate that the stresses are acceptable in a heeled condition. Acceptable calculation methods are given in Detailed racking analyses shall be carried out for a realistic load distribution with maximum load carried on the upper decks. A minimum GM for racking analysis shall be 0.05 B shall be considered, where B is the width of the vessel.

7.2.2.2 Car carriers may be designed for transverse strength secured by having self supporting side verticals. A simplified racking assessment using beam models will then be accepted for documentation of the strength.

7.2.2.3 For vessels where the transverse strength is secured by a few heavy racking constraining structures and where the load distribution between these structural elements and the bow and the stern area is unknown, a global Finite Element Analysis shall be carried out to document the transverse strength.

7.2.3 Fatigue

7.2.3.1 Racking constraining structural details shall be specially considered to ensure a proper resistance against fatigue..

7.2.3.2 The loading condition (ie. mass distribution) used for analysis of fatigue, shall have a GM not less than 0.035 B.

7.2.3.3 For ships of limited size ($L < 150$ m), the side verticals are usually designed as self supporting with respect to racking. In such case, a proper fatigue performance can be ensured by controlling the general stress level of the side verticals in way of the supporting areas.

7.3 Strength of Car Decks

7.3.1 General

7.3.1.1 This section is applicable to those ships equipped with permanent or movable car decks or pontoons.

7.3.1.2 The pontoons may be made of steel or aluminium alloys suitable for marine use. Movable card deck are normally built as pontoons consisting of a grillage of girders and stiffeners with deck plating welded to the supporting structures.

7.3.1.3 Permanent car decks are also normally built as grillage systems of girders and stiffeners integrated in the hull structure with deck plating welded to the supporting strength members.

7.3.1.4 Alternate types and combination of car decks, materials etc may be approved after special consideration.

7.3.1.5 Movable decks and deck pontoons shall be effectively supported at the ship's sides and bulkheads and by pillars or suspensions. Movable decks may also be supported by deck girders above. Due attention should then be brought to the strength assessment of the girder also taking into account the loads from the movable decks.

7.3.1.6 Supporting structures such as pillars or suspensions carrying several tiers of decks shall be designed for the number of decks they carry.

7.3.1.7 Tensile and or compressive forces, as relevant shall be considered in the design of the supports for pillars.

7.3.2 Load and Strength Requirements for Decks

7.3.2.1 The most severe conditions of stowed vehicles shall be considered in finalising the scantlings.

7.3.2.2 The total load at the girders, including the mass of deck structure may normally be regarded as evenly distributed.

The design pressure is given by:

$p = (q_c + q_0)(9.81 + 0.50\, a_q)$ (kN/m^2)

Where,

a_v = Vertical acceleration as defined in Pt 3, Ch 4.

q_c = Specified distribute cargo load (t/m^2)

q_0 = Distributed mass of deck structure (t/m^2)

$q_c + q_0 = 0.25$ (t/m^2) minimum

7.3.2.3 Plate, stiffeners and girders of car decks and pontoons shall satisfy the relevant requirements in Sec 4.3 with additions as given below.

7.3.2.4 The value of m shall be considered as below for the calculation of section modulus of stiffeners on movable car decks and pontoons:

$m = 8 / (2 – [a / l])$

Where,
l = Span of stiffener (m)
a = Extend of load in direction of stiffener (m)
Based on a detailed direct stress analysis the value of m may be adjusted.

7.3.2.5 The section modulus for simple girders is provided as below:

$z = 6.25 S^2 b p / (m [1 / k_m])$ (cm^3)

Where,

S = Girder span (m)
b = Breadth of area supported by the girder (m)
p = As defined in Sec 7.3.2.2.
m = 12 for girders fixed at both ends
= 8 for girders simply supported at both ends (pontoon edges)
For effective plate flange, refer Pt 3, Ch 3, Sec 3.

7.3.2.6 The web area requirement after deduction of cut-outs at the girder ends shall be:

$A = 0.06 S b p k_m$ (cm^2)

The web area at the middle of the span shall not be less than 0.50 A

7.3.2.7 For complex girder systems and or loads not being evenly distributed, the scantlings shall be based on direct stress analysis.

Allowable normal stress, $\sigma = 160 / k_m$ (N/mm^2)
Allowable shear stress, $\tau = 90 / k_m$ (N/mm^2)

7.3.2.8 Moment of inertia of girders shall not be less than the following:

$I = C_1 Z S / k_m$ (cm^4)

Where,
C_1 = 1.10 for steel
= 3.0 for aluminium alloy
Z = Section modulus of girder (cm^3)
S = Span of girder (m)

7.3.2.9 The critical buckling stress of plating acting as flange of the girder shall not be less than the following:

$\sigma_c = (\sigma_a / 0.87)$ (N/mm^2)
Where,
σ_a = Calculated compressive design stress (N/mm^2)
Tripping brackets and local stiffening of plating/ webs shall be provided as necessary.

7.3.3 Load and Strength Requirements for Support and Suspension

7.3.3.1 The total load at the movable deck or pontoon including the self weight shall be considered for calculation of supports and suspensions. The design load shall be uniform deck load as applicable to the girders

7.3.3.2 Direct strength analysis shall be considered for scantling assessment.

7.3.3.3 Allowable stresses in support elements shall be as below:

Allowable tensile/ compressive stress,

σ = 110 / k_m (N/mm^2)

Allowable shear stress,
τ = 65 / k_m (N/mm^2)

Allowable equivalent stress $(\sigma^2 + 3\,\tau^2)^{0.5}$
σ_e = 120 / k_m (N/mm^2)

7.3.3.4 Local stress concentration shall be avoided by proper detailing.

7.3.3.5 Allowable stresses shall be specially considered for slender supports loaded in compression.

7.3.3.6 For wire rope type suspensions, the minimum breaking load shall not be less than:

P_m = 4 P_a (kN)

Where,
P_a = Calculated design force of wire (kN)

The construction and testing of steel wire suspensions shall comply with the requirements given in Pt 4, Ch 3 for towlines and mooring lines.

7.4 Stowage Arrangements for Deck Pontoons When Not in Use (Class Notation MCDK)

7.4.1 General

7.4.1.1 Stowing arrangement for all movable deck pontoons shall be provided on board.

7.4.1.2 The pontoons shall be fastened and secured by efficient means which will not slacken or loosen by the stresses arising when the ship is at sea.

7.4.1.3 Pontoons shall have hoisting equipment which is normally not to be stressed when the pontoons are in stowed position. If the hoisting equipment will be stressed by the stowed pontoons, its scantlings shall be determined accordingly.

7.4.2 Arrangement on weather deck

7.4.2.1 Pontoons in contact with the securing arrangement shall be lockable in racks. In racks for stowing of movable deck pontoons on weather deck the clearance between pontoon and racks shall not be greater than necessary for pontoon handling.

7.4.2.2 Requirements for drainage is provided in Sec 7.4.2.3 ad 7.4.2.4 are to be complied with for all cargo hatches on weather deck. If the pontoon stacks at the foremost 30% of the ship's length L extend higher than top of nearest cargo hatch, a significant increase of the drainage area as calculated from Sec 7.4.2.3 and Sec 7.4.2.4 may be required, upon consideration in each case.

7.4.2.3 At forward and after ends of pontoon stacks (or continuous row of stacks) and below these, there shall be a total free transverse drainage area on each side of the ship, taken to top of pontoon stacks, not less than the value provided below:

$a = v / (30\,[\,h\,]^{0.5})$ (m^2)

Where,
h = Height (m) from deck to top of pontoon deck
v = Volume (m^3) of the quantity of water which can fill the space between pontoon stacks on each side of the ship to top of stacks, taken over a length of

deck between midpoints of openings at forward and after ends of stacks (or continuous row). The length is, however, not to be taken to extend more than the stack height h beyond the forward and after end of stacks.

7.4.2.4 Outside pontoon stacks, passages overboard for water, shall be provided. Any bulwark shall have openings with area as calculated from Sec 7.4.2.3, and such that the volume v is increased by the quantity of water which can fill the space between bulwark and pontoon stacks up to top of bulwark. The area between top of bulwark and top of stacks at their ends, which is included in the calculation of v from 203, may be deducted from the requirement to openings in bulwark.

7.4.3 Design Loads

7.4.3.1 For determination of scantlings of racks on weather deck and supporting structures, the pontoon stacks shall be regarded as subjected to the following one-sided pressure as detailed below:

$p = a (p_l + [135\ y / (B + 75)] – 4\ h_0)$ (kN/m²)
$= 12.50$ (kN/m^2) Minimum

Where,
a = 1.70 in transverse direction
= 1.30 in longitudinal direction for ends protected by another stack or bulkhead
= 2.00 in longitudinal direction for unprotected ends (Eg forward end in ships not having a forecastle terminating forward of the foremost cargo hatch)
$p_l = k_s C_w + f$, in general

$= (k_s C_w + f) (0.80 + 0.15 V / [L^{0.5}])$, when $V / [L^{0.5}] > 1.50$

Where,

f = Vertical distance (m) form the waterline to top of ships side at transverse section considering maximum C_W.

y = Horizontal distance (m) from the center line to the point considered
= B/4 Minimum

$k_s = 2 + (3.10 / [C_B^{0.5}])$
= 2 between 0.20 L and 0.70 L from AP
$= 2 + (4.70 / C_B)$ at FP and forward
For intermediate locations k_s shall be linearly interpolated.

C_w = Wave coefficient as provided in Pt 3, Ch. 4.

Transverse and longitudinal pressures need not be considered acting simultaneously.

For pontoons stowed below deck, stowing and securing devices shall be designed for the following loads:

Transverse load not less than 5Q (kN)
Vertical load not less than 13Q (kN)
Longitudinal load not less than 2.50 (kN)

Where,
Q = Total load (t) for the relevant stowed positions.

7.4.4 **Allowable Stresses**

7.4.4.1 The nominal combined stresses in stowing devices and their connections to supporting structures shall not exceed 120 / k_m (N/mm^2).

7.4.4.2 Strength members subjected to buckling loads, shall have a safety factor against buckling not less than 1.75.

SECTION 8 STATUTORY AND IACS REQUIREMENTS FOR HULL STRENGTH AND ARRANGEMENT FOR BULK CARRIERS AND ORE CARRIERS

Contents

8.1 Additional Requirements for Loading Conditions, Loading Manuals and Loading Instruments

8.1.1 Application

8.1.1.1 The requirements in this section shall be complied with for ships as given in Sec 5.1.5 and Sec 12 Table 12.1.3.

8.1.2 Loading Manual

8.1.2.1 The loading manual shall detail the following:

A. The loading conditions on which the design of the ship has been based, including permissible limits of stillwater bending moments and shear forces.

B. The results of calculations of stillwater bending moments, shear forces and where applicable, limitations due to torsional loads.

C. Envelope results and permissible limits to stillwater bending moments and shear forces in the hold flooded conditions are also to be included. Refer Sec 8.3.2.

D. The cargo hold (s) or combination of holds that might be empty at full draught. If no cargo hold is allowed to be empty on full draught, this shall be clearly stated in the loading manual.

E. Maximum allowable and minimum required mass of cargo and double bottom contents of each hold as a function of the draught at mid-hold position.

F. Maximum allowable and minimum required mass of cargo and double bottom contents of any two adjacent holds as a function of mean draught in way of these holds. This mean draught may be calculated by averaging the draught of the two mid-hold positions.

G. Maximum allowable load on tank top together with specification of the nature of the cargo for cargoes other than bulk cargoes.

H. Maximum allowable load on deck and hatch covers. If the vessel is not approved to carry load on deck or hatch covers, this shall be clearly stated in the loading manual.

I. The maximum rate of ballast change together with the advice that a load plan shall be agreed with the terminal on the basis of achievable rates of change of ballast.

(Refer IACS UR S1A.2.1, Rev. 5)

8.1.3 Loading Instrument

8.1.3.1 The Loading computer system shall be an approved digital system as given in Pt 3, Ch 5 and Pt.6 Ch.9 The Loading computer system is, in addition to requirements given in Pt 3, Ch 5, Sec 1.1.2, to ascertain as applicable that:

- The mass of cargo and double bottom contents in way of each hold as a function of the draught at mid-hold position
- The mass of cargo and double bottom contents of any two adjacent holds as a function of the mean draught in way of these holds.

- The stillwater bending moments and shear forces in the hold flooded conditions are within permissible values.

(Refer IACS UR S1A.2.2, Rev. 5)

8.1.4 Conditions of Approval of Loading Manuals

8.1.4.1 The loading manual is, in addition to the requirements as given in Sec 5.1 and Pt 3, Ch 5, Sec 6.2, to include the following loading conditions, subdivided into departure and arrival:

A. Alternate light and heavy cargo loading conditions at maximum draught, where applicable.

B. Homogeneous light and heavy cargo loading conditions at maximum draught.

C. Ballast conditions. For vessels having ballast holds adjacent to topside wing, hopper and double bottom tanks, it shall be strengthwise acceptable that the ballast holds are filled when the topside wing, hopper and double bottom tanks are empty.

D. Short voyage conditions where the vessel shall be loaded to maximum draught but with limited amount of bunkers.

E. Multiple port loading and unloading conditions.

F. Deck cargo conditions, where applicable.

G. Typical loading sequences where the vessel is loaded from commencement of cargo loading to reaching full deadweight capacity, for homogeneous conditions, relevant part load conditions and alternate conditions where applicable.

   Typical unloading sequences for these conditions shall also be included. The typical loading and unloading sequences shall be developed to not exceed applicable strength limitations. The typical loading sequences shall also be developed paying due attention to the loading rate, and the de-ballasting capability.

H. Typical sequences for change of ballast at sea, where applicable.

   (Refer IACS UR S1A.3, Rev. 5)

   Note:

   The above listed loading conditions should be considered as mandatory for all vessels as applicable. I.e. loading conditions, which are not applicable or not intended to be used, need not be considered in the design.

   Furthermore, the specification of e.g. short voyage and multiple port conditions are in general subject to agreement between owner and builder. This relates to the specification of the design loading conditions, which should take into consideration the intended modes and areas of operation. A short voyage condition may be a homogeneous or an alternate condition where the cargo deadweight is increased with approximately 50% of the bunker weight. However, if some or all of the above conditions are not included in the Loading Manual a note to this effect shall be given in the Loading Manual.

8.1.5 Conditions of Approval of Loading Instrument

8.1.5.1 The loading instrument is subject to approval. The approval of loading instrument shall include as applicable:

- Acceptance of hull girder bending moments limits for all read-out points

- Acceptance of hull girder shear force limits for all read-out points
- Acceptance of limits for mass of cargo and double bottom contents of each hold as a function of draught
- Acceptance of limits for mass of cargo and double bottom contents in any two adjacent holds as a function of draught
- Acceptance of shear force corrections.

(IACS UR S1A.4, Rev. 5)

8.2 Side Structure

8.2.1 Application

8.2.1.1 These requirements apply to side structure of cargo holds for ships as given in Sec 5.1.5.

8.2.2 Plating and Stiffeners

8.2.2.1 Thickness and cross-section properties are in general to be calculated as given in Pt 3, Ch 7.

8.2.2.2 The minimum thickness of side plating, located between hopper and top wing tanks and extending in length over the whole cargo area, shall not be less than that provided below:

$t = L^{0.50}$

Where,
L as defined in Pt 3, Ch 1, Sec 2.1.

(IACS UR S12.8, Rev. 4)

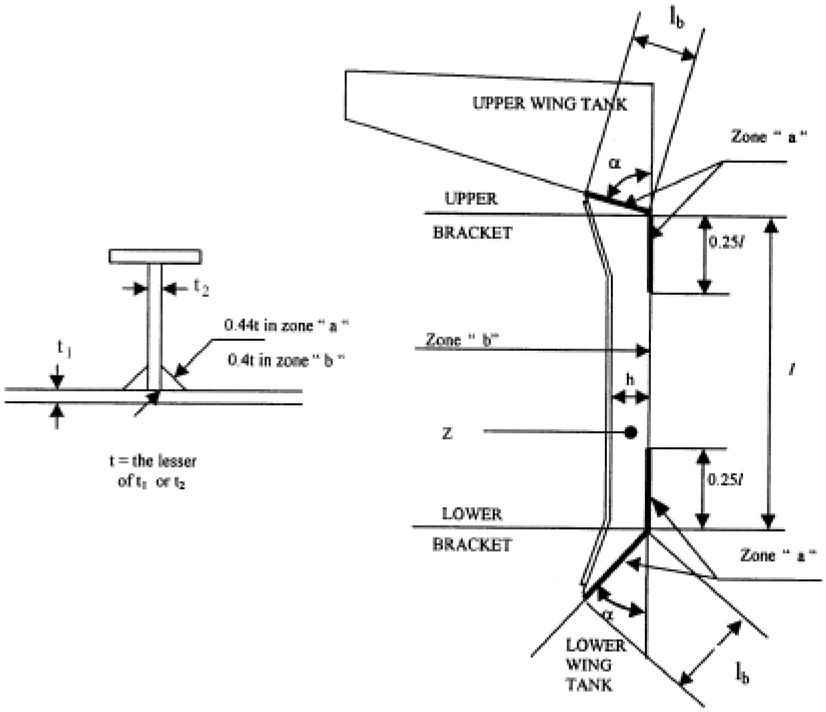


Fig 1 Typical Main Frame

8.2.3 Main Frames

8.2.3.1 Main frames are frames located outside the peak tanks, connected to hopper tanks and extended to the top wing tank on the ship side, Refer Fig 1. Main frames, including brackets built in compliance with the requirements given in this subsection need not to be checked for the requirements as given in Pt 3, Ch 7, Sec 3.4.

8.2.3.2 The minimum section modulus requirement for the main frames is as below:

$Z = 1000\, l^2 s p w_k / (m\sigma)$ (cm^3)

Where,

p = p_1 to p_s as relevant as provided in Pt 3, Ch 7, Sec 2.1, Table 7.2.1.
w_k = 1.05 For section modulus for mid span and upper end
= 1.15 For section modulus for lower end
σ = 130 / k_m for internal p_3 or p_8
σ = 150 / k_m for external loads p_1, p_2 and p_{min} provided above
m = 18 in general
= 12 at upper end (including bracket) in combination with internal load p_3 to p_8.
= 9 at lower end (including bracket) and for upper end in combination with external loads p_1, p_2 and p_{min}.

For main frames situated next to plane transverse bulkheads, e.g. at the ends of the cargo region, the section modulus of the mid portion of the frame is generally to exceed the section modulus of the adjacent frame by a factor 3ha/h where:

h_a = Web height of adjacent frame
h = Web height of considered frame.

The increased section modulus of the main frame adjacent to plane transverse bulkheads need not be fitted if other equivalent means are applied to limit the deflection of these frames.

8.2.3.3 Minimum thickness of frame webs within the cargo area shall not be less than tw, min, as provided below:

$t_{w,min}$ = 7.0 + 0.03 L (mm)

Where,
L = As defined in Pt 3, Ch 1, but need not be taken greater than 200m.
(IACS UR S12.3, Rev 4)

8.2.3.4 Minimum thickness of web frames in way o fthe formost hold shall not be taken less than $t_{w1,min}$, as provided below:

$t_{w1,min}$ = 1.15 $t_{w,min}$ (mm)
(IACS UR S12.3, Rev 4)

8.2.3.5 Web depth to thickness ratio of frames shall not exceed the following values:

$h / t_w \leq 60\ (k_m)^{0.50}$ for symmetrical flanged frame

$h / t_w \leq 50\ (k_m)^{0.50}$ for asymmetrical flanged frame

For flange outstands the flange breadth, b_f, shall not exceed as below:

$b_f \leq 10\ t_f\ (k_m)^{0.5}$

The face plate or flange of bracket shall be sniped at ends. Brackets shall be arranged with soft toes. To control the stress concentration at end of sniped flanges the total sniping angle, φ, of the top flange or bracket stiffener shall not exceed:

$\phi < 35 \, (t_w / t_f)$ (deg)

h = As defined in Fig 1
k_m = As defined in Pt 3, Ch 2
t_w = Web thickness
t_f = Flange thickness

(IACS UR S12.5 Rev 4)

8.2.3.6 Thickness of the frame lower brackets shall not be less than the greater of t_w, $t_{w,min}$ and $t_{w1,min}$ as provided in Sec 8.2.3.3 and Sec 8.2.3.4 plus 2 mm, where tw is the as fitted thickness of side frame web. The thickness of the frame upper brackets shall not be less than the greater of t_w, $t_{w,min}$ and t_{w1}, min as given in Sec 8.2.3.3 and Sec 8.2.3.4. The welded length of brackets, l_b, as shown in Fig. 1 shall not be less than:

$l_b = 60 \, (1 / \sin \alpha) \, \{ Z / ([t_w - t_{kw}] \, w_k) \}^{0.5}$ (mm)

Where,
Z, w_k = As provided in Sec 8.2.3.2.
t_w = As defined above
α = As defined in Fig 1
t_{kw} = 3 mm for the lower bracket
= 1 mm for upper bracket

The dimensions of the lower and upper brackets shall not be less than that shown in Fig 2.

(IACS UR S12.4, Rev 4)

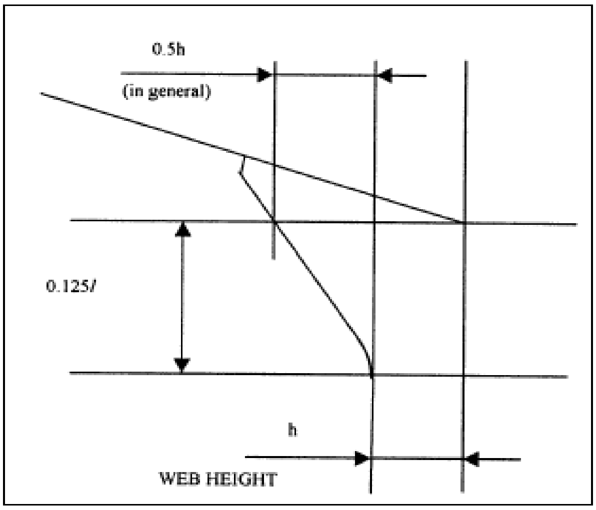


Fig 2 Minimum Dimensions of Brackets

8.2.3.7 Structural continuity with the upper and lower end connections of side frames shall be ensured within top sides and hopper tanks by connecting brackets. The brackets shall be in accordance with Fig. 3 and shall be adequately stiffened against buckling.

(IACS UR S12.4, Rev 4)

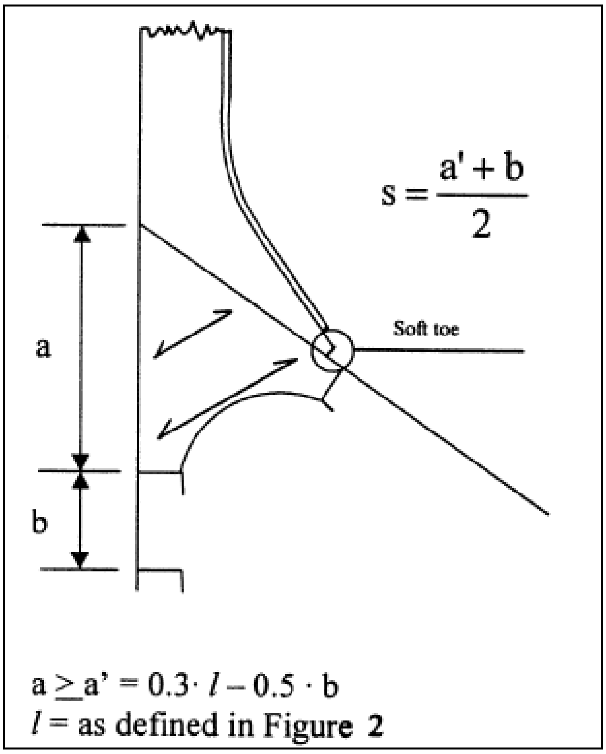


Fig 3 Details of Brackets

8.2.3.8 The section modulus of the side and sloping bulkhead longitudinals which support the connecting brackets (at top and bottom) shall be determined according to Pt 3, Ch 7, Sec 3.3 and Pt 3, Ch 9, Sec 3.2 with the span taken between the transverses.

Alternatively, the scantlings of side and sloping bulkhead longitudinals may be based on direct strength calculations. In such cases the most extreme loading for the supporting bracket /longitudinal connection (at top and bottom) shall be considered. The calculations should also reflect any relative deformation between connection supporting bracket/ longitudinal and the adjacent transverse frame/transverse bulkhead.

(IACS UR S12.4, Rev 4)

Note:
As a guidance to the bracket size the bracket length a may be taken as:
$a \geq a' = 0.30l - 0.50b$
Where,
a, b, l as defined in Fig 1.When checking the supporting longitudinals, the spacing should be taken as:
$s = (a' + b) / 2$

As a means to reduce the relative deformation as described in Sec 8.2.3.8, one enlarged supporting bracket may be arranged midway between frames and connected to the next longitudinal.

8.2.3.9 Frames shall be fabricated symmetrical sections with integral upper and lower brackets and shall be arranged with soft toes. Refer also Sec 8.2.3.11.
(IACS UR S12.4, Rev 4)

8.2.3.10 The side frame flange shall be curved (not knuckled) at the connection with the end brackets. The radius of curvature shall not be less than r, as provided below:

$r = (0.40\ b_f^2) / t_f$ (mm)

Where,
b_f (mm) and t_f (mm) are the flange width and thickness respectively.
(IACS UR S12.5, Rev 4)

8.2.3.11 In ships less than 190 m in length, mild steel frames may be asymmetric and fitted with separate brackets.
(IACS UR S12.5, Rev 4)

8.2.3.12 In way of foremost hold, side frames of asymmetrical section shall be fitted with tripping brackets at every two frames, as shown in Fig 4. (Refer Pt 3, Ch 7, Sec 5).
(IACS UR S12.6, Rev 4)

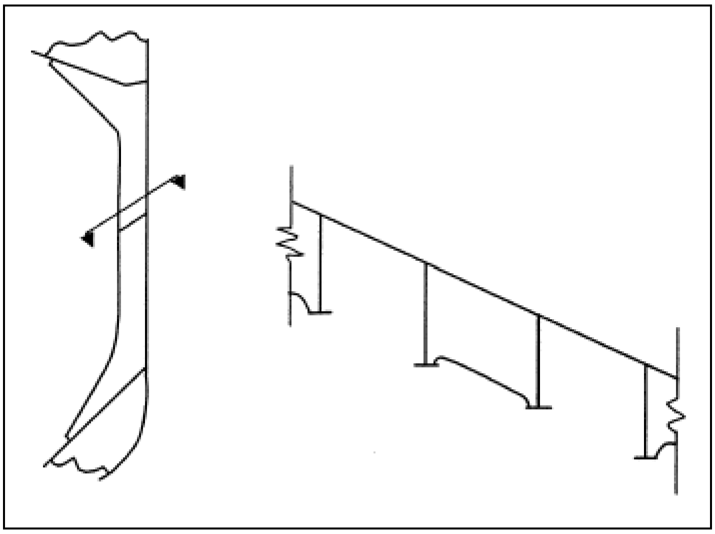


Fig 4 Positioning of Tripping Brackets

8.2.3.13 For the connections of frames and brackets to side shell, hopper and upper wing tank plating and web to face plates, double continuous welding shall be adopted. For this purpose, the weld throat, a, shall be (Refer Fig 1):

a = 0.44 t in Zone “a”
a = 0.40 t in Zone “b”
Where
t is the thinner of the two connected members and represent the as fitted thickness.

8.2.3.14 The weld throat thickness for the connecting bracket shall be according to Pt 3, Ch 13, using a C-factor of 0.52.

Where the hull form prohibits an effective fillet weld, edge preparation of the web of frame and bracket may be required, in order to ensure the same efficiency as the weld connection stated above.
(IACS UR S12.7, Rev. 4)

8.3 Longitudinal Strength of Hull Girder in Flooded Condition

8.3.1 General

8.3.1.1 The requirements in this section shall be complied with in respect of the flooding of any cargo hold of ships, as given in Sec 5.1.4 and Table 12.1.3.

8.3.1.2 The hull girder strength shall be checked for specified flooded conditions in each of the cargo and ballast loading conditions given in Pt 3, Ch 5, Sec 2.1/ Sec 2.2 and in every other condition considered in the intact longitudinal strength calculations, including those given in Sec 8.1, except that harbour conditions, docking condition afloat, loading and unloading transitory conditions in port and loading conditions encountered during ballast water exchange need not to be considered.
(IACS UR S17.1, Rev 7)

8.3.2 **Flooded Conditions**

8.3.2.1.1 Each cargo hold shall be considered individually flooded to the equilibrium waterline. The stillwater loads in flooded conditions shall be calculated for cargo and ballast loading conditions as given in 101. The wave loads in the flooded conditions are assumed to be equal to 80% of those given in Pt 3, Ch 5, Sec 2.1/ Sec 2.2.
(IACS UR S17.2, Rev 7)

8.3.3 **Flooding Criteria**

8.3.3.1 The following assumptions shall be made to calculate the mass of water ingress:

- The permeability of empty cargo spaces and volume left in loaded cargo spaces above any cargo shall be taken as 0.95.

- Appropriate permeabilities and bulk densities shall be used for any cargo carried. For iron ore, a minimum permeability of 0.3 with a corresponding bulk density of 3.0 t/m^3 shall be used. For cement, a minimum permeability of 0.3 with a corresponding bulk density of 1.3 t/m^3 shall be used. In this respect, “permeability” for solid bulk cargo means the ratio of the floodable volume between the particles, granules or any larger pieces of the cargo, to the gross volume of the bulk cargo.

- For packed cargo conditions (such as steel mill products), the actual density of the cargo should be used with a permeability of zero.

(IACS UR S17.3, Rev 7)

Note:
A permeability of 0.30 is considered generally acceptable also for light cargoes in order to check the longitudinal strength in the flooded condition.

8.3.4 **Stress Assessment**

8.3.4.1 The actual hull girder bending stress σ_{fld}, at any location is given by:

σ_{fld} = 1000 (M_{sf} + 0.80 M_w) / Z_z (N/mm^2)

Where,
M_{sf} = Still water bending moment (kNm), in the flooded condition for the section under consideration.
Mw = wave bending moment (kNm) as provided in Pt 3, Ch 5, Sec 2.1/ Sec 2.2.
Z_z = Section modulus (cm^3) for the corresponding location the hull girder
σ_{fld} ≤ 175 / k_m (N/mm^2) within cargo area.

The shear strength of the side shell and the inner hull (longitudinal bulkhead) if any, shall at any location of the vessel be checked according to the requirements given in Pt 3, Ch 5, Sec 4 in which Q_S and Q_W shall be replaced by Q_{sf} and Q_{wf} respectively, where:

Q_{sf} = Still water shear force (kN), in the flooded conditions for the section under consideration

Q_{wf} = 0.8 Q_w

Q_w = Wave shear force (kN) as provided in Pt 3, Ch 5, Sec 2.2.3 for the section under consideration.

$\tau_{fld} \leq 110 / k_m$ (N/mm^2)

(IACS UR S17.4 Rev 7)

8.3.4.1.1 The damaged structure is assumed to remain fully effective in resisting the applied loading. Uniaxial buckling capacity shall be checked according to Pt 3, Ch 14, Sec 3.
(IACS UR S17.5, Rev. 7)

8.4 Corrugated Transverse Watertight Bulkheads Considering Hold Flooding

8.4.1 **Application and definition**

8.4.1.1 These requirements are applicable to vertically corrugated transverse watertight bulkheads. The requirements in this section shall be complied with in respect to the flooding of any cargo hold of ships, as given in Sec 5.1.4 and Table 12.1.2.

The net thickness t_{net} is the thickness obtained by applying the strength criteria as given in Sec 8.4.3 to Sec 8.4.3.8.

The required thickness is obtained by adding the corrosion addition t_s, given in Sec 8.4.5, to the net thickness t_{net}.

In this requirement, homogeneous loading condition means a loading condition in which the ratio between the highest and the lowest filling ratio, evaluated for each hold, does not exceed 1.2 (corrected for different cargo densities).

For non-corrugated bulkheads, scantlings for plates, stiffeners and girders shall not be less than required in Pt 3, Ch 9, Sec 3, applying the pressure loads as given in Sec 8.4.2.1 to Sec 8.4.2.7.

Vertically corrugated bulkheads built in compliance with the requirements given in this subsection need not to be checked for the requirements relating to watertight bulkhead loads given in Pt 3, Ch 9, Sec 3.
(IACS UR S18.1, Rev 7)

8.4.2 **Load Model**

8.4.2.1 General

The loads to be considered as acting on the bulkheads are those given by the combination of the cargo loads with those induced by the flooding of one hold adjacent to the bulkhead under examination. In any case, the pressure due to the flooding water alone shall be considered. The most severe combinations of cargo induced loads and flooding loads shall be used for the check of the scantlings of each bulkhead, depending on the loading conditions included in the loading manual:

— Homogeneous loading conditions
— Non-homogeneous loading conditions

Considering the individual flooding of both loaded and empty holds.

The specified design load limits for the cargo holds shall be represented by loading conditions defined by the designer in the loading manual.

Non-homogeneous part loading conditions associated with multi port loading and unloading operations for homogeneous loading conditions need not be considered according to these requirements.

Holds carrying packed cargoes shall be considered as empty holds for this application.

Unless the ship is intended to carry, in non-homogeneous conditions, only iron ore or cargo having bulk density equal or greater than 1.78 t/m3, the maximum mass of cargo which may be carried in the hold is also to be considered to fill that hold up to the upper deck level at centreline.

(IACS UR S18.2.1, Rev 7)

Note:
Bulk Carriers as defined in Sec 5.1 without class notation ***BC-A****,* ***HC-A*** *and* ***HC-B*****, and only to be homogeneously loaded as defined in Sec 8.4.2.1, may have their bulkheads checked for homogeneous loading and flooding water alone only, provided this limitation is explicitly stated in the ship's Loading Manual.*

8.4.2.2 Bulkhead corrugation flooding head

The flooding head h_f (Refer Fig. 5) is the distance (m), measured vertically with the ship in the upright position, from the calculation point to a level located at a distance d_f, (m), from the baseline equal to:

A. In general:
- D for the foremost transverse corrugated bulkhead
- 0.90 D for other bulkheads

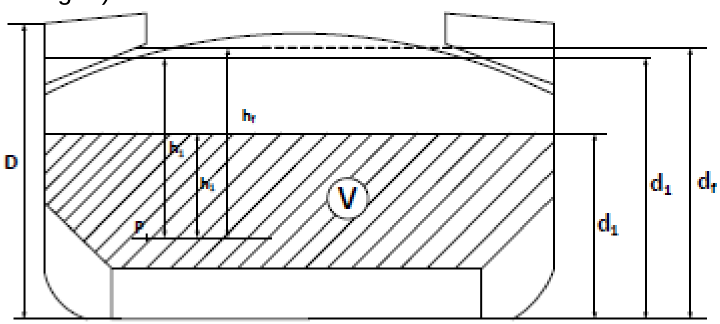
Where the ship shall carry cargoes having bulk density less than 1.78 t/m^3 in non-homogeneous loading conditions, the following values can be assumed:

-0.95 D for the foremost transverse corrugated bulkheads
-0.85 D for other bulkheads

B. For ships less than 50,000 t deadweight with Type B freeboard:
- 0.95 D for the foremost transverse corrugated bulkheads
- 0.85 D for other bulkheads

Where the ship shall carry cargoes having bulk density less than 1.78 t/m^3 in non-homogeneous loading conditions, the following values can be assumed:
- 0.90 D for the foremost transverse corrugated bulkheads
- 0.80 D for other bulkheads

D is the distance (m) from the baseline to the freeboard deck at side amidships (Refer Fig. 5).



V = Volume of cargo

P = Calculation point

Fig 5 Definition of D, h_1 and d_1

8.4.2.3 Pressure in non-flooded bulk cargo loaded holds

At each point of the bulkhead, the pressure p_c, is provided below:

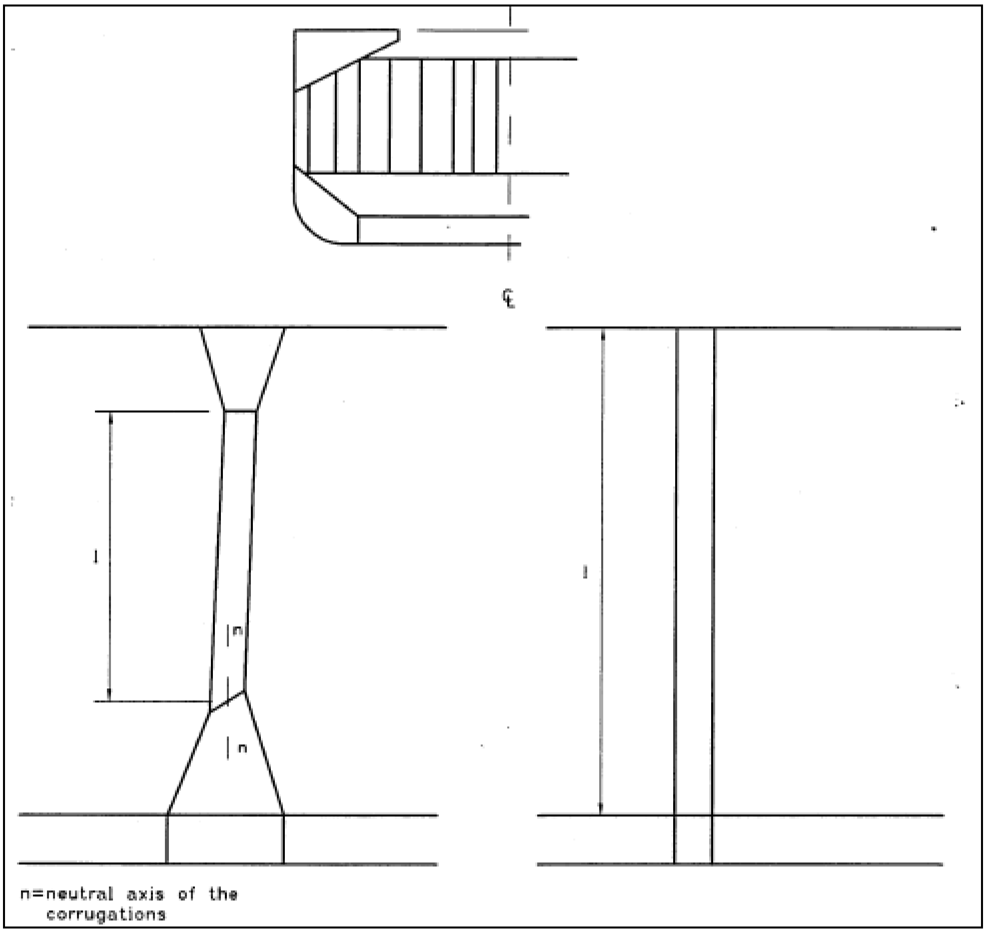
$p_c = \rho_c \, g \, h_1 \, K$ (kN/m^2)

Where,
ρ_c = Bulk cargo density (t/m^3)
g = Acceleration due to gravity (m/s^2)
h_1 = Vertical distance (m) from the calculation point to horizontal plane corresponding to the volume of the cargo (Refer Fig 5), located at a distance d_1 (m) from the base line.
K = $\sin^2 \alpha \, . \, \tan^2 (45 - 0.5\delta) + \cos^2 \alpha$
= $\cos \alpha$ (minimum)
α = angle (deg) between panel in question and the horizontal plane
δ = angle of repose of the cargo, in degrees, that may generally be taken as 35° for iron ore and 25° for cement

The force Fc, acting on a corrugation is as below:
$F_c = 0.50 \, \rho_c \, g \, s_1 \, K \, (d_1 - h_{DB} - h_{LS})^2$

Where,
s_1 = Spacing of corrugations (m)
h_{LS} = Mean height of the lower stool (m) from the inner bottom
h_{DB} = Height of the double bottom (m)
Other variables as provided above and in Fig 5.

(IACS UR S18.2.3, Rev 7)



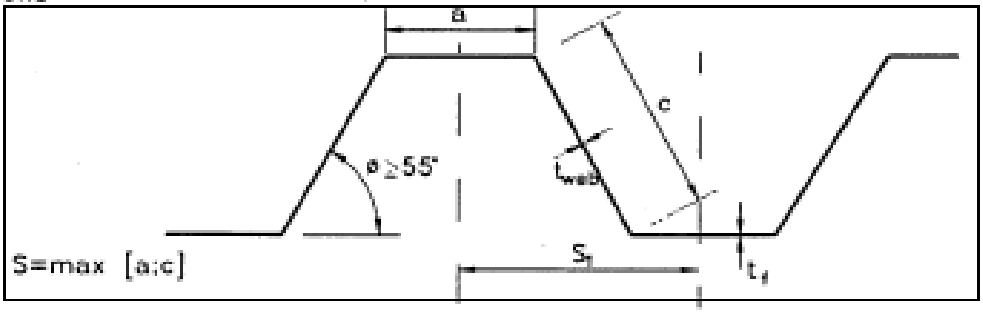


Fig 6 Spacing of the Corrugations

8.4.2.4 Pressure in flooded bulk cargo holds

Two cases shall be considered, depending on the value of d_1 and d_f

A) $d_f > d_1$

At each point of the bulkhead located at a distance between d1 and df from the baseline, the pressure $p_{c,f}$, is as provided below:

$p_{c,f}$ $= \rho\ g\ h_f$ (kN/m^2)

Where,
ρ = Sea water density (t/m^3)
g = As provided in Sec 8.4.2.3
h_f = Flooding head as defined in Sec 8.4.2.2

At each point of the bulkhead located at a distance lower than d1 from the baseline, the pressure $p_{c,f}$ as provided as below:

$p_{c,f}$ $= \rho\ g\ h_f + [\rho_c - \rho\ (1 - perm)]\ g\ h_1\ K$ (kN/m^2)

Where,
ρ, h_f = As provided above
ρ_c, g, h_1, K = As provided in Sec 8.4.2.3
perm = permeability of cargo, to be taken as 0.3 for ore (corresponding bulk cargo density for iron ore may generally be taken as 3.0 t/m^3), coal cargoes and for cement (corresponding bulk cargo density for cement may generally be taken as 1.3 t/m^3)
The force $F_{c,f}$, acting on a corrugation is provided below:

$F_{c,f}$ $= s_1$ (row_1 + row_2 $[\delta_1 - \eta_{DB} - \eta_{LS}]$)

Where,
row_1 = $0.50\ \rho\ g\ (d_f - d_1)^2$
row_2 = $0.50\ \rho\ g\ (d_f - d_1) + (p_{c,f})_{le}$
$(p_{c,f})_{le}$ = Pressure (kN/m^2) at the lower end of corrugation.
ρ = As provided above
s_1, d_1, g = As provided in Sec 8.4.2.3.
h_{DB}, h_{LS} = As provided in Sec 8.4.2.2.

B) $d_f < d_1$
At each point of the bulkhead located at a distance between d_f and d_1 from the baseline, the pressure $p_{c,f}$, is as provided below:

$p_{c,f}$ $= \rho_c\ g\ h_1\ K$ (kN/m^2)

Where,
ρ_c, g, h_1, K = As provided in Sec 8.4.2.3.

At each point of the bulkhead located at a distance lower than d_f from the baseline, the pressure $p_{c,f}$, is as provided below:

$p_{c,f}$ = ρ g h_f + [ρ_c h_1 – ρ (1 – perm) h_f] g K (kN/m^2)
Where,
ρ_c, g, h_1, K = As provided in Sec 8.4.2.3.
ρ, h_f, perm = As provided in A) above

The force $F_{c,f}$, acting on a corrugation is as provided below:

$F_{c,f}$ = s_1 [0.50 ρ_c g K (d_f – d_1)^2 + 0.50 {ρ_c g (d_f – d_1) K + $(p_{c,f})_{le}$ } d_{f_corr}]

Where,
d_{f_corr} = d_f – h_{DB} – h_{LS}
d_f = As provided in Sec 8.4.2.2
ρ_c, g, K = As provided in Sec 8.4.2.3
s_1, d_1, h_{DB} = As provided in Sec 8.4.2.3
$(p_{c,f})_{le}$ = Pressure (kN/m^2) at the lower end of corrugation.
(IACS UR S18.2.4.1, Rev 7)

8.4.2.5 Empty holds and pressure due to flooding water alone

At each point of the bulkhead, the hydrostatic pressure p_f induced by the flooding head h_f shall be considered. The force F_f, acting on a corrugation is as provided below:

F_f = 0.50 s_1 ρ g (d_f –h_{DB} – h_{LS})^2 (kN)

Where,
d_f = As provided in Sec 8.4.2.2
ρ = As provided in Sec 8.4.2.4 A)
s_1, g, h_{DB} = As provided in Sec 8.4.2.3
h_{LS} = As provided in Sec 8.4.2.3

(IACS UR S18.2.5.1, Rev 7)

8.4.2.6 Resultant pressure and force- Homogenous loading conditions

At each point of the bulkhead structures, the resultant pressure p, to be considered for the scantlings of the bulkhead is as provided below:

p = $p_{c,f}$ – 0.80 p_c

The resultant force F, acting on a corrugation is as provided below:

F = $F_{c,f}$ – 0.8 F_c

(IACS UR S18.2.5.1, Rev 7)

8.4.2.7 Resultant pressure and force- Non- homogenous loading conditions At each point of the bulkhead structures, the resultant pressure p, to be considered for the scantlings of the bulkhead is as provided below:

p = $p_{c,f}$ (kN/m^2)

The resultant force F, acting on a corrugation is provided below:

F = $F_{c,f}$ (kN)
(IACS UR S18.2.5.2, Rev 7)

8.4.2.8 Bending moment in the bulkhead corrugation

The design bending moment M, for the bulkhead corrugation is as provided below:

M = 0.125 Fl (kNm)

Where,

F= Resultant force (kN) as provided in Sec 8.4.2.5, Sec 8.4.2.6, Sec 8.4.2.9 as relevant

l = Span of corrugation (m) to be taken according to Fig 6 and Fig 7

(IACS UR S18.3.1 Rev 7)

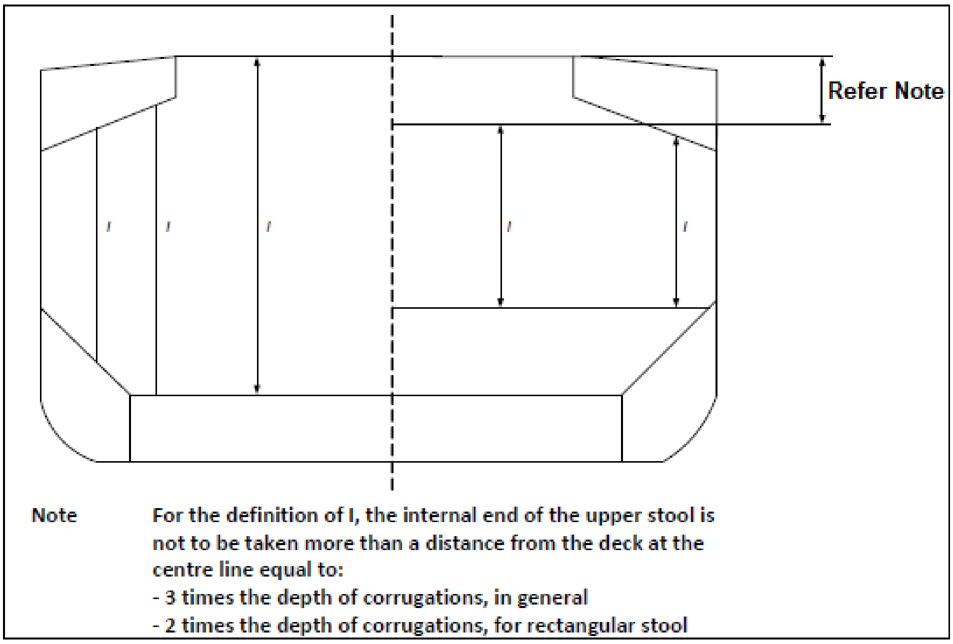


Fig 7 Definition of l

8.4.2.9 Shear force in the bulkhead corrugation

The shear force Q, at the lower end of the bulkhead corrugations is provided below:

Q = F / 1.25

Where,

F = As provided in Sec 8.4.2.8.

(IACS UR S18.3.2, Rev 7)

8.4.3 **Strength Criteria**

8.4.3.1 General

For transverse bulkhead with vertical corrugation the following criteria are applicable (Refer Fig 6 and Fig 7). For ships of 190 m of length and above, these bulkheads shall be fitted with a lower stool, and generally with an upper stool below deck. For smaller ships, corrugations may extend from inner bottom to deck; if the stool is fitted, it shall comply with the requirements in D.

The corrugation angle ϕ shown in Fig.6 shall not be less than 55°. Requirements for local net plate thickness are provided in Sec 8.4.3.8. In addition the criteria ss provided in Sec 8.4.3.2 and Sec 8.4.3.5 shall be complied with.

The thickness of the lower part of corrugations considered in the application of Sec 8.4.3.2 and Sec 8.4.3.3 shall be maintained for a distance from the inner bottom (if no lower stool is fitted), or the top of the lower stool not less than 0.15 l.

The thickness of the middle part of corrugations as considered in the application of Sec 8.4.3.2 and Sec 8.4.3.4 shall be maintained to a distance from the deck (if no upper stool is fitted), or the bottom of the upper stool not greater than 0.3 l.

The section modulus of the corrugation in the remaining upper part of the bulkhead shall not be less than 75% of that required for the middle part, corrected for different yield stresses.

(A)Lower Stool

Height of the lower stool is generally to be not less than 3 times the depth of the corrugations. The thickness and material of the upper portion of vertical or sloping stool side plating within the depth equal to the corrugation flange width from the stool top shall not be less than the required flange plate thickness and material to meet the bulkhead stiffness requirement at lower end of corrugation. However, the thickness of the stool side plating and the section modulus of the stool side stiffeners shall not be less than those required in Pt 3, Ch 9. Sec 3, on the basis of loads as given in Sec 8.4.2.1. to Sec 8.4.2.7. Corresponding allowable stresses to be used in combination with above loads is given in Pt 3, Ch 9, Sec 3 as for watertight bulkheads and corrosion additions shall be in compliance with Pt 3, Ch 2, Sec 4. The ends of stool side vertical stiffeners shall be attached to brackets at the upper and lower ends of stool.

The distance from the edge of the stool top plate to the surface of the corrugation flange shall be in accordance with Fig.13. The stool bottom shall be installed in line with double bottom floors and shall have a width not less than 2.5 times the mean depth of the corrugation. The stool shall be fitted with diaphragms in line with the longitudinal double bottom girders for effective support of the corrugated bulkhead. Scallops in the brackets and diaphragms in way of the connections to the stool top plate shall be avoided.

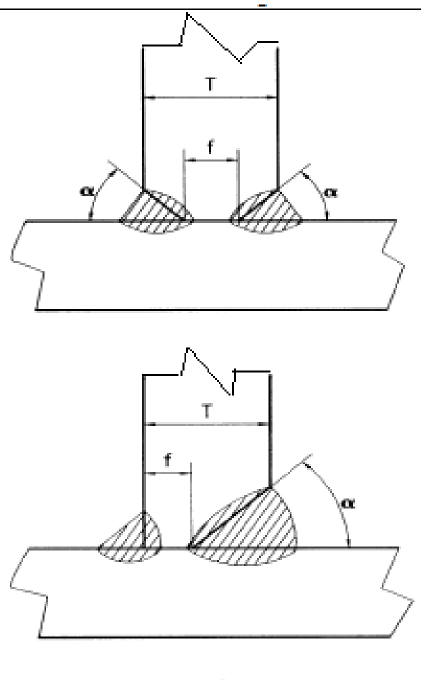
Where corrugations are cut at the lower stool, corrugated bulkhead plating shall be connected to the stool top plate by full penetration welds. The stool side plating shall be connected to the stool top plate and the inner bottom plating by either full penetration or deep penetration welds (Refer Fig 8). The supporting floors shall be connected to the inner bottom by either full penetration or deep penetration welds (see. Refer Fig 8).

(B)Upper Stool

Rectangular stools shall have a height generally equal to 2 times the depth of corrugations, measured from the deck level and at hatch side girder. The upper stool, where fitted, shall have a height generally between 2 and 3 times the depth of corrugations. The upper stool shall be properly supported by girders or deep brackets between the adjacent hatch-end beams.

The width of the stool bottom plate is generally to be the same as that of the lower stool top plate. The stool top of non-rectangular stools shall have a width not less than 2 times the depth of corrugations. The thickness and material of the stool bottom plate shall be the same as those of the bulkhead plating below. The thickness of the lower portion of stool side plating, within the depth equal to the corrugation flange width from the stool bottom plate, shall not be less than 80% of that required for the upper part of the bulkhead plating where the same material is used. However, the thickness of the stool side plating and the section modulus of the stool side stiffeners shall not be less than those required in Pt 3, Ch 9, Sec 3, on the basis of pressure loads as given in Sec 8.4.2.1 to Sec 8.4.2.7. Corresponding allowable stresses to be used in combination with above loads is given Pt 3, Ch 9, Sec 3 as for watertight bulkheads and corrosion additions shall be in compliance with Pt 3, Ch 2, Sec 4.

The ends of stool side stiffeners shall be attached to brackets at upper and lower end of the stool. Diaphragms shall be fitted inside the stool in line with and effectively attached to longitudinal deck girders extending to the hatch end coaming girders for effective support of the corrugated bulkhead.



Root Face (f) : 3 mm to T/3 mm
Groove Angle (α) : 40° to 60°

Fig 8 Full Penetration Or Deep Penetration Welds

Scallops in the brackets and diaphragms in way of the connection to the stool bottom plate shall be avoided.

(C)Alignment

At bottom, if no stool is fitted, the corrugation flanges shall be in line with the supporting floors. At deck, if no stool is fitted, two transverse reinforced beams shall be fitted in line with the corrugation flanges. Corrugated bulkhead plating shall be connected to the inner bottom plating by full penetration welds. The plating of supporting floors shall be connected to the inner bottom by either full penetration or deep penetration welds. (Refer Fig 8)

The thickness and material properties of the supporting floors shall be at least equal to those provided for the corrugation flanges. Moreover, the cut-outs for connections of the inner bottom longitudinals to double bottom floors shall be closed by collar plates. The supporting floors shall be connected to each other by suitably designed shear plates.

Stool side plating shall align with the corrugation flanges and stool side vertical stiffeners and their brackets in lower stool shall align with the inner bottom longitudinals to provide appropriate load transmission between these stiffening members. Stool side plating shall not be knuckled anywhere between the inner bottom plating and the stool top.
(IACS UR S18.4.1, Rev 7)

8.4.3.2 Bending Capacity and Shear Stress

The bending capacity shall comply with the following relationship:

$M \le 0.00095\ (0.5\ Z_{le}\ \sigma_{a,le} + Z_m\ \sigma_{a,m})$

Where,

M = Bending moment (kNm) as provided in Sec 8.4.2.8.
Z_{le} = Section modulus (cm^3) at lower end of corrugations, detailed in Sec 8.4.3.3.
Z_m = Section modulus (cm^3) at midspan of corrugations, detailed in Sec 8.4.3.4.
$\sigma_{a,le}$ = Allowable stress (N/mm^2) as in Sec 8.4.3.5, for lower end corrugation
$\sigma_{a,m}$ = Allowable stress (N/mm^2) as in Sec 8.4.3.5, for mid-span corrugation

Z_m shall not be taken greater than the lesser of 1.15 Z_{le} and 1.15 Z'_{le} for calculation of the bending capacity, Z'_{le} as being defined below.

Where shedder plates are fitted which:

— are not knuckled
— are welded to the corrugations and the top of the lower stool by one side penetration welds or equivalent
— are fitted with a minimum slope of 45° and their lower edge is in line with the stool side plating
— have thickness not less than 75% of that provided by the corrugation flanges
— and material properties at least equal to those provided by the flanges

Or where gusset plates are fitted which:
— are in combination with shedder plates having thickness, material properties and welded connections in accordance with the above requirements
— have a height not less than half of the flange width
— are fitted in line with the stool side plating
— are generally welded to the top of the lower stool by full penetration welds, and to the corrugations and shedder plates by one side penetration welds or equivalent
— have thickness and material properties at least equal to those provided for the flanges

The section modulus Z_{le}, shall be taken not larger than the value provided by:

$Z'_{le} = Z_g + (1000 / \sigma_a)\ (Q\ h_g - 0.5\ h_g^2\ s_1\ p_g)$ (cm^3)

Where,
Z_g = Section modulus (cm^3) of the corrugations calculated according to Sec 8.4.3.4, in way of the upper end of the shedder or gusset plates as applicable.
Q = Shear force (kN) as provided in Sec 8.4.2.9.
h_g = Height (m) of shedders or gusset plates s applicable (Refer Fig 9, 10 ,11, 12)
s_1 = As provided in Sec 8.4.2.3.
p_g = Resultant pressure (kN/m^2) as defined in Sec 8.4.2.6 or Sec 8.4.2.7 as relevant calculated in way of the middle of the shedders or gusset plates as applicable.
σ_a = Allowable stress (N/mm^2) as provided in 305.

Stresses, τ, are obtained by dividing the shear force, Q, by the shear area. The shear area shall be reduced in order to account for possible non-perpendicularity between the corrugation webs and flanges. In general, the reduced shear area may be obtained by multiplying the web sectional area by (sin ϕ), ϕ being the angle between the web and the flange.

While calculating the section modulus and the shear area, the net plate thickness shall be used. The section modulus of corrugations shall be calculated on the bases of the following requirements given in Sec 8.4.3.3 and Sec 8.4.3.4
(IACS UR S18.4.2, Rev 7)

8.4.3.3 Section modulus at the lower end of corrugations

The section modulus shall be calculated with the compression flange having an effective flange width, b_{ef}, not larger than as given in Sec 8.4.3.6.

In case the corrugation webs are not supported by local brackets below the stool top (or below the inner bottom) in the lower part, the section modulus of the corrugations shall be calculated considering the corrugation webs 30% effective.

a) Provided that effective shedder plates, as defined in Sec 8.4.3.2, are fitted (refer Fig 9 and Fig10), when calculating the section modulus of corrugations at the lower end (cross- section (1) in Fig.9 and Fig10), the area of flange plates, (cm^2), may be increased by 2.50 a $(t_f\ t_{sh})^{0.50}$ and not be taken greater than 2.50 a t_f, where:

   a = width (m) of the corrugation flange (refer Fig 6)
   t_{sh} = Nett sheeder plate thickness (mm)
   t_f = Net flange thickness (mm)

b) Provided that effective gusset plates, as defined in Sec 8.4.3.2, are fitted (refer Fig 11 and Fig12) when calculating the section modulus of corrugations at the lower end (cross- section (1) in Fig 11 and Fig 12), the area of flange plates, in cm^2, may be increased by (7 h_g t_f) where:

   h_g = Height of gusset plate (m) refer Fig 11 and Fig 12, not to be taken greater than (10/7 s_{gu}) where:

   s_{gu} = Width of gusset plate (m)
   t_f = Net flange thickness (mm) based on the as built section.

c) In case the corrugation webs are welded to a sloping stool top plate which have an angle not less than 45 degrees with the horizontal plane, the section modulus of the corrugations may be calculated considering the corrugation webs fully effective. In case effective gusset plates are fitted, while calculating the section modulus of corrugations the area of flange plates may be increased as specified in b) above. No credit can be given to shedder plates only.

   Where angles less than 45 degrees, the effectiveness of the web may be obtained by linear interpolation between 30% for zero degrees and 100% for 45 degrees.
   (IACS UR S18.4.3 Rev 7)

8.4.3.4 Section modulus of corrugations at cross-sections other than the lower end

The section modulus shall be calculated with the corrugation webs considered effective and the compression flange having an effective flange width, b_{ef}, not larger than as given in Sec 8.4.3.6.

(IACS UR S18.4.4 Rev 7)

8.4.3.5 Allowable stress check

The normal and shear stresses σ and τ, shall not exceed the allowable values σ_a and τ_a, provided as below:

σ_a = σ_f

τ_a = σ_f / 2

Where,

σ_f = Minimum upper yield stress (MPa) of the material

(IACS UR 18.4.5, Rev 7)

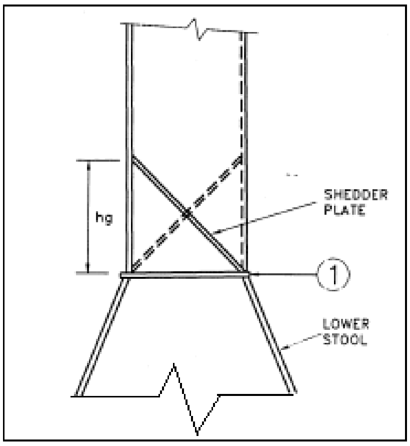


Fig 9 Symmetric Shedder Plates

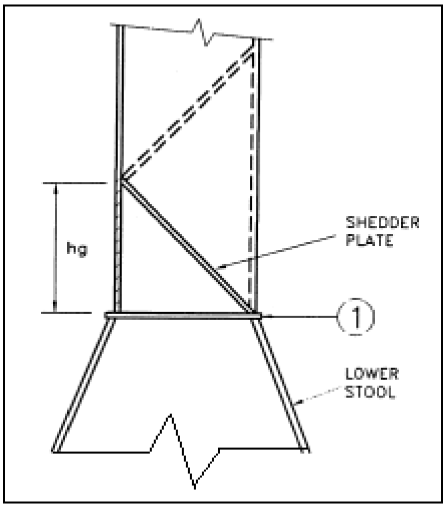


Fig 10 Asymmetric Shedder Plates

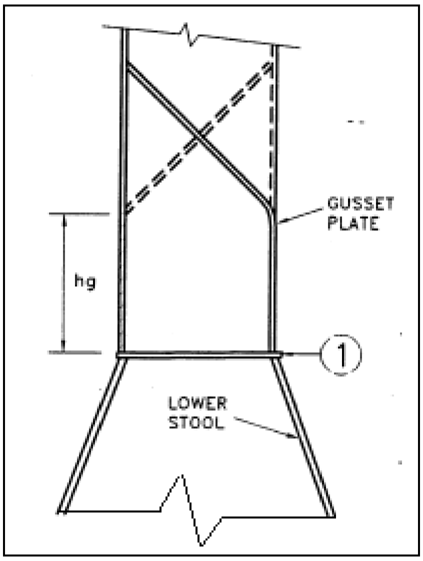


Fig 11 Symmetric Gusset/ Shedder Plates

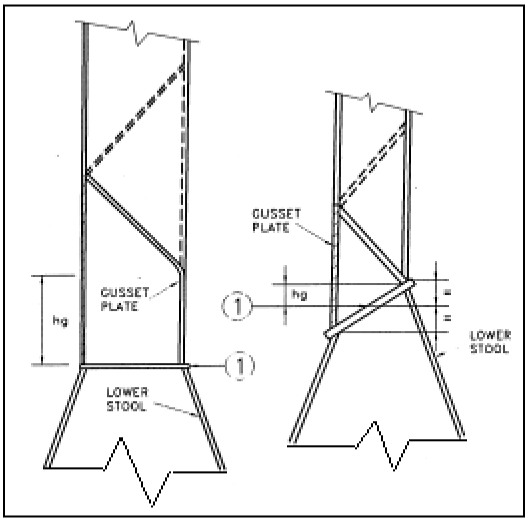


Fig 12 Asymmetric Gusset/ Shedder Plates

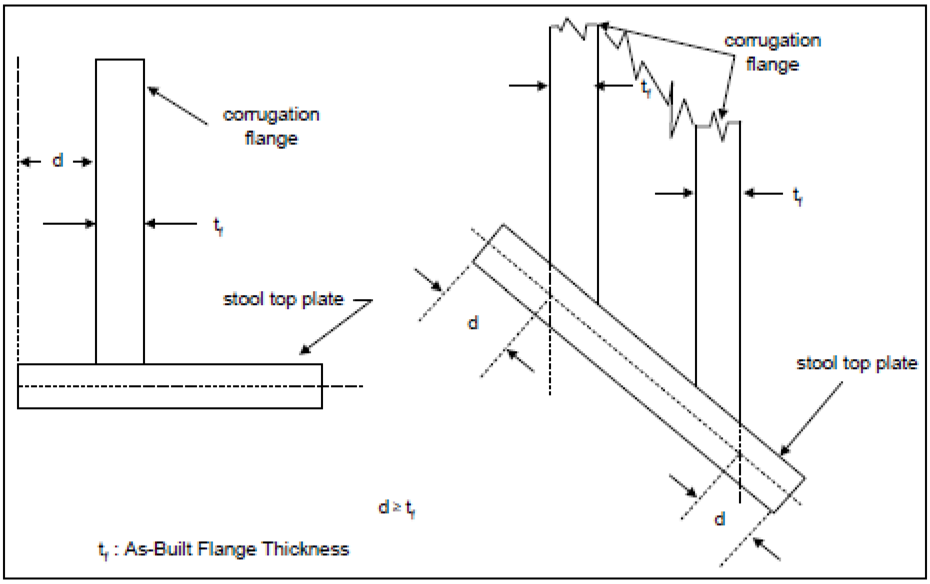


Fig 13 Permitted distance, d, from edge of stool top plate to surface of corrugation flange

8.4.3.6 Effective width of compression flange of corrugations

The effective width b_{ef} (m) of the corrugation flange is given by:

b_{ef} = C_e a

Where,

C_e = $(2.25 / \beta) - (1.25 / \beta^2)$ for $\beta > 1.25$

C_e = 1.00 for $\beta \leq 1.25$

Where,

t_f = Net flange thickness (mm)

β = $100 (a / t_f) (\sigma_f / E)^{0.50}$

t_f = Net flange thickness (mm)

a = Width (m) of the corrugation flange (refer Fig 6)

E = Modulus of elasticity of the material (N/mm^2)

= For steel consider 2.06×10^5 N/mm

σ_f = Minimum upper yield stress (N/mm^2) of material

(IACS UR S18.4.6.1 Rev 7)

8.4.3.7 Shear Buckling

The buckling check shall be performed for the web plates at the corrugation ends.

The shear stress, τ, as obtained by applying forces as given in Sec 8.4.2.9, shall not exceed the critical value τ_c, as provided in Pt 3, Ch 12, assuming a buckling factor k_t = 6.34 and net plate thickness as defined in this subsection.
(IACS UR S18.4.6.2 Rev 7)

8.4.3.8 Local net plate thickness

Bulkhead local net plate thickness is provided as below;

t = $14.9\ s_w (1.05p / \sigma_f)^{0.5}$

Where,

s_w = Plate width (m) to be taken equal to the width of the corrugation flange or web whichever is greater (refer Fig 6)

p = Resultant pressure (kN/m^2) as defined in Sec 8.4.2.6 or Sec 8.4.2.7 as relevant, at the bottom of each strake of plating. In all cases, the net thickness of the lowest strake shall be determined using the resultant pressure at the top of the lower stool or at the inner bottom, if no lower stool is fitted or at the top of shedders, if shedder or gusset/ shedder plates are fitted.

σ_f = Minimum upper yield stress (N/mm^2) of material

For built-up corrugation bulkheads, when the thickness of the flange and web are different, the net thickness of the narrower plating shall be not less than t_n, (mm), provided as below:

t_n = $14.90\ s_n (1.05p / \sigma_f)^{0.50}$

Where,

s_n = Width (mm) of the narrower plating

Net thickness of the wider plating (mm) shall not be taken less than the maximum of the following values:

t_w = $14.90\ s_w (1.05p / \sigma_f)^{0.50}$

and

t_w = $([440\ s_w^2\ 1.05\ p / \sigma_f] - t_{np}^2)^{0.50}$

Where $t_{np} \leq$ actual net thickness of the narrower plating and not to be greater than $14.90\ s_w (1.05p / \sigma_f)^{0.50}$

(IACS UR S18.4.7, Rev 7)

8.4.4 **Local Details**

8.4.4.1 The design of local details, for the purpose of transferring the corrugated bulkhead forces and moments to the boundary structures, shall reflect local stress concentration due to abrupt change in stiffness. Areas of concern are in particular connection to double bottom, cross-deck structures and connection of stool construction (upper and lower) to top-wing and hopper tank construction.

8.4.4.2 The thickness and stiffening of effective gusset and shedder plates, as defined in Sec 8.5.3.2, shall comply with Pt 3, Ch 9, on the basis of the pressure load as given in Sec 8.4.2.1 to Sec 8.4.2.7.

8.4.4.3 Unless otherwise stated, weld connections and materials shall be dimensioned and selected in accordance with Pt 3.
(IACS UR S18.5, Rev. 7)

8.4.5 **Corrosion addition**

8.4.5.1 The corrosion addition, t_s, shall be taken equal to 3.5 mm.

8.4.5.2 Steel renewal is required where the gauged thickness is less than t_{net} + 0.5 mm.

8.4.5.3 Where the gauged thickness is within the range t_{net} + 0.5 mm and t_{net} + 1.0 mm, coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal. Coating shall be maintained in good condition
(IACS UR S18.6, Rev. 7)

8.5 Limit to Hold Loading, Considering Hold Flooding

8.5.1 **Application and definition**

8.5.1.1 Below requirements apply to the double bottom structure of all cargo holds of ships, as given in Sec 5.1.4 and Table 12.1.2.

8.5.1.2 The loading in each hold shall not exceed the limit to hold loading in flooded condition, calculated as per Sec 8.5.4.1, using the loads given in Sec 8.5.2.1 to Sec 8.5.2.2 and the shear capacity of the double bottom given in Sec 8.5.3.1 to Sec 8.5.3.3.

In no case is the loading in each hold to exceed design hold loading in intact condition.
(IACS UR S20.1, Rev 4)

8.5.2 **Loading Model**

8.5.2.1 General

The loads to be considered as acting on the double bottom are those given by the external sea pressures and the combination of the cargo loads with those induced by the flooding of the hold which the double bottom belongs to.

Most unfavourable combinations of cargo induced loads and flooding loads shall be considered, depending on the loading conditions included in the loading manual:
- Homogeneous loading conditions
- Non-homogeneous loading conditions
- Packed cargo conditions (steel mill products etc)

For each loading condition, the maximum bulk cargo density to be carried shall

be considered in calculating the allowable hold loading limit.
(IACS UR S20.2.1, Rev 4)

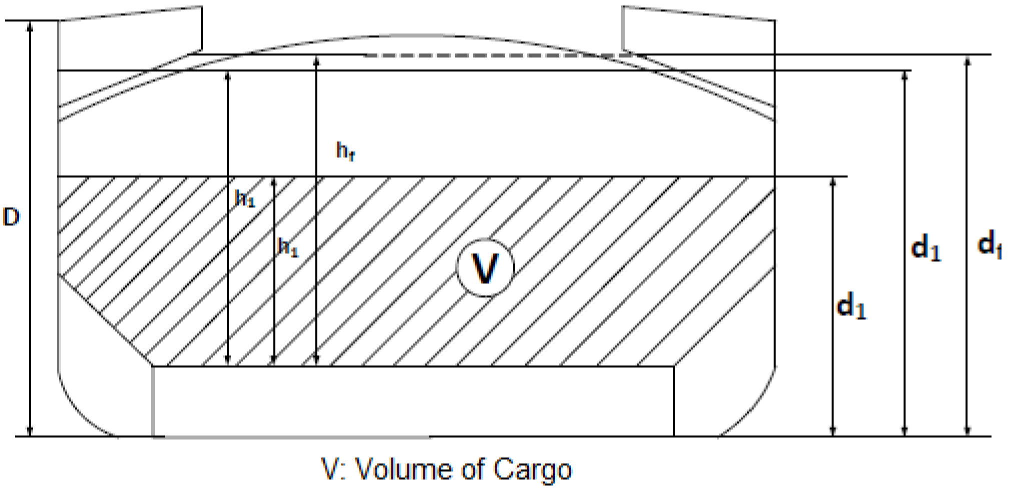


Fig 14 Definition of Flooding Head and D

8.5.2.2 Inner bottom flooding head

The flooding head hf (refer Fig.14) is the distance (m), measured vertically with the ship in the upright position, from the inner bottom to a level located at a distance df, (m) from the baseline equal to:

a) In general:
- D for the foremost hold
- 0.90 D for the other holds

b) For ships less than 50,000 t deadweight with Type B Freeboard:
- 0.95D for the foremost hold
- 0.85D for the other holds

Where, D is the distance (m) from the baseline to the freeboard deck at side amidships (Refer Fig 14)
(IACS UR S20.2.22, Rev 4)

8.5.3 **Shear Capacity**

8.5.3.1 Shear capacity of the double bottom

The shear capacity, C, of the double bottom is defined as the sum of the shear strength at each end of:

- all floors adjacent to both hoppers, less one half of the strength of the two floors adjacent to each stool, or transverse bulkhead if no stool is fitted (refer Fig.15)

- all double bottom girders adjacent to both stools, or transverse bulkheads if not stool is fitted.

For the holds at the ends, where girders or floors run out and are not directly attached to the boundary stool or hopper girder, their strength shall be evaluated for the one end only.

The floors and girders to be considered are those inside the hold boundaries formed by the hoppers and stools (or transverse bulkheads if no stool is fitted). The hopper side girders and the floors directly below the connection of the bulkhead stools (or transverse bulkheads if no stool is fitted) to the inner bottom shall not be included.

The shear capacity, C of double bottom will be subject to special consideration, when the geometry and/or the structural arrangement of the double bottom are such to make the above assumptions inadequate.

The net thickness of floors and girders shall be considered in the calculation of shear strength. The net thickness t_{net}, is as below:

t_{net} = t – 2.50 (mm)
Where,
t = thickness (mm) of the floors and girders.
(IACS UR S20.3, Rev 4)

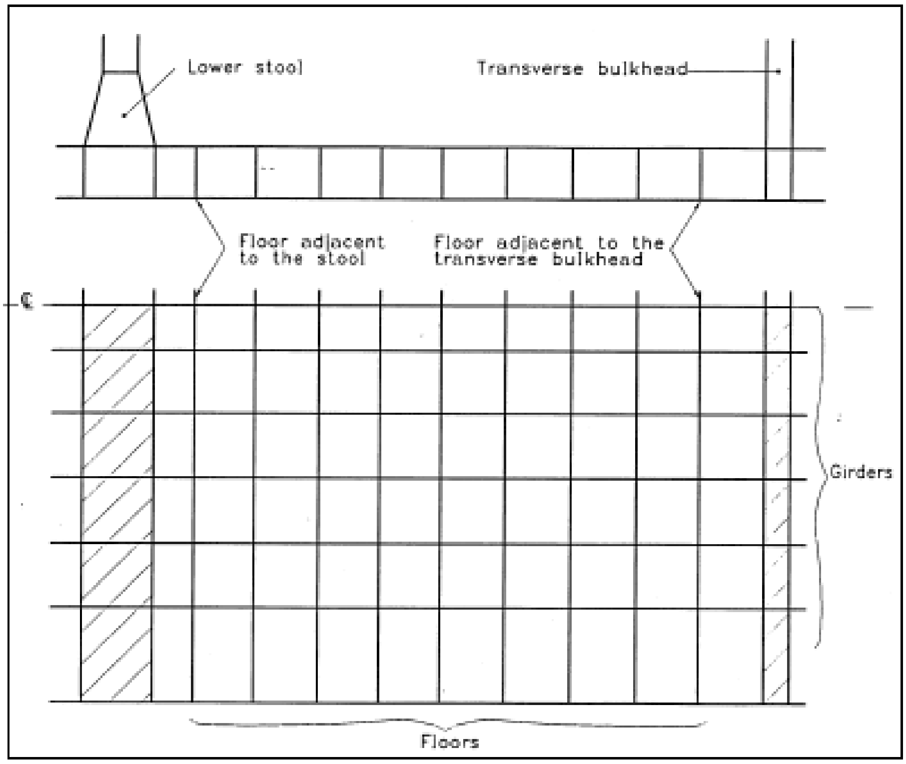


Fig 15 Arrangement of Double Bottom

8.5.3.2 Floor shear strength

The floor shear strength in way of the floor panel adjacent to hoppers S_{f1},(kN), and the floor shear strength in way of the openings in the outmost bay (i.e. that bay which is closer to hopper) S_{f2}, (kN), are provided below:

S_{f1} = $(A_f / 1000) (\tau_a / \eta_1)$ (kN)
S_{f2} = $(A_{f,h} /1000) (\tau_a / \eta_2)$ (kN)

Where,
τ_a = Allowable shear stress (N/mm^2) to be taken equal to the lesser of the following:
τ_a = $162\ \sigma_F^{0.60} / (s / t_{net})^{0.80}$ and $\sigma_F / (3^{0.50})$

For floor adjacent to the stools or transverse bulkheads, as identified in Sec 8.5.3.1.
τ_a = $\sigma_F / (3^{0.50})$

A_f = Sectional area (mm^2) of the floor panel adjacent to hoppers.
$A_{f,h}$ = net sectional area, in mm2, of the floor panels in way of the openings in the outmost bay (i.e. that bay which is closer to hopper)
σ_F = Minimum upper yield stress (N/mm^2) of the material
s = Spacing of the stiffening members (mm) of panel under consideration
η_1 =1.10
η_2 =1.20
η_2 may be reduced down to 1.10 when appropriate reinforcements are fitted around openings.
(IACS UR S20.3.1, Rev 4)

8.5.3.3 Girder shear strength
The girder shear strength in way of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted) S_{gl}, and the girder shear strength in way of the largest opening in the outmost bay (ie. that bay which is closer to stool, or transverse bulkhead, if no stool is fitted) S_{g2}, are provided as below:

S_{g1} = $(A_g / 1000) (\tau_a / \eta_1)$ (kN)

S_{g2} = $(A_g / 1000) (\tau_a / \eta_2)$ (kN)

Where,
A_g = Minimum sectional area (mm^2) of the girder panel adjacent to stools (or transverse bulkhead, if no stool is fitted)

$A_{g,h}$ = net sectional area (mm^2) of the girder panel in way of the largest opening in the outmost bay (the bay which is closer to stool, or transverse bulkhead, if no stool is fitted)
τ_a = Allowable shear stress (N/mm^2) as provided in Sec 8.5.3.2.
η_1 = 1.10
η_2 = 1.15

η_2 may be reduced down to 1.10 when appropriate reinforcements are fitted around openings.
(IACS UR S20.3.2, Rev 4)

8.5.4 Limit on Hold Loading, Considering Flooding

8.5.4.1 Limit on hold loading W, is provided as below:
W = $\rho_c V (1/F)$

Where,
F = 1.10 in general
= 1.05 for steel mill products
ρ_c = Bulk cargo density (t/m^3) (Refer Sec 8.5.2.1). For steel products, ρ_c shall be taken as the density of steel
V = Volume (m^3) occupied by cargo at a level h_1
h_1 = X / ρ_{cg}
X = For bulk cargoes, the lesser of X_1 and X_2 given by:

X_1 = $(Z + \rho g [E – h_f]) / (1 + [(\rho/\rho_c) (perm -1)])$
X_2 = $Z + \rho g (E – h_f\ perm)$

Where,
ρ = Sea water density, (t/m^3)
g = Acceleration due to gravity, 9.81 (m/s^2)
E = Ship immersion (m) for flooded hold condition
= $d_f – 0.10D$
d_f, D = As provided in Sec 8.5.2.2.
h_f = Flooding head (m) as defined in Sec 8.5.2.2.

perm = Permeability of cargo (the ratio between the voids within the cargo mass and the volume occupied by the cargo), needs not be taken greater than 0.3

Z = the lesser of Z_1 and Z_2 provided by

$Z_1 = C_h / A_{DB,h}$

$Z_2 = C_e / A_{DB,e}$

Where,

C_h = Shear capacity (kN) of the double bottom , as defined in Sec 8.5.3.1, considering, for each floor, the lesser of the shear strengths Sf1 and Sf2 (Refer Sec 8.5.3.2) and, for each girder, the lesser of the shear strengths Sg1 and Sg2 (Refer Sec 8.5.3.3)

C_e = Shear capacity (kN) of the double bottom, as defined in Sec 8.5.3.1, considering, for each floor, the shear strength S_{fl} (Refer Sec 8.5.3.2) and, for each girder, the lesser of the shear strengths S_{g1} and S_{g2} (Refer Sec 8.5.3.3)

$$A_{DB,h} = \sum_{i=1}^{i=n} S_i B_{DB,i}$$

$$A_{DB,e} = \sum_{i=1}^{i=n} S_i (B_{DB} - s_l)$$

n = Number of floors between stools (or transverse bulkheads, if no stool is fitted)

S_i = Space of i^{th} floor (m)

B_{DB} = Breadth of double bottom (m) between hoppers (Refer Fig 16)

$B_{DB,h}$ = Distance (m) between two considered opening (Refer Fig 16)

s_l = Spacing (m) of double bottom longitudinals adjacent to hoppers

$B_{DB,i}$ = $B_{db} - s_l$, for floors whose shear strength I provided by s_{fl} (Refer Sec 8.5.3.2)

$B_{DB,i}$ = $B_{DB,h}$ for floors whore shear strength is given by s_{f2} (Refer Sec 8.5.3.2.)
(IACS UR S20.4, Rev 4)

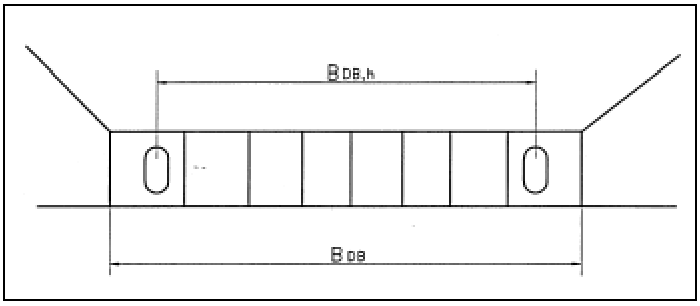


Fig 16 Dimensions of Double Bottom

8.6 Evaluation of scantlings of hatch covers and hatch coamings of cargo holds of bulk carriers, ore carriers and combination carriers

8.6.1 Application and definition

8.6.1.1 The requirements apply to ships, as provided in Sec 5.1.5 and Table 12.1.3.

8.6.1.2 These requirements are applicable to hatch covers and hatch coamings of stiffened plate construction. The secondary stiffeners and primary supporting members of the hatch covers shall be continuous over the breadth and length of the hatch covers, as far as practical. When this is impractical, sniped end connections shall not be used and appropriate arrangements shall be adopted to ensure sufficient load carrying capacity.

The spacing of primary supporting members parallel to the direction of secondary stiffeners shall not exceed 1/3 of the span of primary supporting members, i.e. between rigid supports.

The secondary stiffeners of the hatch coamings shall be continuous over the breadth and length of the hatch coamings.

These requirements are in addition to those provided in Pt 4, Ch 6.

The net thickness, t_{net}, is the thickness necessary to obtain the below net minimum scantlings. The required thickness is obtained by adding the corrosion addition t_s, given in Sec 8.6.10.1 to the net thickness t_{net}.

Material for the hatch covers shall be steel according to the requirements for ship's hull.

The design of closing arrangements for all hatch covers shall comply with the requirments provided in Pt 4, Ch 6.
(IACS S21.1, Rev. 4, Corr. 1)

8.6.2 Hatch Cover Load

The pressure p , on the hatch cover panels is provided below:
For ships with length 100 m and above:

p = $34.30 + 4\ (p_{FP} – 34.30)\ (0.25 – [x / L_F])$

Where,

P_{FP} = Pressure at the forward perpendicular
= $49.10 + (L_F – 100)\ a$

a = 0.0726 for Type B freeboard ships
= 0.356 for ships with reduced freeboard

L_F = Freeboard length (m) as provided in Pt 3, Ch 1, Sec 2.

x = Distance (m) of the mid length of the hatch cover under examination from the forward end of L_F.

For ships less than 100m in length:

p = $15.80 + ([L_F / 3]\ [1 – 5x/ 3L_F]) – (3.60\ [x / L_F])$ (kN/m^2)

Where,

P $\geq 0.195\ L_F + 14.90$, for hatch ways located at the freeboard deck.

Where two or more panels are connected by hinges, each individual panel shall be considered separately.
(IACS S21.2, Rev 4, Corr 1)

8.6.3 Hatch Cover Strength Criteria

8.6.3.1 Allowable stress check

The normal and shear stresses σ and τ in the hatch cover structures shall not exceed the allowable values σ_a and τ_a, as provided below:

σ_a = $0.80\ \sigma_F$ (N/mm^2)
τ_a = $0.46\ \sigma_F$ (N/mm^2)

Where

σ_F = Minimum upper yield stress (N/mm^2) of the material

The normal stress in compression of the attached flange of primary supporting members shall not exceed 0.8 times the critical buckling stress of the structure according to the buckling check as given in Pt 3, Ch 14.

The stresses in hatch covers that are designed as a grillage of longitudinal and transverse primary supporting members shall be determined by a grillage or a FE analysis.

When a beam or a grillage analysis is used, the secondary stiffeners shall not be included in the attached flange area of the primary members. When calculating the stresses σ and τ, the net scantlings shall be considered.

In case of stiffeners of variable cross-section, refer Pt 4, Ch 6, Sec 5.4.
(IACS S21.3.1, Rev 4, Corr 1)

8.6.3.2 Effective cross sectional area of panel flanges for primary supporting members.

The effective flange area A_f, (cm^2), of the attached plating, to be considered for the yielding and buckling checks of primary supporting members, when calculated by means of a beam or grillage model, is obtained as the sum of the effective flange areas of each side of the girder web as appropriate:

$$A_f = \sum_{nf} (10\, b_{ef}\, t)$$

Where,
nf = 2 the flange of the attached plate extends on both sides of the web
= 1 the flange of the attached plate extends on one side of the web
t = Net thickness (mm) of considered attached plate
b_{ef} = Effective breadth (m) of attached plate flange on each side of girder web
= b_p, but shall not be taken greater than 0.165l
bp =Half distance (m) between the considered primary supporting member and the adjacent one.
l = Span (m) of the primary supporting members
(IACS UR S21.3.2, Rev 4, Corr 1)

8.6.3.3 Local net plate thickness
Local net plate thickness t, of the hatch cover top plating shall not be less than the following:
$t = (s\, F_p / 0.0633)\ (\{ p / [0.95\, \sigma_f] \}^{0.5})$ (mm)

But shall not be less than 1% of the stiffener spacing or 6 mm if that being greater.
Where,
F_p = Factor for combined membrane and bending response
= 1.50 in general
= $1.90\ \sigma / \sigma_a$, for $\sigma / \sigma_a \geq 0.80$, for the attached plate flange of primary supporting members
s = Stiffener spacing (m)
p = As provided in Sec 8.6.2.
σ = As provided in Sec 8.6.3.5
σ_a = As provided in Sec 8.6.3.1
(IACS UR S21.3.3, Rev 4, Corr 1)

8.6.3.4 Net scantlings of secondary stiffeners

The minimum net section modulus, of secondary stiffeners of the hatch cover top plate based on stiffener net member thickness is provided as below:

$Z = (83.4\ s\ p\ l^2 / \sigma_a)$ (cm^3)

Where,
l = Secondary stiffener span (m) shall be taken as the spacing of primary supporting members or the distance between a primary supporting members and the edge support, as applicable. When brackets are fitted at both ends of all secondary stiffener spans, the secondary stiffener span may be reduced by an amount equal to 2/3 of the minimum brackets arm length, but not greater than 10% of the gross span, for each bracket
s = Secondary spacing (m)

The net section modulus of the secondary stiffeners shall be determined based on an attached plate width assumed equal to the stiffener spacing
(IACS UR S21.3.4., Rev 4, Corr 1)

8.6.3.5 Net scantlings of primary supporting members

The section modulus and web thickness of primary supporting members, based on member net thickness, shall be such that the normal stress σ in both flanges and the shear stress τ, in the web, do not exceed the allowable values σ_a and τ_a, respectively, as given in Sec 8.6.3.1.

Breadth of the primary supporting member flange shall not be less than 40% of their depth for laterally unsupported spans greater than 3.0 m. Tripping brackets attached to the flange may be considered as a lateral support for primary supporting members.

The flange outstand shall not exceed 15 times the flange thickness.
(IACS UR S21.3.5, Rev 4, Corr 1).

8.6.4 **Buckling**

8.6.4.1 Plate buckling of hatch covers with primary supporting members parallel to the direction of secondary stiffeners shall be in accordance with Pt 3, Ch 14, Sec 2 with ψ = 1.0.

Plate buckling of hatch covers with primary supporting members perpendicular to the direction of secondary stiffeners shall be in accordance with Pt 3, Ch 14, Sec 2.

For secondary stiffeners, buckling shall comply with the requirements as provided in Pt 3,Ch 14, Sec 3.

For flat bar secondary stiffeners and buckling stiffeners, the ratio h/tw shall not be greater than $15\ (k_m)^{0.50}$.

Where,
h = height of stiffener
t_w = net thickness of stiffener

Buckling for web panels for hatch cover primary supporting members shall be in accordance with Pt 3, Ch 14, Sec 2.3.

For primary supporting members parallel to the direction of secondary stiffeners, the actual dimensions of the panels shall be considered.

For primary supporting members perpendicular to the direction of secondary stiffeners or for hatch covers built without secondary stiffeners, a presumed square panel of dimension d shall be taken for the determination of the stress τ_c. In such a case, the average stress τ between the values calculated at the

ends of this panel shall be considered.
(IACS UR S21.3.6 Rev 4, Corr 1)

8.6.5 Deflection Limit and Connections Between Hatch Cover Panels

8.6.5.1 The load bearing connections between the hatch cover panels shall be fitted with the purpose of restricting the relative vertical displacements.

8.6.5.2 The vertical deflection of primary supporting members shall not be more than 0.0056 l, where l is the greatest span of primary supporting members.
(IACS UR S21.3.7 Rev 4, Corr 1)

8.6.6 Hatch Coaming Load Model

The pressure p_{coam}, on the No.1 forward (foremost hold) transverse hatch coaming is provided by:

p_{coam} = 220 (kN/m^2), when a forecastle is fitted in accordance with Sec 8.7
= 290 (kN/m^2), in other cases

The pressure p_{coam} on the other other hatch coamings is provided as below:

p_{coam} = 220 (kN/m^2)

(IACS UR S21.4.1 Rev 4, Corr 1)

8.6.7 Hatch Coaming Strength Criteria

8.6.7.1 Local net plate thickness
The local net plate thickness of the hatch coaming plate is provided as below:

$$t = (s / 0.067) \left([p_{coam} / \sigma_{a,\,coam}] \, S_{coam} \right)^{0.50} \quad \text{(mm)}$$

Where,
s = Spacing (m) of secondary stiffener
p_{coam} = As provided in Sec 8.6.3.1.
S_{coam} = Safety factor
= 1.15
$\sigma_{a,coam}$ = 0.95 σ_f

The local net plate thickness shall not be less than 9.50 mm.
(IACS UR S21.4.2 Rev 4, Corr 1)

8.6.7.2 Net scantlings of longitudinal and transverse secondary stiffeners
The required net section modulus of the longitudinal or transverse secondary stiffeners of the hatch coamings, based on net member thickness, is provided as below:

$$Z = (1000 \, S_{coam} \, l^2 \, s \, p_{coam}) / (m \, c_p \, \sigma_{a,coam}) \quad (\text{cm}^3)$$

Where,
m = 16 in general
= 12 for the end spans of stiffeners sniped at the coaming corners
l = Span (m) of secondary stiffeners
c_p = Ratio of the plastic section modulus to the elastic section modulus of the secondary stiffeners with an attached plate breadth equal to 40t, where t is the net plate thickness.
= 1.16 in the absence of precise evaluation
(IACS UR S21.4.3 Rev 4, Corr 1)

8.6.7.3 Net scantling of coaming stays

The minimum required net section modulus and net we thickness of coaming stays designed as beams with flange connected to the deck or sniped and fitted with a bracket, refer Fig 17, at their connection with the deck, based on member net thickness is provided as below:

$Z = (500\ H_c^2\ S\ p_{coam}) / (2\ \sigma_{a,coam})$ (cm³)
$t_w = (1000\ H_c\ s\ p_{coam}) / (h\ \tau_{a,coam})$ (cm³)

Where,
H_c = Height of stay (m)
S = Spacing of stay (m)
h = Depth of stay (mm), at the connection with the deck
$\tau_{a,coam} = 0.50\ \sigma_t$

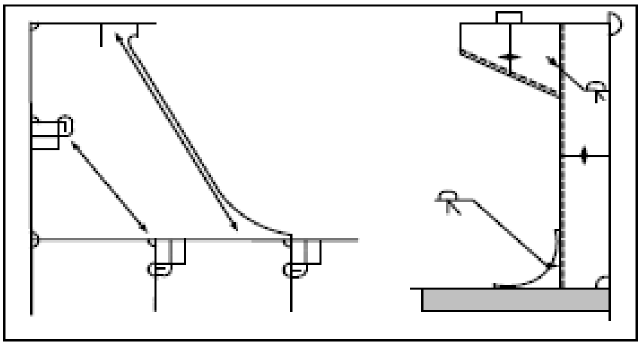


Fig 17 Hatch Coaming

For calculating the section modulus of coaming stays, their face plate area shall be taken into account only when it is welded with full penetration welds to the deck plating and adequate under deck structure is fitted to support the stresses transmitted by it.

For other designs of coaming stays, such as for example those shown in Fig.18, the stress levels as given in Sec 8.6.3.1 apply and shall be checked at the highest stressed locations.
(IACS UR S21.4.4, Rev 4, Corr 1)

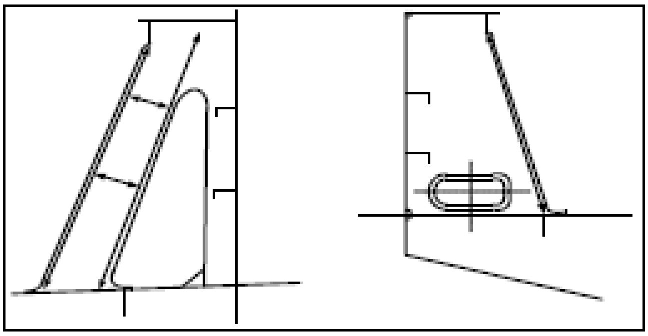


Fig 18 Hatch Coaming (Alternate)

8.6.8 **Local Details**

8.6.8.1 The design of local details for the purpose of transferring the pressure on the hatch covers to the hatch coamings and, through them, to the deck structures below, shall comply with requirements given in Pt 4, Ch 6.

The hatch coamings and supporting structures shall be adequately strengthened to accommodate the loading from hatch covers, in longitudinal, transverse and vertical directions.

Under deck structures shall be checked against the load transmitted by the stays, adopting the same allowable stresses as given in Sec 8.6.7.3.

Those ships without forecastle or breakwater, the scantlings of the coamings for the No.1 hold (foremost hold) shall not be less than that required by Pt 3, Ch 10 for front bulkheads of deckhouses at that position.

Weld connections and materials shall be dimensioned and selected in accordance with Pt 3, unless stated otherwise.

Double continuous welding shall be adopted for the connections of stay webs with deck plating and the weld throat shall not be less than 0.44 t_w, where t_w is the gross thickness of the stay web. Toes of stay webs shall be connected to the deck plating with deep penetration double bevel welds extending over a distance not less than 15% of the stay width.
(IACS UR S21.4.5, Rev 4, Corr 1)

8.6.9 **Closing Arrangements**

8.6.9.1 The strength of securing devices shall comply with the following requirements:

Appropriate devices such as bolts, wedges or similar arrangement suitably spaced alongside the coamings and between cover elements shall be provided to secure the panel hatch covers.

Arrangement and spacing shall be determined with due attention to the effectiveness for weather-tightness, depending upon the type and size of the hatch cover, as well as on the stiffness of the cover edges between the securing devices.

The net sectional area of each securing device shall not be less than the following:

$A = 1.40\ (a / f)$ (cm^2)

Where,
a = Spacing (m) of the securing devises, but not less than 2.00 m
f = $(\sigma_y\ 235)^e$
σy = Specified minimum upper yield stress (N/mm^2) of the steel used for fabrication, shall not be taken greater than 70% of the ultimate tensile strength
e = 0.75 for $\sigma_y > 235$ MPa
= 1.00 for $\sigma_y \leq 235$ MPa

Rods or bolts shall have a net diameter not less than 19 mm for hatchways exceeding 5 m^2 in area.

Between cover and coaming and a cross-joints, a packing line pressure sufficient to obtain weather tightness shall be maintained by the securing devices.

For packing line pressures exceeding 5 N/mm, the cross-section area shall be increased in direct proportion. The packing line pressure shall be specified.

The cover edge stiffness shall be sufficient to maintain adequate sealing pressure between securing devices. The minimum moment of inertia of edge elements shall be as detailed below:

$I = 6\ p\ a^4$ (cm^4)

Where,
p = Packing line pressure (N/mm) with minimum of 5 N/mm
a = Spacing (m) of securing devices

Securing devices shall be of reliable construction and securely attached to the hatchway coamings, decks or covers. Individual securing devices on each cover shall have approximately the same stiffness characteristics.

Where rod cleats are fitted, resilient washers or cushions shall be incorporated. Where hydraulic cleating is adopted, a positive means shall be provided to ensure that it remains mechanically locked in the closed position in the event of failure of the hydraulic system.
(IACS UR S21.5.1, Rev 4, Corr 1)

8.6.9.2 Hatch covers shall be effectively secured, by means of stoppers, against the transverse forces arising from a pressure of 175 kN/m^2.

With the exclusion of the No. 1 (foremost hold) hatch cover, hatch covers shall be effectively secured, by means of stoppers, against the longitudinal forces acting on the forward end arising from a pressure of 175 kN/m^2.

With the exclusion of the No. 1 (foremost hold) hatch cover, hatch covers shall be effectively secured, by means f stoppers, against the longitudinal forces acting on the forward end arising from a pressure of 175 kN/m^2.

The No. 1 (foremost hold) hatch cover shall be effectively secured, by means of stoppers, against the longitudinal forces acting on the forward end arising from a pressure of 230 kN/m^2.

This pressure may be reduced to 175 kN/m^2 when a forecastle is fitted in accordance with Sec 8.7.

The equivalent stress in stoppers and their supporting structures, and at the throat of stopper welds shall not exceed the allowable value of 0.8 σy.

(IACS UR S21.5.2, Rev 4, Corr 1)

8.6.9.3 Stoppers or securing devices shall be manufactured from materials, including welding electrodes, meeting relevant IACS requirements.
(IACS UR S21.5.3, Rev 4, Corr1)

8.6.10 Steel Renewal and Corrosion Addition

8.6.10.1 Hatch covers
For all structures including plating, stiffeners etc of single skin hatch cover, the corrosion addition t_s shall be 2.0 mm. For double skin hatch covers, the corrosion addition shall be considered as below:
For top and bottom plating: 2.00 mm
For all internal structures: 1.50 mm

For single skin hatch covers and for the plating of double skin hatch covers, steel renewal is required where the gauged thickness is less than t_{net} + 0.50 mm.

Where the gauged thickness is within the range t_{net} + 0.5 mm and t_{net} + 1.0 mm, coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal. Coating shall be maintained in good condition.

For the internal structure of double skin hatch covers, thickness gauging is required when plating renewal shall be carried out or when this is deemed necessary, at the discretion of the surveyor, on the basis of the plating corrosion

or deformation condition. In these cases, steel renewal for the internal structures is required where the gauged thickness is less than t_{net}.
(IACS UR S21.6.1, Rev 4, Corr 1)

8.6.10.2 Hatch coamings
For the hatch coamings and coaming stays, the corrosion addition t_s shall be 1.50 mm. When the gauged thickness is less than t_{net} + 0.50 mm, steel renewal is required.

Where the gauged thickness is within the range t_{net} + 0.5 mm and t_{net} + 1.0 mm, coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal. Coating shall be maintained in good condition,
(IACS UR S21.6.2, Rev 4, Corr 1)

8.7 Requirements for the Fitting of a Forecastle for Bulk carriers, Ore carriers and Combination Carriers

8.7.1 Application and Definition

8.7.1.1 The requirements apply to ships as provided in Sec 5.1.5 and Sec 12, Table 12.1.3.
(IACS UR S28.1, Rev 2)

8.7.1.2 Structural arrangements and scantlings of the forecastle shall comply with requirements as given in Pt 3.
(IACS UR S28.1, Rev 2)

8.7.2 Dimensions

8.7.2.1 The forecastle shall be located on the freeboard deck with its aft bulkhead fitted in way of the forward bulkhead of the No. 1 hold (foremost hold), refer Fig. 19.

However, if this requirement hinders hatch cover operation, the aft bulkhead of the forecastle may be fitted forward of the forward bulkhead of the foremost cargo hold provided the forecastle length is not less than 7% of the ship length abaft the forward perpendicular where the ship length and forward perpendicular are defined in the International Convention on Load Line 1966 and its protocol 1988.
(IACS UR S28.2, Rev 2)

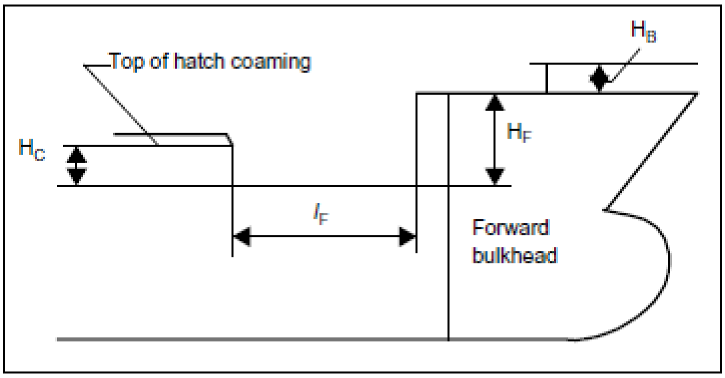


Fig 19 Forecastle Details

8.7.2.2 The height H_F above the main deck shall not be less than the greater of the following:

- HC + 0.5 m, where HC is the height of the forward transverse hatch coaming of cargo hold No.1 (foremost hold).

- The standard height of a superstructure as specified in the International Convention on Load Line 1966 and its Protocol of 1988.
(IACS UR S28.2, Rev.2)

8.7.2.3 All points of the aft edge of the forecastle deck shall be located at a distance l_F, refer Fig 19:

$l_F \leq 5 (H_F - H_C)^{0.50}$

from the hatch coaming plate in order to apply the reduced loading to the No.1 forward (foremost hold) transverse hatch coaming and No.1 (foremost hold) hatch cover in applying Sec 8.6.6 and Sec 8.6.9.2, respectively.
(IACS UR S 28.2, Rev. 2)

A breakwater shall not be fitted on the forecastle deck with the purpose of protecting the hatch coaming or hatch covers. If fitted for other purposes, it shall be located such that its upper edge at centre line is not less than H_B / tan 20° forward of the aft edge of the forecastle deck, where H_B is the height of the breakwater above the forecastle, refer Fig 19.
(IACS UR S 28.2, Rev. 2)

8.8 Coating Protection

8.8.1 Application

8.8.1.1 These requirements apply to ships as given in Sec 5.1.4 to Sec 5.1.5 and Sec 12 Table 12.1.2 and Table 12.1.3.

8.8.2 Protective Coatings of Double-side Skin Spaces of Bulk carriers

8.8.2.1 Double-side skin spaces arranged in ships with freeboard length L_F (ref. Pt 3, Ch 1, Sec 2.1 ≥ 150 m shall be coated during construction same as for dedicated ballast tanks in accordance with Table 7.1.1 in Pt 4, Ch 7, Sec 1.2/ Sec 1.3.
Note:
For the purpose of applying coating, the top wing void space arranged in ships with freeboard length L_F ≥ 150 m may be interpreted as not a part of double-side skin spaces.

8.8.3 Corrosion Protection Coatings for Cargo Hold Spaces on Bulk Carriers

8.8.3.1 All internal and external surfaces of hatch coamings and hatch covers and all internal surfaces of the cargo holds, excluding the flat tank top areas and the hopper tanks sloping plating and transverse bulkheads bottom stool approximately 300 mm below the side shell frame and brackets, shall have an efficient protective coating (epoxy or equivalent) applied in accordance with the manufacturer's and builder's recommendation. (Refer Fig. 20).

Note:
In the selection of coating, due consideration should be given by the owner to intended cargo conditions expected in service.

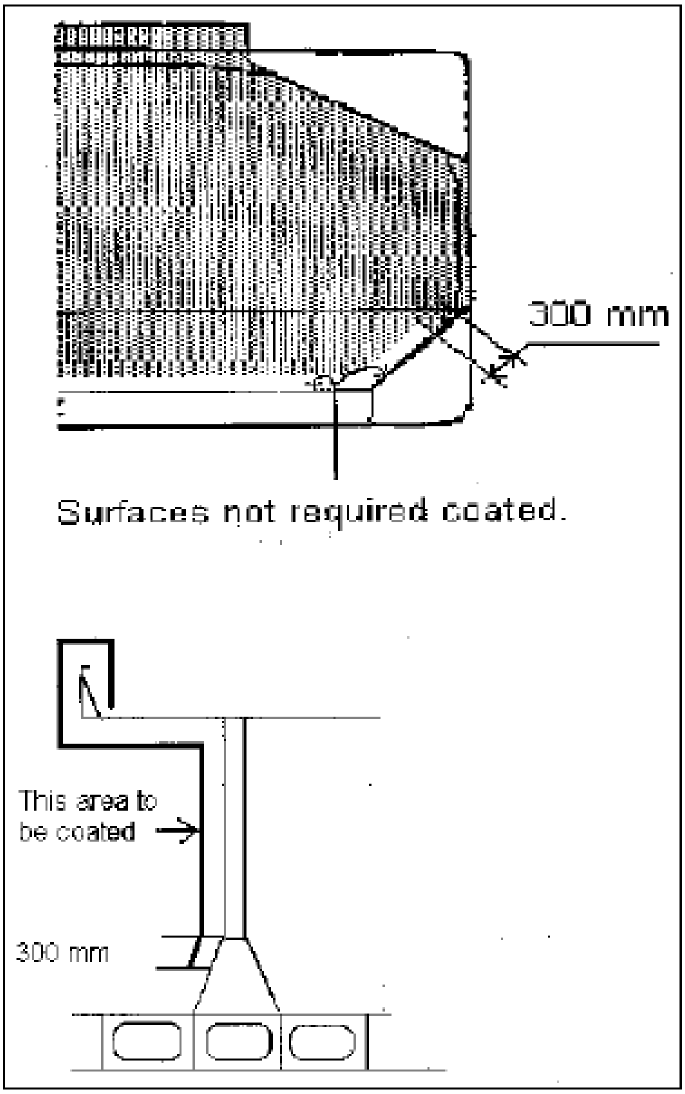


Fig 20 Extend of Coating. Transvers Bhds Bottom Stool as for Hopper Tank

8.9 Additional Safety Measures

8.9.1 Application

8.9.1.1 These requirements apply to ships as given in Sec 5.1.5 and Sec 12, Table 12.1.2.

8.9.2 Access to and Within Spaces in and Forward of the Cargo Area

8.9.2.1 For ships of gross tonnage ≥ 20,000 with notation **Bulk Carrier ESP** or **Ore Carrier ESP**, access to and within spaces in, and forward of, the cargo area shall comply with SOLAS Regulation II-1/3-6.

8.9.3 Structural and Other Requirements

8.9.3.1 For ships with double side skin construction of freeboard length L_F (ref. Pt 3, Ch 1, Sec 2.1) ≥ 150m, in all areas with double-side skin construction shall comply with the following requirements:

1) Primary stiffening structures of the double-side skin shall not be placed inside the cargo hold space.

2) Subject to the provisions below, the distance between the outer shell and the

inner shell at any transverse section shall not be less than 1000 mm measured perpendicular to the side shell. The double-side skin construction shall be such as to allow access for inspection as provided in SOLAS regulation II-1/3-6 and the Technical Provisions referring thereto.

- The clearances below need not be maintained in way of cross ties, upper and lower end brackets of transverse framing or end brackets of longitudinal framing.

- The minimum width of the clear passage through the double-side skin space in way of obstructions such as piping or vertical ladders shall not be less than 600 mm.

- Where the inner and/or outer skins are transversely framed, the minimum clearance between the inner surfaces of the frames shall not be less than 600 mm.

- Where the inner and outer skins are longitudinally framed, the minimum clearance between the inner surfaces of the frames shall not be less than 800 mm. Outside the parallel part of the cargo hold length, this clearance may be reduced where necessitated by the structural configuration, but, in no case, shall be less than 600 mm.

- The minimum clearance referred to above shall be the shortest distance measured between assumed lines connecting the inner surfaces of the frames on the inner and outer skins.
  (SOLAS XII/6.2)

8.9.3.2 The double-side skin spaces, with the exception of top-side wing tanks, if fitted, shall not be used for the carriage of cargo.
(SOLAS XII/6.3)

For ships with freeboard length L_F (refer Pt 3, Ch 1, Sec 2.1) ≥ 150m, carrying solid bulk cargoes having a density ≥ 1.0ton/m3, following requirements shall be complied with:

1) The notation IB-3 is mandatory. For ships with HC-M, IB-1 or IB-2 may be applied instead.

2) Wire rope grooving in way of cargo holds openings is to be prevented by fitting suitable protection such as half-round bar on the hatch side girders (i.e. upper portion of top side tank plates)/hatch end beams in cargo hold and upper portion of hatch coamings;

3) Effective continuity between the side shell structure and the rest of the hull structure shall be assured; and

4) For ships with single side structures the material grade shall not be less than grade D/DH for:

— Lower bracket of side frame
— Side shell plate between two points located to 0.125*l* above and 0.125*l* below the intersection of side shell and bilge hopper sloping plate or inner bottom plate. The span of the side frame, *l*, is defined as the distance between the supporting structures.

In case of side frames built with multiple spans, the above requirements apply to the lower part only. Illustrations are given in Fig.21.

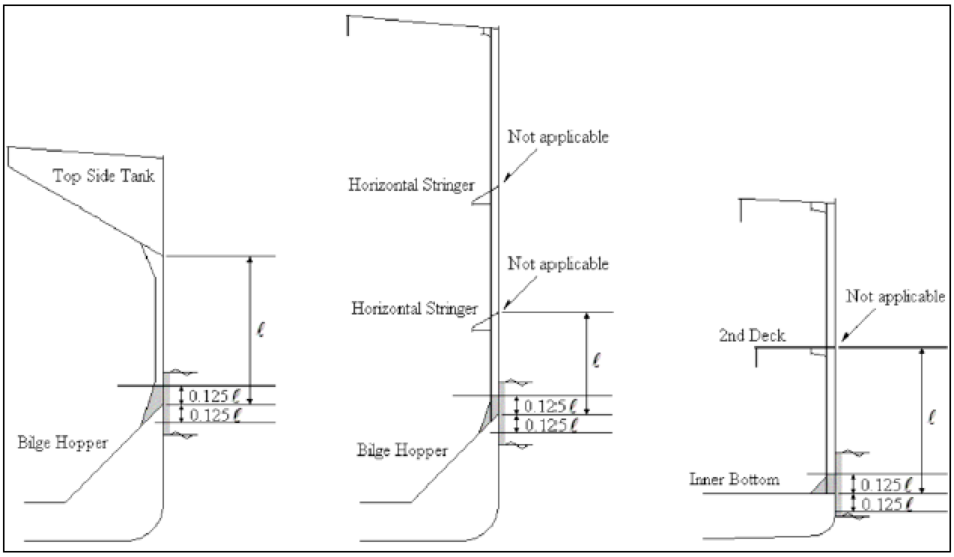


Fig 21 Side Frame Details

5) The lateral buckling requirements of longitudinal and transverse ordinary stiffeners shall be in accordance with Pt 3, Ch 14, Sec 3.2.2, in which the utilisation factor η shall be 0.85 divided by 1.15, i.e., 0.74 for the following areas:

- Stiffened transverse bulkhead (if any)
- Top stool and bottom stool of transverse bulkhead (if any)
- Side hell (if directly bounding the cargo hold)
- Inner bottom
- Inner side (if any)
- Sloped stiffened panel of topside tanks and hopper tanks (if any)
- Hatchway coaming

(SOLAS XII/6.4, IACS UI SC208 & 209)

Note:
For longitudinals, the compressive stress may be taken as the longitudinal stress as specified in Pt 3, Ch 14, Sec 2.2.3. For other stiffeners, the compressive stress may be taken as the axial stress as found from direct strength calculations.

8.9.4 **Hold, Ballast and Dry Space Water Ingress Alarms: Requirements**

8.9.4.1 Water level detectors capable of giving audio visual alarms at the navigation bridge shall be installed in the bulk carriers.

1) In each cargo hold, one when the water level above the inner bottom in any hold reaches a height of 0.5 m and another at a height not less than 15% of the depth of the cargo hold but not more than 2.0 m.

2) In any ballast tank forward of the collision bulkhead, when the liquid in the tank reaches a level not exceeding 10% of the tank capacity.

3) In any dry or void space other than a chain cable locker, any part of which extends forward of the foremost cargo hold, at a water level of 0.10 m above the deck. Such alarms need not be provided in enclosed spaces the volume of which does not exceed 0.1% of the ship's maximum displacement volume. (SOLAS Ch. XII/12)

8.9.4.2 The water ingress detection system shall be type tested in accordance with MSC.188 (79) "Performance Standards for Water Level Detectors on Bulk Carriers", and be suitable for the cargoes intended.

Note:
The appendix to the Classification Certificate will contain information as to which cargoes the systems are approved for.

8.9.5 **Hold, Ballast and Dry Space Water Ingress Alarm: Installation**

8.9.5.1 Water ingress sensors shall be located in a protected position that is in communication with the after part of the cargo hold or tank and or space, such that the position of the sensor detects the level that is representative of the levels in the actual hold space or tank.

Sensors shall be located at:

- Either as close to the centre line as practicable, or
- at both the port and starboard sides

8.9.5.2 Installation of detector shall not obstruct the use of any sounding pipe or other water level gauging device for cargo holds or other spaces.

8.9.5.3 Detectors and equipment shall be installed where they are accessible for survey, maintenance and repair.

8.9.5.4 Any filter element fitted to detectors shall be capable of being cleaned before loading.

8.9.5.5 Electrical cables and any associated equipment installed in cargo holds shall be protected from damage by cargoes or mechanical handling equipment associated with bulk carrier operations, such as in tubes of robust construction or in similar protected locations.

8.9.5.6 The part of the electrical system which has circuitry in the cargo area shall be arranged intrinsically safe.

8.9.5.7 The power supply shall be in accordance with Pt.6

8.9.6 **Hold, Ballast and Dry Space Water Ingress Alarm: Survey Onboard**

8.9.6.1 Post installation the system is subject to survey consisting of:

- Installation inspection
- Demonstration of filter cleaning facilities
- Demonstration of detector testing
- Alarm loop testing
- Alarm panel functional test

8.9.7 **Availability of Drainage Forward Spaces**

8.9.7.1 On board bulk carriers, means for draining and pumping ballast tanks forward of the collision bulkhead, and bilges of dry spaces, any part of which extends forward of the foremost cargo hold, shall be capable of being brought into operation from a readily accessible enclosed space. The location of which shall be accessible from the navigation bridge or propulsion machinery control position, without need for traversing exposed freeboard or superstructure decks. (SOLAS reg XII/13)

This does not apply to the enclosed spaces the volume of which does not exceed 0.1% of the ship's maximum displacement volume. Nor does it apply to the chain cable lockers.

.

8.9.7.2 Dewatering system for ballast tanks forward of the collision bulkhead and for bilges of dry spaces any part of which extends forward of the foremost cargo

hold shall be designed to remove water from the forward spaces at a rate of not less than 320A m3/h, where A is the cross-sectional area in m2 of the largest air pipe or ventilator pipe connected from the exposed deck to a closed forward space that is required to be dewatered by these arrangements.
(IACS UR M65)

8.9.7.3 The installation and survey on board shall be in accordance with Pt.5A for bilge systems.

SECTION 9 SHIPS SPECIALISED FOR CARRIAGE OF SINGLE TYPE OF DRY BULK CARGO

Contents

9.1 General

9.1.1 Classification

9.1.1.1 Requirements in this section apply to ships intended for the carriage of a single cargo type. The notation **X Carrier** may be given to ships built in compliance with the requirements in this section, where **X** denotes the type of cargo to be carried, e.g. **Alumina**, **Cement**, **Sugar** etc.

9.1.1.2 Cargo holds shall be arranged with a closed loading and unloading arrangement. Documentation of the intended loading and unloading system shall be submitted for information.

9.1.1.3 The ships, in general, to have a double bottom within the cargo region and have double sides and a single deck. Hatches to cargo holds shall be arranged as required for access only, and for the closed loading and unloading arrangement.

9.1.2 Documentation

9.1.2.1 Information regarding the properties of the cargo, relevant to the design (eg. bulk density, angle of repose, humidity limit, etc.) shall be submitted for information.

9.1.2.2 Information regarding the intended cargo and ballast conditions, including typical loading and unloading sequences, shall be submitted for approval. This shall include conditions with uneven distribution of cargo between holds, e.g. part loading conditions with empty cargo holds, as applicable.

9.1.3 Design Loads

9.1.3.1 Design pressures for local elements, i.e. plates and stiffeners, shall be as detailed in Pt 3, Ch 4, using parameters as provided in Sec 9.1.2, as applicable.

9.1.3.2 In the direct calculations, design pressures shall be as detailed in Pt 3, Ch 14, using the information given in Sec 9.1.2.

9.1.4 Longitudinal Strength

9.1.4.1 The longitudinal strength shall be determined as provided in Pt 3, Ch 5. The ships shall belong to category I, refer Pt 3, Ch 5, Sec 4 or Pt 3, Ch5, Sec 1. Ships intended for the carriage of homogeneous loads only, may upon request, be considered according to the requirements for ships in category II.

9.1.5 Plating and Stiffeners

9.1.5.1 Minimum plate thickness and the cross-sectional properties of stiffeners are in general to be calculated as detailed in Pt 3, using design pressures according to Sec 9.1.2 where applicable.

9.1.5.2 Minimum thickness of the inner bottom plating of the double bottom of cargo holds, shall be taken as given in Pt 3, Ch 6, Sec 3.4.2 for ships with length less than 100 m, with t_o = 5 mm.

9.1.5.3 The section modulus of longitudinal stiffeners of double bottom structures shall be calculated, as detailed in Pt 3, Ch 6, with double bottom stress $\sigma_{db} = 20 / k_m$ (N/mm^2). For ships designed for non-homogeneous seagoing loading conditions, the section modulus of double bottom longitudinals is also to be calculated, as detailed in Pt 3, Ch 5, Sec 3.3, based on double bottom stresses as is determined according to Sec 9.1.6.

9.1.6 **Girder Systems**

9.1.6.1 Primary structure scantlings of the bottom, sides, transverse bulkheads and deck of the cargo region may have to be determined, based on a direct stress analysis, as considered necessary by the Society.

9.1.6.2 Wherever direct calculations are considered necessary, the following cases are normally to be considered:

a) Unevenly distributed cargo between the holds (harbour). The design condition shall be based on the intended loading and unloading sequence.

b) Unevenly distributed cargo between the holds, as applicable, according to the ship's loading manual (seagoing).

c) Ballast condition (Seagoing).

SECTION 10 CARRIAGE OF REFRIGERATED CONTAINERS

Contents

10.1 Classification

10.1.1 Application

10.1.1.1 This section applies to ships equipped to carry refrigerated containers in hold and/ or on deck when the class notation in Sec 10.1.2 is requested.

10.1.1.2 Refrigerated container means a container with a self-contained refrigeration system, located within the containers outer dimensions and driven by electrical power fed from an external power supply. This may be a clip-on or an integral unit.

10.1.1.3 Alarm and monitoring system installed in the individual containers not covered in this section.

10.1.1.4 Those ships with novel arrangement and design not directly covered by these rules may also be given the notations described in Sec 10.1.2 after special consideration with respect to documentation and testing.

10.1.2 Class Notation

10.1.2.1 Those vessels designed, built, equipped and tested under the supervision of the Society in compliance with the requirements of this section may be given the additional class notation: **RC-1**, **RC-2** or **RC-3**

10.1.2.2 Class notation **RC-1**:
Applicable for vessels that carry mostly fruit (bananas) and chilled cargo in addition to deep frozen cargoes, i.e. a design ratio between 80% and 100% chilled cargo.

10.1.2.3 Class notation **RC-2**:
Applicable for vessels that carry both frozen and chilled cargo with a design ratio of between 50% and 80% chilled cargo.

10.1.2.4 Class notation **RC-3**:
Applicable for vessels mainly intended for vessels that carry mostly deep frozen cargoes with a design ratio below 50% chilled cargo.

10.1.2.5 For ships with class notations as given in Sec 10.1.2.2 to Sec. 10.1.2.4, will in addition be given a notation of the maximum number of forty-foot equivalent refrigerated units (FEU) that may be carried, eg. (200/70) meaning that the vessel may carry 200 reefer containers on deck and 70 in the holds.

The following information shall be submitted:
- Ambient conditions and details
- Design ratio of chilled cargo
- Number of containers that may be loaded which are not at their pre-determined set temperature

This information will be included in the Appendix to the Classification Certificate.

10.2 Operational Performance

10.2.1 General

10.2.1.1 The ship shall be designed, arranged and equipped to make it suitable for carrying cargoes as relevant according to the design operating conditions and class notation. The builders and possible sub contractor’s specifications of the ships operational performances and abilities will together with the specific requirements of this chapter will be used as basis for assignment of class.

10.2.1.2 The refrigerated containers in general are at their predetermined set temperature at the time of loading. If containers shall be loaded which are not at their predetermined set temperature this shall be taken into consideration when calculating the capacity required for the electrical and ventilation systems.

10.2.1.3 It is considered that the container refrigeration units are capable of functioning fully at an ambient temperature of +50°C.

10.3 Documentation

10.3.1 Plans and Particulars

10.3.1.1 The following plans and particulars shall be submitted for approval,as relevant:

a) General:

The builders and possible subcontractor's specifications of the ships operational performances and abilities, for information.

b) Ventilation Arrangement:

Location and installation details of ventilation system showing duct arrangement and sizes, for each hole, including schematic arrangement of the ventilation system showing proposed air volume and velocity at junctions.

Details of all fans including location, number, design condition, capacities and power consumption.

Details or air inlets and outlets including number, type, size and location.

Details and location of dampers and flaps, if applicable.

Calculation of specified air through put rate and proposals for it's measurement.

Design temperature rise in the hold space and corresponding ambient air temperature and relative humidity.

Cooling water systems for containers equipped with water cooled condensers (fresh and sea water).

c) Hull Structure:

Design pressure of vacuum in each hold
Hatch cover sealing arrangements and details
Personnel access arrangements
Pressure vacuum safety valves and details in each hold space
Details of associated openings through the hull structure

d) Electrical Installation in accordance with Pt.6

Electric power demand calculation covering all refrigerated containers and the necessary fans.

e) Control and Monitoring System:

Refrigerating container supply monitoring
Ventilation control and monitoring.

For documentation types, refer Pt 6

f) Testing:

Testing and commissioning program details, including description and set-up of instrumentation to be used to verify installation.

10.4 Ventilation and Hold Temperature

10.4.1 General

10.4.1.1 Effective provision shall be provided to remove the waste heat, from each container refrigerant condenser and electrical motors, local to the condenser's air outlet. This shall be arranged in such a way as to minimize the effect on the hold space temperature. This may be accomplished by the use of a ventilation system or a combination of ventilation and water cooling.

10.4.1.2 Air distribution systems to be provided for air supply directed to each container refrigeration unit.

10.4.1.3 For each stack intended for refrigerated containers, separate supply air duct and fan shall be provided, except for the outermost stacks and in way of access to hold which may be arranged such that one duct splits into two.

10.4.1.4 The positions of supply air inlets and exhaust air outlets shall be such as to reduce the possibility of short circuit. The effect heat ingress from deck stowed containers into the hold as well as the effects of warm exhaust air on deck stowed containers shall be considered.

10.4.1.5 Air flow resistance between container refrigeration units and the exhaust air outlets shall be minimised. Restrictions to the free air flow by walkways etc. shall be kept to a minimum.

10.4.1.6 Where container holds are designed for simultaneous carriage of 8'6'' and 9'6'' containers the ventilation supply outlets shall be adjustable to allow direct air supply to the containers condenser independent of the stowage pattern.

Note:
As most of the refrigerated containers are high cube containers (9'6'') it is advisable to optimise the reefer positions for this size of container. Reference is also made to Sec 10.7.1.4 concerning access to reefer containers.

10.4.1.7 Means of stopping all ventilation fans shall be provided (outside the spaces being served) at positions which will not be cut-off in the event of fire in the hold. Fans shall be controlled centrally from a position outside of the hold. In case of fire arrangements shall be provided to permit a rapid shutdown and effective closure of the ventilation system in each hold space.

10.4.1.8 A minimum of one replacement fan, or fan motor, of each size shall be carried onboard. Fans shall be arranged to enable each to be replaced whilst the remaining parts of the system continue in operation.

10.4.1.9 Cargo hold ventilation inlet and exhaust openings shall be arranged such that air supply to the refrigerated containers will be ensured also under heavy weather conditions.

10.4.2 Air Supply

10.4.2.1 Design ambient climatic conditions are in general not to be taken less than air 35°C, seawater 32°C and relative humidity 70%.

10.4.2.2 Permissible cargo hold temperature in general shall not exceed 45^{0}C.

10.4.2.3 Supply of air for each container with air cooled condensers shall not be taken less than the following:

$$Q = 3600\ (P_{cont} + P_{fan} + Q_{resp} + Q_T)\ /\ [\rho_{air}\ c_{air}\ (T_{hold} - T_{air})]\ \ (m^3/h)$$

Where,

P_{cont} = Power demand for reefer unit, not to be taken less than the following:
= 11.0 kW minimum for 40’ container for **RC-1** notation (80% chilled)
= 8.4 kW minimum for 20’ container for **RC-1** notation (80% chilled)
= 9.8 kW minimum for 40’ container for **RC-2** notation (50% chilled)
= 7.4 kW minimum for 20’ container for **RC-2** notation (50% chilled)
= 8.6 kW minimum for 40’ container for **RC-3** notation (100% frozen)
= 6.4 kW minimum for 20’ container for **RC-2** notation (100% frozen)
For other cargo mix linear interpolation may be used.

P_{fan} = Power demand for fans (kW)
Q_{resp} = Respiration from reefer containers
= 64 W/t for **RC-1** notation, carriage of bananas
= 0 for **RC-2** and **RC-3** notation
Q_T = Heat transfer (kW) from adjacent tankes heated above 45^0C
c_{air} = Specific heat capacity of air, 1.01 kJ/(kg K) (at +35^0C, 70% RH and 101.3 kPa)
ρ_{air} = Density of air (1.13 kg/m^3) (at + 35^0C, 70% RH and 101.30 kPa)
T_{hold} = Maximum allowable hold temperature, in general not to be taken more than 45^0C.
T_{air} = Temperature of air at design ambient condition, in eneral not to be taken less than 35^0C.

10.4.2.4 For containers with water cooled condenser the required air supply shall be calculated in accordance with Sec 10.4.2.3 using the following power demand for the containers:

P_{cont} = Power demand for reefer, 2.10 kW minimum for 40’ container and 1.50 kW minimum for 20’ container.

10.4.2.5 For ships where containers shall be loaded which are not at their predetermined set temperature, additional capacity shall be conidered.

10.5 Electrical Installations

10.5.1 General

10.5.1.1 Electrical installation onboard shall comply with Pt 6. Reefer containers and ventilation systems shall be considered as important services in all sailing and manoeuvring modes planned for the vessel. However, diversity factors (simultaneous factors) as given in Sec 10.5.1.4 may be used.

10.5.1.2 Under sea-going conditions, the number and rating of service generators shall be sufficient to supply all container socket outlets and the hold space ventilation system in addition to services listed in Pt.6, when any one generator set is out of service.

10.5.1.3 Power rating and the number of all service generators shall be sufficient to supply all container sockets and the hold space ventilation system in addition to the consumers needed under manoeuvring conditions.

10.5.1.4 When calculating the electric power demand the following simultaneous factors may be applied to account for the fact that not all refrigerating units are running at the same time:

Number of Refrigerated FEU	Simultaneous Factor
≤ 100 FEU	0.90
> 100 FEU	0.84
>250 FEU	0.80
> 100 FEU	0.77

Additional capacity shall be added for ships where containers shall be loaded which are not at their predetermined set temperature. Lower values may be applied to account for different cargo mixes, such lower values shall be documented.

10.5.1.5 Socket connections for refrigerated containers shall be supplied from distribution boards, not directly from the main switchboard. The supply to these distribution boards shall be divided approximately equally between the two sides of the main switchboard with one separate supply for each distribution panel.

The number of container sockets connected to one final circuit shall not exceed 10.

Note:
The electric power supply to refrigerated container sockets should preferably be galvanic isolated from the ship mains to avoid any influence in case of insulation faults. These rules do not include any requirements to earth fault disconnection or earth fault indication for individual reefer containers.

It is not required that the generating capacity connected to each side of the main switchboard is sufficient to supply power to all reefer containers.

10.5.1.6 Distribution panels with feeder circuits for reefer containers shall provide individual indications for each outgoing feeder showing when a feeder breaker is switched on.

10.6 Instrumentation and Control System

10.6.1 **General**

10.6.1.1 Control and monitoring system shall comply with Pt 6, Ch 8.

10.6.1.2 An alarm system for monitoring of the reefer containers and required auxiliary ship systems shall be installed. This system may be integral with the ship's main alarm and monitoring system as long as a proper grouping is arranged in order to separate container alarms from other types of alarms (eg. machinery alarms). This also covers extension alarms, where any container alarms shall not disturb personnel without cargo responsibilities.

Note:
These rules do not require that the alarms for refrigerated containers are routed through an extension alarm system.

10.6.2 **Ventilation Alarm System**

10.6.2.1 A separate alarm shall be initiated upon failure of each independent ventilation system in each hold. If a balanced ventilation (mechanical exhaust and supply) system is installed, alarm for failure of each individual part shall be given.

10.6.3 **Cargo Refrigerating System**

10.6.3.1 In case of a power supply failure a separate alarm shall be initiated to each refrigerating container circuit.

10.6.3.2 Ships designed for the carriage of more than 150 reefer containers shall be equipped with a remote reefer container monitoring system of power cable transmission type in accordance with a recognised standard eg. ISO10368.

10.7 Hold Access

10.7.1 General

10.7.1.1 Safe access for personnel to the hold shall be ensured by suitable means when the ventilation system is in operation. Consideration shall be given to the possible over-pressure that may occur in the hold space.

10.7.1.2 If the ventilation system is capable of producing a positive pressure above this allowable figure, means shall be provided to protect the hold and personnel from the effect of over-pressure or vacuum. The maximum permitted pressure or vacuum that may occur in the hold shall be stated.

10.7.1.3 Consideration shall be given to the use of a pressure/vacuum relief valve set to operate below the maximum allowable hold pressure/vacuum.

10.7.1.4 Suitable accesses shall be provided to allow the removal of compressors or electric motor for each refrigerated container's. Access from each applicable hold space to the designated container refrigeration equipment maintenance area, shall be provided.

10.7.1.5 In all loading conditions of the ship, access shall be provided for maintenance and replacement of the cargo hold fans.

10.8 Inspection and testing

10.8.1 General

10.8.1.1 Prior to the system put into service and prior to the certificate being issued trials of the system in each hold space shall be witnessed onboard by surveyors.

10.8.1.2 The ability of the ventilation system to supply and/or extract air at the specified flow rate at each outlet shall be verified by the test. The deviation from the rated flow should be maximum +/-10%.

10.8.1.3 Verification of function of hold ventilation system with exhaust outlets closed on one side of the vessel.

10.8.1.4 Alarm and control systems shall be tested to demonstrate their correct operation. Testing shall take into account the electric power supply arrangements.

SECTION 11 GREAT LAKES BULK CARRIERS

Contents

11.1 General

11.1.1 Introduction

11.1.1.1 Backgrounds

Rules herein describe relevant requirements for Bulk Carriers navigating on the Great Lakes and St. Lawrence Seaways.

11.1.1.2 Scope

This section describes the following subjects:

- Design principles
- Longitudinal strength
- Hull Structures
- Opening and closing appliances
- Anchoring and mooring equipment

11.1.1.3 Objective

The objective of this section is to ensure that the specific conditions for Bulk Carriers operating on the Great Lakes and St Lawrence river are met by describing additional requirements to and deviations from our standard main class requirements.

11.1.1.4 Application

This section apply to Bulk Carriers designed to operate within the limits of the Great Lakes and the St. Lawrence River to the seaward limits defined by the Anticosti Island. The requirements shall be regarded as supplementary to those given for the assignment of main class.

These Rules are applicable to steel ships designed to carry dry cargo in bulk. Typically, the ships are designed as single deck ships with cargo holds of double bottom and double side construction. Hopper side tanks and top-wing tanks may be fitted below the upper deck.

Ships built in compliance with the modifications and additional requirements as given in this chapter, will be assigned the type and service notation: **Great Lakes Bulk Carrier**.

11.2 Requirements

11.2.1 General

11.2.1.1 Such vessels shall meet the requirements of the service area notation **RE** taking into account the specific requirement as described in this section.

11.2.1.2 The flag authority whose domestic requirements are being applied under the provision , shall be indicated in parentheses after the service area notation, eg. **RE** (can).

Note:
For ships under Canadian registration, the assignment of the load line shall be in accordance with the Canadian Shipping Act Load Line Regulation (inland).

11.2.2 Structural Configuration

11.2.2.1 The Rules are applicable to ships designed as single deck ships with cargo holds of double bottom and double side construction. Hopper side tanks and top-wing tanks may be fitted below the upper deck.

11.2.3 **Number of transverse watertight bulkheads**

11.2.3.1 Requirement of transverse bulkheads shall be taken in accordance with Pt 3, Ch 3, Sec 1.3.1.

11.2.3.2 Based on the structural configuration as described in Sec 11.2.2.1, watertight bulkheads will not be required fitted between the cargo holds.

11.2.4 **Position of collision bulkhead**

11.2.4.1 The distance $x_{c'}$ from the forward perpendicular to the collision bulkhead shall be as below:

$x_{c'}$ = 0.04 L_F
Where,
L_F = Load line length (m) as defined in Pt 3, Ch 1, Sec 2.1.

11.3 Longitudinal Strength

11.3.1 **Stillwater and Wave Induced Hull Girder Bending Moments, Shear Forces**

11.3.1.1 The design hull girder moments and shear forces are to be taken in accordance with Pt 3, Ch 5, Sec 2.1/ Sec 2.2.

11.3.2 **Bending Strength and Stiffness**

11.3.2.1 Minimum midship section modulus about the transverse neutral axis shall be taken as given in Pt 3, Ch 5, Sec 3.3.3. For ships with service restriction **RE**, the reduction of the wave coefficient factor C_{WO} as specified in Pt 3, Ch 5, Sec 3.3.6 may be replaced by a reduction of 50%.

11.3.2.2 Section modulus requirements about the transverse neutral axis based on cargo and ballast conditions shall be taken as given in Pt 3, Ch 5, Sec 3, 3.3.12.

11.4 Hull Structures

11.4.1 **Bottom Structures**

11.4.1.1 Strengthening requirements for bottom slamming loads as given in Pt 3, Ch 6, Sec 8.3 / Sec 8.4 need not be complied with.

11.4.2 **Side Structures**

11.4.2.1 Strengthening requirements for bow impact loads as given in Pt 3, Ch 7, Sec 5, 5.1 need not be complied with.

Note:
Based on operational experience in such areas indicates that navigation in the Seaway locks and in light ice may cause contact damages to plating and framing in fore and aft shoulder areas. In order to reduce the risk of local structural deformations, it is advised that this is considered in the design.

11.4.3 **Transvers Bulkheads**

11.4.3.1 Collision bulkhead shall have a minimum thickness not less than 12% greater than the required thickness of the dry cargo bulkheads. Minimum section modulus of stiffeners shall not be less than 25% greater than the required section modulus of stiffeners on the dry cargo bulkheads.

11.4.3.2 The minimum thickness of plating in way of non-watertight bulkheads in cargo region, shall not be less than 9.5 mm in the upper part, and 12 mm in the lower part.

11.5 Anchoring and Mooring Equipment

11.5.1 Equipment

11.5.1.1 Two bower anchors of mass in accordance with calculated equipment number, and stud-link chain cable of total length 330 m to be provided onboard.

11.5.1.2 Stern anchor to be fitted as required by the St. Lawrence Seaways Authority.

11.5.2 Equipment Number

11.5.2.1 The equipment number (EN') shall be as detailed below:

$EN' = (L_s\ B\ D / 3.33) + a + b$

Where,

a = addition for the 1st tier of superstructure and deck houses. 17.6% of volume of 1st tier (length x breadth x height)

b = addition for the 2nd tier of deckhouses and other erections. 13.2% of the volume of the 2nd tier (length x breadth x height)

11.6 Opening and Closing Appliances

11.6.1 General

11.6.1.1 Coaming and sill heights:
Air pipes ventilators, closing appliances, freeing ports areas, sanitary discharges etc shall be in accordance with the requirements of Pt.3 Ch.3 Sec.6, except as otherwise specified in this subsection.

11.6.1.2 Doors:
Doors in position 1 or Position 2 shall have a sill height, measured from the deck of at least 300 mm.

11.6.1.3 Hatchways:
Hatchways are to be fitted with efficiently constructed weathertight hatchway covers. The height above deck of hatchway coamings shall be at least 460 mm in Position 1 and at least 300 mm in Position 2. The coaming height may be reduced if the hatchway is fitted with a watertight cover.

11.6.1.4 Cargo ports and similar openings:
The lower edge of cargo ports and other similar openings shall not be below a line drawn parallel to the freeboard deck at side that has the upper edge of the uppermost load line at its lowest point.

11.6.1.5 Machinery space opening:
The lower edge of any access opening in the casing shall be at least 300 mm above the deck. If the opening is a funnel or machinery space ventilator that needs to be kept open for the essential operation of the vessel, then the coaming height is to be at least 3.8 m in Position 1 and 1.8 m in Position 2.

11.6.1.6 Ventilators
Ventilator coamings shall be at least 760 mm above deck in Position 1 and at least 600 mm above deck in Position 2. Ventilator openings shall have permanently attached weather tight means of closing. The requirement for weather tight closing appliances is not applicable for ventilators in Position 1 with coamings that extend 3.8 m or more above the deck or to ventilators in Position 2 with coamings that extend 1.8m or more above deck.

11.6.1.7 Air pipes

Air pipes are to have a coaming height of at least 760 mm on the freeboard deck, 600 mm on raised quarter decks and 300 mm other superstructure decks.

11.6.1.8 Freeing Ports

The freeing port area is to be calculated as described in Pt 4, Ch 6 with due attention to adjustments due to the height of the bulwark as provided below:

The freeing port area shall be increased by 0.04 m² per metre of length of the well for each metre that the height of the bulwark exceeds

— 600 mm, in the case of vessels that are 73 m in length or less;
— 1200 mm, in the case of vessels that are 146 m in length or more; and
— In the case of vessels that are of intermediate length, the height obtained by linear interpolation between the heights set out in paragraphs a) and b).

11.6.1.9 Scuppers, Drains Inlets and Discharges

1) Every discharge pipe passing through the shell from spaces below the freeboard deck shall be provided with the following:

a) An automatic non-return valve fitted at the shell with a positive means of closing that is operable

1. from above the freeboard deck or
2. from a readily accessible location if the discharge originates in a space that is crewed or equipped with a means of continuously monitoring the level of bilge water; or

b) Two automatic non-return valves, one of which is fitted at the shell and one inboard that is accessible for examination when the vessel is in service.

2) Every discharge pipe that passes through the shell from within an enclosed superstructure, or from within a deckhouse that protects openings to below the freeboard deck, shall:

a) Meet the requirements detailed in 1) a) or b) or

b) Have an automatic non-return valve fitted at the shell, if the discharge originates in a space that is regularly visited by the crew.

3) Every scupper, drain or discharge pipe that passes through the shell above the summer fresh water load line at a distance that is less than the greater of 5 per cent of the breadth and 600 mm shall have an automatic non-return valve fitted at the shell.

4) Subsection 3) does not apply in respect of a scupper, drain or discharge pipe that originates above the freeboard deck if the part of the pipe that is between the shell and the freeboard deck has substantial thickness.

5) In crewed machinery spaces, every main and auxiliary sea inlet and discharge necessary for the operation of machinery shall have a valve with a positive means of closing that can be controlled locally.

6) The valves required by this section to have positive means of closing shall have indicators at the operating position to show whether the valve is open or closed.

11.6.2 **Protection of Crew**

11.6.2.1 All exposed parts of the freeboard and superstructure decks shall be fitted with guardrails or bulwarks that are at least 900 mm in height.

11.6.2.2 Guard rails shall be fitted:

a) in at least three courses in which the space between the lowest course and the deck does not exceed 230 mm and the other courses are not spaced more than 380 mm apart; or

b) if the sheer strake projects at least 200 mm above the deck, in at least two courses in which the space between the lower course and the sheer strake or the upper course does not exceed 380 mm.

11.6.2.3 Vessels shall be provided with lifelines, gangways or under deck passages for the protection of the crew while passing to and from their accommodation spaces, the machinery space and all other spaces used in the normal operation of the vessel.

If an exposed part of a freeboard deck is in way of a trunk, guardrails shall be fitted for one-half the length of the exposed part.

Whenever bulkhead openings are closed, other access shall be provided for the crew to reach accommodation spaces or machinery or other working spaces in enclosed superstructures that are bridges or poops.

SECTION 12 ORE CARRIERS

Contents

12.1 General

12.1.1 Introduction

12.1.1.1 Objective

The current section details the specific design criteria for ore carriers are met by describing applicable requirements in addition to those for main class.

12.1.1.2 Scope

This section describes requirements to arrangement and hull strength in addition to the requirements as described in Pt.3. This includes the following:

— Applicable SOLAS and IACS requirements for hull strength and arrangement.
— Design loads.
— Hull arrangement and strength requirements.
— Optional class notation **EL-2**.

12.1.1.3 Application

The rules shall be applicable to vessels primarily intended for the carriage of ore cargoes in dry bulk with density up to 3 t/m^3, eg. iron ore, and with the following characteristics:

Sea-going single deck ships having two longitudinal bulkheads and a double bottom throughout the cargo region, and intended for carrying ore cargoes in the centre holds only, as indicated in Fig. 1.

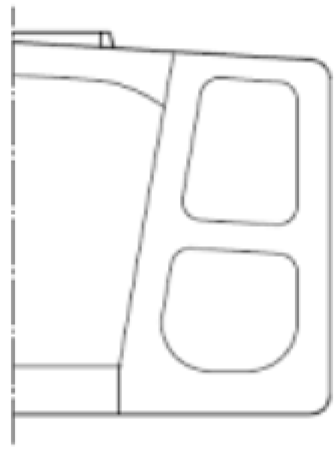


Fig 1 Typical Midship Section of Ore Carriers

12.1.1.4 Those vessels complying with the requirements of this section shall be assigned the mandatory main ship type class notation **Ore Carrier**.

12.1.1.5 Additional class notations and their applications, as defined in Table 12.1.1, are relevant for ore carriers and will be assigned to vessels complying with the associated requirements for design, construction and testing.

Table 12.1.1 Additional Class Notations Applicable for Ore Carriers			
Class Notation	**Description**	**Application**	**Requirements**
ESP	Enhanced survey programme	Mandatory for Ore Carriers	Pt.7B.Ch.1 (..Fleet in service / Survey Requriements not in INTLREG)
NAUTICUS (Newbuilding)	Requirements to extended fatigue and direct strength calculations	Mandatory for vessels with length L, greater than 190 m	
IB-3	Requirements for strengthening for grab loading and discharging	Mandatory when freeboard length L_F (ref. Pt 3, Ch 1, Sec 2.1) ≥ 150 m, and carrying solid bulk cargoes having a density ≥ 1.0 t/m3	Pt 3, Ch 6.
EL-2	Requirements for easy loading of cargo hold	Optional Class Notation	Sec 12.4

12.1.1.6 Strength Analysis of Hull Structure

Strength analysis of hull structure for non CSR bulk carriers shall be carried out based on relevant requirments of IACS / IACS member societies.

12.1.2 **Definitions**

12.1.2.1 References

SOLAS requirements indicating requirement for hull strength and arrangements are listed in Table 12.1.2 below:

Table 12.1.2 SOLAS Regulation for Hull Strength and Arrangement	
SOLAS Regulation	**Rule Reference**
II-1/3-2 Protective coatings of dedicated seawater ballast tanks in all types of ships and double-side skin spaces of bulk carriers	Pt 4, Ch 7 and Sec 8.8.2
II-I/3-6 Access to and within spaces in, and forward of, the cargo area of oil tankers and bulk carriers[1]	Sec 8.9.2
XII/5 Additional safety measures for bulk carriers: Structural strength[4,5]	Pt 3, Ch 9[3] and Sec 8.3, Sec 8.4[3], Sec 8.5
XII/6 Additional safety measures for bulk carriers: Structural and other requirements[2]	Sec 8.9.3
XII/11 Additional safety measures for bulk carriers: Loading instrument[2]	Sec 8.
XII/12 Additional safety measures for bulk carriers: Hold, ballast and dry space water ingress alarms	Sec 8.9.4 to 8.9.6
XII/13 Additional safety measures for bulk carriers: Availability of drainage forward spaces	Sec 8.9.7

1) Mandatory only for Ore Carrier of gross tonnage ≥ 20,000.
2) Mandatory only for Ore Carrier with freeboard length L_F (ref Pt 3, Ch 1, Sec 2.1) ≥ 150 m
3) Only the transverse bulkhead subject to flooding needs to be considered flooded.
4) Only cargo holds in way of the double side-skin space of which does not meet the criteria given in 1 need to be considered flooded
5) Mandatory only for Ore Carrier with freeboard length L_F (ref. Pt 3, Ch 1, Sec 2.1) ≥ 150 m, if any part of longitudinal bulkhead in any cargo hold is located within B/5 or 11.5 m, hichever is less, inboard from the ship's side at right angle to the centreline at the assigned summer load line

Requirements reflection IACS unified Requirements for hull strength and arrangement are listed in Table 12.1.3

Table 12.1.3 IACS Unified Requirements- Hull Strength and Arrangement	
IACS Unified Requirements	**Rule Reference**
UR S1A Additional requirements for loading conditions, loading manuals and loading instruments[1]	Sec 8.1 and Refer IACS UR S1A
UR S21 Scantlings of hatch covers	Sec 8.6
UR S28 Fitting of forecastle	Sec 8.7
1 Mandatory only for Ore Carrier with length L ≥ 150 m	

12.1.2.2 Symbols and Definitions

M_H = the actual cargo mass (t) in a cargo hold corresponding to a homogeneously loaded condition at maximum draught.

MFULL = the cargo mass (t) in a cargo hold corresponding to cargo with virtual density (homogeneous mass/hold cubic capacity, minimum 1.0 t/m3) filled to the top of the hatch coaming)
M_{FULL} in no case to be less than M_H.
V_H = Hold volume (m^3), including hatch coaming
V_{HR} = Hold volume (m^3) below a level 0.40H + 0.20 b_f within 60% of the middle width of the hold, and linearly reduced to 0.4H at the hold sides.
$V_{HR, A\&F}$ = Hold volume (m^3) below a level 0.40H + 0.2 b_f
H = Height of hold (m) from inner bottom to top of coaming
b_f = Breadth of hold (m) at level 0.4H above inner bottom at hold mid length.
δ = Design angle (deg) of repose
= 35 degrees for heavy bulk cargo (density > 1.78 t/m^3)
α = Angle (deg) between the panel in question and horizontal plane
K = $\sin^2 \alpha \tan^2 (45 – 0.50\delta) + \cos^2 \alpha$, minimum $\cos \alpha$
T = Scantling draught (m)
T_{HB} = Maximum ballast draught (m) in seagoing condition
T_{LB} = Minimum ballast draught (m) in seagoing condition

$T_{MIN,FULL,S}$ = Minimum draught (m) for a single hold being filled with M_{FULL} in harbour condition according to the loading and unloading sequences

$T_{MIN,FULL,ADJ}$ = Minimum draught (m) for two adjacent holds being filled with MFULL in harbour condition according to the loading and unloading sequences.

$T_{MAX,EMPTY,S}$ = Maximum draught (m) for a single hold being empty in harbour condition according to the loading and unloading sequence.

$T_{MAX,EMPTY,ADJ}$ = Maximum draught (m) for two adjacent holds being empty in harbour condition according to the loading and unloading sequences.

$T_{MAX,EMPTY,WBE}$ = Maximum draught (m) for empty wing tank and empty cargo hold (empty across) in seagoing condition according to the sequential water ballast exchange procedures.

12.1.3 Documentation Requirements

12.1.3.1 Vessels with class notation **Ore Carrier**, documentation shall be submitted as required in Pt 3, Ch 1, Sec 3. In addition, documentation as given in Table 12.1.4 shall be submitted.

Table 12.1.4 Documentation Requirements- Class Notation Ore Carrier			
Object	**Documentation Type**	**Additional Description**	**(A)/(I)**

Ship hull Structure	Midship section drawing	Including: - M_{FULL} for each cargo hold - Specification if transverse bulkheads separating cargo holds are watertight	(A)
	Preliminary loading manual Loading Manual	Including: — Corrected shear force in way of transverse bulkhead positions within the cargo hold area — Hold mass curves. Each loading condition to be checked against the allowable hold mass limits[1] — Longitudinal strength in flooded conditions (bending and shear, including shear force correction)[2,3]	(A)
	Loading sequence description (Preliminary)[1] Loading sequence description (Final)[1]	Including: — Corrected shear force in way of transverse bulkhead positions within the cargo hold area — Required minimum amount of ballast in the wing tank when the adjacent cargo hold is empty — Hold mass curves. Each loading sequence to be checked against the allowable hold mass limits[1]	(A)
	Ship structure access manual	-	(A)
	Strength analysis	3D complex girder analysis of transverse primary supporting members in midship area[5]	(I)
	Strength analysis	3D complex girder analysis of primary supporting members in engine room	(I)
	Strength analysis	3D complex girder analysis of primary supporting members in the fore peak	(I)
Loading computer application software	Test Conditions, Preliminary Test Conditions, Final	Including, in addition to Pt.6 : — Corrected shear force in way of transverse bulkhead positions within the cargo hold area — Hold mass curves. Each loading condition / loading sequence to be checked against the allowable hold mass limits — Longitudinal strength in flooded conditions (bending and shear, including shear force correction)[2,3]	(A)
Water Ingress Alarm System	Control system functional description	-	(A)
	Block diagram	-	(A)
	Power supply Arrangement	-	(A)
	Arrangement Plan	Detection and alarm panel	(A)
	Report from test at manufacturer	Type test report	(A)

1 Mandatory only for Ore Carrier with length L ≥ 150 m or freeboard length LF (ref. Pt 3, Ch 3, Sec 2.1.1) ≥ 150 m, and Ore Carrier with the optional notation **EL-2**
2 Mandatory only for **Ore Carrier** with freeboard length L_F (ref. Pt 3, Ch 3, Sec 2.1.1) ≥ 150 m, if any part of longitudinal bulkhead in any cargo hold is located within B/5 or 11.5 m, whichever is less, inboard from the ship's side at right angle to the centreline at the assigned summer load line.
3 Only cargo holds in way of the double side-skin space of which does not meet the criteria given in 2 need to be considered flooded
4 Mandatory only for **Ore Carrier** of gross tonnage ≥ 20,000
5 Only relevant for **Ore Carrier** without **NAUTICUS(Newbuilding)** notation
6 (A): For Approval; (I): For Information

12.1.3.2 For Ore Carrier with the additional notation **NAUTICUS(Newbuilding)** documentation as given in Table 12.1.5 shall be submitted.

Table 12.1.5 Documentation Requirements- Class Notation NAUTICUS(Newbulding)

Object	Documentation Type	Additional Description	
Ship Hull Structure	Strength Analysis		
	Strength Analysis		
	Strength Analysis		
	Strength Analysis		
	Strength Analysis		

Table 12.1.5 Documentation Requirements- Class Notation NAUTICUS(Newbulding)

Object	Documentation Type	Additional Description	(A)/(I)
Ship Hull Structure	Strength Analysis	3D Finite element analysis of primary supporting members in the midship area,	(I)
	Strength Analysis	3D Finite element analysis of primary supporting members in the foremost cargo hold, refer	(I)
	Strength Analysis	3D Finite element analysis of primary supporting members in the aftermost cargo hold,	(I)
	Strength Analysis	Local structure analysis of longitudinal stiffeners in way of transverse bulkheads in midship area.	(I)
	Strength Analysis	Fatigue assessment for end structures of longitudinals in cargo area, including effect of relative deformations,	(I)
Note: (A): For Approval; (I): For Information			

12.1.3.3 For Ore Carrier with the optional notation **EL-2** documentation as given in Table 12.1.6 shall be submitted.

Table 12.1.6 Documentation Requirements- Class Notation EL-2

Object	Documentation Type	Additional Description	(A)/(I)
Ship Hull Structure	Loading sequence description preliminary	Including, in addition to Table 12.1.4: — Design loading rates — Air-draught to top of hatch, if restrictions are applicable	(A)
	Loading sequence description preliminary		(A)
Note: (A): For Approval; (I): For Information			

12.2 Design Loads

12.2.1 Design cargo density and angle of repose

12.2.1.1 The design angle of repose, δ, of heavy bulk cargo is generally not to be taken greater than 35 degrees (associated cargo density > 1.78 t/m3).

12.2.1.2 For the calculation of plates and stiffeners, the cargo density of any hold shall be taken as detailed below:

$\rho = M_{FULL} / V_H$ (t/m^3)

12.2.1.3 For the direct calculation of cargo hold bulkheads, the design cargo density shall be taken a detailed below:

$\rho = M_{FULL} / V_H$ (t/m^3)

12.2.1.4 For the direct calculation of girder structures other than cargo hold bulkheads, the design cargo density shall be taken as detailed below:

— Within the parallel cargo hold area: $\rho = M_{FULL} / V_{HR}$ (t/m^3)
— Outside the parallel cargo hold area: $\rho = M_{FULL} / V_{HR,A\&F}$ (t/m^3)

12.2.2 Lateral Pressure Loads

12.2.2.1 Design bulk pressures for local elements (i.e. plates and stiffeners) shall be determined based on Pt 3, Ch 4 using parameters given in Sec 12.2.1.

12.2.2.2 The design bulk pressures shall be determined based on Pt 3, Ch 4 using parameters given in Sec 12.2.1, for direct calculation of girder structures.

For direct calculation of girder structures other than cargo hold bulkheads, the filling height, h_c, shall be based on the following cargo surface:

— Within the parallel cargo hold area: Surface applied for V_{HR}
— Outside the parallel cargo hold area: Surface applied for $V_{HR,A\&F}$

12.2.2.3 For direct calculation of girder structures, a shear load is to be applied to sloping parts of bulkheads in order to obtain correct total downward force from ore cargo.

The shear load, p_s acting on sloping parts of bulkheads is to be taken as detailed below:

$p_s = (\rho [g_0 + 0.50 a_v] [1 – K] h_c) / \tan \alpha$ (kN/m^2)

12.3 Hull arrangement and Strength

12.3.1 Hull arrangement

12.3.1.1 The ship shall have two effective longitudinal bulkheads.

12.3.1.2 It is assumed that only spaces between the longitudinal bulkheads are used as cargo holds.

12.3.1.3 A double bottom shall be fitted in way of the cargo holds.

12.3.2 Longitudinal Strength

12.3.2.1 Hull girder shear strength shall be checked in accordance with Pt 3, Ch 5, Sec

4 with the shear force distribution factor Φ and I_N / S_N based on a shear flow calculation. The shear force correction ΔQ_S shall be calculated for both the ship sides, and for the longitudinal bulkheads.

12.3.2.2 The longitudinal bulkhead shall continue inside the engine room at a distance not less than 4.5 m or five transverse frame spacing, whichever is greater, before starting the tapering of the bulkhead structure (eg. scarfing brackets). The longitudinal bulkhead inside the engine room shall have the same hull girder shear strength (plate thickness and yield strength) as that required immediately in front of the engine room bulkhead according to Sec 12.3.2.1.

12.3.2.3 Impact on longitudinal strength due to asymmetrical loading conditions, including ballast water exchange conditions, will be specially considered.

12.3.3 Plating and Stiffeners

12.3.3.1 Thicknesses and cross-sectional properties are in general to be calculated as detailed in Pt 3, considering design pressure as given in Sec 12.2 where applicable.

12.3.3.2 The thickness of inner bottom plating in cargo holds shall not be less than as detailed below:

$t = 9.00 + k / (1 / k_m)^{0.5} + t_k$ (mm)

Where,

k = 12 s

= 0.03 L_1, whichever is greater

12.3.3.3 For ore carriers with the **NAUTICUS(Newbuilding)** notation, local structure analysis is mandatory for stiffeners subject to large deformations in way of transverse bulkheads. The designer shall demonstrate compliance with the principles given in Pt 3, Ch 13.

12.3.3.4 For ore carriers with the **NAUTICUS(Newbuilding)** notation, fatigue assessment for end structures of longitudinals in the cargo hold is mandatory. The designer shall demonstrate compliance with the principles given in Pt.3

Acceptable calculation methods are further described in Classification Note No. 31.10.

12.3.4 Design load cases for strength assessments

12.3.4.1 Any cargo hold shall be capable of carrying M_{FULL} at:
- Seagoing condition, T and
- Harbour condition, $T_{MIN,FULL,S}$

12.3.4.2 Any cargo hold shall be capable of being empty at:

- Seagoing condition, T_{HB}; and
- Harbour condition, $T_{MAX,EMPTY,S}$.

12.3.4.3 Any two adjacent holds shall be capable of carrying M_{FULL} at:

- Seagoing condition, T; and
- Harbour condition, $T_{MIN,FULL,ADJ}$.

12.3.4.4 Any two adjacent holds shall be capable of being empty at:

- Seagoing condition, T_{HB}; and
- Harbour condition, $T_{MAX,EMPTY,ADJ}$

12.3.4.5 Any wing ballast tank shall be capable of:

- Being empty in seagoing condition, T; and
- Being full in seagoing condition, T_{LB}

12.3.4.6 Any transverse bulkhead in the cargo areas shall be capable of withstanding M_{FULL} from one side at scantling draught, T in seagoing condition.

In the damage condition, the watertight transverse bulkheads in the cargo area shall be capable of withstanding flooding of sea water up to the deepest equilibrium waterline. If not available in early design, flooding up to the moulded depth D may be assumed.

12.3.4.7 In case of water ballast exchanged by sequential method, the longitudinal bulkhead shall be capable of having empty wing tank and empty cargo hold (empty across) at $T_{MAX,EMPTY,WBE}$ in seagoing condition.

12.3.4.8 The required minimum amount of ballast in the wing tank when the adjacent cargo hold is empty shall be specified, for the various loading and unloading sequences.

If no minimum amount of ballast is specified, it shall be assumed that the longitudinal bulkhead shall be capable of having empty ballast tank and empty cargo hold (empty across) at $T_{MAX,EMPTY,S}$ and $T_{MAX,EMPTY,ADJ}$ in harbour condition.

12.3.4.9 For seagoing loading conditions involving partially filled wing water ballast tanks, the girder system shall be strengthened for filling levels empty and full.

12.3.4.10 The web frames and the deck girder structure, in the wing tanks are to be able to withstand the hatch cover reaction forces specified by the hatch cover manufacturer. Acceptance criteria are given in Pt 4, Ch 6.

12.3.4.11 Ore carriers having a deadweight capacity above 200 000 DWT are to be capable of being loaded to the full deadweight capacity using one pour per hold.

For ore carriers with length L ≥ 150 m and for ore carriers with the additional class notation **EL-2**, hold mass curves are to be included in the loading manual and the loading instrument showing maximum allowable and minimum required mass as a function of draught in seagoing conditions, as well as during loading and unloading in harbour. The hold mass curves shall be based on the design load cases for local strength given in Sec 12.3.4.1 to 12.3.4.3and 12.3.4.11.

12.3.5 Girder system in cargo area

12.3.5.1 Transverse strength of the double bottom, wing tank, deck structures, and transverse bulkhead structures shall be based on direct strength analysis as outlined in Pt 3, Ch 13.

12.3.5.2 Finite element analysis of cargo hold area at the midship region is mandatory for ore carriers with the NAUTICUS(Newbuilding) notation. The designer shall demonstrate compliance with the principles given in Pt 3, Ch 13.

12.3.5.3 Cargo hold analysis by use of finite element methods for the foremost cargo hold and the aftermost cargo hold are mandatory for ore carriers with the **NAUTICUS(Newbuilding)** notation. The designer shall demonstrate compliance with the principles given in Pt 3, Ch13.

12.3.5.4 For ore carriers with the **NAUTICUS(Newbuilding)** notation, for cargo holds not covered by Sec 12.3.5.2 and 12.3.5.3, having primary strength members with structural arrangements as for the midship area, the scantlings of such primary strength members are not to be less than those required based on Sec 12.3.5.2, with due attention to reduction in longitudinal stresses.

12.3.5.5 The requirement provided in Sec 12.3.5.4 can be dispensed from, provided the designer can demonstrate compliance with the principles given in Pt 3, Ch 13, by FE cargo hold analysis.

12.3.5.6 The load cases to be applied to each cargo hold model shall envelope all seagoing conditions, loading and unloading sequences and ballast water exchange conditions (where applicable) in accordance with Sec 12.3.4.

12.3.5.7 For ore carriers with the **NAUTICUS(Newbuilding)** notation, the allowable compressive stress in Pt 3, Ch 8, Sec 5, 5.1.1 may be increased to 160 / k_m.

12.3.5.8 For ore carriers with the **NAUTICUS(Newbuilding)** notation the effect of relative deformation of stiffener end connections in way of transverse bulkhead shall be taken into account in the fatigue assessment. Additional fatigue load cases as given in Pt 3, Ch 15 are to be applied to the midship cargo hold model. Relevant fatigue load cases

12.3.6 Strength Requirements in Engine Room

12.3.6.1 The spacing of side web frames in engine room shall not be taken greater than 4.5 m or five transverse frame spacings, whichever is smaller. Web frames are to be connected at the top and bottom to members of suitable stiffness, and supported by deck transverses.

12.3.6.2 Partial end bulkheads forming the boundary of heavy fuel oil storage tanks shall extend down to outer bottom with vertical stiffening.

12.3.6.3 Thickness of strength deck and platform deck, acting as transverse strength members shall not be less than that detailed below:

$t = 14\,s + t_k$ (mm)

12.3.6.4 Stiffeners supporting decks mentioned in Sec 12.3.6.3 subject to compressive stress perpendicular to the stiffener direction, the moment of inertia of the stiffener section (including effective plate flange) shall not be less than:

$I = 19\,l^4$ (cm^4)

12.3.6.5 Primary supporting members being part of a complex 3-dimensional structural system such as side girders, side stringers, and deck girders are to be based on a direct strength analysis. The designer shall demonstrate compliance with the principles given in Pt 3, Ch 13 at scantling draught in upright seagoing condition.

If scantlings of all primary supporting members within the engine room are based on FE analysis, the requirements given in Sec 12.3.6.1 to 12.3.6.3 and Sec 12.3.2.2 may be dispensed from.

Note:
Stress results for longitudinal and transverse primary strength members in the engine room will in a FE model depend considerably on the hull girder loads induced in the model. In order to obtain realistic results, the FE model shall include hull girder loads, applying target position in way of the engine room front bulkhead. Weight of deck house and heavy component such as the main engine

should be applied to the FE model.

12.3.7 Strength Requirements in Fore peak

12.3.7.1 In way of fore peaks structure with transverse framing, floors are to be fitted at each web frame location.

In way of fore peak structure with longitudinal framing, the spacing of floors shall not be taken greater than 4.5 m or five transverse frame spacings, whichever is smaller.

The depth of the floors is not to be less than the height of the double bottom in the foremost cargo hold and the upper edge is to be stiffened.

12.3.7.2 A centerline girder and side girders should be provided in the fore peak regions. The transition (scarfing) of the longitudinal bulkhead is to be connected to a side girder.

Where transverse framing is adopted, the spacing of bottom girders is not to exceed 2.5 m.

Where longitudinal framing is adopted, the spacing of bottom girders is not to exceed 3.5 m.

The depth of the bottom girders is not to be less than the height of the double bottom in the foremost cargo hold and the upper edge is to be stiffened.

12.3.7.3 Alternatively to the requirements to longitudinal girders given in Sec 12.3.7.2, a perforated centerline bulkhead may be fitted supporting all floors in the fore peak, and extending not less than two platform decks / stringer levels above the inner bottom.

12.3.7.4 Spacing of side web frames in fore peak shall not be taken greater than 4.5 m or five transverse frame spacings, whichever is smaller. Perforated flats are to be fitted with a vertical spacing not greater than 10 m.

12.3.7.5 The chain lockers shall be supported by the ship's side or fore peak bulkhead with partial bulkheads. Alternatively, the designer shall demonstrate that the structures supporting the chain locker have sufficient strength.

Note:
An acceptable method to demonstrate sufficient strength of the chain locker support is to assume the chain lockers filled with sea water in upright seagoing condition, including weight of chain cable, and demonstrate compliance with the principles given in Pt 3, Ch 13.

12.3.7.6 Thickness of decks and perforated flats, acting as transverse strength members shall not be less than the following:

$t = 14\,s + t_k$ (mm)

12.3.7.7 For stiffeners subject to compressive stress perpendicular to the stiffener direction supporting decks as mentioned in Sec 12.3.7.6, the moment of inertia of the stiffener section (including effective plate flange) shall not be less than the following:

$I = 19\,l^4$ (cm^4)

12.3.7.8 Complex 3-dimensional structural system of primary supporting members such as bottom girders, floors, side girders, side stringers, and deck girders are to be based on a direct strength analysis. The designer shall demonstrate compliance the principles given in Pt 3, Ch 13 at scantling draught in upright seagoing condition.

If scantlings of all primary supporting members within the fore peak are based on FE analysis, the requirements given in Sec 12.3.7.1 to 12.3.7.7 may be dispensed from.

Note:
*For ships with the **NAUTICUS(Newbuilding)** with cargo hold analysis of the foremost cargo hold modelled in the primary supporting members within the fore peak may be assessed based on the foremost cargo hold model.*

12.4 Optional Class Notation EL-2

12.4.1 General

12.4.1.1 Ships with the optional class notation **EL-2** shall be able to handle average loading rates as given in Table 12.4.1, unless higher rates are specified and provided as part of the documentation for approval.

In the loading and unloading sequence, each step right from commencement of cargo loading to full deadweight is to be time-wise synchronized with the de-ballasting operation. Time-wise synchronized in this context means that the de-ballasting is completed within the same time as the loading.

Table 12.4.1 Design Loading Rates

DWT	Average loading rate, t/h
> 250 000	16 000
250 000 – 220 000	14 000

Due to operational reasons, if the Master deems necessary to deviate from the approved loading sequence, calculations with ratings according to **EL-2** he may do so provided he is in compliance with SOLAS Ch.VI Pt.B, Reg.7.3 and on this condition agree with the terminal on a new loading plan.

12.4.1.2 The de-ballast capacity of the vessel at loading berth prior to commencement of loading, including arrangement of ballast tanks and relevant piping system, shall meet the requirements for the average loading rates as specified in Table 12.4.1.

In case the average loading rate is specified to be higher than those given in Table 12.4.1, the loading operation shall not be interrupted due to de-ballast operations.

The vessel shall be fitted with a separate stripping system. To enhance de-ballasting and stripping the trim should preferably be by stern during the whole operation.

12.4.1.3 Vessel shall be capable of being loaded / unloaded to the full deadweight capacity using one pour per hold.

12.4.1.4 A remote sounding for water ballast and fuel oil storage tanks and draught reading system shall be installed with an on-line interface into the software of the on board loading computer.

12.4.1.5 Local strength check for single and adjacent hold loading pattern shall be integrated into the software of the on board loading computer.

CHAPTER 3 OIL CARRIERS

CONTENTS

SECTION 1 GENERAL REQUIREMENTS

Contents

1.1 Classification

1.1.1 Scope

1.1.1.1 The requirements in this section deals with the safety hazards, marine pollution hazards and functional capability of systems. Incorporated in the rules are some requirements of SOLAS Ch. II-2, where these are specifically mentioned as applicable for tankers only, and the requirements in MARPOL Annex I, insofar design and equipment are concerned.

1.1.1.2 Machinery installations and their auxiliary systems that support cargo handling, are to meet the same rule requirements as if they were considered to support a main function; refer Pt 1, Ch 1, Sec 1.1.

1.1.2 Application

1.1.2.1 Rules in this section apply to ships intended for carriage of liquid oil cargoes in bulk with a flash point not exceeding 60°C (closed cup test), as well as ships heating its cargo to within 15°C or more of its flashpoint.

For ships intended for carriage of oil products with flashpoint exceeding 60°C, the requirements in Sec 2, Sec 3.1, Sec 3.2.1.7, Sec 3.2.1.8, Sec 3.3, Sec 3.4.2, Sec 3.5, Sec 3.9, Sec 4.1 to 4.4, Sec 7, Sec 8.3.3.1, Sec 9.1 to 9.5 are applicable.

Liquid cargoes with vapour pressure above atmospheric pressure at 37.8°C, Reid vapor pressure (RVP) shall not be carried unless the ship is especially designed and equipped for this purpose.

The requirements shall be regarded as supplementary to those given for the assignment of main class.

1.1.2.2 Oil cargoes and cargoes other than oils covered by the classification in accordance with this chapter are listed in Sec 16.

1.1.2.3 Oil carriers of 20 000 tonnes dwt and above and all ships fitted with equipment for crude oil washing shall fulfil the requirements for inert gas plants as given in Sec 11.

1.1.2.4 Simultaneous carriage of dry cargo (including vehicles and passengers) and oil cargo with flashpoint not exceeding 60°C is not permitted for ships with class notations as stated in Sec 1.1.3. [SOLAS Ch.II-2 Reg.2.6.5]

1.1.2.5 Ships designed for alternate carriage of liquid cargoes with a flash point not exceeding 60°C and dry cargo shall comply with the requirements in Sec 10 and the requirements to protected slop tank in Sec 12.

1.1.2.6 Tanks for cargoes with specific gravity exceeding 1025 kg/m3, refer Pt 3, Ch 1.

1.1.3 Class Notations

1.1.3.1 Sea-going ships having integral tanks and intended for the carriage of oil in bulk shall be provided with mandatory ship type and service notation **Tanker for Oil ESP.**

The mandatory ship type and service notation **Tanker for oil products with FP above 60°C** or **Tanker for oil products with FP above 60°C ESP** shall be assigned to ships intended for the carriage of all types of oil products with flashpoint above 60°C and built in accordance with the requirements specified in Sec 1.1.2.1.

1.1.3.2 The mandatory ship type and service notation **Tanker for Oil Products ESP** shall be assigned to ships intended for the carriage of all types of oil products except crude oil.

1.1.3.3 The general term combination carrier is applied to ships intended for the carriage of oil and dry cargoes in bulk. It is assumed, however, that dry cargoes and oil cargoes will not be carried simultaneously, with the exception of oil retained in slop tanks.

The mandatory ship type and service notation **Bulk Carrier or Tanker for Oil ESP** (alternatively **Tanker for Oil Products ESP**) shall be assigned to single deck ships of double skin construction, with a double bottom, hopper side tanks and topside tanks fitted below the upper deck, and intended for the carriage of oil or dry cargoes in bulk.

The mandatory ship type and service notation **Ore Carrier or Tanker for Oil ESP** (alternatively **Tanker for Oil Products ESP**) shall be assigned to sea-going single deck ships having two longitudinal bulkheads and a double bottom and double skin throughout the cargo region, and intended for the carriage of ore cargoes in the centre holds or of oil cargoes in the centre holds and wing tanks.

The ships shall comply with Sec 1 to Sec 13 of this chapter, except Sec13 when only oil products are carried.

1.1.3.4 Ships having a bow loading arrangement will be assigned the additional notation **BOW LOADING** and shall meet the relevant requirements in Sec 14.

1.1.3.5 Ships having a submerged turret loading (STL) arrangement will be assigned the additional notation **STL**, and shall meet the relevant requirements in Sec 14.

1.1.3.6 Vessels installed with equipment enabling them to be moored to single point moorings will be assigned the additional notation **SPM** and shall meet the relevant requirements in Sec 15.

1.1.3.7 Arrangements shall be provided for efficient cleaning of tanks when changing from dirty to clean oil cargoes.

1.1.3.8

Ships having cargo tanks, systems and cleaning arrangement complying with the following requirements will be assigned the additional notation **ETC**:

- Tanks shall be designed with smooth surfaces. Under deck longitudinals of slab type are acceptable. Horizontal areas on stiffeners and brackets are generally not acceptable.

Horizontally corrugated bulkheads should normally not have an angle of the corrugations in excess of 45° related to the vertical plane, refer Fig.1. Bulkheads with larger angles - but not more than 65° - might be accepted taking into consideration the location of washing machines in the tanks and the shadow diagrams. Bulkheads may have horizontal or vertical corrugations.

Vertical girders in horizontally corrugated bulkheads may only be accepted after special consideration. Any shadow area created by such structures shall however be included in the shadow area calculations and arrangements for portable washing without tank entry.

- Tanks are of stainless steel or coated.
- Cargo piping is of stainless steel.
- Heating coils are of stainless steel or equivalent material.
- Capability of cargo tank washing with hot water of min 85°C with a capacity

sufficient for washing at least the largest cargo tank. The heater capacity shall be based on a seawater temperature of 0°C.

- Cargo tanks served by individual in-tank cargo pumps.
- Cargo suction wells to be located for optimum drainage results.
- Permanently installed tank washing machines giving minimum coverage of 96% based on effective jet length at normal operating pressure according to INTLREG Type Approval Programme.

For calculation of coverage, shadow areas shall include areas where the angle between jet and tank surface is less than 10°, and shadow from cargo pump stacks.

Heating coils and ladders and platform of grating type shall not be included in the shadow areas. Areas where the angle between jet and tank surface is less than 10°, shall be considered shadow areas.

In addition to the permanent washing machines, portable washing equipment and necessary access openings enabling complete washing of shadow areas shall be provided. The additional washing is to be carried out without need for tank entry.

The class notation **ETC** may be given to ships where slop tanks do not comply with the requirements. In such cases the notation will read **ETC (except slop tanks)**.

Note:
Small brackets in way of cross joint of longitudinal and transverse stool top/bottom plate and end of stool top/bottom plate which are required from a strength point of view may be accepted acceptable. The size of bracket shall be specially considered based on detail direct analysis. Such brackets shall be designed to be as small as possible.Any shadow area created by such structures shall however be included in the shadow area calculations and arrangements for portable washing without tank entry.

For chemical carriers, any horizontal surface where cargo may accumulate, need be inclined or otherwise arranged for self-drainage under normal conditions of trim and heel (including aft trim). This applies to small brackets as indicated above, as well as any other horizontal surface other than tank top such as the top of transverse lower stools.

Alternatively, the volume which can be accumulated needs to be included in the stripping result as required by MARPOL Annex II. The maximum allowable volume of cargo that may be accumulated in tanks and associated piping is 75 litres.

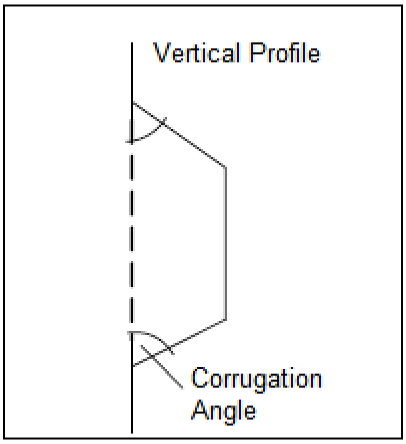


Fig 1 Definition of Corrugation Angle

(Horizontally Corrugated Bulkhead)

1.1.4 Special Features Notations

1.1.4.1 Oil carriers less than 20,000 tons deadweight fitted with inert gas system complying with the requirements in Sec 11 may be assigned the special features notation **INERT**.

1.1.4.2 Noxious Liquid Substances **NLS**

The notation implies that the ship is acceptable for an NLS certificate in accordance with MARPOL Annex II for carriage of IBC Code Ch.18, Category Z products

1.1.5 Registration Information

1.1.5.1 Materials of contruction (**SSP**)

The notation **SSP** indicates that cargo piping and all equipment in contact with cargo and cargo vapours is made of stainless steel.

1.1.6 Structural and Leak testing

1.1.6.1 Testing shall be in accordance with Pt.2

1.2 Defintions

1.2.1 Terms and Abbreviations

Table 1.2.1 Terms

Term	Defintion
Accommodation spaces	Accommodation spaces are those used for public spaces, corridors, lavatories, cabins, offices, hospital, 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.
Air lock	An enclosed space for entrance between an hazardous area on open deck and a non-hazardous space, arranged to prevent ingress of gas to the non-hazardous space
Cargo area	That part of the ship which contains the cargo tanks, pump rooms, cofferdams and similar compartments adjacent to cargo tanks, and includes deck areas over the full beam and length of above spaces. The cargo area extends to the full beam of the ship from the aftmost bulkhead of compartment adjacent to the aftmost cargo tanks to the full beam of the forward most bulkhead of a compartment adjacent to the forward most cargo tank. Where independent tanks are installed in hold spaces, cofferdams, ballast or void spaces at the after end of the aftermost hold space or at the forward end of the forward-most hold space are excluded from the cargo area.
Cargo control room	A space used in the control of cargo handling operations on board the ship
Cargo handling spaces	Are cargo pump rooms and other enclosed spaces which contain fixed cargo handling equipment, and similar spaces in which work is performed on the cargo. It includes enclosed spaces containing cargo handling systems where cargo liquid, residue or vapour will be present during operation

Cargo handling systems	Are piping systems in which cargo liquid, vapour or residue is transferred or likely to occur in operation and includes systems such as cargo pumping systems, cargo stripping systems, drainage systems within the cargo area, cargo tank venting systems, cargo tank washing systems, inert gas systems, vapour emission control systems and gas freeing systems for cargo tanks
Cargo tank	The liquid-tight shell designed to be the primary container of the cargo Cargo tanks shall be taken to include also slop tanks, residual tanks and other tanks containing cargo with a flashpoint not exceeding 60°C.
Cargo tank block	The part of the ship extending from the aft bulkhead of the aftmost cargo tank and to the forward bulkhead of the forward most cargo tank, extending to the full beam of the ship, but not including the area above the deck of the cargo tank
Cofferdam	Th isolating space between two adjacent steel bulkheads or deck. This space may be a dry space or a tank, refer Sec 3.6.
Control stations	Those spaces in which the ship's radio or main navigating equipment or the emergency source of power is located or where the fire recording or fire control equipment is centralised.
Design vapour pressure	p_0 : The maximum gauge pressure at the top of the tank which has been used in the design of the tank
Flame arrester	A device through which an external flame front cannot propagate and ignite an internal gas mixture
Flame screen	A flame arrester, consisting of a fine-meshed wire gauze of corrosion-resistant material
Hazardous Area	Hazardous areas are divided into Zone 0, 1 and 2 as defined below and according to area classification specified in Sec 8.3. Zone 0: Area in which an explosive gas atmosphere is present continuously or is present for long periods. Zone 1: Area in which an explosive gas atmosphere is likely to occur in normal operation. Zone 2: Area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it does occur, is likely to do so only infrequently and will exist for a short period only.
High velocity vent valve	Cargo tank vent valve which at all flow rates expels the cargo vapour upwards at a velocity of at least 30 m/s, measured at a distance equal to the nominal diameter of the standpipe above the valve outlet opening
Non hazardous area	Area not considered to be hazardous
Pressure- vacuum valve	Valve of pressure-vacuum type which keeps the tank overpressure or under-pressure within approved limits
Residual tank	A tank particularly designated for carriage of cargo residues and cargo mixtures typically transferred from slop tanks, cargo tanks and cargo piping. Residual tanks which are intended for the storage of cargo or cargo residue with a flashpoint not exceeding 60°C or which are connected to cargo handling piping systems serving cargo or slop tanks shall comply with the requirements for cargo tanks. Residual tanks which are not intended for carriage of cargo, are not required to comply with the requirements to Crude Oil Washing in Sec 13.
Seggregated ballast tanks	Tanks which are completely separated from the cargo oil and fuel oil systems and which are permanently allocated to the carriage of ballast or cargoes other than oil or noxious substances as defined in MARPOL
Services spaces	Spaces 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
Slop Tanks	Tanks particularly designated for the collection of tank draining, tank washing and other oily mixtures.

	Slop tanks which are intended for the carriage of cargo or cargo residue with a flashpoint not exceeding 60°C or which are connected to cargo handling piping systems serving cargo or slop tanks shall comply with the requirements for cargo tanks. Slop tanks which are not intended for carriage of cargo, are not required to comply with the requirements to crude oil washing in Sec 13.
Spaces not normally entered	Cofferdams, double bottoms, duct keels, pipe tunnels, stool tanks, spaces containing cargo tanks and other spaces where cargo may accumulate
Spark arrester	A device which prevents sparks from the combustion in prime movers, boilers etc. from reaching the open air.
Tank deck	The following decks are designated tank deck: - a deck or part of a deck which forms the top of a cargo tank - the part of a deck upon which are located cargo tanks, cargo hatches, valves, pumps or other equipment intended for loading, discharging or transfer of the cargo - that part of a deck within the cargo area, which is located lower than the top of a cargo tank - deck or part of deck within the cargo area, which is located lower than 2.4 m above a deck as described above.
Void space	An enclosed space not forming a cargo tank, ballast space, fuel oil tank, cargo pump room, or any space in normal use by personnel

Table 1.2.2 Abbreviations

Abbreviation	Definition
CCR	Cargo control room
LEL	Lower explosive limit
MBL	Maximum breaking load
NLS	Noxious liquid substances
P/V	Pressure - vacuum
RVP	Reid vapour pressure
STL	Submerged turret loading
STS	Ship to ship
USCG	US Coast guard

1.3 Certification

1.3.1 Certification Requirments

1.3.1.1 Components shall be certified as detailed in Table 1.3.1

Table 1.3.1 Certification Requirments

Object	Certification Type		Additional Description
Emergency towing strong points	Certificate	INTLREG Product certificate/ Material certificate	
Emergency towing fairloads	Certificate	INTLREG Product certificate/ Works Material certificate	
P/V valve and other flame arresting elements	Certificate	INTLREG Type approval certificate	
Cargo pumps	Certificate	INTLREG Product certificate	Including stripping pumps
Cargo tank gas freeing fans	Certificate	INTLREG Product certificate	
Ventilation fans for hazardous areas	Certificate	INTLREG Product certificate	Permanently installed fans
Hydrocarbon gas detection and alarm	Certificate	INTLREG Product certificate	

system (fixed)			
Cargo valves and pumps control and monitoring system	Certificate	INTLREG Product certificate	
Cargo tanks level monitoring system	Certificate	INTLREG Product certificate	
Cargo tanks overflow protection alarm system	Certificate	INTLREG Product certificate	
Cargo tanks pressure monitoring alarm system	Certificate	INTLREG Product certificate	If required as a secondary mean of cargo tank venting as per Sec 5.
Cargo tank temperature monitoring system	Certificate	INTLREG Product certificate	If required as per Sec 4.4.4.
Portable cargo tanks oil and water interface detection system	Certificate	INTLREG Type approval certificate	Refer Sec 9.
Portable gas detectors	Certificate	INTLREG Type approval certificate	Refer Sec 9

1.4 Documentation

1.4.1 Documentation Requirements

1.4.1.1 The builder shall be responsible for submitting the documentation required by Table 1.4.1. The drawings shall show clearly that the requirements are fulfilled.

1.4.1.2 Other plans, specifications or information may be required depending on the arrangement and the equipment used in each separate case.

Table 1.4.1 Documentation Requirments - Builder

Object	Documentation Type	Additional Description	(A)/(I)
Internal access	Ship structure access manual	The plan is to include details enabling verification of compliance with requirements to safe access to cargo tanks, ballast tanks, cofferdams and other spaces within the cargo area as required by SOLAS Ch.II-2 Reg.3-6.	(A)
Vessel arrangement	General arrangement plan	Including: cargo hatches, butterworth hatches and any other openings to cargo tanks doors, hatches and any other openings to pump rooms and other hazardous areas ventilating pipes and openings for cargo hatches, pump rooms and other hazardous areas doors, air locks, hatches, ventilating pipes and openings, hinged scuttles which can be opened, and other openings to non-hazardous spaces adjacent to the cargo area including spaces in and below the forecastle cargo pipes over the deck with shore connections including stern pipes for cargo discharge or pipes for bow loading arrangement.	(I)
Hazardous Areas	Hazardous area classification drawing	Identifying all hazardous areas on board the vessel	(A)

Electrial equipment in hazardous areas	Electrical schematic drawing	Single line diagrams for all intrinsically safe circuits, for each circuit including data for verification of the compatibility between the barrier and the field components.	(A)
	Arrangement Plan	Where relevant, based on an approved 'Hazardous area classification drawing' where location of electric equipment in hazardous area is added (except battery room, paint stores and gas bottle store).	(A)
	Maintenance Manual		(A)
Hydrocarbon gas detection and alarm System (Fixed)	Arrangement Plan	Shall include fixed gas detection for pumprooms and spaces adjacent to cargo tanks. Shall include arrangement of sampling piping, location of all sampling points, detectors, call points and alarm devices	(I)
	Control and monitoring system documentation		(A)
Ventilation systems for hazardous cargo areas	Ducting diagram		(A)
	Capacity Analysis		(A)
	Detailed drawing	Rotating part and casing of fans	(A)
	Control and monitoring system documentation		
Oil pollution prevention	Shipboard oil pollution emergency plan (SOPEP)	Applicable when gross tonnage ≥ 150	(A)
	Operation Manual	Ship to ship (STS) transfer manual. Applicable for oil carriers involved in ship to ship transfer when gross tonnage ≥ 150.	(A)
Cargo handling Arrangement	Detailed drawing	Gastight bulkhead stuffing boxes: Including details of lubrication arrangement and temperature monitoring.	(A)
	Operation Manual	VOC management plan, refer MARPOL Annex VI Reg 15	(A)
Cargo piping system	Piping diagram	Including cargo stripping system. For vacuum stripping systems details are to include termination of air pipes and openings from drain tanks and other tanks. For ships with cargo pumprooms specification of temperature monitoring equipment for cargo pumps and shaft penetrations shall be included.	(A)
Cargo pumps and remotely operated valves control and monitoring system	Piping diagram		(A)
	Control and monitoring system documentation	For ships with cargo pumprooms, specification of temperature monitoring equipment for cargo pumps and shaft penetrations shall be included.	(A)
Vapour return systems	Piping diagram		(A)
Oil discharge control and monitoring system (ODM)	Control and monitoring system documentation		(A)
	Piping diagram		(A)
	Operation manual	*Note:*	(A)

		In accordance with IMO MEPC.108 (49) as amended by IMO Res. MEPC.240(65) - Revised Guidelines and Specifications for Oil Discharge Monitoring and Control Systems for Oil Tankers.	
Cargo Tanks	Protected tank location drawing	In accordance with MARPOL Annex I Reg. 19 and 22.	(A)
	Calculation report	Accidental oil outflow performance in accordance with MARPOL Annex I Reg.23.	(I)
Cargo tanks gas freeing system	Piping diagram	Only applicable for fixed mechanical ventilation cargo tank gas freeing system if installed	(A)
Cargo tanks venting system	Piping diagram	Including setting of P/V devices	(A)
	Specification	For P/V-devices and other flame arresters: Details, flow curves and references to type approval certificates.	(I)
Cargo level measurement system – Cargo tank (Fixed)	Control and monitoring system documentation		(A)
	Arrangement Plan	Shall indicate type and location of the level indicators	(I)
Cargo level alarm system- Cargo tank (Fixed)	Control and monitoring system documentation		(A)
	Arrangement Plan	Shall indicate type and location of sensors, as well as location of audible and visible alarms	(I)
Cargo tanks pressure monitoring system (Fixed)	Control and monitoring system documentation	If required as a secondary means of cargo tank venting as per Sec 5.	(A)
	Arrangement plan	Shall indicate type and location of sensors, as well as location of audible and visible alarms	(I)
Cargo temperature monitoring system	Control and monitoring system documentation	If required by Sec 4.4.4.	(A)
Bilge system	Piping diagram	As required by Pt.4 Ch.6 but shall also include bilge and drainage piping systems serving e.g. pump rooms, cofferdams, pipe tunnels and other dry spaces within cargo area. The drawing shall include arrangement for transfer of sludge /bilge water to slop tanks if installed. The drawing shall also include number and location of any bilge level sensors	(A)
Ballast system	Piping diagram	As required by Pt.4 Ch.6 but shall also include ballast systems serving ballast tanks in the cargo area The diagram is to include piping arrangement for forepeak tank (if connected to the ballast system serving the cargo area) as well as details related to ballast treatment systems if installed. For ships with cargo pumprooms, specification of temperature monitoring equipment for ballast pumps and shaft penetrations shall be included.	(A)
Note: (A) For Approval; (I) For Information			

1.5 Surveys and Testing

1.5.1 General

1.5.1.1 All systems covered by this chapter are as far as possible, to be function tested under working conditions to the satisfaction of the attending surveyor.

1.6 Signboards

1.6.1 References

1.6.1.1 Signboards are required by the rules in the following:

- Sec 3.4.1.1 regarding plates bolted to boundaries facing the cargo area and which can be opened for removal of machinery. These shall be supplied with signboards giving instruction that the plates shall be kept closed unless ship is gas-free.

- Sec 8.6.1.1 regarding opening of a lighting fitting. Before opening its supply circuit shall be disconnected.

- Sec 8.6.1.2 regarding spaces where the ventilation shall be in operation before the lighting is turned on.

- Sec 8.6.1.3 regarding portable electrical equipment supplied by flexible cables. This equipment shall not be used in areas where there is gas danger.

- Sec 8.6.1.4 regarding welding apparatus. These shall not be used unless the working space and adjacent spaces are gas-free.

- Sec 10.2.3.4 regarding access to stool tanks.

- Sec 12.3.1.1 regarding hatches and other openings to cargo slop tanks. These shall be kept closed and locked during handling of dry cargo.

- Sec 12.3.1.2 regarding instructions for handling of slop.

SECTION 2 MATERIALS AND HULL STRENGTH

Contents

2.1 General

2.1.1 Application

2.1.1.1 The requirments for selection of hull materias and strength of hull structure in general to follow the requirments and principles provided in Pt 3. supplemented by the requirements given in this section. For scantlings and testing of tanks other than integral tanks

2.1.1.2 The additional notation **CSR** is mandatory for tankers and combination carriers with class notations and length as described below:

- Ships with class notation **Tanker for Oil** or **Tanker for Oil Products** and with L > 150m. This includes combination carriers and chemical tankers with L > 150 m, also intended for carriage of oil.

- The CSR notation describes that the newbuilding is designed and built according to IACS Common Structural Rules for Bulk Carriers and Oil Tankers as described in Sec 2.1.2. (L= length as provided in Pt 3, Ch 1, Sec 2.1.)

2.1.2 IACS Common Structural Rules

2.1.2.1 Application of the mandatory class notation **CSR** .

2.1.2.2 The requirements detailed in CSR Pt.1 and Pt.2 shall apply to CSR ships, for which the building contract is placed on or after 1 July 2015.

2.1.2.3 Requirements with respect to strength of the hull structure, including scantlings and testing of integral tanks and selection of hull materials given in Pt 3 Ch 1 and the requirements given in Sec 2.2, Sec 2.3, and Sec 2.4

2.1.2.4 The following requirements are in addition covered by the common structural rules and are not applicable for vessels with **CSR** notation:
Corrosion Prevention, Pt 4, Ch 7, Sec 1
Opening and Closing Appliance, Pt 3, Ch 3, Sec 6
Anchoring and Mooring Equipment, Pt 4, Ch 3

2.1.2.5 Regions of the structure for which the common structural rules do not apply, the appropriate classification rules shall be applied. In cases where the common structural rules do not address certain aspects of the ship's design, the applicable classification rules shall be applied.

2.1.2.6 Optional design feature notations described in Pt 3, Ch 1 may be given to vessels with **CSR** notation.

2.1.2.7 Combination carriers with class notation **Bulk Carrier** or **Tanker for Oil ESP** or **Ore Carrier** or **Tanker for Oil ESP** shall fulfil design requirements for bulk carrier or ore carrier in addition to the common structural rules for double hull oil tankers.

2.1.2.8 For ships of gross tonnage ≥ 500 with notation **CSR** , access to and within spaces in, and forward of, the cargo area shall comply with SOLAS Regulation II-1/3-6 and IACS UI SC191.

2.1.3 Definitions

2.1.3.1 The following symbols are used:

T_A = Minimum relevant seagoing draught (depending on the loading condition considered)
L_F = Ship length as provided in Pt 3, Ch 1, Sec 2.1
D = Moulded depth as provided in Pt 3, Ch 1, Sec 2.1

2.2 Materials and Corrosion Prevention

2.2.1 Selection and Testing

2.2.1.1 Materials are generally to be selected according requirements given in Pt 3, Ch 2 for hull materials. The selected materials shall be tested according to the requirements in Pt 2.

2.2.1.2 Alternate materials may be accepted after special consideration.

2.2.1.3 Specifications for corrosion prevention systems for water ballast tanks, comprising selection, application and maintenance, as defined in Pt 4, Ch 7, Table 7.1.1, shall be submitted for information for all vessels designed to carry products listed in Ch 3.

2.3 Hull Strength

2.3.1 General

2.3.1.1 Structural design are in general to follow requirements and principles as given in Pt 3.

2.3.2 Design Loads

2.3.2.1 In general the design loads are to be taken as described in Pt 3.

2.3.3 Girders

2.3.3.1 Girder scantlings shall be based on requirements given in Pt 3 and the principles for direct calculations as given in this section.

2.3.4 Lower Hopper Knuckle

2.3.4.1 Special attention should be paid to the fatigue strength of the knuckle between inner bottom and hopper plate. Calculations according to Pt 3, Ch 15 should be carried out for at least one transverse frame in the midship area. If the hot spot stress is not calculated by a fine mesh finite element model, a geometrical stress concentration factor may be used when the nominal stress is calculated according to Sec 2.4.

Note:
For hopper knuckles with angles between inner bottom and hopper plate between 30° and 75° a geometrical stress concentration factor of 7.0 may be applied.

2.3.4.2 The dynamic stresses shall be based on the simplified approach for calculation of dynamic loads or wave loads derived from direct load calculations, using the wave scatter diagram representative for world-wide routes.

2.3.4.3 The fatigue calculation required in Sec 2.3.5.1 and Sec 2.3.5.2 may be omitted for knuckles with proper support.

Note:
To ensure proper support of the knuckle, brackets should be fitted in ballast tanks in line with the inner bottom. Geometrical eccentricity in the knuckle should be avoided or kept to a minimum. In addition, one of the following structural solutions for knuckles with angles between inner bottom and hopper plate between 30° and 75°, should be adequate:

a) Bracket inside cargo tank. The bracket should extend approximately to the first longitudinals and the bracket toe should have a soft nose design.

b) Insert plate of 2.0 times the thickness normally required. Insert plates should be provided in inner bottom, hopper plate, and web frame. The insert plates should extend approximately 400 mm along inner bottom and hopper plate, approximately 800 mm in longitudinal direction, and 400 mm in the depth of the web.

2.3.5 Emegrency Towing

2.3.5.1 Tankers of 20 000 tonnes deadweight and above, including oil tankers, chemical tankers and gas carriers shall be fitted with an emergency towing arrangement in accordance with IMO resolution MSC.35(63).

2.3.5.2 Arrangement drawing which includes details of towing pennant, chafing chain and pick-up gear, shall be submitted for approval. Towing arrangements shall be arranged both forward and aft. Supports shall be adequate for towing angles up to 90° from the ship's centreline to both port and starboard and 30° vertically downwards.

2.3.5.3 Safe working load (SWL) of emergency towing arrangement shall be as below :

- 1000 kN for vessels less than 50 000 tonnes deadweight
- 2000 kN for vessels of 50 000 tonnes deadweight and above.

Minimum breaking load (MBL) of the major components of the towing arrangements, as defined in MSC.35(63), shall be 2 times the SWL.

2.3.5.4 Supporting structure and the strong point for the towing arrangement shall be designed for a load of 1.3 times the SWL with allowable stresses as detailed below:

- Bending stress (allowable): 160 / k_m N/mm^2
- Shear stress (allowable): 90 / k_m N/mm^2

2.3.5.5 Material of welded parts used in the strong point shall be Charpy V-notch tested (minimum 27 J at 0°C), refer Pt 2, Ch 5.

2.3.5.6 The pick-up gear shall be a floating line of minimum length 120 m and with a minimum breaking load (MBL) of 200 kN.

2.3.5.7 Emergency towing components shall be certified as required by Sec 1, Table 1.3.1.

2.3.6 Vertically Corrugated Bulkhead Without Stool

2.3.6.1 For vertically corrugated bulkhead and moulded depth equal to or greater than 16 m, a lower stool is to be fitted. The inner bottom and hopper tank plating in way of corrugations is to be of at least the same material yield strength as the attached corrugation and Z-grade steel in accordance with Pt 2, Ch 1, Sec 1.11 shall be used or through thickness properties shall be documented. Brackets shall be arranged below inner bottom and hopper tank plating in line with corrugation webs as far as practicable.

2.3.7 Small Voids Adjacent to Cargo Tanks

2.3.7.1 Small voids adjacent to cargo tanks shall be provided with arrangements for inerting, gas-freeing and inspection from a space with equivalent hazardous area classification (other than cargo tanks) or open deck. Refer also Sec 3.2.1.8.

2.4 Direct Strength Calculations

2.4.1 General

2.4.1.1 For girders that are part of a complex 2 or 3 dimensional structural system, a complete structural analysis may have to be carried out to demonstrate that the stresses are acceptable when the structure is loaded as described in Sec 2.4.2.

2.4.1.2 Detailed calculations as mentioned in Sec 2.4.1.1 shall be carried out for:

- Double bottom structures
- Transverse bulkhead structures
- Transverse ad vertical girders in cargo tanks
- Other structures as deemed necessary bt the Society

2.4.2 Loading Conditions

2.4.2.1 In way of the cargo region the girder structure of oil carriers and chemical carriers is generally to be considered for load conditions given in Sec 2.4.2.2 to Sec 2.4.2.5.

2.4.2.2 Various loading conditions as detailed below sall examined for the vessel in the upright seagoing conditions:

a) Any cargo tank to be empty on full draught (T) with adjacent cargo tanks full.

b) Any cargo tank to be filled on a minimum relevant seagoing draught (TA) with the adjacent tanks empty.

c) All cargo tanks within a transverse section of the ship to be filled on minimum relevant seagoing draught (TA) with adjoining cargo tanks forward and aft empty.

2.4.2.3 Various loading conditions as detailed below shall be examined for upright harbour conditions:

a) Any cargo tank may be filled on a draught of 0.25 D (0.35 T if this is less) with adjacent tanks empty.

b) All cargo tanks in a section of the ship to be filled at a draught of 0.35 D (0.5 T if this is less) with adjoining cargo tanks forward and aft empty.

2.4.2.4 The principles outlined in Sec 2.4.2.2 ad Sec 2.4.2.3 are exemplified for different tankers as follows:

For ships with 2 longitudinal bulkheads:

- Seagoing conditions, refer Fig. 1
- Harbour conditions, refer Fig. 2

For ships with 1 longitudinal bulkhead:

- Seagoing conditions, refer Fig. 3
- Harbour conditions, refer Fig. 4

For ships without longitudinal bulkheads:

- Seagoing conditions, refer Fig. 5
- Harbour conditions, refer Fig. 6

2.4.2.5 The girder structure of cargo- and ballast tanks with breadth, b > 0.6 B shall be checked for a seagoing load condition with filled tanks at a minimum draught (TA), or 0.35 D if T_A is not known, and heeled to an angle of φ/2 with adjacent tanks empty. Refer Fig 7. φ is provided in Pt 3, Ch 4, Sec 2.

2.4.2.6 Girders on transverse bulkheads in ships with 1 or 2 longitudinal bulkheads are in addition to be considered for alternate loading of cargo tanks, see Fig 8. In this condition a draught of T_A to be considered. The condition is a seagoing condition.

2.4.2.7 Ships with 2 longitudinal bulkheads and with cross ties in the centre tank shall be considered for an asymmetric load condition with one wing tank filled and other tanks empty, unless reservations are given against the practising of this condition or such condition will result in unrealistic heeling. The draught shall be taken as 0.25 D. The loading condition is a harbour condition and is illustrated in Fig 9.

2.4.2.8 The sloshing pressure given in Pt 3, Ch 1, Sec 3.3.3 to Sec 3.3.6 need not be taken to act simultaneously over the total area of any exposed tank boundary. When found necessary, relevant parts of the girder system shall be checked.

2.4.3 **Acceptance Criteria**

2.4.3.1 Acceptance criteria shall be taken as given in Pt 3, Ch13.

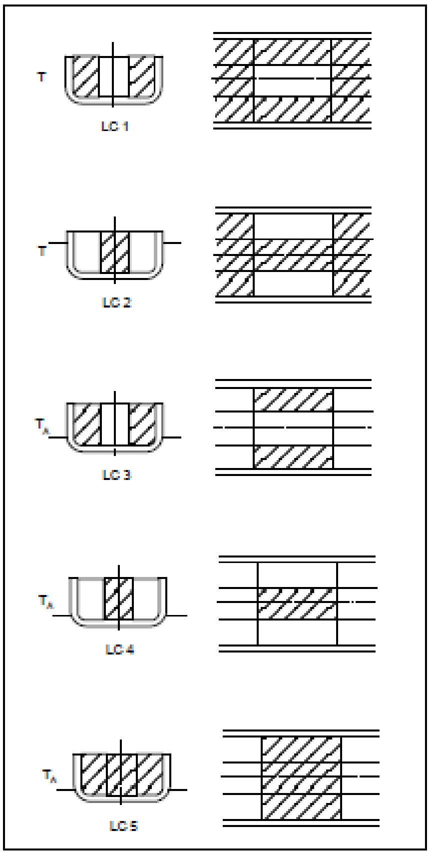


Fig 1 Seagoing Conditions for Vessels with 2 Longitudinal Bulkheads

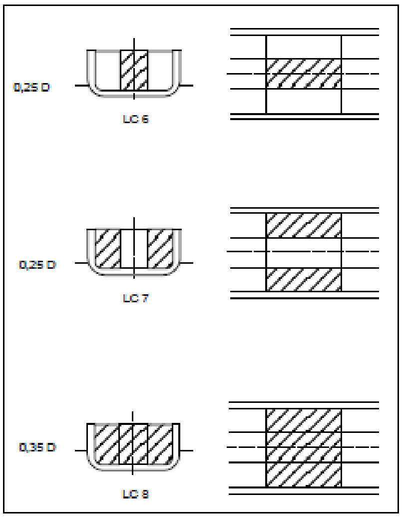


Fig 2 Harbour Conditions for Vessels with 2 Longitudinal Bulkheads

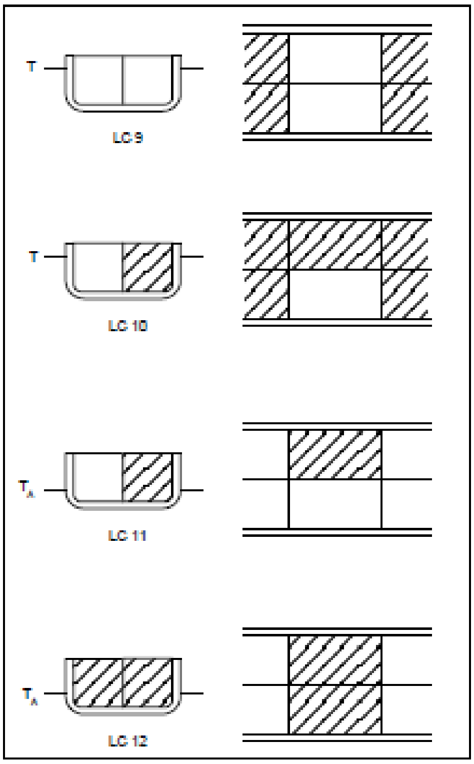


Fig 3 Seagoing Conditions for Vessels with 1 Longitudinal Bulkhead

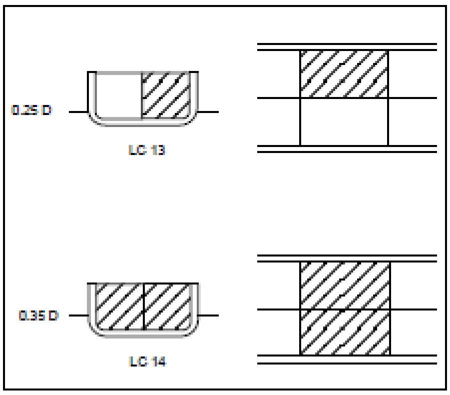


Fig 4 Harbour Conditions for Vessels with 1 Longitudinal Bulkhead

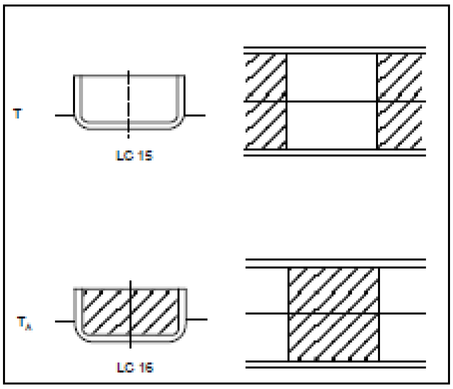


Fig 5 Seagoing Conditions for Vessels without Longitudinal Bulkheads

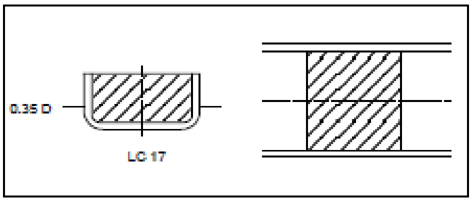


Fig 6 Harbour Conditions for Vessels without Longitudinal Bulkheads

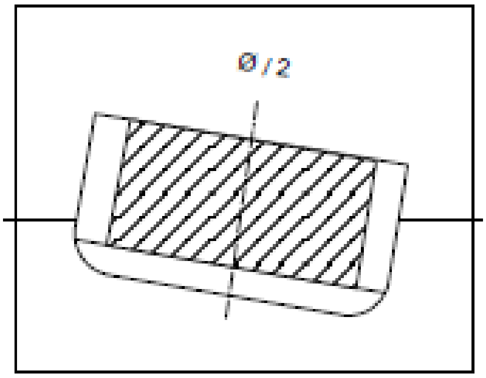


Fig 7 Heeled Loading Condition

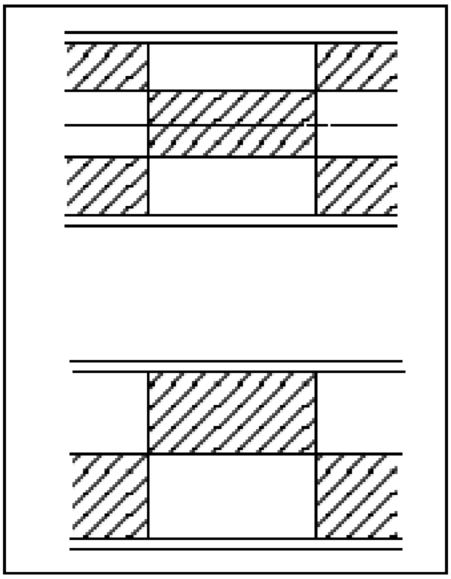


Fig 8 Alternate Loading Conditions

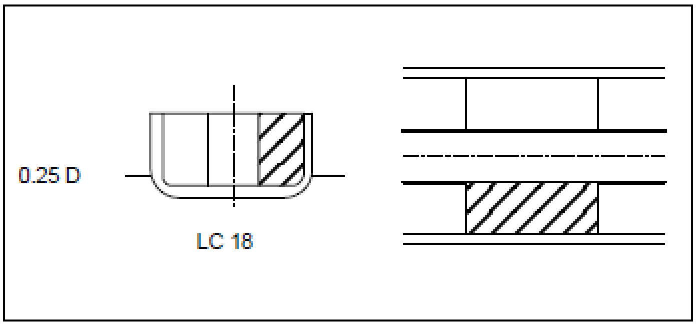


Fig 9 Additional load condition for vessels with cross tie in center tank

SECTION 3 SHIP ARRANGEMENT AND STABILITY

Contents

3.1 Intact Stability

3.1.1 Intact Stability

3.1.1.1 Intact stability requirements of Pt 8, shall be complied with. In addition, vessels with class notation **Tanker for Oil** of 5000 tonnes deadweight and above shall comply with the intact stability criteria as specified in MARPOL Annex I, Reg. 27.

3.2 Location and Separation of Spaces

3.2.1 General

3.2.1.1 Machinery space shall be isolated from cargo tanks and slop tanks by cofferdams, pump rooms, oil fuel bunker tanks or ballast tanks. Spaces which may be approved as cofferdams, refer Sec 3.6. Spaces which may be approved as cofferdams, refer Sec 3.6.

3.2.1.2 Fuel oil bunker tanks shall not be situated within the cargo tank block. Such tanks may, however, be situated at forward and aft end of the cargo tanks instead of cofferdams. Fuel oil tanks shall not extend fully nor partly above or beneath cargo or slop tanks and are not permitted to extend into the protective area of cargo tanks required by Sec 3.3.

3.2.1.3 Machinery and boiler spaces and accommodation and service spaces shall be positioned aft of the cargo area, but not necessarily aft of fuel oil tanks.

Note:
Machinery spaces shall not be located fully nor partly within the cargo area including within e.g. pumprooms or other spaces approved as cofferdams, except as specified in Sec 3.2.1.4. Machinery spaces other than those of category A that contain electrically driven equipment or systems required for cargo handling may upon special considerations be accepted located within the cargo area. Area classification requirements apply. Examples of such systems are: hydraulic power units for cargo systems, nitrogen generators and dehumidification plants.

3.2.1.4 Lower portion of the cargo pump room may be recessed into machinery and boiler spaces to accommodate pumps, provided the deck head of the recess is in the general not more than one-third of the moulded depth above the keel, except that in the case of ships of not more than 25 000 tons deadweight, where it can be demonstrated that for reasons of access and satisfactory piping arrangements this is impracticable, a recess in excess of such height may be permitted, though not exceeding one half of the moulded depth above the keel.

3.2.1.5 Spaces mentioned in Sec 3.2.1.3 except machinery spaces of category A, may be positioned forward of the cargo area after consideration in each case.

Note:
Machinery spaces other than those of category A may be accepted located in forecastle spaces above forepeak tanks even if said forepeak tank is located adjacent to cargo tank. Bow thruster spaces cannot be located adjacent to cargo tanks (SOLAS Ch.II-2 Reg.4.5.1.3).

3.2.1.6 Where the fitting of a navigation position above the cargo area is shown to be necessary, it shall be for navigation purposes only, and it shall be separated from the cargo tank deck by means of an open space with a height of at least 2 m.

3.2.1.7 Oil spill on the deck shall be kept away from accommodation and service areas and from discharge into the sea by a permanent continuous coaming of minimum 100 mm high surrounding the cargo deck. In the aft corners of the cargo deck the coaming shall be at least 300 mm high and extend at least 4.5 m forward from each corner and inboard from side to side. Scupper plugs of mechanical type are required. Means of draining or removing oil or oily water within the coamings shall be provided.

3.2.1.8 Where a corner-to-corner situation occurs between a non-hazardous space and a cargo tank, a cofferdam created by a diagonal plate across the corner on the non-hazardous side, may be accepted as separation. Such cofferdams shall be provided with means for inspection, cleaning and gas-freeing preferably from a space with equivalent hazardous area classification (other than cargo tanks) or open deck.

3.2.1.9 Paint lockers shall not be located within the cargo tank block, but may be located above oil fuel bunker tanks or ballast tanks aft of cargo tanks / slop tanks.

3.2.2 Arrangement of Barges

3.2.2.1 Any space forward of the collision bulkhead (forepeak) and aft of the aftermost bulkhead (afterpeak) shall not be arranged as cargo oil tanks.

3.3 Tank and Pump Room Arrangement

3.3.1 Segregated Ballast Tanks

3.3.1.1 Ships of 20 000 tons deadweight and above having the class notation **Tanker for Oil** and ships of 30 000 tons deadweight and above with class notation **Tanker for Oil Products** shall have segregated ballast tanks.

Capacity of segregated ballast tanks shall be at least such that, in any ballast condition at any part of the voyage, including the conditions consisting of lightweight plus segregated ballast only, the ship's draughts and trim can meet each of the following requirements:

a) The moulded draught amidships (dm) in metres (without taking into account any ship's deformation) shall not be less than:

$d_m = 2.00 + 0.02\ L_F$

Where L_F is the ships length as defined by MARPOL.

b) The draughts at the forward and after perpendiculars shall correspond to those determined by the draught amidships (dm) as specified in subparagraph a) of this paragraph, in association with the trim by the stern of not greater than 0.015 LF; and

c) In any case the draught at the after perpendicular shall not be less than that which is necessary to obtain full immersion of the propeller(s).

3.3.2 Protection of Cargo Tanks

3.3.2.1 Ships of 600 tons deadweight but less than 5 000 tons deadweight shall have a double hull arrangement covering the entire cargo tank length with particulars as follows:

a) Double side width (m)
$w = 0.40 + (2.4DW / 20{,}000)$ or
$w = 0.76$; whichever is greater

Where,

DW = Deadweight capacity of ship (t)

b) Tankers wwhere each cargo tanke does not excess 700 m^3cmay be designed with single side.

Ships intended for carriage of heavy grade oil (as defined in MARPOL Annex I, Reg. 21) as cargo, shall comply with a).

c) Double bottom height (m):

h = B /15 or
h = 0.76; whichever is greater

3.3.2.2 Ships of 5 000 tons deadweight and above shall have double hull in the entire cargo tank length with arrangement as follows:

a) Double side width (m)

w = 0.50 + (DW / 20000) or
w = 2.00 whichever is lesser, but not less than 1.00 m

b) Double bottom height (m)

h = B / 15 or
h = 2.00 whichever is lesser, but not less than 1.00 m

When the distances h and w are different, the distance w shall have preference at levels exceeding 1.5 h above the baseline as shown in Fig. 1.

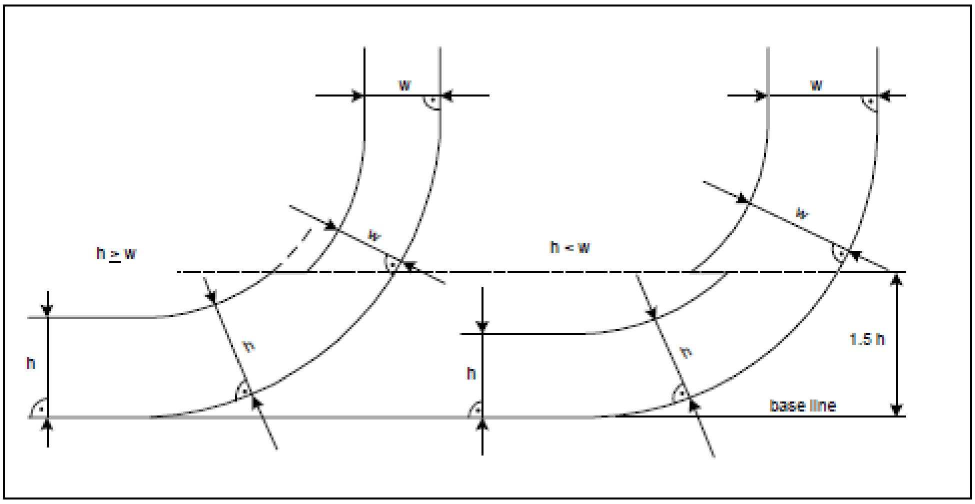


Fig 1 Double Hull Distances

3.3.2.3 Double bottom tanks or spaces as required by 201 may be dispensed with, provided that the design of the tanker is such that the cargo and vapour pressure exerted on the bottom shell plating forming a single boundary between the cargo and the sea does not exceed the external hydrostatic water pressure, as expressed by the following formula:

$f\ h_c\ \rho_c\ g + 100\ \delta_p \leq d_n\ \rho_s\ g$
Where,
h_c = Height of cargo in contact with the bottom shell plating (m)
ρ_c = Maximum cargo density (t/m^3)

d_n = minimum operating draught (m) under any expected loading condition
ρ_s = Density of sea water (t/m^3)
δ_p = Maximum set pressure of pressure vacuum valve provided in the cargo tank (bar)
f = Safety factor = 1.10
g = Standard acceleration due to gravity (m/sec^2)

Any horizontal partition necessary to fulfil the above requirements shall be located at a height of not less than B/6 or 6 m, whichever is the lesser, but not more than 0.6 D, above the baseline where D is the moulded depth amidships.

The location of wing tanks or spaces shall be as defined in Sec 3.3.2.2 except that below a level 1.5 h above the baseline where h is as defined in Sec 3.3.2.2 the cargo tank boundary line may be vertical down to the bottom plating.

3.3.2.4 Suction wells in cargo tanks may protrude into the double bottom below the boundary line defined by the distance h provided that such wells are as small as practicable and the distance between the well bottom and bottom shell plating is not less than 0.5 h.

3.3.3 **Cargo Tanks and Slop Tanks**

3.3.3.1 Accidental oil outflow performance in the case of side damage and bottom damage shall be within the limits required in MARPOL Annex I, Reg. 23.

3.3.3.2 Oil carriers of 150 gross tonnage and above shall be provided with arrangements of slop tank or combination of slop tanks with a total capacity complying with MARPOL Annex I, Reg. 29.

3.3.3.3 Oil carriers of 70 000 tons deadweight and above shall be provided with at least two slop tanks.

3.3.3.4 Slop tanks shall be designed particularly with respect to decantation purpose. Positions of inlets, outlets, baffles or weirs where fitted, shall be placed so as to avoid excessive turbulence and entrainment of oil or emulsion with the water.

3.3.4 **Double Bottom in Pump Rooms**

3.3.4.1 Pump rooms containing cargo pumps in ships of 5000 tons deadweight and above, shall be provided with a double bottom with depth h as follows:

h = B / 15 (m) or
h = 2.00 m; whichever is lesser, but not less than 1.00 m

3.4 Arrangement of access and openings to spaces and tanks

3.4.1 **Accommodation and Non-hazardous Spaces**

3.4.1.1 Air inlets, entrances and openings to accommodation spaces, service spaces, control stations and machinery spaces shall not face the cargo area. They shall be located on the end bulkhead and or on the outboard side of the superstructure or deckhouse at a distance of at least L/25 but not less than 3 m from the end of the superstructure or deckhouse facing the cargo area. This distance, however, need not exceed 5 m.

The following shall be applicable within the limits specified above:

a) Bolted plates for removal of machinery may be fitted. Such plates shall be insulated to A-60 class standard. Signboards giving instruction that the plates shall be kept closed unless the ship is gas-free, shall be posted on board.

b) Windows of the wheel house may be non-fixed and wheelhouse doors may be located within the above limits as long as they are so designed that a rapid and efficient gas and vapour tightening of the wheelhouse can be ensured.

c) Windows and side scuttles shall be of the fixed (non-opening) type. Such windows and side scuttles except wheelhouse windows, shall be constructed to A-60 class standard.

3.4.1.2 Cargo control rooms, stores and other spaces not covered by Sec 3.4.1.3 but located within accommodation, service and control stations spaces, may be permitted to have doors facing the cargo area. Where such doors are fitted, the spaces are not to have access to the spaces covered by Sec 3.4.1.3 and the boundaries of the spaces are to be insulated to A-60 class.

3.4.1.3 For access and openings to non-hazardous spaces other than accommodation and service spaces, the following provisions apply:

- Entrances from hazardous areas on open deck are normally not to be arranged. If air locks are arranged such entrances may, however, be approved, refer Sec 3.4.1.5 and Sec 3.4.1.6.

- Entrances to non-hazardous forecastle spaces from hazardous areas shall be arranged with air locks, refer Sec 3.4.1.4.

- Entrances shall not be arranged from hazardous spaces.

3.4.1.4 Ventilation inlets for the spaces mentioned in Sec 3.4.1.1 are to be located as far as practicable from gasdangerous zones, and in no case are the ventilation inlets nor outlets to be located closer to the cargo area than specified for doors in Sec 3.4.1.1.

3.4.1.5 Entrance through air locks to non-hazardous spaces shall be arranged at a horizontal distance of at least 3 m from any opening to a cargo tank or hazardous space containing gas sources, such as valves, hose connections or pumps used with the cargo.

3.4.1.6 Air locks shall comply with the following requirments:

a) Air locks shall be enclosed by gastight steel bulkheads with two substantially gas tight self-closing doors spaced at least 1.5 m and not more than 2.5 m apart. The door sill height shall comply with the requirement given in Pt.3 Ch.3 Sec.6 B, but shall not be less than 300 mm.

b) Air locks shall have a simple geometrical form. They shall provide free and easy passage, and shall have a deck area not less than about 1.5 m^2. Air locks shall not be used for other purposes, for instance as store rooms.

c) For requirements to ventilation of airlocks, refer Sec 6.

3.4.2 Access to and Within Hazardous Spaces

3.4.2.1 Access to and within spaces in, and forward of, the cargo area shall comply with SOLAS Regulation II- 1/3-6.

3.4.2.2 Doors to hazardous spaces, situated completely upon the open deck, shall have as low a sill height as possible. Such compartments shall not be connected with compartments at a lower level.

For deck openings for scaffolding wire connections, the number and position of holes in the deck are subject to approval. The closing of the holes may be effected by screwed plugs of metal or an acceptable synthetic material, refer Sec 4.1.

The material used in the manufacture of plugs and jointing, if any, shall be impervious to all cargoes intended to be carried.

Metal plugs shall have a fine screw thread to ensure an adequate number of engaging threads. A number of spare plugs equal to at least 10% of the total number of holes shall be kept on board.

3.5 Protection of Crew

3.5.1 Arrangement

3.5.1.1 Bulwarks, guardrails and arrangements for safe access to bow shall be arranged in accordance with Pt.3 . On tank deck open guard rails are normally to be fitted. Plate bulwarks, with a 230 mm high continuous opening at lower edge, may be accepted upon consideration of the deck arrangement and probable gas accumulation.

Note:
Permanently constructed gangways for safe access to bow shall be of substantial strength and be constructed of fire resistant and non-slip material.

3.5.1.2 Systems with a surface temperature above 60°C shall be provided with insulation or mechanical shielding if they are so located that crew may come in contact with them during normal operation or access.

3.6 Cofferdams and Pipe Tunnels

3.6.1 Cofferdams

3.6.1.1 Cofferdams shall be of sufficient size for easy access to all parts, and they shall cover the entire adjacent tank bulkhead. Minimum distance between bulkheads (and requirements to sizes of openings) are to be in accordance with Sec 3.4.2, however not less than 600 mm.

3.6.1.2 Pump rooms and ballast tanks will be accepted as cofferdams. Ballast tanks will, however, not be accepted as cofferdams for protected slop tanks. Refer Sec 12.

3.6.2 Pipe Tunnels

3.6.2.1 Ample space for inspection of the pipes shall be ensured in pipe tunnels.

3.6.2.2 Pipes inside the pipe tunnels shall be situated as high as possible above the ship's bottom.

There shall be no connection between a pipe tunnel and the engine room neither by pipes nor manholes.

3.6.2.3 Provision shall be made for at least two exits to the open deck arranged at a maximum distance from each other. One of these exists fitted with a watertight closure may lead to the cargo pump room.

3.6.2.4 Where there is permanent access from a pipe tunnel to the main pump-room, a watertight door shall be fitted complying with the requirements of SOLAS Ch. II-1/25-9, and in addition with the following requirements:

a) In addition to bridge operation, the watertight door shall be capable of being manually closed from outside the main pump-room entrance.

b) The watertight door shall be kept closed during normal operations of the ship except when access to the pipe tunnel is required.

3.7 Diesel Engines for Emergency Fire Pumps

3.7.1 General

3.7.1.1 Diesel engines for emergency fire pump, shall be installed in a non hazardous space.

3.7.1.2 The exhaust pipe of the diesel engine, if fitted forward of the cargo area, shall have an effective spark arrester, and shall be led out to the atmosphere outside hazardous areas.

3.8 Chain Locker and Anchor Windows

3.8.1 General

3.8.1.1 The chain locker shall be arranged as a non hazardous space.

3.8.1.2 Windlass cable lifters and chain pipes shall be situated outside hazardous areas.

3.9 Equipment in Tanks and Cofferdams

3.9.1 General

3.9.1.1 Permanently attached equipment units in tanks and cofferdams such as anodes, washing machines etc shall be securely fastened to the structure. The units and their supports shall be able to withstand sloshing in the tanks and vibratory loads as well as other loads which may be imposed in service.

Note

Construcition materials in permanently attached equipment units in tanks and cofferdams shall be such that they do not have any contact spark producing properties.

3.10 Surface Metal Temperatures in Hazardous Areas

3.10.1 General

3.10.1.1 Surface metal temperatures of equipment and piping in hazardous areas shall not exceed 220°C.

SECTION 4 PIPING SYSTEMS IN CARGO AREA

Contents

4.1 Piping Materials

4.1.1 Selection and Testing

4.1.1.1 Piping materials shall be selected according to the requirements as provided Pt.5A(..Machinery and System/ Piping) for piping materials.

4.1.1.2 Any other materials may be accepted based on special consideration by the Surveyor.

4.1.1.3 Components and piping of synthetic material may be approved on a case by case basis.

4.1.2 Special Requirments for Cargo Piping System

4.1.2.1 Manifold valves and distance pieces or reducers outboard of valves, which are connected directly to the cargo pipeline's shore connection on deck, shall be made of steel and of flanged type.

4.1.3 Plastic Pipes in Cargo Area

4.1.3.1 Plastic pipes of approved type and tested according to an approved specification may be accepted. For the application of plastic pipes, refer Pt.4 Ch.6.

4.1.3.2 The surface resistance per unit length of pipes, when used in hazardous area, shall not exceed 105 Ω/m and the resistance to earth from any point in the piping system shall not exceed 106 Ω.

4.1.4 Aluminium Coatings

4.1.4.1 Generally aluminised pipes are accepted in non-hazardous areas and may be permitted in hazardous areas on open deck and in inerted cargo tanks and ballast tanks.

Restrictions on use of aluminium paints, refer Pt 4, Ch 7, Sec 1.

4.2 Piping Systems Not Used for Cargo Oil

4.2.1 General

4.2.1.1 The cargo area piping systems shall not be connected to piping systmes in the remainder of the ship, unless explicitly specified in this section.

Note:
Piping systems for e.g. hydraulic oil, fuel lines, compressed air, steam and condensate, fire and foam located in the cargo area are permitted to be connected to systems in the remainder of the ship, provided they are not permanently connected to cargo handling systems or have open ends in cargo tanks.

4.2.1.2 Piping systems such as compressed air, hydraulic oil which serve systems within tanks or spaces that are not used for cargo shall not be led through cargo tanks.

4.2.1.3 Piping systems such as hydraulic oil serving systems within cargo tanks, shall be led to tanks from deck level and not penetrate boundaries between cargo tanks and tanks and compartments that do not contain cargo.

4.2.1.4 All piping led from machinery spaces, into the cargo area shall be provided with means to preserve the integrity of the machinery space bulkhead.

4.2.2 Drainage of Pump rooms, Cofferdams, Pipe tunnels, Ballast and Fuel oil tanks

4.2.2.1 Cargo pump rooms shall have a bilge system connected to pumps or bilge ejectors. The bilge system shall be capable of being operated from outside the cargo pumproom.

4.2.2.2 Cargo pumps may be used for bilge service provided each bilge suction pipe is fitted with a screw-down non-return valve, and an additional stop valve is fitted to the pipe connection between pump and the non-return valve.

4.2.2.3 Bilge pipes in the cargo pump room shall not be led into the engine room.

4.2.2.4 Bilge suctions shall be provided in cofferdams, pipe tunnels, voids and other dry-compartments below main deck and within the cargo area.

Note:
For small voids, with direct access from open deck (e.g. transverse upper stool spaces), portable draining arrangements may be accepted. Arrangements where the use of the portable drainage equipment requires entry into the void will not be accepted.

4.2.2.5 Hazardous spaces (including any compartment or tank, cofferdams or void) within the cargo area shall only be drained by bilge pumps or ejectors located within the space itself or within a space with an equivalent hazard.

4.2.2.6 Pipe tunnels shall be drained from the cargo pump room or an equivalent hazardous space.

4.2.2.7 Ballast tanks shall be provided with at least two drain pumping units. Segregated ballast tanks within the cargo area shall be served by ballast pumps in the cargo pump room, in a similar hazardous space or inside ballast tanks. At least one of the pumps shall be exclusively used for ballast. As another means an eductor or an emergency connection to a cargo pump may be accepted. Segregated ballast systems shall not have any connections to the cargo system, but an emergency discharge of ballast water may be arranged by connection to a cargo pump.

The connection pipe shall be provided with a removable spool piece and a closing valve and non-return valve in series in the suction side to the cargo oil pump.

4.2.2.8 For discharge of water ballast and oil contaminated water from the cargo areas, arrangements shall be made above the waterline in the deepest ballast condition, in accordance with MARPOL Annex I, Reg.30.

4.2.2.9 A discharge manifold for connection to reception facilities for the discharge of dirty ballast water or oil contaminated water shall be located on the open deck on both sides of the ship.

4.2.2.10 For ships arranged with emergency connection between the cargo system and the segregated ballast system as specified in Sec 4.2.2.8, Ballast tanks forward of cargo area may be connected to the ballast pumps in the aft cargo pump room, refer Sec 4.2.2.13.

4.2.2.11 Ballast piping and other piping such as sounding and vent piping to ballast tanks shall not pass through cargo tanks.

4.2.2.12 Fuel oil bunker tanks adjacent to cargo tanks may be connected directly to pumps in the engine room. The pipes shall not pass through cargo tanks and shall have no connection with pipelines serving such tanks.

4.2.2.13 Ballast water treatment systems are to comply with safety requirements of Pt.5A

4.2.3 **Fore Peak Ballast Tank**

4.2.3.1 The fore peak tank can be ballasted with the system serving other ballast tanks within the cargo area, provided:

a. Fore peak tank is considered hazardous.

b. The air pipes shall be located on open deck. The hazardous zone classification in way of air pipes shall be in accordance with Sec.8.

c. Means are provided, on the open deck and within tanks, to allow measurement of flammable gas concentrations within the fore peak tank by a suitable portable instrument.

d. Arrangements for sounding, gas detection and other openings to the fore peak tank are direct from open deck.

e. The access to the fore peak tank is direct from open deck

As an alternative to direct access from open deck, indirect access to the fore peak tank through an enclosed space may be accepted provided that:

f. Wherever the enclosed space is non-hazardous and separated from the cargo tanks by cofferdams, the access is through a gas tight bolted manhole located in the enclosed space and a signboard is to be provided at the manhole stating that the fore peak tank may only be opened after it has been proven to be gas free or any electrical equipment which is not certified safe in the enclosed space is isolated.

g. Wherever the enclosed space has a common boundary with the cargo tanks and is therefore hazardous, the enclosed space is well ventilated to open deck and a signboard is provided at the manhole(s) stating that the forepeak may only be opened when the enclosed space is being thoroughly ventilated. (IACS UR F44 Rev.1)

4.2.3.2 The requirements in Sec 4.2.3.1 also apply to spaces other than forepeak tanks, such as upper forward voids spaces, with common boundary with cargo tanks and located below non-hazardous enclosed spaces (eg. forecastle spaces) and without access to open deck. In order to comply with the condition that the space can be well ventilated, adequate gas-freeing arrangements shall be provided. For forepeak tanks or other ballast tanks adequate gas-freeing to open deck is ensured through filling and emptying the tank. For voids without direct access to open deck, fixed piping extending to the bottom of the void will normally be required to ensure thorough ventilation from open deck.

4.2.4 **Oil Discharge Monitoring and Control Systems**

4.2.4.1 Oil carriers of 150 gross tonnage and above shall be equipped with an approved arrangement for oil content monitoring of oily ballast and tank washing water in accordance with MARPOL Annex I, Reg. 31. The system shall record continuously the discharge of oil in litres per nautical mile and total quantity of oil discharged, or the oil content and rate of discharge.

4.2.4.2 Operation manual and instruction describing all essential procedures for manual and automatic operations shall be submitted for approval in accordance with

Sec 1, Table 1.4.1.

Note:
Reference is made to IMO MEPC.108(49) as amended by MEPC.240(65) - Revised Guidelines and Specifications for Oil Discharge Monitoring and Control Systems for Oil Tankers.
IMO Res. MEPC240(65) is applicable to ships that intend to carry bio-fuel blends.
Manufacturer recommended spares for the ODME should be carried to ensure the operation of the equipment.

4.2.4.3 Oil tankers of 150 gross tonnage and above, shall be provided with an effective oil and water interface detector of approved type in accordance with MARPOL Annex I, Reg. 32, for determination of the oil water inter face in slop tanks and other tanks where separation of oil and water is effected and from which it is intended to discharge effluent direct to sea.

4.2.5 **Oil Record Book, Shipboard Oil Pollution Emergency Plan, Ship-to-Ship Transfer**

4.2.5.1 Applicable for oil carriers of 150 gross tonnage and above shall be provided with an oil record book in accordance with MARPOL Annex I, Reg. 36.

4.2.5.2 Applicable for oil carriers of 150 gross tonnage and above shall be provided with a Shipboard Oil Pollution Emergency Plan (SOPEP) approved by an Administration in accordance with MARPOL Annex I, Reg. 37.

4.2.5.3 Applicable for oil carriers of 150 gross tonnage and above, which are to be engaged in transfer of oil cargo between oil tankers at sea, shall be provided with a ship-to-ship (STS) transfer manual in accordance with MARPOL Annex I, Reg. 41.

4.2.6 **Air, Sounding and Filling Pipes**

4.2.6.1 Within cargo areas filling of tanks shall be carried out from the cargo pump room or a similar hazardous space.

4.2.6.2 Filling lines to permanent ballast tanks and other discharge lines to cargo area may be connected to pumps outside the cargo area (eg. engine room), provided the lines are not carried through cargo tanks and adjacent spaces and do not have a permanent connection to any cargo tank. The arrangement is subject to approval in each separate case.

4.2.6.3 Filling lines to permanent ballast tanks shall be so arranged that the generation of static electricity is reduced, e.g. by reducing the free fall into the tank to a minimum.

4.2.6.4 Suction for seawater to permanent ballast tanks shall not be arranged in the same sea chest as used for discharge of ballast water from cargo tanks refer to also Sec 4.3.2.8.

Note:
Seawater suction should be arranged at the opposite side from the discharge of ballast water from cargo tanks.

4.2.6.5 Sounding and air pipes from cofferdams shall be lead to the atmosphere. The air pipes shall be fitted with flame screens at their outlets.

4.2.6.6 An arrangement for transferring sludge, bilge water and similar from machinery spaces to eg. slop tank may be accepted on the following conditions:

- The filling pipe is routed via deck level

- The filling pipe is provided with a closable non-return valve (or automatic non-return valve and a closable valve in series) located in the cargo area.

- A spool piece or flexible hose not exceeding 2 m in length is provided on open deck. The design is to incorporate valve(s) so that when mounting or dismantling the spool piece the crew is not exposed to vapour from the slop tank. Blanks shall be provided for when the spool piece or hose is dismantled when it is not in use.

- The open end in the slop tank extends to the bottom of the slop tank or with the outlet bent towards a bulkhead in a suitable location of the tank in order to prevent free fall.

- Signboards with operational instructions are fitted in cargo control room and in the engine control room.

4.3 Cargo Oil Systems

4.3.1 General

4.3.1.1 Permanent systems of pumps and piping shall be provided for the cargo tanks. This system shall be entirely separate from all other piping systems on board. For excemption refer Sec 5.1.

4.3.1.2 A minimum of two independently driven cargo oil pumps shall be connected to the system.

4.3.1.3 In tankers where cargo tanks are equipped with independent pumps (eg. deep well pumps), the installation of one pump per tank may be approved. Satisfactory facilities shall be provided for emptying the tanks in case of failure of the regular pump.

4.3.1.4 Hydraulically powered pumps, submerged in cargo tanks (eg. deep well pumps), shall be arranged with double barriers, preventing the hydraulic system serving the pumps from being directly exposed to the cargo. The double barrier shall be arranged for detection and drainage of possible cargo leakages.

4.3.1.5 Cargo pumps shall be certified as required by Sec 1, Table 1.3.1. For electrically driven pumps, associated electric motors and motor starters shall be certified as required by Pt.6. For steam driven pumps, steam turbines shall be certified in accordance with Pt.5A. For hydraulically driven pumps, hydraulic pumps shall be certified in accordance with Pt.5A (..Piping systems).

4.3.1.6 The wall thickness of cargo pipes will be specially considered on the basis of anticipated corrosion. The thickness of the pipes are, however, not to be less than given in Pt.5A .

4.3.1.7 All cargo piping shall be electrically bonded to the ship's hull. The resistance to earth from any point in the piping system is not to exceed 106 Ω. Fix points may be considered as an effective bonding.

Fix points may be considered as an effective bonding.

Piping sections not permanently connected to the hull, shall be electrically bonded to the hull by bonding straps.

4.3.1.8 Vent pipes from drain tanks shall terminate in a sage location of open deck. For cargo pumps designed with a separate vacuum stripping system (eg. pumproom tankers), all vent pipes from the vacuum system are to be led to a slop tank or terminate in a safe location on open deck as to prevent crew exposure to vapor as well as water ingress in the system.

4.3.1.9 Drainage systems from cargo deck, drip trays etc. are to be arranged for transfer to cargo or slop tanks. Connections to cargo and slop tanks are to be provided with means for prevention of backflow of vapor.

4.3.1.10 The cargo piping system shall be dimensioned according to Pt.5A . The design pressure p is the maximum working pressure to which the system may be subjected. Due consideration shall be given to possible liquid hammer in connection with the closing of valves.

4.3.1.11 A minimum of 10 bar shall be considered as the design pressure for cargo piping. For ships designed for the carriage of high density cargo, the design pressure shall take into account density of such cargo.

Note:
Maximum pressure will occur with cargo pumps running at full speed against closed manifold valves, when pumping cargo with the maximum design density (regardless of cargo tank filling limitations). As an alternative to increased design pressure when carrying high density cargo, a pressure monitoring system which automatically prevents the design pressure from being exceeded may be accepted. The system shall activate an alarm at the cargo control station. The system shall not impair the operation of ballast and bilge pumps connected to the cargo pump power supply system.

4.3.2 **Cargo Piping System**

4.3.2.1 The complete cargo piping system, except for bow and stern loading systems complying with Sec 4.5, shall be located within the cargo area.

4.3.2.2 Valves or branch pieces, which connect the cargo pipeline's shore connection on deck, and cargo piping shall be supported with due regard to load stresses.

4.3.2.3 As required the expansion elements shall be provided in the cargo piping to minimise support reactions.

4.3.2.4 Means for drainage of the cargo lines shall be provided. Tankers for oil (**Tanker for Oil**) of 20 000 tons deadweight and above, and tankers for oil products (**Tanker for Oil Products**) of 30 000 tons deadweight and above, shall be provided with a special small diameter line, not exceeding 10% of the cross-sectional area of main cargo line, for discharge ashore. This line shall be connected outboard of the ship's manifold valves.

Stripping systems for ships provided with deep well cargo pumps shall be specially considered.

4.3.2.5 The cargo piping system shall not have any connection to permanent ballast tanks.

4.3.2.6 Cargo piping and similar piping to cargo tanks shall not pass through ballast tanks or vice versa. Exemptions to this requirement may be granted for short length of pipes with heavy wall thickness, provided that they are completely welded.

Note:
Short length of pipes may be such as through stool tanks used for ballast etc.

4.3.2.7 Filling lines to cargo tanks shall be so arranged that the generation of static electricity is reduced, eg. by reducing the free fall into the tank to a minimum.

4.3.2.8 The discharge of ballast water from cargo tanks shall be arranged in such a way as to prevent the ballast water from being drawn into sea suctions for other pipe systems, i.e. cooling water systems for machinery.

4.3.2.9 Isolation of cargo piping connections to sea shall be made by means of at least two shut-off valves. Arrangement for tightness monitoring of sea valves shall be provided.

Note:
Tankers delivered on or after 01- Jan-2010, MARPOL Annex I, Reg 30.7 shall apply for the arrangement. For arrangement of tightness tesing of sea valves, refer OCIMF's recommendation "Prenention of oil spillages through cargo pump room sea valves".

4.3.2.10 Where pumps in cargo room or other hazardous spaces are driven by shafting passing into the pump room through bulkheads or deck plating, gastight glands of approved type shall be fitted. The glands shall be efficiently lubricated and constructed so as to reduce the risk of overheating. Systems requiring periodic greasing type is not permitted. The glands shall be visible and easily accessible.

Parts which may accidentally come into contact if the seal is badly aligned or if a bearing is damaged, shall be of such materials that no spark may occur. If an expansion bellow is fitted, it shall be hydraulically pressure ntested.

4.3.2.11 Relief valves with discharge to the suction line shall be provided for the displacement pumps.

4.3.2.12 For systems served by centrifugal pumps the design pressure for the piping shall be at least equal to the highest pressure the pump may generate. Alternatively a pressure relief valve or alternative means for automatically safeguarding against overpressure shall be provided.

4.3.2.13 Means shall be provided for stopping the cargo pumps at the cargo manifolds and at the lower pump room level.

4.3.2.14 Remote control and monitoring of the cargo handling, refer Sec 9.

4.3.2.15 All ships having a Noxious Liquid Substances (NLS) Certificate for the carriage of liquid substances as listed in the IBC Code Chapter 18 Category Z, are to have on board a Cargo Record Book according to MARPOL Annex II, Appendix 2.

4.3.3 Cargo Piping System for Barges

4.3.3.1 The barge shall be equipped with a permanent piping system for the oil cargo. Closing valves operable from outside the tank shall be fitted to each branch pipe within the tank it serves.

4.3.3.2 A minimum of two independently driven cargo pumps shall be connected to the cargo piping system. If each cargo tank is fitted with a separate cargo pump, one cargo pump per tank may be accepted.

4.3.3.3 For unmanned barges without auxiliary machinery, non-permanent cargo pumps with external power supply may be acceptable. The pumps shall be connected to the piping system on open deck or in a cargo pump room.

4.3.3.4 Cargo pump room may have bilge suctions connected to the cargo pumps. Cargo pump room situated below deck shall have a power operated bilge system.

4.3.4 Testing

4.3.4.1 Cargo piping shall be hydrostatically tested in the presence of the surveyor to a test pressure = 1.5 x the maximum working pressure. If hydrostatic testing of separate lengths of piping valves, expansion elements etc. has been carried out prior to the installation on board, a tightness test to at least the design pressure is required after completion of the installation onboard.

4.3.4.2 Cargo oil pumps shall be hydrostatically tested to 1.3 times the design pressure, with a minimum of 14 bar. For centrifugal pumps the maximum pressure shall be the maximum pressure head on the head-capacity curve. For displacement pumps the design pressure shall not be taken less than the relief valve opening pressure. The steamside of steam-driven pumps shall be hydraulically tested to 1.5 times the steam pressure. Hydrostatic testing of pump housings on submerged pumps will normally not be required

4.3.4.3 Pump capacities shall be checked with the pump running at design condition (rated speed and pressure head, viscosity, etc.). Capacity test may be dispensed with for pumps produced in series when previous satisfactory tests have been carried out on similar pumps.

For centrifugal pumps having capacities less than 1000 m3/h, the pump characteristic (head-capacity curve) shall be determined for each type of pump. For centrifugal pumps having capacities equal to or greater than 1000 m3/h, the pump characteristic shall be determined over a suitable range on each side of the design point, for each pump.

4.3.4.4 Special survey arrangements for testing of pumps may be agreed upon with INTLREG.

4.4 Cargo Heating

4.4.1 General

4.4.1.1 The cargo oil heating media shall be compatible with the cargo and the temperature of the heating medium is normally not to exceed 220°C.

4.4.1.2 Supply and return pipes for heating coils fitted in cargo tanks, shall be arranged for blank flanging outside the engine or boiler room.

4.4.2 Steam Heating

4.4.2.1 Water systems and steam systems shall comply with Pt.5A unless otherwise stated.

4.4.2.2 Condensate from cargo heating systems shall be led into an observation tank placed in an easily accessible, well ventilated and well illuminated position where it can easily be observed whether the condensate is free from oil or not. The scum pipes shall be led to a waste oil tank. If the condensate shall be used as feed water for boilers, an effective oil filtering system shall be arranged.

4.4.3 Thermal Oil Heating

4.4.3.1 Various requirements to thermal-oil installations are given in Pt.5A

4.4.3.2 Heating of liquid cargoes with flash point not exceeding 60°C shall be arranged by means of a separate secondary system located in the cargo area. However, a single circuit system may be accepted on the following conditions:

— System is so arranged that a positive pressure in the heating coil within a cargo tank shall be at least 3 m water column above the static head of the cargo when circulating pump is not in operation
— The thermal oil system expansion tank shall be fitted with high and low level

alarms.

— Means shall be provided in the thermal oil system expansion tank for detection of flammable cargo vapours

— Valves for the individual heating coils shall be provided with locking arrangement to ensure that the coils are under static pressure at all times.

4.4.4 **Heating of Cargo with Temperaturess above 120^0 C**

4.4.4.1 For asphalt tanks heating plants shall be arranged with redundancy. Redundancy is required for boilers/ thermal oil heaters, heat exchangers and as well as active components (eg. circulation pumps). Failure of a redundant component is not to reduce the installed heating capacity by more than 50%.

4.4.4.2 In asphalt tanks the heating coils shall be separated into at least two independent systems. Emergency cross connections may however be accepted.

4.4.4.3 Cargo lines, cargo pumps P/V-valves (if fitted) and, automatic vent heads (if fitted) are to be provided with arrangements for heating.

1.1.1.1 To prevent overheating of cargo, temperature gauges shall be arranged in each cargo tanks enabling the recording of temperatures at bottom, midway between bottom and deck and at deck level.

1.1.1.2 Heating coils shall be tested according to the non-destructive testing requirement listed in Pt.5A

4.5 Bow and Stern Loading and Unloading Arrangements

4.5.1 **General**

1.1.1.3 Subject to the approval of the society, cargo piping may be fitted to permit bow and stern loading and unloading.

4.5.2 **Piping Arrangement**

1.1.1.4 In addition to Pt.5A(..Piping systems/ Pipes, pumps, valves etc.) , the following provisions apply:

a) Bow and stern loading and unloading pipes shall be led outside accommodation spaces, service and machinery spaces within the accommodation or control stations.

b) Cargo, stripping and vapour return piping (if fitted) forward or aft of the cargo area, except at the loading shore connection valve, shall have welded connections only. Such piping shall be clearly identified and fitted with two valves or one valve and a spool piece or blanks at its connection to the cargo piping system within the cargo area.

c) The shore connection shall be fitted with a shut-off valve and a blank flange.

d) Spray shields shall be provided at the connections specified in c).

e) Arrangements shall be provided for complete drainage of the stern loading pipe back to the to the cargo area, preferably into a cargo tank. This can be achieved by arranging the pipe as self-draining or providing connections for line-blowing. For piping that is not self-draining, the ability to obtain complete draining is subject to testing.

f) Arrangements shall be made to allow for inert gas purging and gasfreeing of the piping to the cargo area.

g) Entrances, air inlets and openings to accommodation, service and machinery spaces and control stations shall comply with SOLAS Reg. II-2/4.5.1.6 to 4.5.2.3. Ref. also IMO MSC/Circ.474/Corr.1.

h) A fixed foam fire-extinguishing system covering loading and unloading areas shall be provided.

i) Loading and unloading arrangements shall not interfere with safety equipment.

j) Continuous coamings or drip trays with a coaming height of at least 300 mm shall be fitted to keep any spills away from accommodation and service areas.

k) Regarding additional class notations **BOW LOADING** or **STL** for offshore loading operations, refer Sec 14.

Note:
In e) partial elevation of the stern loading pipe should be avoided as it impairs the ability to drain the pipe back to the cargo area.

In g) the references imply that openings and access doors to mentioned spaces shall not face the cargo shore connection. An opening which does not have a direct line of sight to the shore connection and is located outside the hazardous zone in way of the shore connection is not considered to face the cargo area. Any opening located more than 10 m from the cargo shore connection may be accepted not facing the cargo shore connection on the condition that it is maintained closed during cargo handling operations. Note that ventilation openings to spaces containing machinery which is in use during cargo handling operations, as well as emergency generator rooms are not considered to be capable of being maintained closed.

SECTION 5 GAS-FREEING AND VENTING OF CARGO TANKS

Contents

5.1 Gas-Freeing of Cargo Tanks

5.1.1 General

5.1.1.1 Effective ways for gas-freeing of the cargo tanks shall be provided.

The gas-freeing system shall be used exclusively for ventilating and gas-freeing purposes. The system may, however, be combined with an inert gas system.

5.1.1.2 There shall be no connection between the gas-freeing system and the ventilation system for cargo pump room.

5.1.1.3 Permanently installed ventilating and gas-freeing systems with non-permanent connections to cargo tanks or cargo piping, shall comply with the following:

— Fans are to be of non-sparking type and certified in accordance with Sec 3.1.2.

— Where the fans are located in a non-hazardous space, the air supply piping from the fan shall have an automatically operated shut-off valve and a non-return valve in series

— The valves shall be located at the bulkhead where the air supply piping leaves the non-hazardous space, with at least the non-return valve on the outside

— The shut-off valve shall open after the fans are started, and close automatically when the fans stop

5.1.1.4 If a connection is inserted between the inert gas supply mains and the cargo piping system, arrangements shall be made to ensure an effective isolation having regard to the large pressure difference which may exist between the systems. This isolation may consist of two shut-off valves with an arrangement to vent the space between the valves. The valve on the cargo side of the separation shall be of non-return type with a positive means of closure. Alternatively, two shut-off valves with a removable spool piece may be accepted. Refer Fig.1. (IACS UI SC62 (1985))

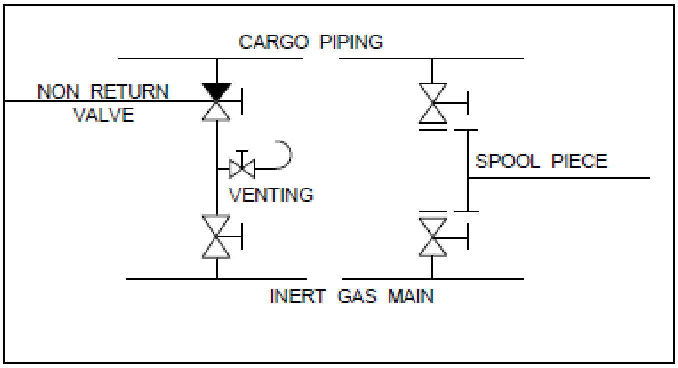


Fig 1 Effective Isolation (Sample option)

5.1.1.5 For ships required to be inerted when carrying flammable oil, before gas-freeing with air, the cargo tanks shall be purged with inert gas. When the ship is provided with an inert gas system, gas outlets for tank purging and gasfreeing purposes shall comply with B, and be positioned as far as practicable from the inert gas and air inlets. Alternatively, gas outlets may be arranged specifically for this purpose. Such outlets shall have a minimum height of 2 m above tank deck and dimensioned to give a minimum vertical exit velocity of 20 m/s, when any three cargo tanks are simultaneously supplied with inert gas, until the concentration of hydrocarbon vapours in the cargo tanks has been reduced to less than 2% by volume. Thereafter, gasfreeing may take place at the cargo tank deck level.

5.1.1.6 If the ships is not provided with an inert gas system the operation shall be such that the flammable vapour is discharged initially through the vent outlets as specified in B, or through outlets at least 2 m above the tank deck level with a vertical efflux velocity of at least 30 m/s maintained during the gasfreeing operation, or through outlets at least 2 m above the tank deck level with a vertical efflux velocity of at least 20 m/s and which are protected by flame arresting elements as specified in Sec 2.2.2.12. When the flammable vapour concentration at the outlet has been reduced to 30% of lower explosive limit (LEL), gasfreeing may be continued at tank deck level.

5.1.2 **Gas-freeing of Cargo Tanks for Barges**

5.1.2.1 The tank hatches are, however, to be arranged so as to facilitate the use of portable gas-freeing equipment. Gas-freeing equipment is not required to be installed nor stored onboard.

5.2 Cargo Tank Venting Systems

5.2.1 **General**

5.2.1.1 System(s) for over and underpressure relief shall be provided for all cargo tanks intended for the carriage of cargoes with a flashpoint not exceeding 60°C, as detailed below:

1) A breathing system for preventing excessive overpressure and vacuum created due to temperature variations and generation of cargo vapour when tanks are not being connected to or have been isolated from a venting system as specified in 2. Such breathing shall be through P/V-valves, (pressure or vacuum relief valves).

2) In order to prevent excessive overpressure or vacuum when tanks are being loaded or unloaded with closed tank hatch covers; an effective venting system shall be provided.

   The breathing and venting systems may be independent or combined and may be connected to an inert gas system.

5.2.1.2 The system(s) shall be designed with a secondary means for preventing excessive overpressure and vacuum in the event the primary means of venting is isolated or fails. The following arrangements are acceptable:

1) For ships where cargo tanks are connected to a common venting system with a gas outlet with capacity as required by Sec 2.2.2.13, the P/V-valves as required by Sec 2.2.2.4 are accepted as the secondary mean of venting.

2) For ships where cargo tanks are not connected to a common venting system with a common gas outlet with capacity as required by Sec 2.2.2.13, one of the following arrangements can be accepted:

   — Pressure sensors fitted in each individual cargo tank, and connected to an alarm.
   — Two P/V-valves fitted to each individual cargo tank, without means for isolation, each with a capacity as required by Sec 2.2.2.13.
   — System may be accepted. The setting of the over-pressure alarm shall be above the pressure setting of the P/V-valve and the setting of the under-pressure alarm shall be below the vacuum setting of the P/ V-valve. The alarm settings are to be within the design pressures of the cargo tanks. The settings are to be fixed and not arranged for blocking or adjustment

in operation, unless the ship is approved for carrying P/V-valves with different settings.

Refer Sec 9 regarding overflow systems, high level alarms etc.

Note:
For ships with tanks connected to a common venting system, the common gas outlet is considered as the primary means of cargo tank venting during loading (and unloading for ships not required to be provided with inert gas systems when carrying oil). For ships without or having tanks not always connected to a common venting system, the full flow P/ V-valves required fitted to each tank are considered to be the primary mean of venting during loading (and unloading for ships not required to be provided with inert gas systems when carrying oil). Inert gas supply is considered to be the primary mean of venting during unloading for ships required to be provided with inert gas systems when carrying oil.

In case the pressure sensors required are also used for US Coast Guard (USCG) vapour return purposes, then the system is to be provided with two fixed settings. For ships where inerting is not mandatory, the system is to be provided with mode selection so that the vapour return alarms are blocked except when the ship is loading with vapour return.

5.2.2 **System Design**

5.2.2.1 Pipes for breathing and venting shall be led from each tank's highest point and shall be self-draining to the cargo tanks under all normal conditions of trim and list.

5.2.2.2 A separate system (e.g. stand pipe) for each tank or connection of tanks to a common cargo tank venting main pipe may be approved. When connection to a common main pipe is arranged, each branch pipe shall be provided with isolation valves. The isolation valves are preferably to be fitted between the cargo tank and any spool piece or spectacle flange if fitted. Any stop valves fitted shall be provided with locking arrangements. There shall be a clear visual indication of the operational status of the valves or other acceptable means.

5.2.2.3 If the tank is not fitted with a separate P/V valve, the means of isolation shall be constructed in such a way that tank breathing is maintained when the branch pipe is isolated.

5.2.2.4 Shut-off valves shall not be fitted neither above nor below P/V valves, but by-pass valves may be provided.

5.2.2.5 The opening pressure of the P/V valves shall be less than the design vapour pressure for the cargo tanks. The opening pressure of the vacuum relief valves is normally not to be lower than 0.07 bar below atmosphericpressure The opening pressure of the vacuum relief valves is normally not to be lower than 0.07 bar below atmospheric pressure and shall not be lower than the vacuum relief opening pressure of any P/V-breaker.

Note:
Those vessels provided with an in-line P/V-breather valve between the common cargo tank venting/Inert gas main line and the mast riser outlet for the purpose of tank pressure control, the opening pressures should be such that the in-line P/ V-breather valve opens before the P/V-valves fitted to each cargo tank.

5.2.2.6 A permanent access arrangement is to be provided to enable checking of P/V valves. P/V valves shall be located on open deck and shall be of a type which allows the functioning of the valve to be easily checked.

5.2.2.7 Hight temperature cargo tank venting requirements are detailed in Sec 4.4.4.3.

5.2.2.8 Intake openings of vacuum relief valves shall be located at least 1.5 m above tank deck, and shall be protected against the sea. The arrangement shall comply with the requirements in Pt 4, Ch 6.

5.2.2.9 If the venting system during loading and unloading is by free flow of vapour mixtures, the outlets shall be not less than 6 m above the tank deck or gangway, if situated within 4 m of the gangway, and located not less than 10 m measured horizontally from air intakes and openings to enclosed spaces containing a source of ignition, and from equipment which may constitute an ignition hazard.

5.2.2.10 In case the venting system during loading and unloading is by high velocity discharge the height of the gas outlets shall be located at a minimum height of 2 m above tank deck or gangway, if situated within 4 m of the gangway, and located not less than 10 m measured horizontally from air intakes and openings to enclosed spaces containing a source of ignition, and from equipment which may constitute an ignition hazard. High velocity devices shall be of an approved type.

5.2.2.11 Gas outlets used during loading shall be directed vertically upwards and without obstructions.

5.2.2.12 Flame arresting elements (tested and approved according to IMO MSC/Circ.677 as amended by MSC/Circ.1009.) shall be provided at the gas outlets and air inlets for all the cargo tanks.

5.2.2.13 Flow area of the venting system used during loading shall be based upon not less than 125% of the gas volume flow corresponding to the maximum design loading rate.

Any P/V-valve fitted to a cargo tank as required by Sec 5.2.1.1 shall have a capacity for the relief of full flow overpressure of not less than 125% of the gas volume flow corresponding to the maximum design loading rate for each tank. Similarly the P/V-valve capacity for the relief of underpressure shall be not less than the gas flow corresponding to the maximum design discharge rate for each tank.

Note:
The requirement to P/V-valve capacity applies to any P/V-valve which is required for the relief of over- and underpressure in case a cargo tank is isolated from a common cargo tank venting system (e.g. closed isolation valve) or gas outlet (e.g. mast riser valve closed).

USCG vapour emission control systems (VECS):
Note that for ship intended to comply with USCG regulations, the maximum allowable liquid loading rate when loading with vapour return will be determined by the capacity of the P/V-valves fitted to each tank. Under USCG regulations the P/V-valve capacity must take into account the vapour growth rate (min. 1.25) and the air vapour density (min. recommended 3.0 kg/m3) of the cargo to be carried. Additionally, a safety margin must be included meaning that the corresponding maximum allowable liquid loading rate is not to exceed to 80% of P/V-valve capacity adjusted for vapour density and vapour growth rate).

For ships provided with eg. an in-line P/V-breather valve between the common cargo tank venting/Inert gas main line and the mast riser outlet, the opening pressure of this P/V-breather valve shall be taken into account in the pressure drop calculations required by the USCG. However, if the P/V-breather valve can be isolated during vapour return and procedures for same is included in the VECS operation manual, the opening pressure need not be taken into account.

5.2.2.14 In systems where in-line P/V valves are installed, means for draining shall be fitted where condensate may accumulate.

5.2.3 Venting of Cargo Tanks for Barges

5.2.3.1 The cargo tanks shall be provided with a venting system to facilitate loading and unloading with closed tank hatches without imposing excessive overpressure or vacuum on the tanks.

5.2.3.2 Breathing system with P/V valves will normally not be required.

5.2.4 Volatile Organic Compounds

5.2.4.1 Crude oil carriers shall be provided with an approved volatile organic compounds (VOC) management plan in accordance with MARPOL Annex VI, Reg. 15.

SECTION 6 VENTILATION SYSTEMS WITHIN THE CARGO AREA OUTSIDE THE CARGO TANKS

Contents

6.1 Ventilation Systems

6.1.1 General

6.1.1.1 Ventilation system within the cargo area shall be independent of other bentilation systems. Any ducting used for the ventilation of hazardous spaces shall be separate from that used for the ventilation of non-hazardous spaces.

6.1.1.2 Air inlets for hazardous enclosed spaces shall be taken from areas which, in the absence of the considered inlet, would be non-hazardous.

Air inlets for non-hazardous enclosed spaces shall be taken from non-hazardous areas at least 1.5 m from the boundaries of any hazardous area.

Where the inlet duct passes through a more hazardous space, the duct shall have over-pressure relative to this space, unless mechanical integrity and gas-tightness of the duct will ensure that gases will not leak into it.

6.1.1.3 Air outlets from non-hazardous spaces shall be located outside hazardous areas.

6.1.1.4 Air outlets from hazardous enclosed spaces shall be located in an open area which, in the absence of the considered outlet, would be of the same or lesser hazard than the ventilated space.

6.1.1.5 Ventilation ducts for spaces within the cargo area are not to be led through non-hazardous spaces.

6.1.1.6 Ventilation of over pressure tyoe shall be arranged for non-hazardous enclosed spaces. Hazardous spaces shall have ventilation with under-pressure relative to the adjacent less hazardous spaces.

6.1.1.7 Starters for fans for ventilation of gas-safe spaces within the cargo area shall be located outside this area or on open deck.

In case electric motors are installed in such spaces, the ventilation capacity shall be large enough to prevent the temperature limits specified in Pt.6 from being exceeded, taking into account the heat generated by the electric motors.

6.1.1.8 Wire mesh protection screens of not more than 13 mm square mesh shall be fitted in outside openings of ventilation ducts. For ducts where fans are installed, protection screens are also to be fitted inside of the fan to prevent the entrance of objects into the fan housing.

6.1.1.9 Spare parts for fans shall be carried onboard. Normally wear parts for one motor and one impeller is required for each type of fan serving spaces in the cargo area.

6.1.1.10 Outlets and inlets of ventilation for spaces in the cargo area that are required to be continuously mechanically ventilated at sea, shall be located so that they are operable in all weather conditions. This implies that they shall be arranged at a height above deck as required in Pt 4, Ch 6, Sec 8, as a ventilator not requiring closing appliances.

Note:
Spaces such as cargo pumprooms, ballast pumprooms and ballast water treatment spaces do normally not require continuous mechanical ventilation at sea. Spaces such as nitrogen rooms, cargo heater rooms and deck trunks containing cargo piping and cargo heaters may however require continuous ventilation also at sea.

6.1.2 **Fans Serving Hazardous Spaces**

6.1.2.1 Fans shall be certified as required by Sec 1 Table 1.3.1.1. Associated electric motors and motor starters shall be certified as required by Pt.6.

Note:
Recommended that fans are certified in accordance with EN13463-1, EN13463-5 and EN14986.

6.1.2.2 Electric fan motors shall not be installed in ventilation ducts for hazardous spaces unless the motor is certified for the same hazard zone as the space served.

6.1.2.3 The fans provided shall be designed with the least possible risk for spark generation during startup or operation.

6.1.2.4 Minimum safety clearances between the casing and rotating parts shall be such as to prevent any friction with each other.

In no case is the radial air gap between the impeller and the casing to be less than 0.1 of the diameter of the impeller shaft in way of the bearing, but not less than 2 mm. The gap need not be more than 13 mm.

6.1.2.5 The parts of the rotating body and of the casing shall be made of materials which are recognised as being spark proof, and they shall have antistatic properties.

The installation on board of the ventilation units shall be such as to ensure the safe bonding to the hull of the units themselves. Resistance between any point on the surface of the unit and the hull, shall not be greater than 10^6 Ohm.

The following combinations of materials and clearances used in way of the impeller and duct are considered to be none-sparking:

1. Impellers and housing of austenitic stainless steel
2. Impellers ad ousing of non-ferrous metals
3. Impellers and/or housing of non-metallic material, due regard being paid to the elimination of static electricity
4. Impellers of aluminium alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non- ferrous materials is fitted in way of the impeller, due regard being paid to static electricity, reliability of the arrangement for securing of the ring to the housing and corrosion between ring and housing
5. Any combination of ferrous (including austenitic stainless steel) impellers and housing with not less than 13 mm tip design clearance.

6.1.2.6 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 spark hazard and shall not be used in these places.

6.2 Ventilation Arrangement and Capacity Requirements

6.2.1 **General**

6.2.1.1 The required capacity of the ventilation plant is normally based on the total volume of the room. An increase in required ventilation capacity may be necessary for rooms with a complicated shape.

6.2.1.2 Failure of required fixed mechanical ventilation shall be alarmed (audible and visual) at a manned station.

6.2.2 Non-hazardous Spaces

6.2.2.1 Non-hazardous spaces with opening to a hazardous area, shall be arranged with one of the following an air-lock arrangements and be maintained at overpressure, relative to the external hazardous area.

1) Airlock without independent mechanical ventilation:

a. Air locks are to be arranged as detailed in Sec 3.4.1.4 and Sec 3.4.1.5.

b. The air lock is connected to the ventilation system required for the protected space and maintained with an overpressure in the space relative to the external hazardous area.

c. The non-hazardous space protected by the air lock shall be arranged with an independent mechanical ventilation system, maintaining an overpressure in the space relative to the external hazardous area.

d. The relative overpressure or air flow is to be continuously monitored and so arranged that in the eventof ventilation failure, an audible and visual alarm is given at a manned control station and the electrical supply to all equipment (not of the certified safe type) is to be automatically disconnected. If the equipment in the protected space is suitable for operating in a zone 2, manual programmed disconnection may be accepted in lieu of automatic disconnection.

e. In case the pressure is monitored by air flow, an alarm (acoustic and visual) shall be released on both sides of the air lock to indicate if more than one door has been moved from the fully closed position.

f. Before energising any electrical installations not certified safe during initial start-up or after loss of overpressure ventilation, the following is required:

— The protected space shall be confirmed pressurised.

— The overpressure ventilation system shall be arranged for pre-purging (at least 5 air changes) or confirmation by gas measurements that the space is non-hazardous.

2) Airlock with independent mechanical ventilation:

a. Air locks are to be arranged in accordance with Sec 3.4.1.4 and Sec 3.4.1.5.

b. The air lock shall be provided with independent mechanical ventilation maintaining an overpressure in the space relative to the external hazardous area.

c. Non-hazardous space protected by the air lock shall be arranged with an independent mechanical ventilation system, maintaining overpressure in the space relative to the external hazardous area.

d. The relative overpressure or air flow is to be continuously monitored and so arranged that in the event of ventilation failure, an audible and visual alarm is given at a manned control station. If the pressurization cannot be restored for an extended period or if the gas concentration is detected to above 30% LEL or above, manual programmed disconnection of power supply to electrical equipment not suitable for operation in the relative hazardous area is required.

e. Where the pressure is monitored by air flow, an alarm (acoustic and visual) shall be released on both sides of the air lock to indicate if more than one door has been moved from the fully closed position.

f. Before energising any electrical installations not certified safe during initial start-up or after loss of overpressure ventilation, the following is required:

— All protected spaces shall be confirmed pressurised.

— The overpressure ventilation system shall be arranged for pre-purging (at least 5 air changes) or confirmation by gas measurements that the space is non-hazardous.

6.2.2.2 Machinery necessary for maintaining main functions, as well as safety systems such as the emergency generator and emergency fire pumps, shall not be located in spaces where automatic disconnection of electrical equipment is required.

Note:
Equipment suitable for operating in a zone 1, is not required to be disconnected. Certified flameproof lighting, may have a separate disconnection circuit, satisfying Sec 6.2.3.2.

6.2.3 **Cargo Handling Spaces**

6.2.3.1 A permanent mechanical ventilation system of the extraction type shall be installed, capable of circulating sufficient air to give at least 20 air changes per hour.

Exhaust trunking in the cargo pump room shall be arranged as follows:
— In the cargo pump room bilges just above the transverse floor plates or bottom longitudinals, so that air can flow over the top from adjacent spaces.
— An emergency intake located 2 m above the pump room lower grating. This emergency intake would be used when the lower intakes are sealed off due to flooding in the bilges. The emergency intake is to have a damper fitted, which can be remotely opened from the exposed main deck in addition to local opening and closing arrangement at the lower grating.

6.2.3.2 Electrical lighting in the cargo pump room shall be fitted with an interlock so arranged that the ventilation shall be in operation before the electrical supply to the lighting in the room can be connected. Emergency lighting shall not be interlocked. Failure of the ventilation system shall not cause the lighting to go out.

6.2.3.3 The exhaust outlets, which shall discharge upwards, shall be situated at least 3 m above tank deck.

6.2.4 **Other Hazardous Spaces Normally Entered**

6.2.4.1 All spaces mentioned in Sec 1.2.1 Spaces not normally entered shall be gas freeable. If necessary ducting shall be fitted in order to ensure efficient gasfreeing.

6.2.4.2 A mechanical ventilation system (permanent or portable) shall be provided, capable of circulating sufficient air to the compartments concerned. The capacity of the ventilation system is normally to give at least 8 air changes per hour for the spaces mentioned in Sec 1.2.1. Spaces not normally entered, except ballast tanks.

6.2.4.3 Double hull and double bottom spaces shall be fitted with suitable connections for the supply of air for gas freeing.

6.2.5 Ventilation System for Barges

6.2.5.1 Engine room and cargo pump room situated below deck shall have separate mechanical ventilation systems of overpressure type and underpressure type, respectively.

6.2.5.2 Engine room, cargo pump room and service spaces situated on deck may have natural ventilation systems.

6.2.5.3 Accommodation spaces shall be provided with mechanical ventilation of the overpressure type.

SECTION 7 FIRE PROTECTION AND EXTINCTION

Contents

7.1 Fire Safety Measure for Tankers

7.1.1 Application

7.1.1.1 The government of the flag state shall ensure that ships are provided with the fire safety measures required by the International Convention for the Safety of Life at Sea, 1974, as amended (hereafter referred as SOLAS).

7.1.1.2 Where the government of the flag state is authorizing the Society to issue the SOLAS Cargo Ship Safety Construction and Cargo Ship Safety Equipment Certificates on its behalf, the Society will apply the SOLAS fire protection, detection and extinction requirements as applicable for tankers.

7.1.1.3 If the government of the flag state is not authorizing the Society to take care of the fire safety measures in SOLAS related to tankers, the SOLAS Cargo Ship Safety Construction and Cargo Ship Safety Equipment certificates from the flag state will be used as basis for this notation.

SECTION 8 AREA CLASSIFICATION & ELECTRICAL SYSTEM

Contents

8.1 General

8.1.1 Application

8.1.1.1 Requirements in this section are in addition to those given in Pt.6 and apply to tankers intended for the carriage of oil cargoes in bulk having a flash point not exceeding 60°C (closed cup test).

8.1.1.2 For ships with class notation for alternative tanker and dry cargo service, the requirement for tankers generally apply. However, exemptions from the requirements for tankers may be accepted for equipment which is only used in dry cargo service, after consideration in each case. Instructions will be given that such equipment shall be disconnected and earthed when the ship is used as tanker and until it has been gas-freed after such service.

8.1.1.3 Tankers exclusively built to carry cargoes with flash point above 60°C, will be specially considered in each case. Refer Sec 8.3.3.

8.1.2 Insulation Monitoring

8.1.2.1 Device(s) to continuously monitoring the insulation earth shall be installed for both insulated and earthed distribution systems. An audible and visual alarm shall be given at a manned position in the event of an abnormally low level of insulation resistance and or high level of leakage current.

8.2 Electrical Installations in Hazardous Areas

8.2.1 General

8.2.1.1 Electrical equipment and wiring are in general not to be installed in hazardous areas. Where essential for operational purposes, arrangement of electrical installations in hazardous areas shall comply with Pt.6 , based on area classification as specified in Sec 8.3.

In addition, installations as specified in Sec 8.2.1.2 are accepted. Except as specified in Sec 8.1.1.2 and Sec 8.3.3, operational procedures are not acceptable as an equivalent method of ensuring compliance with these rules.

Electrical equipment installed in hazardous areas shall as a minimum comply with the requirements to gas group II A and temperature class T3.

8.2.1.2 In Zone 1, Impressed cathodic protection equipment, electric depth-sounding devices and log devices are accepted provided the following is complied with:

- Such equipment shall be of gas-tight construction or be housed in a gas tight enclosure
- Cables are to be installed in steel pipes with gas-tight joints up to the upper deck
- Corrosion resistant pipes, providing adequate mechanical protection, shall be used in compartments which may be filled with seawater (eg. permanent ballast tanks)
- Wall thickness of the pipes shall be as for overflow and sounding pipes through ballast or fuel tanks, in accordance with Pt.5A

8.3 Area Classification

8.3.1 General

8.3.1.1 Area classification is a method of analyzing and classifying the areas where explosive gas atmospheres may occur. The object of the classification is to allow the selection of electrical apparatus able to be operated safely in these areas.

8.3.1.2 To facilitatate the selection of appropriate electrical apparatus an the design of suitable electrical installations, hazardous areas are divided into zones 0, 1 and 2 according to the principles of the standards IEC 60079-10 and IEC 60092-502.

Classification of areas and spaces typical for tankers, is given in Sec 8.3.2 and Sec 8.3.3, based on IEC 60092-502.

8.3.1.3 Areas and spaces other than those classified in Sec 8.3.2 and Sec 8.3.3 , shall be subject to special consideration. The principles of the IEC standards shall be applied.

8.3.1.4 Area classification of a space may be dependent on ventilation as specified in IEC 60092-502, Table 1.

8.3.1.5 A space with opening to an adjacent hazardous area on open deck, may be made into a less hazardous or non-hazardous space, by means of overpressure. Requirements to such pressurisation

8.3.1.6 Ventilated space and ventilation ducts shall have the same area classification.

8.3.1.7 With the exception of spaces arranged in accordance with Sec 6.2.2.1, any space having an opening into a hazardous area or space, having a more severe hazardous zone classification, will be considered to have the same hazardous zone classification as the zone it has an opening into.

Note:
Openings are considered to be any access door, ventilation inlets or outlets or other boundary openings. Bolted plates that are normally closed and only opened when area has been confirmed gas free may be accepted.

8.3.2 Tankers for Carriage of Products with Flashpoint Not Exceeding 60ºC

8.3.2.1 Hazardous area Zone 0

The interiors of cargo tanks, slop tanks, any pipework of pressure-relief or other venting systems for cargo and slop tanks, pipes and equipment containing the cargo or developing flammable gases or vapours.

8.3.2.2 Hazardous area Zone 1

1. Void spaces and cofferdams adjacent to, above and below integral cargo tanks
2. Hold spaces containing independent cargo tanks
3. Ballast tanks and other tank adjacent to cargo tanks
4. Cargo handling spaces (including cargo pump rooms)
5. Enclosed or semi-enclosed spaces, immediately above cargo tanks (for example, between decks) or having bulkheads above and in line with cargo tanks bulkheads, unless protected by a diagonal plate acceptable to the appropriate authority.
6. Spaces, other than cofferdam, adjacent to and below the top of a cargo tanks (for example, trunks, passageways, pumprooms, ballast treatment spaces and hold spaces)
7. Areas on open deck, or semi- enclosed spaces on deck, within 3 m of any cargo tanks

outlet, gas or vapour outlet (see note), cargo manifold valve, cargo valve, cargo pipe flange, cargo pump-room ventilation outlets and cargo tank openings for pressure release provided to permit the flow of small volumes of gas or vapour mixtures caused by thermal variation.

Note:
Such areas are, for example, all areas within 3 m of cargo tank hatches, sight ports, tank cleaning openings, ullage openings, sounding pipes, cargo vapour outlets.

8. Areas on open deck, or semi-enclosed spaces on open deck above and in the vicinity of any cargo gas outlet designed for the passage of large volumes of gas or vapour mixture during cargo loading and ballasting or during discharging, within a vertical cylinder of unlimited height and 6 m radius centred upon the centre of the outlet, and within a hemisphere of 6 m radius below the outlet.

9. Areas on open deck, or semi-enclosed spaces on deck, within 1.5 m of cargo pump room entrances, cargo pump room ventilation inlets, openings into cofferdams or other zone 1 spaces.

10. Areas on the open deck within spillage coamings surrounding cargo manifold valves and 3 m beyond these, up to a height of 2.4 m above the deck.

11. Areas on open deck over all cargo tanks (including ballast tanks within the cargo tank area) where structures are restricting the natural ventilation and to the full breadth of the ship plus 3 m fore and aft of the forwardmost and the aft-most cargo tank bulkhead, up to a height of 2.4 m above the deck.

12. Compartments for cargo hoses and contaminated cargo equipment.

13. enclosed or semi-enclosed spaces in which pipes containing liquid cargoes or cargo vapour are located.

8.3.2.3 Hazardous area Zone 2

1. Areas within 1.5 m surrounding open or semi-enclosed spaces of zone 1 as specified in Sec 8.3.2.2, if not otherwise specified in this standard.

2. Spaces 4 m beyond the cylinder and 4 m beyond the sphere defined in Sec 8.3.2.2 (8).

3. Spaces forming an air-lock as defined in Sec 1.2.1 Air lock and Sec 3.4.1.4 and Sec 3.4.1.5.

4. Areas on open deck extending to the coamings fitted to keep any spills on deck and away from the accommodation and service areas and 3 m beyond these up to a height of 2.4 m above deck.

5. Areas on open deck over all cargo tanks (including all ballast tanks within the cargo tank area) where unrestricted natural ventilation is guaranteed and to the full breadth of the ship plus 3 m fore and aft of the forward-most and aft-most cargo tank bulkhead, up to a height of 2.4 m above the deck .For ships subject to Sec 8.3.2.2 (11), the area within 1.5 meters of the area specified in Sec 8.3.2.2 (11).

6. Spaces forward of the open deck areas to which reference is made insect 8.3.2.2 (11) and Sec 8.3.2.3 (5), below the level ofthe main deck, and having an opening on to the main deck or at a level less than 0.5 m above the main deck, unless:

a) The entrances to such spaces do not face the cargo tank area and, together with all other openings to the spaces, including ventilating system inlets and exhausts, are situated at least 10 m horizontally from any cargo tank outlet or gas or vapour outlet; and

b) The spaces are mechanically ventilated

7. Fore peak ballast tanks, if connected to a piping system serving ballast tanks within the cargo area. Refer Sec 4.2.3.

8. Ballast pumprooms or ballast treatment spaces which are not located adjacent to cargo tanks, but which could contain contaminated ballast water from ballast tanks located adjacent to cargo tanks.

8.3.3 **Tankers for carriage of products with flashpoint exceeding 60°C**

8.3.3.1 Unheated cargoes and cargoes heated to a temperature below and not within 15°C of their flashpoint.
Hazardous areas zone 2:
The interiors of cargo tanks, slop tanks, any pipework of pressure-relief or other venting systems for cargo and slop tanks, pipes and equipment containing the cargo.

8.3.3.2 Cargoes heated above their flashpoint and cargoes heated to a temperature within 15°C of their flashpoint.
The requirements of Sec 8.3.2 are applicable.

Note:
It is acceptable that an operational limitation is inserted in the appendix to the class certificate specifying that the ship is approved on the condition that cargo is not heated to within 15°C of its flashpoint.

8.4 Inspection and Testing

8.4.1 **General**

8.4.1.1 All electrical installations in hazardous areas shall be inspected and tested before they are put into service or considered ready for use. All equipment, cables, etc. shall be verified to have been installed in accordance with installation procedures and guidelines issued by the manufacturer of the equipment, cables, etc., and that the installations have been carried out in accordance to Pt.6

8.4.1.2 Those spaces protected by pressurisation shall be examined and tested that the purging can be effected. Purge time at minimum flow rate shall be documented. Required shutdowns and or alarms upon ventilation overpressure falling below prescribed values shall be tested.

For other spaces where area classification depends on mechanical ventilation it shall be tested that ventilation flow rate is sufficient, and that and required ventilation failure alarm operates correctly.

8.4.1.3 For equipment for which safety in hazardous areas depends upon correct operation of protective devices (for example overload protection relays) and or operation of an alarm (for example loss of pressurisation for an Ex(p) control panel) it shall be verified that the devices have correct settings and / or correct operation of alarms.

8.4.1.4 Interlocking and shutdown arrangements (such as for submerged cargo pumps), wherever provided shall be tested.

8.4.1.5 Intrinsically safe circuits shall be verified to ensure that the equipment and wiring are correctly installed.

8.4.1.6 Verification of the physical installation shall be documented by yard. The documentation shall be available for the Society's surveyor at the site.

8.5 Maintenance

8.5.1 General

8.5.1.1 The maintenance manual referred to in Sec 1, Table 1.4.1 shall be in accordance with the recommendations in IEC 60079-17 and 60092-502 and shall contain necessary information on the following:

— Overview of classification of hazardous areas, with information about gas groups and temperature class.

— Records sufficient to enable the certified safe equipment to be maintained in accordance with its type of protection (list and location of equipment, technical information, manufacturer's instructions, spares etc.)

— Inspection routines with information about detailing level and time intervals between the inspections, acceptance/rejection criteria.

— Register of inspections, with information about date of inspections and name(s) of person(s) who carried out the inspection and maintenance work.

8.5.1.2 Inspection and maintenance of installations shall be carried out only by experienced person nel whose training has included instruction on the various types of protection of apparatus and installation practices to be found on the vessel. Appropriate refresher training shall be given to such personnel on a regular basis.

8.6 Signboards

8.6.1 General

8.6.1.1 Where electric lighting is provided for spaces in hazardous areas, a signboard at least 300 mm shall be fitted at each entrance to such spaces with text:

“BEFORE A LIGTHING FITTING IS OPENED ITS SUPPLY CIRCUIT SHALL BE DISCONNECTED”

Alternativel a signboard with the same text can be fitted at each individual lighting fitting.

8.6.1.2 Where electric lighting is provided in spaces where the ventilation shall be in operation before the electric power is connected, a signboard at least 200 × 300 mm shall be fitted at each entrance, and with a smaller signboard at the switch for each lighting circuit, with text:

“BEFORE THE LIGHTING IS TURNED ON, THE VENTILATION SHALL BE IN OPERATION”

8.6.1.3 Where socket-outlets are installed in cargo area or adjacent area, a signboard shall be fitted at each socket-outlet with text:

“PORTABLE ELECTRICAL EQUIPMENT SUPPLIED BY FLEXIBLE CABLES SHALL NOT BE USED IN AREAS WHERE THERE IS GAS DANGER”

Alternatively signboards of size approximately 600 x 400 mm, with letters of height approximately 30 mm, can be fitted at each end of the tank deck.

8.6.1.4 Where socket-outlets for welding apparatus are installed in areas adjacent to cargo area, the socket outlet shall be provided with a signboard with text:

"WELDING APPARATUS NOT TO BE USED UNLESS THE WORKING SPACE AND ADJACENT SPACES ARE GAS-FREE".

SECTION 9 INSTRUMENTATION AND AUTOMATION

Contents

9.1 General Requirements

9.1.1 General

9.1.1.1 For instrumentation and automation, including computer based control and monitoring, the requirements in this chapter are additional to those given in Pt.6 Ch.9 (…Control and Monitoring system).

9.1.1.2 The control and monitoring systems shall be certified as required by Sec 1, Table 1.3.1.1.

9.2 Cargo Valves and Pumps- Control and Monitoring

9.2.1 General

9.2.1.1 In case the pumps and valves for loading and unloading the ship are remotely controlled, all controls, indicators and alarms associated with a given cargo tank shall be centralised in one control station. Pump discharge pressure and vacuum meter to be fitted in the control station.

9.2.1.2 The cargo pumps, ballast pumps and stripping pumps, installed in cargo pump rooms and driven by shafts passing through pump room bulkheads shall be fitted with temperature sensing devices for bulkhead shaft glands, bearings and pump casings. An alarm shall be initiated in the cargo control room or the pump control station.

9.2.1.3 Hold spaces and cargo pump rooms containing independent cargo tanks, shall be provided with bilge high level alarms. The alarm signals (visual and audible) shall be activated in the cargo control room or station.

9.2.1.4 Local operation of valves may be carried out from separate deck stands provided satisfactory position indication is arranged locally and at the control station mentioned in Sec 9.2.1.1.

9.2.1.5 Cargo tank valves which are remote controlled shall be provided with an indication system, which at the manoeuvring stand indicates to the operator whether the valves are in open or closed position. A flow indicator in the hydraulic system for manoeuvring valves can be accepted. The flow indicator shall show whether the valves are in open or closed position.

9.2.1.6 Remote-controlled tank valves shall be arranged with means for manual (emergency) operation. A handpump which can be connected to the control system as near the valve as possible, will normally be accepted.

9.2.2 Computer Based System for Cargo Handling

9.2.2.1 Local control of cargo handling systems independent of computer controlled systems will be required.

9.2.3 Centralised Cargo Control

9.2.3.1 Ships having their cargo and ballast systems built and equipped, surveyed and tested in accordance with the requirements in Pt.6 C (Additional class notation)

9.2.4 Design of Integrated Cargo and Ballast Systems

9.2.4.1 The operation of cargo and/or ballast systems may be necessary, under certain emergency circumstances or during the course of navigation, to enhance the safety of tankers. As such, measures are to be taken to prevent cargo and ballast pumps becoming inoperative simultaneously due to a single failure in the integrated cargo and ballast system, including its control and safety systems.

9.2.4.2 Integrated cargo and ballast systems meaning any integrated hydraulic and/or electric system used to drive both cargo and ballast pumps (including active control and safety systems and excluding passive components, eg. piping), are to be designed and constructed as detailed below:

1. Emergency stop circuits of the cargo and ballast systems are to be independent from the circuits for the control systems. A single failure in the control system circuits or the emergency stop circuits are not to render the integrated cargo and ballast system inoperative;

2. Manual emergency stops of the cargo pumps are to be arranged in a way that they are not to cause the stop of the power pack making ballast pumps inoperable;

3. Control systems are to be provided with backup power supply, which may be satisfied by a duplicate power supply from the main switch board. The failure of any power supply is to provide audible and visible alarm activation at each location where the control panel is fitted.

4. In the event of failure of the automatic or remote control systems, a secondary means of control is to be made available for the operation of the integrated cargo and ballast system. This is to be achieved by manual overriding and/or redundant arrangements within the control systems.

9.3 Cargo Tank Level Monitoring

9.3.1 General

9.3.1.1 Types of level measuring devices:

Open Type:
Open type devices makes use of an opening in the tank and directly exposes the operator to the cargo or its vapours. Examples of this type are ullage openings and gauge hatches.

Restricted Type:
The restricted type penetrates the tank and which, when in use, permits a limited quantity of cargo vapour or liquid to be expelled to the atmosphere. When not in use, the device is completely closed. Examples of this type are rotary tube, fixed tube, slip tube and sounding pipe.

Closed Type:
A device which penetrates the tank, but which is part of a closed system which keeps the cargo completely sealed off from the atmosphere. Examples of this type are sight glasses, pressure cells, float-tape systems, electronic or magnetic probe.

9.3.1.2 Each cargo tank shall be fitted with at least one level gauging device. Where only one liquid level measuring device is fitted it shall be arranged so that any necessary maintenance can be carried out while the cargo tank is in service.

9.3.1.3 If a closed measuring device is not mounted directly on the tank, it shall be provided with shut-off valves situated as close as possible to the tank.

9.3.1.4 Level measuring in ships with inerted tanks, refer Sec 11.3.5. For crude oil and petroleum products having a flashpoint not exceeding 60°C, “closed type” only is acceptable. For other cargo oils, “open type” or “restricted type” are acceptable.

9.4 Cargo Tank Overflow Protection

9.4.1 General

9.4.1.1 Provision shall be made to guard against liquid rising in the venting system to a height which will exceed the design head of cargo tanks. This shall be accomplished by high level alarms or overflow control systems or other equivalent means, together with gauging devices and cargo tank filling procedures.

High level alarms shall be independent of the closed level measuring system.

Combined level measuring system and high level alarm systems may be accepted as equivalent to independent systems provided extensive self-monitoring is incorporated in the system covering all credible faults.

9.5 Oil and Water Interface Detector

9.5.1 General

9.5.1.1 Vessel shall be provided with instruments for measuring the interface level between oil and water. The instrument(s) may be fixed or portable.

Note:
Oil and water interface detection shall be approved by an administration.

9.6 Gas Detection in Cargo Pump Room

9.6.1 General

9.6.1.1 A continuous monitoring system of the concentration of hydrocarbon gases shall be fitted. Sampling points or detector heads shall be located in suitable positions in order that potentially dangerous leakage is readily detected. When the hydrocarbon gas concentration reaches a pre-set level, which shall not be higher than 10% of the lower flammable limit, a continuous audible and visual alarm signal shall be automatically initiated in the pump-room, engine control room, cargo control room and navigation bridge, to alert personnel to the potential hazard. Sequential sampling is acceptable as long as it is dedicated for the pump room only, including exhaust ducts, and the sampling time is reasonably short.

Note:
Suitable positions may be the exhaust ventilation duct and lower parts of the pump room above the floor plates.

9.7 Gas Detection Outside Cargo Pumprooms

9.7.1 Portable gas detection

9.7.1.1 Approved portable gas detectors shall be provided on board the ship.

Ships with inert gas systems shall be provided with two instruments for measuring O2-content, two instruments for measuring hydrocarbon-content in the range of 0 to 20% hydrocarbon gas by volume and two instruments for measuring low hydrocarbon gas-content 0 to 100% LEL.

Ships without inert gas system shall be provided with two instruments for measuring low hydrocarbon gascontent 0 to 100% LEL.

Where the atmosphere in double hull spaces cannot be reliably measured using flexible gas sampling hoses, such spaces shall be fitted with permanent gas sampling lines. Alternatively a fixed gas detection system shall be fitted in these spaces. Alarms (visual and audible) to be provided on the bridge and in the cargo control room.

Ships for alternate carriage of oil and dry cargo, refer Sec 10.3.1.4.

Note:
Gas detectors shall be approved by an administration.

9.7.2 **Fixed Gas Detection**

9.7.2.1 Oil tankers of 20 000 tonnes deadweight and above, shall be provided with a fixed hydrocarbon gas detection system for measuring hydrocarbon gas concentrations in all ballast tanks and void spaces of doublehull and double-bottom spaces adjacent to the cargo or slop tanks, including the forepeak tank and any other tanks and spaces under the bulkhead deck adjacent to cargo tanks. The system shall comply with Reg.16 of the FSS code and MSC.1/Circ.1370 as well as the requirements in this section.

9.7.2.2 As the cargo pumproom gas detection system is required to be continuous, sequential type gas detection system serving a cargo pumproom is to be separated from that serving spaces adjacent to cargo tanks.

9.7.2.3 Any tank or compartment, except fuel tanks, located below the bulkhead deck and adjacent to a cargo or slop tank shall be provided with fixed gas detection. This includes eg. cofferdams/voids, ballast pumprooms, freshwater tanks etc. [IACS UI SC268]

9.7.2.4 The term "adjacent to the cargo tanks", also includes tanks and compartments located below the bullhead deck with a cruciform contact with the cargo or slop tanks, unless the structural configuration eliminates the possibility of leaks. [IACS UI SC268]

9.7.2.5 For void spaces, cofferdams and other dry compartments such as ballast pump rooms, one bottom sampling detector is acceptable. [IACS Rec. 123].

9.7.2.6 Fresh water tanks and ballast water tanks top and bottom sampling points are always required unless the prohibition of partial filling is clearly stated in the Trim and Stability Booklet/Loading Manual. [IACS Rec. 123]

9.7.2.7 Gas detection system is to be arranged with single sampling lines from each sampling point to the gas detection cabinet. Sampling lines from each sampling point in the same space may however be combined at deck level via a manually operated three-way valve arrangement or similar. The valve has to be provided with local indication of which sampling point is active (top or bottom). A signboard should be provided in CCR to specify procedure for manual operation of valves depending on operational mode as follows:

In loaded condition: valve to be set so that lower sampling point is active.
In ballast/partial ballast condition: valve to be set so that upper sampling point is active.
[IACS Rec. 123]

9.7.2.8 Gas sampling pipes may penetrate a watertight subdivision provided the total cross sectional area of such pipes do not exceed 710 mm^2 between any two watertight compartments (ie. a maximum single pipe diameter of 30 mm). The gas sampling pipes may however not be led through a cargo tank boundary. The penetrations shall be located as far as practical away from the ships shell. [IACS Rec. 123]

9.8 Installation Requirments for Analysing Units

9.8.1 General

9.8.1.1 Non explosion proof measuring equipment for gas analysing units may be located in areas outside cargo areas, for example in the cargo control room, navigation bridge or engine room when mounted on the forward bulkhead provided the following requirements are observed.

a) Sampling lines shall not run through gas non-hazardous spaces, except where permitted under e).

b) The gas sampling pipes shall be equipped with flame arresters. Sample gas shall be led to the atmosphere with outlets arranged in a safe location.

c) Bulkhead penetrations of sample pipes between non-hazardous and hazardous areas shall be of an approved type and have the same fire integrity as the division penetrated. A manual isolating valve shall be fitted in each of the sampling lines at the bulkhead on the gas safe side.

d) The gas detection equipment including sample piping, sample pumps, solenoids, analysing units etc. shall be located in a reasonably gas tight (e.g. fully enclosed steel cabinet with a door with gaskets) which shall be monitored by its own sampling point. At gas concentration above 30% LFL inside the steel cabinet the entire gas analysing unit shall be automatically shut down.

e) Where the cabinet cannot be arranged directly on the bulkhead, sample pipes shall be of steel or other equivalent material and without detachable connections, except for the connection points for isolating valves at the bulkhead and analysing units, and shall be routed on their shortest ways.

SECTION 10 SHIPS FOR ALTERNATE CARRIAGE OF OIL CARGO AND DRY CARGO

Contents

10.1 General

10.1.1 Application

10.1.1.1 This section apply to ships intended to carry in bulk liquid cargoes with a flashpoint not exceeding 60°C or dry cargo, alternately.

10.1.1.2 The requirements are supplementary to those for the class notation **Tanker for Oil** or **Tanker for Oil Products**.

10.1.2 Class Notation

10.1.2.1 Ships satisfying the requirements in this section may be assigned one of the following class notations:
Bulk Carrier or Tanker for Oil (alternatively **Tanker for Oil Products**)
Ore Carrier or Tanker for Oil (alternatively **Tanker for Oil Products**)

10.1.3 Basic Assumptions

10.1.3.1 The requirments in this section are based on the following assumptions:

— Dry cargo and liquid cargo with a flashpoint not exceeding 60°C are not carried simultaneously, except for cargo oil-contaminated water (slop) in the protected slop tank(s)

— Before the ship enters dry cargo service, all cargo piping, tanks and compartments in the cargo area shall be cleaned and ventilated to the extent that the content of hydrocarbon gases is brought well below the lower explosion limit. Further, the cleaning shall ensure that the concentration of hydrocarbon gases remains below the lower explosion limit during the forthcoming dry cargo voyage.

— Measurements of hydrocarbon gas content are carried out regularly during dry cargo service.

Note:
Measurement of hydrocarbon gas content once every day is considered appropriate during the first two weeks. Later on this may be reduced, depending on the results of the previous measurements. When sailing into higher air or seawater temperatures, measurements should be taken daily.

10.1.4 Documentation

10.1.4.1 In addition to the documentation required for the class notation **Tanker for Oil** in Sec 1.4, the builder is responsible for providing the documentation specified in Table 10.1.1.

Table 10.1.1 Documentation Requirements for Combination Carriers

Component	Documentation Type	Additional Description	(A)/(I)
Cargo handling arrangments	Operational manual	Refer Sec 10.1.4.2.	(A)
Cargo tank cleaning system	Piping diagram	Shall also include arrangements for cleaning of cargo piping and shall include water supply and discharge piping.	(A)
Cargo tank gas freeing system	Piping diagram	Shall also include arrangements for gas freeing of cargo piping	(A)
Note: (A) For Approval; (I) For Information			

10.2 Cargo Arrangement and Systems

10.2.1 General

10.2.1.1 The vessel shall comply with the requirements of Sec 12 for protected slop tank.

10.2.2 Design of Cargo Oil Tanks

10.2.2.1 The cargo tanks shall be designed to facilitate efficient cleaning. The bottom, side and end boundaries of the tanks may be of the following alternative designs.

- Plane surfaces
- Corrugated surfaces
- Vertical stiffeners, but no inernal primary structural members in tanks.

10.2.2.2 Where primary structural members are unavoidable inside tanks, particular attention has to be paid to the arrangement and outfitting of cleaning facilities. The efficiency of such equipment shall be verified by a test after the discharge of the ship's first oil cargo. The established cleanliness and gas-free condition shall be verified by a measuring program approved by the Society.

10.2.3 Access Arrangements to Compartments

10.2.3.1 Compartments in the cargo area such as pipe tunnels, stool tanks, cofferdams, etc. shall be arranged so as to avoid the spreading of hydrocarbons. For instance, stool tanks and cofferdams shall not have permanent openings to pipe tunnels.

10.2.3.2 Double bottom shall be arranged for segregated ballast with length of such tanks not exceeding 0.2 L.

10.2.3.3 Pipe tunnels and other compartments of comparable extent in the cargo area shall be provided with access openings at forward and aft end. For tunnels and compartments exceeding 100 m in length, an additional access opening shall be provided near the half length. The access entrances shall be arranged from open deck or a cargo pump room, and shall be suitable for use for cleaning and gas-freeing operations.

10.2.3.4 Stool tanks shall be provided with access from open deck. The access openings shall be suitable for use for cleaning and gas-freeing operations.

Access to stool tanks from pipe tunnel may be accepted if the following items are complied with:

— Ventilation pipes of sufficient size on port and starboard side for cross ventilation and gas-freeing by portable fans.

— Bolted manhole cover or equivalent gastight closing with oil-resistant packings and signboards with instruction to normally keep it closed. The cover shall be lifted 300 mm above bottom of stool tank to prevent back-flow of oil when opened.

10.2.3.5 Access entrances and passages shall have a clear opening of at least 600 by 600 mm.

10.2.3.6 Openings which may be used for cargo operations are not permitted in bulkheads and decks separating oil cargo spaces from other spaces not designed and equipped for the carriage of oil cargoes unless alternative approved means are provided to ensure equivalent integrity.

10.2.4 Cargo Piping, Bilge and Drainage

10.2.4.1 The cargo oil piping shall be located on open deck or within the cargo tanks as far as practicable in compatible with the general arrangement.

10.2.4.2 In case the piping locations stated in Sec 10.2.4.1 are not appropriate, the cargo oil piping may be located within special pipe tunnels of limited size.

10.2.4.3 The cargo oil piping system shall be designed and equipped so as to minimise the risk of oil leakage due to corrosion or to failures in the pipe connection fittings. Steel pipes inside water ballast tanks shall have a wall thickness not less than 12.5 mm.

10.2.4.4 For the compartments intended for carrying dry cargo a separate bilge system shall be provided. A separate cargo oil stripping system may be used for bilge pumping, provided the system has no connection to, or is easily isolated from, tanks not intended for dry cargo.

10.2.4.5 For the bilge suctions in cargo holds, refer Pt.5A

10.2.4.6 When the ship is carrying oil, the bilge suctions of separate bilge system in cargo holds shall be arranged for blank flanging.

10.2.4.7 The cargo oil suctions in the holds intended for dry cargo shall be arranged for blank flanging when the ship is carrying dry cargo.

10.2.4.8 Arrangements required by Sec 10.2.4.6 and Sec 10.2.4.7 are not necessary if the ship is fitted with separate cargo pumps in each cargo hold.

10.2.4.9 Arrangements shall be made to avoid damage to oil wells and blank-flanging arrangements due to dry cargo, grab discharging, etc.

10.2.4.10 Top wing tanks may be arranged with gravity overboard discharge, refer Pt 4, Ch 6.

10.2.4.11 Dry compartments adjacent to cargo tanks shall be provided with bilge or drainage arrangement. Pipe tunnels shall be provided with bilge suctions at forward and aft ends. Bulkhead stool tanks to be provided with bilge suctions.

10.2.5 **Cleaning and Gas-Freeing**

10.2.5.1 All cargo tanks shall be equipped with fixed or portable means for cleaning and gas-freeing.

10.2.5.2 The water cleaning system for cargo tanks with internal primary structural members shall comprise possibility for heating the cleaning water.

10.2.5.3 Compartments in the cargo area adjacent to the cargo tanks shall be arranged for cleaning and gas-freeing by equipment available onboard.

10.2.5.4 Cargo oil piping shall be arranged for easy cleaning, and an arrangement for gas-freeing shall be provided.

10.2.5.5 A branch line from the fire main shall be arranged in pipe tunnels housing cargo oil piping. A suitable number of hydrant valves shall be located along the length of the tunnel. The branch line shall be arranged for blank flanging outside the tunnel.

10.2.6 **Ventilation**

10.2.6.1 Ballast pump room, pipe tunnel and similar spaces within the cargo area, where access may be necessary for normal operation and maintenance, shall be equipped with a fixed separate ventilation system.

10.2.6.2 For ballast pump room the capacity of the ventilation systems shall be at least 8 air changes per hour and spaces normally entered. If cargo piping and equipment is arranged in ballast pump room, or the ballast pumproom is located adjacent to cargo tanks, the ventilation capacity shall be at least 20 air changes per hour.

10.2.6.3 Cofferdams, double bottoms, pipe tunnels, stools and ballast tanks and similar spaces not normally entered shall be gasfreeable with a mechanical ventilation system (permanent or portable). The ventilation capacity is normally to be at least 8 air changes per hour for the spaces mentioned except ballast tanks.

10.2.6.4 Pump room arranged adjacent to protected slop tank shall be fitted with interlock between electric lighting and ventilation, so arranged that the ventilation shall be in operation before the electrical current supply to the room can be connected.

10.3 Gas Measuring Equipment

10.3.1 Measurement of Hydrocarbon Gases

10.3.1.1 Arrangements shall be made to facilitate measurement of gas concentration in all tanks and other compartments within the cargo area. Measurements shall be made possible from open deck or other easily accessible locations.

10.3.1.2 Measuring equipment used shall be of approved type, and may be fixed or portable except as stated in Sec 10.3.1.3. However that the requirements as detailed in Sec 9.7.2 is also applicable.

10.3.1.3 Cargo pump room and pipe tunnel shall be equipped with a fixed hydrocarbon gas detection system with alarm. The system shall cover at least 3 locations along the length of the tunnel, however, spaced not more than 30 m apart.

10.3.1.4 Apart from the gas detection arrangements required by Sec 10.3.1.1 to Sec 10.3.1.3 the ship shall have two sets of portable gas measuring equipment, each set consisting of one apparatus for measuring O_2 content, one apparatus for measuring hydrocarbon contents in the range 0 to 20% hydrocarbon gas by volume and one apparatus for measuring low hydrocarbon gas contents (0 to 100% LEL).

10.4 Instructions

10.4.1 **Operations Manual**

10.4.1.1 An operations manual shall be developed covering all essential operational procedures. As a minimum the following are to be included:

— Procedure and methodology for conversion from tanker trade to dry cargo trade, and vice versa
— Procedure and methodology for cleaning and gas-freeing of cargo tanks, cargo piping and adjacent spaces
— Procedure and methodology related to tanker cargo handling operations in port and during voyage
— Description and listing of cleaning equipment and its intended use
— Procedures for gas monitoring
— Actions to be taken when the gas concentration exceeds the defined acceptable limits.

Note:
The actions to be taken when gas concentrations are exceeded may be repeated ventilation, cleaning and ventilation, inerting, water filling, depending on type of compartment, nature of problem and available equipment.

10.4.2 **Instructions Onboard**

10.4.2.1 Instructions for dry cargo and **Tanker for Oil** service shall be permanently posted in cargo control rooms and deck office.

SECTION 11 INERT GAS (IGES) SYSTEM

Contents

11.1 General

11.1.1 Application

11.1.1.1 This section is applicable to inert gas systems for inerting of tanks and void spaces within the cargo area.

11.1.1.2 Oil carriers (**Tanker for Oil** or **Tanker for Oil Products**) of 8000 tons deadweight and aboveintended for the carriage of oil cargoes having a flash point not exceeding 60°C (closed cup test) and all ships with crude oil washing arrangement regardless of size shall be fitted with a permanently installed inert gas system complying with the rules in this section.

11.1.1.3 Oil carriers (**Tanker for Oil** or **Tanker for Oil Products**) less than 8000 tons deadweight fitted with inert gas system complying with the requirements in this section may be assigned the special features notation INERT.

Note:
The requirements in this section are considered to meet the FSS Code Ch.15 and SOLAS Reg. II-2/ 4.5.5 and II-2/ 11.6.3.4 and as amended by IMO Res. MSC.367(93).

11.1.2 Certification Requirements

11.1.2.1 Various components shall be certified as detailed in Table below:

Table 11.1.1 Certification Requirments for Inert Gas Systems

Component	Type of Certificate		Additional Description
Inert gas blowers	INTLREG	INTLREG product certificate	
Inert gas generators	INTLREG	INTLREG product certificate	
Scrubbers	INTLREG	INTLREG product certificate	
Deck water seals	INTLREG	INTLREG product certificate	
Scrubber SW supply pumps	INTLREG	INTLREG product certificate	
Deck water seal SW supply pumps	INTLREG	INTLREG product certificate	
Liquid pressure / vacuum breakers	INTLREG	INTLREG works product certificate	
Pressure/ Vacuum valves	INTLREG	INTLREG type approval certificate	For EEA flagged vessels
Control and monitoring systems	INTLREG	INTLREG product certificate	

11.1.2.2 FAssociated electric motors and motor starters shall be certified as required by Pt.6

11.1.3 Documentation Requirments

11.1.3.1 The builder shall provide the documentation as in the Table below:

Table 11.1.2 Documentation requirments for Inert Gas Systems- Builder			
Component	**Documentation type**	**Additional Description**	**(A)/(I)**
Inert Gas System	Detailed drawing	-Non return valves -Deck water seals -Double block bleed arrangement -Scrubbers -PV Breakers	(A)
	Piping diagram	Inert gas distribution to cargo tanks, ballast tanks and cargo Piping. Shall include connections to e.g. cargo tank venting and vapour return systems.	(A)
	Piping diagram	Piping systems serving the inert gas unit such as exhaust gas, fuel supply, water supply and discharge piping.	(A)
	Operations Manual	Refer Ch.8 and Ch.11 of MSC / Circ.353, as amended by MSC / Circ.387	(A)
Inert gas generator	Specification	As applicable	(A)
Note: (A) For Approval; (I) For Information			

11.1.3.2 The manufacturer shall be responsible for providing the documentation as in the table below:

Table 11.1.2 Documentation requirments for Inert Gas Systems- Builder			
Component	**Documentation type**	**Additional Description**	**(A)/(I)**
Inert gas control and monitoring system	Control and monitoring system documentation		(A)

Note:
Refer to Ch.8 and 11 of MSC/Circ.353, as amended by MSC/Circ.387.

11.2 Materials

11.2.1 **General**

11.2.1.1 For inert gas plants, the materials used in the piping system shall comply with the requirements specified in Pt.7B

11.2.1.2 For other parts of the inert gas plant, the materials used shall comply with the requirements in applicable chapters of the rules. Works' certificates will be accepted.

11.2.1.3 Materials shall be selected so as to reduce the probability for corrosion and erosion. Those components which may be subjected to corrosion are to be either constructed of corrosion-resistant material or lined with rubber, glass fibre epoxy resin or other equivalent coating material.

11.3 General Arrangement and Design

11.3.1 General

11.3.1.1 The inert gas system shall be capable of supplying a gas or mixture of gases with an oxygen content of not more than 5% at a capacity to satisfy the intended use under all normal operating conditions. The system shall be able to maintain an atmosphere with an oxygen content not exceeding 8% by volume in any part of any cargo tank and at a positive pressure in port and at sea except when it is necessary for such a tank to be gas-free.

Inert gas plants based on flue gas from boilers which normally are not in operation during sea voyages (motor ships), and which are not equipped with separate inert gas generator for topping-up purposes, shall be arranged to enable production of flue gas of adequate quantity and quality (artificial load) whenever topping-up shall be carried out.

11.3.1.2 The inert gas system shall be designed and equipped in such a way as to prevent hydrocarbon gases from reaching non-hazardous spaces, and prevent interconnection between tanks and spaces within the cargo area, which normally do not have such connections, eg. between segregated ballast tanks and cargo tanks.

11.3.1.3 Inert gas may be also based on flue gas from boilers or from separate inert gas generators with automatic combustion control.

11.3.1.4 Systems using stored carbon dioxide is not generally accepted unless the Society is satisfied that the risk of ignition from generation of static electricity by the system itself is minimised.

11.3.1.5 Inert gas systems based on other means than combustion of hydrocarbons such as inert gas produced by passing compressed air through hollow fibres, semi-permeable membranes or absorber materials

11.3.1.6 Inert gas generators based on combustion of fuel, shall be located outside the cargo area. Spaces containing inert gas generators shall have no direct access to accommodation service or control station spaces, but may be located in machinery spaces. When located in a separate compartment, it shall be separated by a gastight steel bulkhead and/or deck from accommodation, service and control station spaces.

Where a separate compartment is provided, it shall be fitted with an independent mechanical extraction ventilation system, providing 6 air changes per hour. Two oxygen sensors (low oxygen alarms) shall be fitted and give audible and visual alarm outside the door. The compartment is to have no direct access to accommodation spaces, service spaces and control stations.

11.3.2 Piping Arrangement

11.3.2.1 The piping arrangement shall be such that the cargo tanks during unloading can be filled with inert gas without having open connection to the atmosphere.

11.3.2.2 Piping arrangement shall be such that cargo tank washing can be carried out in an inert atmosphere.

11.3.2.3 The supply pipes for inert gas shall be so arranged that the velocity and direction of the jet will facilitate effective change of the tank atmosphere.

Note:
With an arrangement utilising the dilution method and inlet at deck level, the diameter and flowrate of inlets shall be such that the jet will penetrate all the way

down to the tank bottom.
Fig. 1 may be used for determining the relationship between jet penetration depth inlet diameter and flowrate

The exhaust gas outlets shall comply with the requirements for cargo tank venting, refer Sec 5.2. Connection to cargo oil pipes, refer Sec 5.1.

11.3.2.4 The inert gas supply main(s) is (are) to be fitted with branch piping leading to each cargo tank. Branch piping for inert gas shall be fitted with either stop valves or equivalent means of control for isolating each tank. Any stop valves fitted shall be provided with locking arrangements. With regard to an arrangement of a common inert gas and vent pipe, refer Sec 5.2.

Each cargo tank not being inerted shall be capable of being separated from the inert gas main by one of the following:

1) Removing spool-pieces, valves or other pipe sections, and blanking the pipe ends; or

2) Arrangement of two spectacle flanges in series with provisions for detecting leakage into the pipe between the two spectacle flanges; or

3) An arrangement of a shut-off valve and a spectacle flange in series with provisions for detecting leakage into the pipe between the two spectacle flanges, is considered to provide level of safety equivalent to that in 1 and 2.

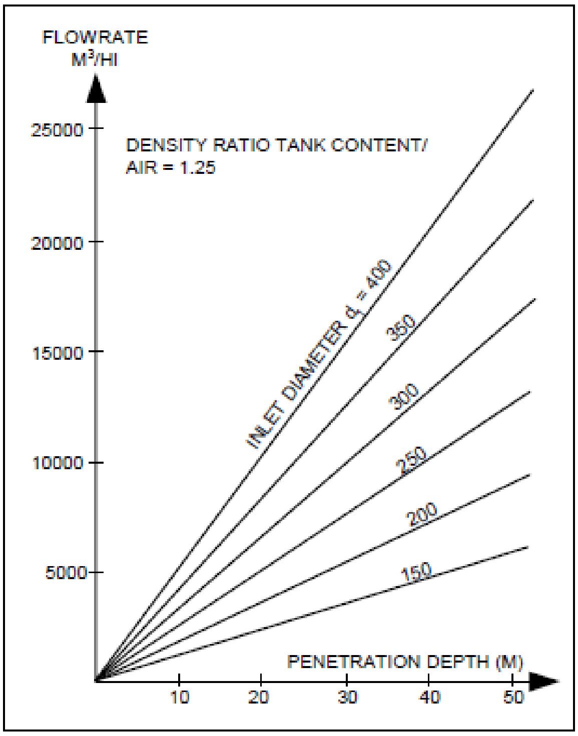


Fig 1 Relation between Flowrate and Penetration depth (selected diameters)

11.3.2.5 One or more pressure/vacuum breaking devices with sufficient capacity shall be provided in the system to protect the tanks from a pressure exceeding design vapour pressure and a vacuum exceeding 0.07 bar. Such device(s) is (are) to be installed on the inert gas main unless such devices are installed in the venting system required by Sec 5, or on individual cargo tanks.

Means for easy control of the liquid level shall be provided if liquid filled pressure/vacuum breaking devices are fitted. The liquid shall be operational in the temperature range -20°C to +40°C.

11.3.2.6 The generation of static electricity shall be minimised by appropriate design of the piping system.

11.3.2.7 Arrangements shall be made to allow bow or stern loading and discharge pipes to be purged after use and maintained gas safe when not in use. The vent pipes connected with the purge shall be located in the cargo area.

11.3.2.8 The piping arrangement shall be such that the main inert gas line cannot be filled with cargo oil, for example by locating the main inert gas line at sufficient height above the cargo tanks or by installing liquid barriers in the branch lines.

11.3.2.9 Effective arrangements shall be provided to enable the inert gas main to be connected to an external supply of inert gas. The arrangements shall be located forward of the non-return valve referred to in Sec 11.3.6.3..

11.3.3 **Inerting of Double Hull Spaces**

11.3.3.1 On oil tankers (**Tanker for Oil**) required to be fitted with inert gas system, double hull spaces shall be fitted with suitable connections for supply of inert gas. Portable means may be used. Where necessary, fixed purge pipes shall be arranged.

11.3.3.2 Where such spaces are connected to a permanently fitted inert gas system means shall be provided to prevent hydrocarbon gases from the cargo tanks entering the double hull spaces through the system, eg. by using blank flanges.

11.3.4 **Fresh Air Intakes**

11.3.4.1 Fresh air intakes to the inert gas system for gas-freeing of cargo tanks shall be provided. The air intakes shall also be provided with blanking arrangement.

11.3.5 **Level Measurig of Inerted Tanks**

11.3.5.1 Means shall be provided to allow ullaging and sounding of inerted tanks without opening the tanks. Separate ullage openings may be fitted as a reserve means.

11.3.6 **Prevention of gas leakage into non-hazardous spaces**

11.3.6.1 Where the main line leaves no-hazardous spaces an automatically controlled valve shall be fitted near the bulkhead. The valve shall close automatically when there is no overpressure in the main line after the fans.

11.3.6.2 The inert gas main line shall have a water seal located in the cargo tank area on deck. The water seal shall prevent the return of hydrocarbon vapour to any non-hazardous spaces under all normal conditions of trim, list and motion of the ship.

The water seal shall prevent entrained water in the gas as far as practicable. Provisions shall be made to secure operation of water seal below water freezing temperature.

Options for easy control of the level in the sealed condition shall be provided. For oil carriers (**Tanker for Oil**) arranged also for carriage of chemicals an arrangement alternative to the water seal may be considered.

11.3.6.3 In addition to the water seal, the inert gas main line shall have a non-return valve installed on tank deck between the water seal and the nearest connection of any cargo tank. The non-return valve shall be provided with positive means of closure. As an alternative to positive means of closure, an additional valve having such means of closure may be provided forward of the non-return valve.

11.3.6.4 Means shall be provided to vent the inert gas main line in a safe manner between the automatically controlled valve and the second closing device on the tank deck.

A water loop or other approved arrangement is also to be fitted to all associated water supply and drain piping and all venting or pressure sensing piping leading to non-hazardous spaces. Means shall be provided to prevent such loops from being emptied by vacuum.

11.3.6.5 Deck water seal and all loop arrangements shall be capable of preventing return of hydrocarbon vapours at a pressure equal to the test pressure of the cargo tanks.

11.3.6.6 Provision shall be made to ensure that the water seal is protected against freezing, in such a way that the integrity of seal is not impaired by overheating.

11.4 Production and Treatment of Inert Gas

11.4.1 General

11.4.1.1 Inert gas generators, fans and scrubbers shall be located aft of all cargo tanks, cargo pump rooms and cofferdams separating these spaces from machinery spaces.

11.4.1.2 The system shall be capable of delivering inert gas to the cargo tanks at a rate of at least 125% of the maximum rate of discharge capacity of the ship expressed as a volume. The fan capacity shall secure an acceptable positive pressure in the tanks and spaces at any normal operation condition.

11.4.1.3 At least two fans shall be provided which together will be capable of delivering to the cargo tanks at least the volume of gas required in Sec 11.4.1.2. However, no fan shall have a capacity less than one third of the combined fan capacity. In systems with gas generators a single fan may be accepted provided that sufficient spares for the fan and its prime mover are carried on board.

11.4.1.4 The fan pressure shall not exceed 0.3 bar.

11.4.2 Flue Gas System

11.4.2.1 Flue gas connection from the boilers shall be located before a rotary air preheater, if fitted.

11.4.2.2 Flue gas isolating valves(s) shall be provided with indicators. These isolating valve(s) is (are) to be fitted in the inert gas supply main(s) between the boiler uptake(s) and the gas scrubber.

11.4.2.3 In addition to the valve nearest to the boiler uptake a sealing shall be arranged to prevent flue gas leakage when the inert gas system is not in operation.

11.4.2.4 A permanent arrangement for cleaning the valves nearest to the boiler uptake shall be arranged.

11.4.2.5 To prevent starting of sootblowing of the boiler when the valve nearest to the boiler uptake is open and interlocking device shall be arranged. For manual soot blowing, alarm and signboard is acceptable.

11.4.2.6 On both suchtion and delivery side of each fan, isolating valves shall be installed.

11.4.2.7 For cleaning the impeller in place an efficient arrangement shall be provided.

11.4.3 Inert Gas Generator

11.4.3.1 Two fuel oil pumps shall be fitted to the inert gas generator. Suitable fuel in sufficient quantity shall be provided for the inert gas generators.

11.4.4 Gas Cleaning and Cooling

11.4.4.1 Devices shall be fitted to minimise carry-over of water and solids. For flue gas system the scrubber shall be fitted on the suction side of the fans. A gas scrubber shall be fitted for the purpose of effective cooling and cleaning of the gas. The scrubber shall be protected against corrosion.

11.4.5 Water Supply

11.4.5.1 Gas scrubber shall be supplied with cooling water from two pumps, each of sufficient capacity for supplying the system at maximum inert gas production, and without interfering with any essential service on the ship. One of the pumps shall serve the inert gas scrubber exclusively.

11.4.5.2 Water seal, if fitted, shall be capable of being supplied by two separate pumps, each of which shall be capable of maintaining an adequate supply at all times.

11.4.6 Water Discharge

11.4.6.1 The effluent water piping from scrubber, valve(s) included, shall be protected against corrosion.

11.4.6.2 Distance piece between overboard valve and shell plating shall be of substantial thickness, at least shell plate thickness, but not less than 15 mm.

11.4.6.3 If water discharge is obtained by means of discharge pumps, a pumping arrangement equivalent to the supply shall be provided.

11.4.6.4 Discharge pipes from the water seal shall lead directly to sea.

11.5 Instrumentation

11.5.1 General

11.5.1.1 Instrumentation shall be in accordance with Pt.6 Ch.9.

11.5.2 Indication

11.5.2.1 Instrumentation shall be fitted for continuous indication of temperature and pressure of the inert gas at the discharge side of the gas fans, whenever the fans are operating.

11.5.2.2 Instrumentation shall be fitted for continuous indication and permanent recording, at all times when inert gas is being supplied, the pressure of the inert gas supply mains forward of the non-return devices on tank deck and oxygen content of the gas in the inert gas supply main on the discharge side of the fan. Such instrumentation is, where practicable, to be placed in the cargo control room, if fitted. In any case the instrumentation shall be easily accessible to the officer in charge of cargo operations.

11.5.2.3 Meters shall be fitted on the navigation bridge to indicate the pressure of the inert gas supply main forward of the non-return devices on tank deck and in the machinery control room or machinery space to indicate the oxygen content of the inert gas in the inert gas supply main on the discharge side of the fans.

11.5.2.4 Portable instruments for measuring oxygen and flammable vapour concentration shall be provided, refer Sec 9.7. In addition, suitable arrangement shall be made on each cargo tank and double hull space, such that the condition of the tank atmosphere can be determined using these portable instruments.

11.5.3 **Monitoring**

11.5.3.1 To indicate failure of the inert gas plant, a common alarm connection shall be provided between the local inert gas control panel and the machinery control room or machinery space.

11.5.3.2 The extent of alarm and safety functions shall be in accordance with Table 11.5.1.

11.5.3.3 Monitoring of water supply to water seal and power supply for instrumentation is also to be maintained when the inert gas plant is not in use.

11.5.3.4 For burner control and monitoring, refer Pt.6

Table 11.5.1 Inert Gas System- Control and Monitoring

Failure/ Indication	**Setting**	**Permanent Recording**	**Continuous Alarm**	**Alarm**
Operational status of the inert gas system			CCR	
Oxygen content (5)		CCR	ECR and CCR	
Pressure in IG main (4)		CCR	ECR, CCR and bridge	
IG Supply temperature			ECR and CCR	
High oxygen content (5)	> 5%			CCR and ECR
Low pressure IG main (4)	< 100 mm			CCR and ECR
Low-low pressure IG main	< 50 mm			CCR or automatic shutdown of cargo pump with alarm
High pressure IG main (5)				CCR
High water level in scrubber				CCR
Low water pressure /flow to scrubber				CCR
High temperature of inert gas supply	65º C			CCR
High-High temperature of inert gassupply	75º C			
Low level in deck water seal				CCR
Blower (fans) failure				CCR

Power failure of the control and monitoring system				CCR and ECR
Power failure to oxygen and pressure indicators and recorders				CCR and ECR
Oxygen level in inert gas room(s)	< 19% O_2			Outside space and ECR
Power failure of inert gas generator				CCR and ECR
Failure of burner (flame failure)				CCR and ECR
Low fuel oil pressure /flow to burner				CCR and ECR
Loss of inert gas supply (flow or differential pressure) (2)				CCR
Faulty operation of double-block and bleed valves				CCR
Double-block and bleed valve position			CCR	
Loss of power to double block and bleed				

Table 11.5.1 Inert Gas System- Control and Monitoring (Contd..)

Failure/ Indication	Shut down gas regulating valve	Automatic shut-dwon blowers (fans)	Activation of double-block and bleed(2)	Comment
Operational status of the inert gas system				Indicator showing that inert gas is being produced and delivered to cargo area (6)
Oxygen content (5)				
Pressure in IG main (4)				To be active also when the IG plant is not in use
IG Supply temperature				
High oxygen content (5)	X			The inert gas shall be automatically vented to atmosphere
Low pressure IG main (4)				
Low-low pressure IG main				Shall be independent of the low pressure alarm. Ie separate pressure transmitter.
High pressure IG main (5)				
High water level in scrubber	X	X		Shall include

				automatic stop of water supply to the scrubber
Low water pressure /flow to scrubber	X	X		
High temperature of inert gas supply				
High-High temperature of inert gas supply	X	X		
Low level in deck water seal				To be active also when the IG plant is not in use
Blower (fan) failure	X			
Power failure of the control and monitoring system				
Power failure to oxygen and pressure indicators and recorders				To be active also when the plant is not in use
Oxygen level in inert gas room(s)				Min. 2 Oxygen sensors to be provided in each space. Visual and audible alarm at entrance to the inert gas room(s).
Power failure of inert gas generator				Inert gas generators only
Failure of burner (flame failure)	X			Inert gas generators only
Low fuel oil pressure /flow to burner				Inert gas generators only
Loss of inert gas supply (flow or differential pressure) 2)	X		X	
Faulty operation of double-block and bleed valves				Refer note (3)
Double-block and bleed valve position				
Loss of power to double block and bleed			X	

(1) Alarms shall be audible and visible
(2) Applicable onl for ships with double-block and bleed replacing deck water seals
(3) Fautly operation of duble-block and bleed valves:
One block valve open and othe block valve closed
Bleed-valve open and block valve open
Bleed valve closed and block valve closed
Block valves open when ther is no inert gas supply
(4) A commn pressure transmitter is acceptable
(5) A common oxygen sensor is acceptable
(6) Indication of position of gas regulating valve is accepted as status of delivery to cargo area

11.6 Survey & Testing

11.6.1 Survey

11.6.1.1 All major components of inert gas plant shall be surveyed during construction by the surveyor. The gas scrubber and water seal shall be tested for tightness.

11.6.1.2 Detailed survey shall be carried out after installation of inert gas plant by the Surveyor.

11.6.2 Testing

11.6.2.1 All safety devices, alarm and shutdown devices shall be function tested.

11.6.2.2 Function test of the plant shall be carried out under normal operating conditions, including actual partial load conditions of boilers.

11.6.2.3 The capacity of the plant shall be confirmed by direct measurement of the gas flow or indirectly by running against maximum discharge capacity of the cargo oil pumps.

SECTION 12 PROTECTED SLOP TANKS

Contents

12.1 General

12.1.1 Application

12.1.1.1 Requirments in this section apply to ships with class notation as given in Sec 10.1.2.1.

12.1.2 Documentation

12.1.2.1 Documentation shall be submitted in accordance with Sec 1.4 and Sec 10.1.1.4.

12.2 Systems and Arrangements

12.2.1 Arrangement

12.2.1.1 Where not bounded by weather decks, pump rooms or fuel oil tanks, the slop tank(s) shall be surrounded by cofferdams. These cofferdams shall not be open to a double bottom, pipe tunnel, pump room or other enclosed space. However, openings provided with gastight bolted covers may be permitted.

12.2.1.2 Cofferdams shall be arranged for water filling and draining.

12.2.1.3 Hatches and other openings to slop tanks shall be arranged for locking in closed position.

12.2.2 Tank Venting

12.2.2.1 Slop tanks shall have a separate, independent venting system with pressure/vacuum relief valves. Gas outlets shall have a minimum height of 6 m above tank deck and a minimum horizontal distance of 10 m from openings to non-hazardous spaces and exhaust outlet from machinery.

12.2.3 Pumping and Piping System

12.2.3.1 Slop tank pipe connections shall have means for blank flanging on open deck or at another easily accessible location.

12.2.3.2 Slop handling pumping systme while the ship is in service not covered by the class notation **Tanker for Oil** or **Tanker for Oil Products** shall be separated from all other piping systems. Separation from other systems by means of removal of spool pieces may be accepted.

12.2.4 Gas Detection

12.2.4.1 Dry spaces surrounding slop tanks shall be equipped with an approved automatic gas detector system with alarm.

12.2.5 Protection Inside Slop Tanks

12.2.5.1 Arrangement for protecting the tank atmosphere by inert gas or similar effective means, shall be provided.

12.2.5.2 Meter shall be fitted in the navigation bridge to indicate at all times the pressure in the slop tanks whenever those tanks are isolated from the inert gas supply main.

12.2.5.3 Inerting of slop tank(s) shall be possible irrespective of the blank flanging from the rest of the system.

12.3 Instructions and Signboards

12.3.1 General

12.3.1.1 Hatches and other openings to cargo slop tanks shall be provided with signboards with the following text:

"TO BE KEPT CLOSED AND LOCKED DURING HANDLING OF DRY CARGO"

12.3.1.2 Instructions for handling of slop shall be permanently posted in cargo pump room, cargo control room and deck office.

The following text (in quotes) shall be included in the instruction:

"When the ship is on dry cargo service and cargo slop is carried in protected slop tanks, the following items shall be complied with:

— All pipe connections to the slop tanks, except vent pipes (and connection to separate slop pumping system) shall be blanked off.

— Inert gas branch connections to the slop tanks shall be kept blanked off, except when filling or re-filling of inert gas is going on.

— Slop is only to be handled from open deck.

— During handling of dry cargo:

- All hatches and opening to the slop tanks shall be kept closed and locked.
- The slop tanks shall be kept filled with inert gas, and the O2-content in the tanks shall not exceed 8% by volume.

— The gas detection system in cofferdams surrounding the slop tanks shall be function tested before loading of dry cargo commences ".

SECTION 13 TANK CLEANING ARRANGEMENTS- CARGO TANK

Contents

13.1 General

13.1.1 Application

13.1.1.1 Crude oil carriers of 20 000 tons deadweight and above shall be fitted with a crude oil washing arrangement complying with MARPOL Annex I, Reg. 33 and Reg. 35, which refers to "Revised Specifications for the Design, Operation and Control of Crude Oil Washing Systems" adopted by IMO with Res. A.446(XI) as amended by A.497(XII) and A.897(21).

13.1.1.2 Crude oil washing installations which are not mandatory according to MARPOL Annex I need only comply with relevant requirements related to safety given in the specifications referred to in Sec 13.1.1.1, such as installation of an inert gas system.

13.1.1.3 Crude oil carriers (**Tanker for Oil**) less than 20 000 tons deadweight, fitted with a crude oil washing arrangement complying with design requirements in the specifications referred to in Sec 13.1.1.1, may be assigned the special feature notation **COW**.

13.1.1.4 Documentation requirement Sec 13.1.2.1 need not be complied with.

13.1.2 Documentation

13.1.2.1 The builder is responsible for providing the documentation required by Table 13.1.1.

Table 13.1.1 Documentation Requirements- Cargo Tanks Cleaning System

System	Documentation Type	Additional Description	(A)/(I)
Cargo tank cleaning system	Piping diagram	The drawing shall show number of and location of cargo tank washing machines	(A)
	Shadow diagram		(A)
	Arrangement plan	a) washing machines including installation and supporting arrangements b) Hand dipping and gas sampling arrangements	(A)
	Operations manual	In accordance with MEPC.3(XII), as amended by resolution MEPC.81(43).	(A)
Crude oil washing machines	Specification	-Manufacturer -Type -Nozzle Diameter -Capacity	(I)
Note: (A) For Approval; (I) For Information			

13.1.2.2 For requirements related to documentation of instrumentation and automation, including computer based control and monitoring, refer Sec 1.

13.1.3 Tank Water Washing Systems

13.1.3.1 Water for tank washing may be supplied by pumps located outside the cargo area provided the connections to the tank washing system is so arranged that they can only be connected to the tank washing system when that system is completely and unmistakably disconnected from the cargo system. The connection arrangements to the tank washing system shall be arranged in the cargo tank area. Where a combined crude oil-water washing supply piping is provided, the piping shall be so designed that it can be drained so far as is practicable of crude oil before water washing is commenced, into a slop tank or a cargo tank.

13.1.3.2 Heaters for tank washing with permanent connections to a cargo system shall be located in the cargo area.

13.1.3.3 Tank washing systems designed for the use of flammable cargo other than crude as the washing medium, shall comply with the requirements to **COW**.

SECTION 14 OFFSHORE LOADING ARRANGEMENTS

Contents

14.1 General

14.1.1 Application

14.1.1.1 The requirements in this section apply to oil carriers having a mooring and loading system for transfer of crude oil from offshore loading terminals to the ship.

14.1.1.2 The requirements are supplementary to those for the class notation **Tanker for Oil**.

14.1.2 Class Notation

14.1.2.1 Vessels installed with a bow loading arrangement satisfying the requirements of this section, shall be assigned the additional class notation **BOW LOADING**.

14.1.2.2 Vessels installed with a submerged turret loading arrangement (STL) satisfying the requirements of this section, shall be assigned the additional class notation **STL**.

14.1.3 Certification Requirments

14.1.3.1 Various components shall be certified as detailed in Table 14.1.1 and Table 14.1.2.

Table 14.1.1 Certification Requirements- Bow Loading Systems

Component	Certification Type		Additional Description
Fairleads	INTLREG	Product Certificate	
	INTLREG	Works Material Certificate	
Chain Stoppers	INTLREG	Product Certificate	
	INTLREG	Material Certificate	
Coupling with Sviwel	INTLREG	Product Certificate	
	INTLREG	Works Material Certificate	
Control and Monitoring	INTLREG	Product Certificate	

Table 14.1.2 Certification Requirements- Submerged Turret Loading System

Component	Certification Type		Additional Description
Mating rings and seals	INTLREG	Product Certificate	
	INTLREG	Works Material Certificate	
Cone hatch	INTLREG	Product Certificate	
	INTLREG	Works Material Certificate	
Coupling with Sviwel	INTLREG	Product Certificate	
	INTLREG	Works Material Certificate	
Locking Mechanism	INTLREG	Product Certificate	
	INTLREG	Works Material Certificate	
Compensators	INTLREG	Product Certificate	
	INTLREG	Works Material Certificate	
Control and monitoring system	INTLREG	Product Certificate	

14.1.3.2 For a definition of the certificate types, refer Pt.1 Ch.1

14.1.3.3 Other load bearing components which are critical for the safe connection and operation of the offshore loading systems, may also be required to be certified.

14.1.3.4 Components shall as a minimum be subject to a function test as a part of the certification.

14.1.4 **Documentation Requirments**

14.1.4.1 For class notation **BOW LOADING** the required documentation shall be submitted as required by Table 14.1.1:

Table 14.1.1 Documentation Requirements- BOW LOADING Notation			
Component	**Documentation Type**	**Additional Description**	**(A)/(I)**
Bow loading System	Arrangement Plan	Including all mechanical, hydraulic, electric, fire protection and ventilation equipment. A detailed plan shall also include hazardous zones, ventilation openings and access doors in the bow loading area.	(A)
	Operations Manual	Refer Sec 14.7.	(A)
Note: (A) For Approval; (I) For Information			

14.1.4.2 For class notation **STL (Submerged Turret Loading)** the required documentation shall be submitted as required by Table 14.1.2:

Table 14.1.2 Documentation Requirements- STL Notation			
Component	**Documentation Type**	**Additional Description**	**(A)/(I)**
Submerged Turret Loading (STL) System	Arrangement Plan	Including all mechanical, hydraulic, electric, fire protection and ventilation equipment.	(A)
	Operations Manual	Refer Sec 14.7	(A)
Note: (A) For Approval; (I) For Information			

14.2 Materials

14.2.1 **General**

14.2.1.1 Materials used in offshore loading piping systems shall comply with the requirements specified in Sec 4.

14.2.1.2 Materials used for the winches (eg. traction and hose handling winches), fairleads, chain stoppers, guide rollers and other load bearing components shall comply with the requirements specified in Pt 4, Ch 3, Sec 6.2.2.

14.2.1.3 The bow door is considered part of the ship structure and is subject to the requirements of Pt 3.

14.3 Arrangement and General Design

14.3.1 **Positioning of Ship**

14.3.1.1 The vessel shall be installed with controllable pitch propeller and side thrusters of sufficient power for adequate manoeuvrability and positioning of the ship during offshore loading operations.

14.3.1.2 In case a dynamic positioning system is installed, this shall include monitoring and self-check facilities equivalent to class notation **DYNPOS-AUT**. Manual override of automatic thruster or propulsion control shall be arranged.

14.3.2 **Piping System for Bow Loading**

14.3.2.1 Cargo pipes and related piping equipment forward of the cargo area shall have only welded connections, except at loading station, and shall be led externally past service and control station and machinery spaces. Such pipes shall be clearly identified and segregated by at least two valves situated in the cargo area or by one valve and other means together providing an equivalent standard of segregation. The piping shall be self-draining to the cargo area and into a cargo tank.

14.3.2.2 Means shall be provided to allow the bow loading pipe to be purged by inert gas after loading and maintained gas free when not in use.

Note:
The bow loading pipe is considered to be in use as long as the ship is operating as a shuttle tanker. It is not required to maintain the pipe gas free on voyages between offshore installations and shore terminals.

When the bow loading coupler is located within an enclosed space, the enclosed space is regarded as the loading station. The number of flanges shall however be restricted as far as practicable within the loading station.

14.3.2.3 The bow loading coupling shall be fitted with a shut-off valve and a blank flange. The blank flange may be omitted when a patent hose coupling is fitted.

14.3.2.4 Means for transfer of content of the spill tray or coaming to the cargo area, is to be provided. A spill tray or coaming arrangement with capacity of not less than 1 m^3 and a coaming height of not less than 300 mm is to be provided in way of the bow loading coupling.

14.3.3 **Hazardous Areas**

14.3.3.1 Openings, entrances and air inlets to service and machinery spaces and control stations that may be exposed to spray or fire in way of the bow loading coupling, shall not face the bow loading coupling, and shall be located at least 10 m from the bow loading coupling. Direct access from the hazardous bow loading coupler room to non-hazardous spaces in the forecastle area, such as manned control stations and hydraulic power pack spaces, is acceptable provided protected from gas ingress as follows:

- The non-hazardous spaces protected shall have alternative means for escape other than via the bow loading coupler room

- An air lock in accordance with Sec 6.2.2.1 (2) is provided between the bow loading coupler room and an intermediate space other than the non-hazardous spaces to be protected. The air-lock will be considered as a hazardous zone 2.

- The intermediate space complies with the requirements to an air lock in Sec 6.2.2.1(2). The intermediate space will be considered as a non-hazardous space.

14.3.3.2 Spaces on the vessel housing the bow loading pipe and bow loading coupling shall be considered as hazardous area zone 1, with corresponding requirements to electrical equipment and wiring.

14.3.3.3 Spaces considered as non-hazardous shall not have any connections with hazardous spaces or areas, and shall be ventilated in accordance with Sec 6.

14.3.3.4 Forepeak tank air vent pipes shall be located outside hazardous areas.

14.3.4 **Bow Chain Stoppers and Fairleads**

14.3.4.1 Mooring strong points at the bow when loading through the bow loading system are to have capacity in accordance with Table 14.3.1.

Table 14.3.1 Capacity and Details for Strong Point for Bow Loading System

Ship DWT (t)	Chafe Chain size (mm)	Chain Grade	Number of bow fairleads	Number of bow stoppers	SWL (t)	Min. Breaking Load (t)
Less than 100,000	76	Grade 3	1	1	200	438
Between 100,000 to 150,000	76	Grade 3	1	1	250	498
Over 150,000	76	Grade 3	1	1	500	768
Note: Ship DWT is the deadweight of the ship at maximum summer draught						

14.3.4.2 The structural strength of the stopper, bow fairlead and supporting structure shall be based on a safety factor of 2.0 against the yield criterion when applying a load equal to SWL.

14.4 Control and Monitoring

14.4.1 **General**

14.4.1.1 The instrumentation and automation, including computer based control and monitoring, the requirements in this chapter are to be considered additional to those given in Pt.6 Ch.9

14.4.2 **Control Station**

14.4.2.1 Control station for offshore loading may be arranged within the bow area or on the navigation bridge. From this station all operations concerning positioning of the ship, operation and monitoring of bow loading safety systems, and monitoring of mooring and loading parameters shall be performed. When the control station is arranged on navigation bridge, the above control and monitoring functions shall be arranged at one bow loading work station.

14.4.2.2 The bridge in normal sailing mode shall be the main command location.

14.4.3 **Instrumentation and Automation**

14.4.3.1 Ship manoeuvring instrumentation shall include the following:

- Main engine(s) emergency stop, or disengagemtn of clutch, if fitted
- Variable pitch control
- Steering gear control
- Side thruster(s) control
- Radar
- Log

14.4.3.2 Bow mooring instrumentation shall include the following:

- Chain stopper control
- Mooring line traction control
- Data logger system for recording of mooring and load parameters.

Mooring system shall be provided with a tension meter continuously indicating the tension during the bow loading operation. This requirement may be waived if the vessel has in operation an approved dynamic positioning system.

14.4.3.3 STL and bow loading instrumentation shall include the following:

- Cargo pressure monitoring in the bow loading line in way of the bow loading coupling with high and low pressure alarms.
- A system for automatic transfer of signals from the control and safety system, to enable automatic termination of cargo supply from the offshore terminal.
- Cargo tank level indicators and high level alarm
- Cargo valve position indicators
- Indicator for loading coupling position and hose tension

14.4.3.4 For tankers with bow loading arrangement an emergency disconnection system shall be provided. The system shall be divided into two modes which are to be activated from the control station.

First mode shall perform the following:
- Automatic termination of cargo supply from the offshore terminal.
- Closing the bow loading coupling and loading hose end coupling valves.
- Closing the isolation valve inboard of the bow loading coupling.

Note:
Valve closing time (minimum) should normally not be less than 25 s. The inboard valve should normally close 3 s after the bow loading coupling valve. In order to enable emergency disconnection, start of hydraulic power supply is normally also required.

Second mode shall perform the following:

- Automatic termination of cargo supply from the offshore terminal.
- Closing the bow loading coupling and loading hose end coupling valves.
- Closing the isolation valve inboard of the bow loading coupling.
- Start of the water sprinkler system.
- Opening of the bow loading coupling claws.
- Opening of the chain stopper.
- Releasing of the brake and speed control of the traction winch where applicable.

All functions shall be sequentially pefromed. In addition to the above automatic disconnection systems, a manually-operated backup emergency disconnection system shall be provided. Such a system may be based on accumulators providing hydraulic pressure.

14.4.4 **Communication**

14.4.4.1 Means of communication between the control station and the offshore loading terminal shall be provided and certified safe for hazardous areas, if necessary.

14.4.4.2 Means of emergency communication between control station and the offshore terminal shall be arranged.

14.4.4.3 Both primary and secondary methods shall be provided to ensure that continuous communication can be maintained between control station and the offshore terminal in the event of any equipment failure or other problems arising during the operations.

14.4.4.4 A detailed communication sequence shall be established concerning premooring, mooring, preloading, loading and tanker departure phases.

14.5 Bow loading Area Safety Installations

14.5.1 General

14.5.1.1 The whole of bow loading area shall be designed with due consideration to means and methods for ensuring a safe and reliable offshore loading operation. The system layout and equipment design shall be optimised with regard to safety aspects.

14.5.1.2 Due care and attention shall be given for minimising the risk for and consequences of explosions or fire caused by system and or equipment failure and/or malfunction.

14.5.1.3 Safety installation shall include the following arrangments, systems, subsystems and equipments:

- For any manned control station mechanical ventialation shall be provided, as a precaution against ingress of hydrocarbon gas.

- Natural ventilation of the bow loading coupling room on the condition that adequate natural ventilation is achieved in the bow coupler space during bow loading when the bow door is open. This will normally imply that additional ventilation openings are provided in the aft part of the space.

- Emergency escape route from any manned control station and bow loading coupling room.

- Fire protection standard equal to A-60 class for the floor, door(s), bulkheads and windows of any manned control station.

- Foam monitors and water jets covering the bow loading and mooring area. Number, location and type of monitors shall be optimised with regard to fire-fighting efficiency. The foam system shall be independent from the vessel's main foam system but it shall be possible also to supply the system from the main foam system.

- Foam-based sprinkler system for the bow loading coupling connector room. The system is to be independent from the vessel's main foam system but it shall be possible also to supply the system from the main foam system. The system shall be capable being activated both locally and at the bow loading control station.

- Water-based sprinkler system to prevent possible sparks during disconnection. The system shall be covering potential spark generating equipment such as the bow loading coupler, wire rollers, mooring chain, fairlead, chain stopper, winches and the exterior of manned control stations, if fitted. The system is to be capable being activated both locally, at the bow loading control station and automatically in case of emergency disconnection. It shall be independent of from the vessel's main fire system but it shall be possible also to supply the system from the main fire system.

- A fixed hydrocarbon gas and fire detection and alarm system shall be provided in the bow loading coupling room. Alarms are to be activated both locally and at the bow loading control station.

- Mooring chain, thimble, shackles, loading hose termination coupling, etc. shall be protected against contact with steel structure elements, via use of hardwood or equivalent material.

- Interlock functions to avoid malfunction of the offshore mooring and loading system.

- Emergency disconnection system, to be used if a hazardous situation should arise, refer Sec 14.4.3.4.

- Sufficient lights (minimum 200 lux) shall be provided in the bow coupler space and bow loading area to ensure good working conditions at night.

Note:
Water-based sprinkler system:
The water based sprinkler system is to have a capacity of 5 liter/min/m2 of the horizontal area protected. A separate self-priming sea water pump is normally required located in the bow area.

Independent foam system:
Application rates are to be in accordance with the FSS Code Chapter 14. The capacity of the foam system shall be calculated for simultaneously protection of all parts of the bow loading area required by these rules. A separate self-priming sea water pump and foam system is normally required located in the bow area.

14.6 Submerged Turret Loading Arrangement Room Safety Installations

14.6.1 General

14.6.1.1 Safety installation shall include the following equipment and arrangement:

a) Permanent mechanical ventilation system of extraction type shall be installed, and shall be capable of circulating sufficient air to give at least 20 air changes per hour with the following arrangement of exhaust trunking:

— The intake shall be just above lower floor plate in the submerged turret loading (STL) arrangement room
— An intake located 2 m above the lower floor plate and one intake located above deepest water line. These intakes shall have dampers fitted which can be remotely opened from main deck. The exhaust outlet shall be situated at least 3 m above tank deck and 6 m from any opening to non-hazardous spaces.

b) The STL room shall be fitted with interlock between electric lighting and ventilation, so arranged that the ventilation shall be in operation before the electrical current supply to the room can be connected.

c) Shall be provided with a fixed fire-extinguishing system according to SOLAS Ch. II-2/10.9 or equivalent.

d) Electrical circuits shall be intrinsically safe type.

e) Connection for supply of inert gas, if connected permanently to the inert gas system the connection shall be provided with a blank flange.

f) Luminaires shall be pressurised or flame proof type and certified safe for such spaces.

g) A fixed gas-detection system. Sampling points or detector heads shall be located at the lower parts of the room and in the ventilation outlet. At least one point shall be located above deepest water line.

h) Electrical equipment, instrumentation and automation installed in STL room shall be of certified safe type and for submerged use (IP 68). Certified safe equipment with degree of protection IP 66 may be accepted on a case by case basis for installation higher up than 2 m above the deepest water line.

14.7 Operation Manual

14.7.1 General

14.7.1.1 Operation manuals required by Table 14.1.1 and Table 14.1.2 shall give information regarding the safe use of the ship during bow loading or submerged turret loading operations and shall have references to enclosed drawings.

14.7.1.2 Operation manual in general shall include the following informationL:

a) Equipment and arrangement
- Tank arrangement
- Cargo transfer system
- Mooring arrangement
- Communication system
- Instrumentation
- Ventilation equipment

b) Safety Installations
- Fire protection and extinction
- Emergency escape routes
- Emergency disconnection system
- Blanking off of pipes

c) Operations
Mooring procedure
Connection and disconnection of cargo hose coupling
Oil cargo transfer
Cargo distribution and loading conditions
Precautions against over filling

d) Cleaning and Gas freeing of the bow loading system

14.8 Installation and Testing

14.8.1 General

14.8.1.1 All arrangement and equipment covered by this section shall be function tested. The function test of a Bow loading system shall involve connection of a dummy bow loading hose to the bow loading coupling.

14.8.1.2 Load cell calibration for tension monitoring in the bow loading system shall be verified by the surveyor.

Note:
or the purpose of monitoring the parameters specified in Sec 14.4.3, load cells would normally be provided in the bow loading coupler, chain stopper and traction winch guide roller.

SECTION 15 SINGLE POINT MOORINGS

Contents

15.1 General

15.1.1 Application

15.1.1.1 The requirements in this section apply to ships fitted with equipment enabling them to be moored to single point moorings.

15.1.1.2 The requirements cover the parts of Oil Companies' International Marine Forum (OCIMF) “Recommendations for Equipment Employed in the Bow Mooring of Conventional Tankers at Single Point Moorings” (Fourth Edition May 2007) applicable for the vessel.

15.1.1.3 Requirements herein are supplementary to those for the type notation **Tanker for Oil**.

15.1.2 Class Notation

15.1.2.1 Ships with equipment that satisfies the requirements of this section shall be assigned the additional notation **SPM.**

Oil carriers having a mooring and loading system in the bow for transfer of crude oil from offshore loading terminals to the ship, ie notation **BOW LOADING** (Sec 14), are not necessarily specially equipped to be moored at single point mooring buoys. In such cases, the class notation **SPM** is not mandatory.

15.1.2.2 The class notation **SPM** may be given in combination with **BOW LOADING**.

Note:
Due to the special bow loading and mooring arrangements for offshore loadings, requirements in Sec 15.3 below may be subject to special considerations. The special considerations, with assumptions, are to be clearly stated in the vessel's Appendix to Classification Certificate.

Tanker owners/operators should check with the SPM terminal operators the suitability of bow mooring arrangements on shuttle tankers on a case-by-case basis

15.1.3 Certification Requirements

15.1.3.1 Components shall be certified as required by Table 15.1.1.

15.1.3.2 For a definition of the ceritificate type refer Pt.1 Ch.1

Table 15.1.1 Certification Requirements- Single Point Mooring

Component	Certification Type		Additional Description
Bow farileads	INTLREG	Product Certificate	
Bow chain stoppers	INTLREG	Product Certificate	
Winch or capstan	INTLREG	Works Product Certificate	Including maximum safe working load (SWL)
Pedestal roller	INTLREG	Works Product certificate	If fitted. Confirming necessary structural strength to withstand the forces to which it will be exposed when the winch or capstan is lifting with its maximum capacity.

15.1.4 Documentation Requirements

15.1.4.1 Documentation shall be submitted as required by Table 15.1.2:

Table 15.1.2 Documentation Requirments- Single Point Mooring System			
Component	**Documentation Type**	**Description**	**(A)/(I)**
Single point mooring arrangment	Arrangement plan	Fairleads, bow chain stoppers, winches, capstans, pedestal rollers and winch storage drums.	(I)
Single point mooring fairleads	Detailed drawing		(A)
Single point mooring equipment supporting structure	Structural drawing		(A)
Note: (A) For Approval; (I) For Information			

15.2 Materials

15.2.1 General

15.2.1.1 Materials used in bow fairleads shall comply with the requirements specified in Pt 2 Ch 1.

15.2.1.2 The materials used for bow chain stopper shall comply with the requirements specified in Pt 4, Ch 3.

15.3 General Design & Arrangement

15.3.1 Bow Chain Stoppers

15.3.1.1 Bow chain stoppers arrangement and capacity shall be in accordance with Table 15.3.1.

Note:
Some terminals may have different requirement than those given in Table 15.3.1 due to their location and operational practices, eg. some terminals may require ships of less than 150 000 tonnes DWT to moor using two bow chain stoppers and some terminals may elect to moor ships of more than 150 000 tonnes DWT on a single bow chain stopper.

15.3.1.2 A standard 76 mm stud-link chain shall be secured when the chain engaging pawl or bar is in closed position. When in open position, the chain and associated fittings shall be allowed to pass freely.

15.3.1.3 The strength of the chain stopper, bow fairlead and supporting structure shall be based on a safety factor of 2.0 against the yield criterion when applying a load equal to SWL.

15.3.1.4 Stoppers shall be positioned between 2.7 m and 3.7 m inboard from the bow fairlead.

15.3.1.5 While laying out, due consideration shall be given to the correct alignment of stoppers relative to the direct lead between bow fairlead and pedestal roller or the drum end of the winch or capstan.

15.3.1.6 Stoppers shall be fitted as close as possible to the deck structure, however, taking due consideration to possible obstacles in order to obtain a free lead through the fairleads.

15.3.1.7 Upon installation bow stoppers shall be load tested to the equivalent SWL and a test certificate shall be issued. The test certificate shall be available for inspection on board the ship.

Note:
The installation test required by Sec 15.3.1.7 may be omitted if the actual bow stopper has been type approved, and proof load testing to the equivalent SWL was carried out for type approval. Applicable strength of the supporting structure should be documented by adequate analyses. INTLREG will issue a declaration confirming that evaluation of the support strength has been carried out with acceptable results. A document issued by the Society should in such cases be available onboard.

Table 15.3.1 Arrangement and Capacity for Single Point Mooring

Ship DWT (t)	**Chafe chain size (mm)**	**Grade**	**Number of bow fairleads**	**Number of bow stoppers**	**SWL (t)**	**Minimum breaking load MBL (t)**
100,000 or less	76	Grade 3	1	1	200	438
Between 100,000 to 150,000	76	Grade 3	1	1	250	498
Over 150,000	76	Grade 4	2	2	350	612
Note: Deadweight (DWT) at maximum summer draught						

15.3.2 Bow Fairleads

15.3.2.1 The size of bow fairleads shall measure atleast 600 x 450 mm.

15.3.2.2 For ships fitted with two fairleads: Where practicable the fairleads shall be spaced 2.0 m apart, from centre to centre. In any event, the fairleads shall not be spaced more than 3.0 m apart.

15.3.2.3 For ships fitted with one fairlead: The fairlead shall be positioned on the centre line.

15.3.2.4 Leads shall be oval or round in shape and adequately faired when fitted in order to prevent chafe chains from fouling on the lower lip when heaving inboard. Square leads are not to be used.

Note:
The design force should be established at an angle of 90° to the sides and 30° up or downwards. The same allowable design stress as for the stoppers applies. "Adequately faired" will be achieved if 3 links of chain have contact with the fairlead simultaneously at the design conditions.

15.3.3 Position of Pedestal Rollers

15.3.3.1 Winches or capstans shall be positioned to enable a direct pull to be achieved on the continuation of the direct lead line between the bow fairleads and bow stoppers. Alternatively, if found suitable, a pedestal roller shall be positioned between the stopper and the winch or the capstan, in order to achieve direct pull.

Note:
The use of more than one pedestal roller or a too acute change of direction of the mooring line is not recommended.

15.3.3.2 The distance between the bow stoppers and pedestal roller shall be considered so that an unrestricted line pull is achieved from the bow fairlead and through the bow stopper

15.3.4 **Winches of Capstans**

15.3.4.1 The winches or capstans shall be capable of lifting at least 15 tonnes.

15.3.5 **Winch Storage Drum**

15.3.5.1 A winch storage drum is provided to stow the pick-up rope, it shall be of sufficient size to accommodate 150 m rope with 80 mm in diameter.

SECTION 16 LIST OF CARGOES

Contents

16.1 List of Oil Cargoes

16.1.1 General

16.1.1.1 The list provided oil cargoes (1) which may be carried on ships with class notation **Tanker for Oil** and **Tanker for Oil Products**(2).

Oils
- Crude Oil
- Clarified
- Mixture containing crude
- Diesel oil
- Fuel Oil No. 4
- Fule Oil No. 5
- Fuel Oil No. 6
- Residual Fuel Oil
- Road Oil
- Transformer Oil
- Aromatic Oil
- Lubrication Oils and Blending Stocks
- Mineral Oil
- Motor Oil
- Penetrating Oil
- Spindle Oil
- Turbine Oil

Asphalt Solutions
- Straight Run Residue
- Roofers Flux
- Blending Stocks

Distillates
- Straight Run
- Flashed Feed Stocks

Gas Oil
- Cracked

Gasoline Blending Stocks
- Alkylates Fuel
- Reformates
- Polymer- Fuel

Gasolines
- Casing head (natural)
- Automotive
- Aviation
- Straight Run
- Fuel Oil No.1 (Kerosene)
- Fuel Oil No. 1-D
- Fuel Oil No. 2
- Fuel Oil No. 2-D

Jet Fuels
- JP-1 (Kerosene)
- JP-3
- JP-4
- JP-5 (Kerosene, heavy)
- Turbo Fuel
- Kerosene

- Mineral Spirit

Naptha
- Solvent
- Petroleum
- Heartcut Distillate Oil

1) The list of oils shall not necessarily be considered as comprehensive. Note the limitation with respect to vapour pressure in Ch 3, Sec 1.1.2.1.
2) May carry all the listed oil cargoes except crude oil.

16.2 Cargoes Other than Oils

16.2.1 Cargoes and Conditons for Carriage

16.2.1.1 Cargoes other than oils may be carried by ships with class notation Tanker for Oil Products as detailed below:

a) OS (Other substances), as per IBC Code Chapter 18 may be carried. No MARPOL requirements apply.

b) Pollution category Z, as per IBC code Chapter 18 may be carried by ships which comply with relevant nrequirements for the **NLS** class notation (Ch 3, Sec 1.1.4.2). In addition, relevant safety criteria such as possible increased foam fire extinguishing requirement shall be complied with. Density of the product will need to be considered additionally.

CHAPTER 4 FISHING VESSELS

CONTENTS

SECTION 1 GENERAL REQUIREMENTS

Contents

1.1 Classification

1.1.1 Application

1.1.1.1 Requirements of this chapter is applicable to vessels intended for fishing and should be regarded as supplementary requirements to those given for the assignment of main class.

1.1.2 Class notations

1.1.2.1 Vessels complying with relevant additional requirements of this Chapter may be assigned one of the following class notations:

Fishing Vessel (Refer Sec 2.2)
Stern Trawlers (Refer Sec 2.3)

1.1.2.2 Vessels with arrangement in cargo holds for fish in bulk in compliance with the requirements given in Sec 4 may have the notation **S** added to the class notations mentioned in Sec 1.1.2.1.

1.1.2.3 Vessels which satisfy the additional requirements in Sec 7 may have the notation **(N)** added to the class notations in Sec 1.1.2.1.

1.1.2.4 Vessels with fish processing spaces/decks and refrigerated holds for frozen fish products may have the notation **RM** added if the refrigeration plant satisfies the requirements

1.1.3 International Regulations and Application

The following international regulations may be applicable:

- Voluntary Guidelines for the Design, Construction and Equipment of Small Fishing Vessels, FAO/ILO/ IMO 2005.
- Code for Safety of Fishermen and Fishing Vessels, IMO 2005.
- Code on Intact Stability for All Types of Ships Covered by IMO Instruments, Resolution A.749(18), as amended.
- European Communities, Commission Directive 1997/70/EC of 11 December 1997 as amended by Commission Directive 2002/35/EC of 25 April 2002 for fishing vessels with a length L larger than 24 m.
- Torremolinos International Convention for the Safety of Fishing Vessels, 1977 amended by Protocol of 1993 as applied by the relevant Flag State Administration for fishing vessels with a length L larger than 45 m (did not enter into force on an international basis)

1.2 Defintions

1.2.1 Symbols

1.2.1.1 The following symbols are relevant to this chapter:

L_{OA} = Length overall (m)
L = Rule length (m)(1)
B = Rule breadth (m)(1)
D = Rule depth (m)(1)
T = Rule draught (m)(1)
s = Stiffener spacing (m)(1)
In the fore and aft body the spacing is to be measured along the plating.
s_s = Standard frame spacing (m)
= 0.48 + 0.002L
Maimum 0.61 m forward of collision bulkhead and aft of the aft peak bulkhed.
l = Siffener span (m)

k_m = Material factor depending on material strength group [1]

[1] For details refer Pt 3.

1.2.1.2 The term freeboard deck used in this Chapter is generally defined as in the International Convention on Load Lines, 1966.

1.2.1.3 Freeboard may be taken equal to zero provided a closed superstructure of length not less than 0.45L is installed.

1.3 Documentation

1.3.1 General

1.3.1.1 Details related to additional classes regarding design, arrangement and strength are in general to be included in the plans specified for the main class.

1.3.1.2 Additional plans and particulars for the following are to be submitted for approval:

— Winch foundations with winch capacities and wire forces.
— Crane foundations, pedestal with capacities and wire forces.

The monitoring system for the bilge wells shall be approved by the Society. For documentation requirements refer Pt 5A

1.4 Signboards

1.4.1 References

Signboards are required by the rules as in Sec 5.1.1.2.

1.5 Hull Arrangement

1.5.1 Arrangement on Deck

1.5.1.1 Masts, rigging, superstructures, deckhouses and other items on deck on vessels intended for service in Arctic waters are to be so designed and arranged that excessive accumulation of ice is avoided. The rigging is to be kept at a minimum, and the surfaces of superstructures and other erections are to be as even as possible and free from projections and irregularities.

1.5.1.2 Air pipes from fuel oil tanks are to extend to a deck above freeboard deck or otherwise be protected to prevent seawater from entering the tanks.

Note:
The term "be protected" means an arrangement utilising common venting through an overflow tank, or a drain pot in the air pipe with automatic drainage to a suitable tank.

1.5.2 Forecastle

1.5.2.1 A forecastle is required for a fishing vessel, if the sheer in the forebody is less than 1.5 times standard sheer according to the International Convention on Load Lines, 1966.

1.5.2.2 Forecastle length is not to be less than 0.07 L (m), and the mean height is not to be less than 1.5 m.

1.5.2.3 The forecastle is to be closed. When the length of the forecastle is greater than

0.07 L, the surplus part may be open if fitted with freeing ports according to the International Convention on Load Lines, 1966.

1.5.2.4 Bow height is defined as the vertical distance at the forward perpendicular from the loaded waterline to the top of the exposed deck at side and given as below:

H_B = 56 L (1 – [L / 500]) (1.36 / [C_B + 0.68]) (mm)

Where,
C_B = Block coefficient at loaded waterline or 0.50 if C_B is not known.

1.5.3 Refrigerated Sea water Tanks

1.5.3.1 The refrigerated sea water (RSW) tanks for transportation of fish, if installed, are to be designed for relevant pressure heads in accordance with the rules.

1.5.3.2 Where an internal skin is fitted and welded continuously to every other frame/stiffener and slot-welded to the rest, and the gap between skin and hull structure is filled with insulation of an approved type an effective flange, b = 40 t (where t = skin thickness, minimum 5 mm) may be included, when calculating the section modulus of strength members. The skin plate is to be made continuous with good end connections and should not be terminated abruptly.

1.5.3.3 The steel surface is to be corrosion protected before it is insulated. The insulation material is to have good adhesion to steel and suitable strength characteristics (eg. polyurethane foam, density of 45 kg/m^3).

1.5.3.4 Corrugated bulkheads are to be supported along both bulkhead flanges in the bottom structure with sufficient connections to crossing members. Carlings are to be fitted in way of corners in corrugations and ends of unstiffened plate panels.

1.6 Stability

1.6.1 Application

1.6.1.1 Vessels with class notations **Fishing Vessel** or **Stern Trawler** with a length L_F of 24 m and above are to comply with the requirements of Pt 8 (as far as applicable), as well as the requirements of this subsection. The rules cover IMO 2008 Intact Stability Code as applicable for fishing vessels, and Chapter III of the Torremolinos International Conference for the Safety of Fishing Vessels, as modified by the Torremolinos Protocol of 1993, with the exception of Regulation 14.

1.6.2 Documentation

1.6.2.1 A simplified form of stability information may be accepted as an alternative or supplement to the stability booklet.

Note:
A diagram showing the necessary amount of cargo in hold to comply with the criteria as a function of the percentage of fuel remaining, may be used as simplified stability information.

1.6.2.2 Details of operational information is to be provided such as general precautions against capsizing and procedures related to severe weather conditions, including precautions to prevent unintentional flooding. This should also include information on safe use of cranes and fishing gear, if relevant.

1.6.2.3 Plan indicating the buoyant volumes with their openings and closing appliances is to be included. This sketch is to include instructions on operation of the closing appliances (example: “To be kept closed at sea”).

1.6.2.4 If any of the closing appliances referred to in Sec 1.6.2.3 have to be left open periodically during fishing, the opening(s) are to be considered as flooding points in the stability calculations. If the angle of flooding is less than 30°, Sec 1.6.7.2 of this subsection applies.

Note:
Internal opening of garbage chute which is operated in such a way that only one of the two required closing devices is open at a time need not be considered as a flooding point. (Refer Sec 5.1.1.5 for arrangement of garbage chutes)

1.6.3 Stability Criteria

1.6.3.1 Stability criteria as detailed below is applicable:

- The area under the righting lever curve (GZ curve) is not to be less than 0.055 metre-radians up to θ = 30° angle of heel and not less than 0.09 metre-radians up to θ = 40° or the angle of flooding θ_f if this angle is less than 40°. Additionally, the area under the righting lever curve (GZ curve) between the angles of heel of 30° and 40° or between 30° and θ_f, if this angle is less than 40°, should not be less than 0.03 metreradians.

- The righting lever GZ is to be at least 0.20 m at an angle of heel equal to or greater than 30°.

- The maximum righting arm should occur at an angle of heel not less than 25°.

Note:
In case the vessel's characteristics render compliance with the above criterion impracticable, the alternative criteria as given in Pt 8, Ch 1 , Sec 4.2 may be applied upon special consideration.

- In any operating condition, the initial metacentric height is not to be less than 0.35 meters.

1.6.3.2 In the light ship condition, the metacentric height is to be positive.

1.6.3.3 Fishing vessels of 45 m in length and over are to comply with the weather criterion of Pt 8, Ch 1, Sec 4.2.

1.6.3.4 Fishing vessels in the length range between 24 m and 45 m are to comply with the weather criterion of Pt 8, Ch 1, Sec 4.2, but the values of wind pressure are to be taken from Table 1.6.1.

Table 1.6.1 Wind Pressure

h (m)	1	2	3	4	5	6 and Over
P (N/m^2)	316	386	429	460	485	504

Note:
h is the height of centroid of the above waterline area (projected area) to the waterline of the vessel (m)
P is the wind pressure (N/m^2)

1.6.4 Loading Conditions

1.6.4.1 The vessel needs to comply with the stability criteria and shall be documented and submitted for the following standard loading conditions:

- Departure for the fishing grounds with full fuel, fresh water, stores, ice, fishing gear, etc.
- Departure from the fishing grounds with full catch, at maximum draught and

no more than 30% fuel, fresh water and stores

- Arrival at home port with full catch and 10% fuel, fresh water and stores remaining
- Arrival at home port with 20% of full catch and 10% fuel, fresh water and stores remaining
- At fishing grounds with maximum catch on deck, hold empty and 50% fuel, fresh water and stores remaining (if consistent with fishing method)

1.6.4.2 In addition to the above, special loading conditions associated with a change in the vessel's mode or area of operation which affect the stability, are to be considered.

1.6.4.3 If water ballast must be filled between departure and arrival in order to meet the stability criteria, a loading condition is to be included showing when the water ballast must be taken on board. The condition is to show the situation just before ballasting, with the maximum free surface moments of the ballast tank(s) included.

1.6.4.4 Due consideration is to be given for the weight of wet fishing net and tackle on deck, as applicable.

1.6.4.5 Ice accretion, if applicable, according to Sec 1.6.5.1 must be shown in the worst operating condition in the stability booklet, if consistent with area of operation.

1.6.4.6 Homogeneous distribution of catch in all holds, hatch coamings and trunks is to be assumed, unless this is inconsistent with practice. (Volumetric centre of gravity and identical specific gravity for all holds available for catch.)

1.6.4.7 Catch on deck is to be included in the loading conditions showing departure from fishing grounds and arrival at port, if this is consistent with practice.

1.6.4.8 If relevant free surface effect f catch is to be included in the calculation.

1.6.4.9 If relevant, free surface effect of water in fish bins is to be included in loading condition at fishing grounds

1.6.4.10 Free surface effect of RSW tanks is to be included, if this is consistent with practice.

1.6.4.11 Complter fishing gear and equipment is to be considered in all loading condition.

1.6.5 **Icing Considerations**

1.6.5.1 Ice accretion and the the calculation of weight and centre of gravity, is to be based on the following assumptions:

- The projected lateral area of discontinuous surfaces of rail, sundry booms, spars (except masts) and rigging of vessels having no sails and the projected lateral area of other small objects should be computed by increasing the total projected area of continuous surfaces by 5% and the static moments of this area by 10%.

- 30 kg per square metre on exposed weather decks and gangways
- 7.5 kg per square metre for projected lateral area of each side of the vessel above the water plane

1.6.6 **Roll Reduction Tanks**

1.6.6.1 In case roll reduction tanks are installed on board, the reduction in stability due to the effect of these tanks must be allowed for in the loading conditions.

1.6.6.2 If the roll reduction tanks can not be used in all conditions of loading, an instruction on the use of these tanks and corresponding limit conditions must be included in the stability booklet. These limit conditions must show the stability of the vessel just before emptying the roll reduction tanks.

1.6.7 Water on Deck and in Compartments Open to the Sea

1.6.7.1 Accumulation of water on deck is to be assumed if the requirements on freeing port area (Refer Sec 6.2) are not fully met, or if the design of the weather deck is such that water may be trapped. The stability calculations shall take the effect of this water into account according to the requirements of Sec 1.6.7.3 to Sec 1.6.7.5.

1.6.7.2 If hatches or similar openings have to be left periodically open during operation, the stability calculations shall take the effect of water in the open compartment(s) into account according to the requirements of Sec 1.6.7.3 to Sec 1.6.7.5, provided that the angle of downflooding for the critical opening is less than 30°.

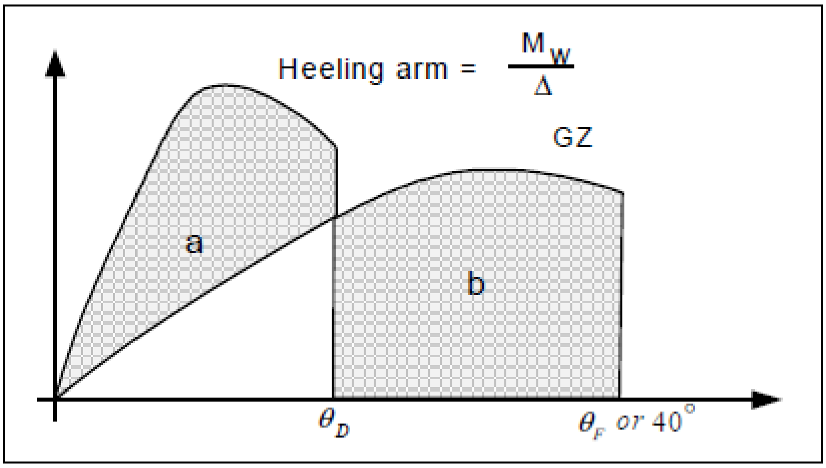


Fig 1 Water on Deck Criterion

1.6.7.3 The ability of the vessel to withstand the heeling effect due to the presence of water on deck, is to be demonstrated by a quasi-static method. With reference to Fig 1, the following criterion is to be satisfied with the vessel in the worst operating condition:

- Area “b” shall be equal to or greater than area “a”

Note:
The angle that limits area “b” shall be taken as the angle of downflooding θ_f or 40^0, whichever is less.

1.6.7.4 The value of the heeling moment M_w (or the corresponding heeling arm), due to the presence of water on deck shall be determined assuming that the deck well is filled to the top of the bulwark at its lowest point (or the flooding point of the open compartment). The vessel is to be heeled up to the angle at which this point is immersed (θ_D), where the heeling moment M_w (or the corresponding heeling arm), shall be terminated.

1.6.7.5 The following assumptions shall be made while calculating M_w:
- The effect of freeing ports shall be ignored.
- At the beginning the vessel is in the upright condition
- During heeling, trim and displacement are constant and equal to the values for the vessel without the water on deck

1.6.8 Onboard Cranes

1.6.8.1 While fishing the effect on the stability of cranes, is to be considered in the stability calculations in accordance with the requirements given in Sec 1.6.8.2 to Sec 1.6.8.4.

1.6.8.2 The maximum possible crane heeling moment is to be considered. The following shall be considered in the calculation of this moment:

- All relevant cranes working in tandem, if consistent with the actual practice during fishing.
- Weight and position of crane boom relative to the crane axis.
- Combination of safe working load on hooks and crane radius.

1.6.8.3 While the effect of the crane heeling moment is checked, the vertical centre of gravity of the loading condition shall be calculated with load on crane hooks. When the static heeling angle exceeds 5°, the heeling lever is to be drawn in the GZ diagram for the critical loading condition(s). Cranes are not to be used at sea, unless it can be demonstrated that the residual stability is sufficient.

1.6.8.4 Operational limitation information on use of cranes, if any, is to be included in the stability booklet.

This could include limitations on allowable load on hooks for certain conditions of loading. The maximum heeling moment calculated according to 802 shall be stated in the stability booklet.

1.6.9 Forces from Fishing Gear

1.6.9.1 When special arrangement of the fishing gear (eg. trawls or purse seines) result in significant forces on the vessel with impact on the stability, this is to be considered in the stability calculations.

1.7 Fire Safety

1.7.1 Application

1.7.1.1 Fishing vessels of less than 500 gross tonnage or less than 45 m length (L) are to comply with the requirements for cargo ships given in Pt.5B (..Fire safety "Fire safety measures for cargo ships of less than 500 GRT) and to Sec 1.7.6.3 and Sec 1.7.6.4.

1.7.1.2 Fishing vessels of 500 gross tonnage and above, or 45 m length (L) and above are to comply with the requirements specified in Sec 1.7.2 to Sec 1.7.8.

1.7.1.3 Fishing vessels complying with the fire safety requirements applicable for a "new vessel" in "Torremolinos International Convention for the Safety Of Fishing Vessels" 1977, as modified by the "Torremolinos Protocol" of 1993, or an equivalent standard such as the Council Directive 97/70/EC of 11 December 1997 as amended, (setting up a harmonised safety regime for fishing vessels of 24 meters in length and over), need not comply with the requirements referred to in Sec 1.7.1.1 and Sec 1.7.1.2 above.

1.7.2 Documentation

1.7.2.1 For fishing vessels documentation as detailed in Table G1 shall be submitted.

Table 1.7.1 Documentation Requirements (Fishing Vessels)			
Group	**Documentation Type**	**Additional Description**	**(A)/(I)**
Structural fire protection	Structural fire protection drawing		(A)
	Penetration drawings		(A)
Fire water system	Piping diagram		(A)
	Capacity		(A)
	System arrangement plan		(A)
Machinery spaced fixed fire fighting system	Fixed fire extinguishing system documentation		(A)
Fire detection and alarm system	Control and monitoring system documentation	If **E0** notation is requested	(A)
	System arrangement plan	If **E0** notation is requested	(A)
Safety, General	Fire control plan		(A)

1.7.3 **Fire Pumps and Water Distribution System**

1.7.3.1 The fire water distribution system including the fire pump/s shall comply with the requirements in SOLAS Ch. II-2 Reg. 10.2 as applicable for cargo ships.

1.7.4 **Fire Safety Arrangement in Machinery Spaces**

1.7.4.1 The fixed total flooding extinguishing system arrangement and fire-extinguishing appliances in machinery spaces shall comply with the requirements in SOLAS Ch. II-2 Reg. 10.5 as applicable for cargo ships. Local application system according to Reg. 10.5.6 will not be required.

1.7.4.2 In machinery spaces the estcape arrangements shall comply with the requirements of SOLAS Ch. II-2 Reg. 13.4.2. This will be reviewed in connection with approval of the structural fire protection plan.

1.7.4.3 Detection in periodically unattended machinery spaces will only be reviewed if notation **E0** is requested.

1.7.5 **Firefighter’s Outfits**

1.7.5.1 Fishing vessels shall be provided with at least two sets of firefighter's outfits complying with SOLAS Ch. II-2 Reg. 10.10.

1.7.6 **Fire Protection of Bulkheads and Decks**

1.7.6.1 The requirments of structural fire protection shall comply with SOLAS Ch. II-2 Reg. 9.2 as applicable for cargo ships. Method of protection as defined in Reg. 2.3.1 should be IC.

1.7.6.2 Materials shall comply with the requirements in SOLAS Ch. II-2 Reg. 5.3 and 6 as applicable for cargo vessels.

1.7.6.3 Insulation materials of combustible nature may be accepted in compartments for stowage of fish provided low ignitability and low flame spread properties are documented.

Testing is to be carried out in accordance with a recognized standard, e.g. DIN 4102.1 B2 or equivalent. The test method chosen is to be suitable for the type of foam in question.

1.7.6.4 Combustible insulation as accepted by Sec 1.7.6.3 is to be protected by close-fitting cladding. Acceptable cladding is steel sheet and marine plywood. Surface coatings are to have low flame spread properties.

1.7.7 Portable Fire Extinguisher

1.7.7.1 Portable fire extinguishers shall be provided in accordance with the requirements in SOLAS Ch. II-2 Reg. 10.3 as applicable for cargo ships.

1.7.8 Fire Control Plan

1.7.8.1 Fire control plans in compliance with the requirements in SOLAS Ch. II-2 Reg.15.2.4 shall be provided.

SECTION 2 DESIGN REQUIRMENTS

Contents

2.1 General

2.1.1 Draught for Scantlings

2.1.1.1 Fishing vessels for which the draught is not limited by any freeboard mark, the moulded depth D instead of draught T is to be used when calculating the scantlings of strength members.

2.1.2 Cargo Hold Bulkheads

2.1.2.1 Bulkheads of the cargo holds may be classified as below:
Type A: Bulkheads in cargo holds intended for dry cargo.
Type B: Bulkheads in cargo holds intended for fish in bulk.
Type C: Bulkheads in cargo holds intended for liquids (eg. RSW tanks, sludge etc.)

The strength of the different bulkhead types is to comply with the requirements given in:

For **Type A**: Pt 3, Ch 9 Bulkhead Structures
For **Type B**: Sec 4
For **Type C**: Pt 3, Ch 9 Bulkhead Structures

2.1.3 Pillars

2.1.3.1 Those pillars acting as supports for deck loadings are to be permanently connected at top or bottom. If the connections are arranged with bolts these bolts are to be secured by welding.

2.1.3.2 Pillars acting as supports for shifting boards only may have ordinary bolt connections.

2.1.4 Bulwarks

2.1.4.1 Bulwark plating thickness shall be minimum 6 mm and is not to be less than 80% of Rule thickness of side shell plating.

2.1.4.2 Stays are to be fitted in bulwarks at every second frame.

2.1.5 Internal Communications

2.1.5.1 In all fishing vessels and stern trawlers, a general emergency alarm system shall be provided.

2.1.5.2 If the 'tweendeck is fitted with side openings, two-way voice communication, fixed or portable, shall be provided between the bridge and in way of the doors in the vessel's side and stern. Alternatively, TV monitoring may be provided.

2.1.5.3 For electrical requirments refer to Pt.6

2.2 Fishing Vessel

2.2.1 Additional Requirments

2.2.1.1 Vessels built for fishing may be given the additional class notation **Fishing Vessel** provided the additional requirements in Sec 2.2.1.2 to Sec 2.2.1.5 are also complied with.

2.2.1.2 Bottom and side shell plating thickness upto a height 2 m above loaded waterline is not to be less than:

$t = [(4 + 0.06 L) / (1 / k_m)^{0.5}] + 2$ (mm)
t shall not be taken more than 10 mm.

However, for ship with L > 125 m t is also to comply with requirements given in Pt 3, Ch 7.

2.2.1.3 Side shell plating thickess above 2 m above loaded water line is not to be less than given in Pt 3, Ch 6.

2.2.1.4 For frame spacings exceeding the rule values given in Sec 1 the plate thicknesses in Sec 2.2.1.2 and Sec 2.2.1.3 are to be increased in direct proportion.

2.2.1.5 The thickness of bottom plating is also to comply with the requirements to buckling strength as given in Pt 3, Ch 14.

2.3 Stern Trawler

2.3.1 Additional Requirments

2.3.1.1 Vessels built for stern trawling may be given the additional class notation **Stern Trawler** provided the additional requirements in Sec 2.3.1.2 to Sec 2.3.1.9 are also complied with.

2.3.1.2 Bottom and side shell plating thickness upto a height 2 m above loaded waterline is not to be less than:
$t = [(4 + 0.04 L) / (1 / k_m)^{0.5}] + 2$ (mm)

t shall not be taken more than 10 mm.

However, for ships with L > 125m t is also to comply with requirements given in Pt 3, Ch 7

2.3.1.3 Side shell plating thickness above the limit given in Sec 2.3.1.2 is not to be less than given in Pt 3, Ch 6.

2.3.1.4 For frame spacings exceeding the rule values given in Sec 1 the plate thickness is to be increased in direct proportion.

2.3.1.5 Bottom plating thickness is also to comply with the requirements to buckling strength as given in Pt 3, Ch 14.

2.3.1.6 The thickness of trawl ramp and adjacent side plating, stern and side plating abaft the point where the trawling boards are normally taken on board, is not to be less than:
$t = (5 + 0.12 L) / (1 / k_m)^{0.5} + 2$ (mm)
t shall be minimum 12 mm^2.

2.3.1.7 The bulwark plating between gallows is to have the same thickness as the side shell plating, and bulwark stays are to be fitted at every frame.

2.3.1.8 Where side shell, bulwark, sheer strake and transom plating are particularly exposed to blows and chafing, steel rubbing pieces are to be fitted, consisting of minimum 75 ´ 37 mm half-round bars or equivalent.

2.3.1.9 Stiffneres in the trawl ramp shall have a minimum section modulus of,

$Z = 15 s l^2 k_m$ (cm^3)

SECTION 3 BILGE AND DRAINAGE

Contents

3.1 Arrangement

3.1.1 Cargo Hold for Fish in Bulk

3.1.1.1 An efficient drainage is to be provided for water, oil or brine from the cargo. Trunks and gutters are to be located such that they at all times will provide good drainage from all layers of the cargo, throughout the hold.

3.1.1.2 In each bin there is to be drainage to bilge well through vertical drainage trunks of perforated plates, grating, etc. as specified in Table 3.1.1.

The minimum acceptable perforated circumference per trunk is 0.3 m. The perforations are to consist of 4-8 mm holes or equivalent.

Table 3.1.1 Drainage Arrangement

Area of bin below main deck (m^2)	Minimum number of drainage trunks per bin	Total lengh of trunk perforated circumference per bin (m)
A < 10	2	0.80
10 ≤ A < 15	3	1.00
15 ≤ A < 20	3	1.20
20 ≤ A < 25	4	1.40
25 ≤ A < 30	4	1.60
30 ≤ A < 35	5	1.80

3.1.1.3 A bilge well is to be provided at the aft end at each cargo hold. If the length of the watertight compartment exceeds 9 m, there is to be a bilge well also at the forward end. Each bilge well is to have a volume not less than 0.15 m^3.

3.1.1.4 A separate branch suction line is to be led to the engine room, from each bilge well. The bilge distribution chest valves are to be of screw-down non-return type. All valves are to be fitted in readily accessible positions.

3.1.1.5 The valve chest collecting branch suction lines from cargo holds for fish in bulk are to have no connections from dry compartments. The valve chest is to be directly connected to the largest bilge pump. In addition, a connection is to be provided to another bilge pump.

3.1.1.6 The internal diameter of the branch suction lines is to be as required in Pt.5A (…Piping systems) for main bilge lines with a minimum diameter 50 mm.

3.1.1.7 An efficient back-flushing mechanism shall be provided for bilge suctions. The connecting of water supply for backflushing is to be by portable means (eg. Hose)

3.1.2 Tanks for Fish in Refrigerated Sea Water Tanks (RSW Tanks)

3.1.2.1 For filling and emptying of sea water, the RSW-tanks are to have an effective pumping system. The system is to have pipe dimensions complying with the requirements for ballast systems.

3.1.2.2 If the tanks are to be used also for carrying dry cargo, the tanks are to be arranged with bilge system. If the tanks are to be used for carrying fish in bulk, the requirements given in Sec 3.1.1.3 and Sec 3.1.1.4 are also to be complied with.

3.1.2.3 Where RSW-tanks are also arranged for carrying dry cargo, blank flanging or two closeable valves in series to avoid ingress of water from RSW system to the bilge system are required.

3.1.3 Tween Deck for Fish in Bulk

3.1.3.1 Fishing vessels intended for carrying fish loose on tween deck are to have a satisfactory arrangement for drainage of tween deck. The drainage may be led to bilge well in the hold below or arranged as given in Sec 3.1.1.4 to Sec 3.1.1.7.

3.1.3.2 Tween deck compartments having no openings where sea may penetrate and where no processing requiring supply of water is taking place, drainage to bilge will in the engine room may be accepted. The drainage pipes are normally not to exceed 50 mm in diameter and are to have a self-closing valve at the engine room side.

3.1.3.3 For combination vessels like longline, net fishing, etc. an efficient drainage system is to be provided for all weathertight divisions/compartments in addition to the drainage from tween deck.

3.1.4 Engine Room Bilge Water Monitoring

3.1.4.1 Alarm for high level in bilge wells in engine room is to be installed on the bridge.

SECTION 4 CARGO HOLDS FOR FISH IN BULK

Contents

4.1 General

4.1.1 Classification

4.1.1.1 The notation **S** may be added if the vessel complies with the requirements of this section and in accordance with Sec 1 and Sec 2 for fishing vessels intended for carrying fish in bulk.

4.1.2 Assumptions

4.1.2.1 The requirements in this sections are based on the following assumptions:

- Cargo holds fully loaded with fish treated with preserving agent, are checked regarding swelling.
- Cargo not carried in tanks, is drained before loading.
- During loading in vessels having one longitudinal bulkhead, the level of cargo at any time will be approximately the same on both sides of the bulkhead.

4.2 Bulkhead Arrangement and Strength

4.2.1 Bulkhead Location

4.2.1.1 Disposition of longitudinal bulkheads shall normally to be arranged as below:

One centre line longitudinal bulkhead if $B < 6.00$ m
Two longitudinal bulkheads if $B \geq 6.00$ m
Where,
B is the internal breadth of ship measured between shll or ceiling.

4.2.1.2 Where longitudinal bulkheads are provided these are to be positioned symmetrically about the ship's centre line.

4.2.1.3 Transverse bulkheads in cargo holds are normally not to be spaced more than 0.15 L apart. The spacing need not be taken less than 9 m and is not to exceed 12 m.

4.2.2 Design Load Conditions

4.2.2.1 Loading condition as defined in A 201 is to be considered if there is one longitudinal centre line bulkhead.

4.2.2.2 For vessels with two or more longitudinal bulkheads, these are to be designed for one-sided loading.

4.2.2.3 Transverse bulkheads are to be designed for one-sided loading.

4.2.3 Longitudinal Bulkheads with Vertical Wooden Boards

4.2.3.1 Hatch openings in which vertical wooden boards are used, a steel stiffener is to be fitted at each side of the bulkhead top, and if necessary also half way up the bulkhead.

The section modulus of the longitudinal stiffeners in accordance with Sec 4.2.3.2 is given on the assumption that stiffeners on each side of the bulkhead are connected to each other at 1/4 and 1/2 span. For area of connection, refer Sec 4.2.6.9. If the stiffeners are not connected to each other, the section modulus according to Sec 4.2.3.2 is doubled.

4.2.3.2 The minimum section modulus of each steel stiffener shall be:

$z = [(s + 3) / (6 / k_m)] k h^2 l^2$ (cm^3)

Where,
k = 1.20 for one longitudinal bulkhead
k = 1.60 for two or more longitudinal bulkheads
h = Heigh of bulkhead (m)
l = Distance between supports of steel stiffeners (m)
s = Greatest transverse distance between bulkheads or between bulkhead and ceiling at side (m)
The minimum section modulus is 40 cm^3.

4.2.3.3 When steel stiffeners are fitted at both the top and half height of bulkhad, the section modulus of the steel stiffeners is decided as follows:

Upper Stiffeners:
$Z = (h^2 l^{2)}) / (2.5 / k_m)$ (cm^3)

Middle Stiffeners:
$Z = ([s + 3] / [6 / k_m]) k h^2 l^2$ (cm^3)

Where,
k = 1.60 for one longitudinal bulkhead
k = 2.20 for two or more longitudinal bulkheads.

4.2.3.4 The wooden board thickness for single longitudinal bulkhead is to be at least:

Without steel stiffener at mid-height;
t = 31 h (mm)

With steel stiffener at mid-height and at bulkhead top;
t = 10h + 35 (mm)
= 63 mm, minimum
Where,
h = Bulkhead height (m)

4.2.3.5 The wooden board thickness for two or more longitudinal bulkhead is to be at least:

$t = 22 l (h)^{0.5}$ (mm)
= 76 mm, minimum

Where,
l = Greatest span between supports (m)
h = Bulkhead height (m)

4.2.3.6 In hatch openings a channel section or similar is to be fitted over the top of the bulkhead to prevent the boards from floating away from the bulkhead. If the channel section is supported by the hatchway beams, these are to be secured to the hatch coamings.

4.2.3.7 For vertical boards the depth of guides is to be at least 100 mm below the deck and at the bottom. The minimum thickness of the section or plate which forms the guide is to be 10 mm. The clearance in the longitudinal direction of the boards is to be as small as possible.

4.2.3.8 Guide bars are to have a continuous weld connection to the deck and bottom structure, refer Sec 4.2.6.4. In way of hatches the bottom guides are to be stiffened with tripping brackets maximum 2 frame spaces apart. Guide bars bedded in concrete are to be fastened to the ship's bottom structure. If this is not feasible, the guide bars are to be securely fastened in the concrete.

4.2.4 Longitudinal Bulkheads with Horizontal Wooden Boards

4.2.4.1 The distance between vertical uprights, or permanent transverse bulkheads and uprights is normally not to be greater than 2.0 m and is in no case to exceed 2.25 m.

4.2.4.2 The minimum section modulus of uprights, if there is one longitudinal bulkhead is:

$Z = [\, 0.5 (s + 3) h^3 b \,] k_m \quad (cm^3)$
$= 40\ cm^3$, minimum

Where,
h = Free span of upright (m)
b = Distance between uprights (m)
s = greatest transverse distance between bulkheads or between bulkhead and ceiling at side (m).

4.2.4.3 The minimum section modulus of uprights, if there are two or more longitudinal bulkheads is:

$Z = (5.0\, h^3 b) k_m \quad (cm^3)$
$= 40\ cm^3$, minimum

Where,
h = Free span of upright (m)
b = Distance between uprights (m)

4.2.4.4 The uprights are to be secured at top and bottom so that the reaction forces are distributed to adjacent structures.

4.2.4.5 Where openings are cut in the uprights for the entering of the upper boards, the boards in the opening are to be locked in position to prevent their slipping out of the guide.

4.2.4.6 Permanent pillars for hatch end beams or transverses which also serve as guides for shifting boards or removable bulkheads in steel ships are to have extra stiffening with brackets at the top. For scantlings of pillars, refer Sec 4.2.4.2 and Sec 4.2.4.3.

4.2.4.7 The thickness of the wooden board to be atleast:
$t = k\, l\, (h)^{0.5} \quad (mm)$
Where,
k = 20 for one longitudinal bulkhead
= 24 for two or more longitudinal bulkheads
h = Bulkhead height (m)
l = Distance between upright (m)

Minimum board thickness thall be 76 mm for bulkhead heights over 1.90m and 63 mm for lower heights.

4.2.4.8 Supporting guides for wooden boards in stiffeners or uprights are to be at least 75 mm deep and made of plates or sections of at least 10 mm thickness. If the sections do not comply with the requirements to groove depth or breadth for bulkhead boards, a flat bar (or similar) is to be welded to the flange of the section and the breadth may be adjusted by inserting a lining into the groove.

4.2.4.9 Bulkheads are to extend to the deck. Between beams, the spaces above bulkheads are to be packed with filling pieces such as steel plates which are to run down the side of the uppermost board and be fastened to this.

4.2.5 Transverse Bulkheads with Vertical Wooden Boards

4.2.5.1 Where horizontal steel stiffeners are fitted at half height of the bulkhead, the section modulus of the steel stiffener is to be at least:

Z = $(2.60\ h^2\ l^2)\ k_m (cm^3)$
= 50 cm^3, minimum

Where,
h = Bulkhead height (m)
l = Distance between supports (m)

4.2.5.2 As an exceptional case the horizontal stiffener may be fitted on the hold side. A 100 x 12 mm flat bar is then to be fitted on the other side of the bulkhead. The bar is bolted to the horizontal stiffener with bolts spaced not more than 200 mm. The sectional area of the bolts at bottom of threads is not to be less than:

A = $1.20\ h^2\ b$ (cm^2)
Where,
h = Bulkhead height (m)
b = Bolt spacing (m)

However, the bolt diameter shall be 16mm, minimum.

4.2.5.3 The horizontal stiffener is fastened to frames etc. with bolts of which at least 2 on each side are to be through bolts. The total sectional area of the bolts at bottom of threads at each end is not to be less than:

A = $h\ l / 1.67$ (cm^2)
where,
h = Bulkhead height (m)
l = Stiffner span (m)

However, the bolt diameter shall be 16mm, minimum.

4.2.5.4 The wooden board thickness is to be at least:

t = $25\ l\ (h^{0.50})$ (mm)

l = Maximum span between supports (m)
h = Bulkhead height (m)
Minmum board thickness shall be 76 mm for bulkhead height more than 1.80 m. The thickness shall be minimum 63 mm for bulkhead height less than 1.80 m.

4.2.5.5 For details refer Sec 4.2.4.4, Sec 4.2.4.5, Sec 4.2.4.6, Sec 4.2.4.8 and Sec 4.2.4.9.

4.2.6 Transverse Bulkheads with Horizontal Wooden Boards

4.2.6.1 Minimum section modulus of upright is to be:

Z = $(5.30\ h^3\ b)\ k_m$ (cm^3)
= 40 cm^3, minimum
Where,
h = Free span of upright (m)

b = Distnace between uprights (m)

4.2.6.2 The minimum board thickness is to be:

$t = 27\, l\, (h)^{0.50}$ (mm)

Where,
h = Bulkhead height (m)
l= Distance between uprights (m), maximum 2.0 m

Minimum board thickness is to be 76mm for bulkhead height over 1.80 m. Minimum board thickness is to be 63mm for bulkhead height below 1.80 m.

4.2.6.3 For details, refer Sec 4.2.4.4, Sec 4.2.4.5, Sec 4.2.4.6, Sec 4.2.4.8 and Sec 4.2.4.9.

4.2.6.4 Minimum area of attachment at lower end of removable uprights is to be:
$A = 0.90\, h^2\, b$ (cm^2)

Where,
h= Bulkhead height (m)
b= Distance between uprights (m)
However minimum bolt diameter shall be 16 mm.

4.2.6.5 Sectional area at bottom of threads per bolt for bolted bulkheads is to be determined according to the formula in Sec 4.2.6.4 when:
b = Bolt spacing (m)
Minimum bolt diameter shall be 16 mm.

4.2.6.6 The area of attachment at the top for single deck vessels can be 60% of the area stipulated in Sec 4.2.6.4 and Sec 4.2.6.5.

4.2.6.7 For the securing of bulkheads and uprights, all welds are to be of the double continuous type.

4.2.6.8 If a U-shaped collar is fitted around beams and keelson and secured with horizontal through bolts, the area of these bolts can be 60% of the area stipulated in Sec 4.2.6.4 and Sec 4.2.6.5.

4.2.6.9 The minimum total area of attachment between horizontal stiffeners mentioned in Sec 4.2.3.1.

$A = 1.05\, h^2\, l$ (cm^2)
Where,
h = Bulkhead height (m)
l = Distance between stiffener support (m)

4.2.7 Permanent Steel Bulkheads

4.2.7.1 The minimum section modulus of stiffeners on permanent longitudinal or transverse bulkheads is to be:

$Z = (s\, h\, k\, l^2)\, k_m$ (cm^3)
= 15 cm^3, minimum
Where,
k = 3.75 for one longitudinal bulkhead
= 4.50 for transverse bulkheads
= 4.50 for two or more longitudinal bulkheads
l = Stiffener span (m)
s = Stifeener spacing (m)

h = Height from midpoint of stiffener span to top of bulkhead or hatch coaming (m)

4.2.7.2 Minimum stiffener moment of inertia:

I = 2.20 k Z $(Z)^{(1/3)}$ (cm^4)
Where
Z = As provided in Sec 4.2.7.1
k_m = 1.00, considered

4.2.7.3 In case of permanent pillars which are welded to permanent bulkheads and also serve as guides for removable bulkheads in way of hatches are to have scantlings as given in Sec 4.2.7.1 and Sec 4.2.7.2, when s = breadth of load surface (m). Remaining symbols as under Sec 4.2.7.1.

4.2.7.4 Plate thickness in permanent steel bulkheads is to be as provided in Sec 4.2.8.2.

4.2.7.5 Corrugated bulkheads may be acceptable provided their strength is equivalent to that of plane bulkheads.

4.2.7.6 Stiffeners are to be fitted with brackets at both ends. The brackets are not to terminate on unstiffened plating or over a scallop. When the corrugations are deep, care is to be taken, particularly at the bottom, that the corners of the corrugations do not end on unstiffened plating.

4.2.7.7 The various structural parts are to be connected by welding in accordance with the requirements for watertight bulkheads.

4.2.8 Steel or Aluminium – Removable Bulkheads

4.2.8.1 Removable steel or aluminium bulkheads which are used in connection with hatches are to be double plated with the stiffeners placed horizontally. Internal surfaces of steel bulkheads are to be covered by a corrosion-resistant coating.

4.2.8.2 Minimum plate thickness of removable bulkhead shall be

Steel removable bulkheads:
t = $[3.40 s (h^{0.5})] / ([1 / k_m]^{0.5}) + 1.50$ (mm)
= 6.00 mm, minimum

Aluminium removable bulkheads:
t = $4.70 s (h^{0.5}) + 1.50$ (mm)
= 6.00 mm, minimum

Where,
s = Stiffener spacing (m)
h = Height (m) from upper edger of bulkhead to lower edge of plating.

4.2.8.3 Minimum section modulus of horizontal stiffeners shall be:
Steel removable bulkheads:
Z = $(7.00 s h l^2) k_m$ (cm^3)

Aluminium removable bulkheads:
Z = $13.50 s h l^2$ (cm^3)

Where,
l = Stiffener span (m)
s = Stifeener spacing (m)
h = Height from midpoint of stiffener span to top of bulkhead or hatch coaming (m)

4.2.8.4 For aluminium materials with a guaranteed 0.1% tensile proof stress ($\sigma_{0.1}$) which exceeds 12.5 kp/mm^2, the requirement to Z can be reduced in direct proportion. If however, the material's guaranteed $\sigma_{0.2}$ value is greater than 70% of the guaranteed ultimate tensile strength, the lower value is to be used as a basis for scantlings.

4.2.8.5 Minimum stiffener moment of inertia:

$I = k\, Z\, (Z)^{(1/3)}$ (cm^4)

Where

k = 2.20 for steel
= 5.75 for aluminium

Z = As provided in Sec 4.2.8.3 for steel with k_m = 1.00

4.2.8.6 While carrying out welding in aluminium, attention should be paid to the reduced strength of the material in the weld area, and the weld should, where practicable, be positioned in less stressed areas.

4.2.8.7 Brackets at 1 m spacing to be provided for guides for removable bulkheads. The depth of the support at the sides of removable bulkheads is to be at least equal to the bulkhead thickness, and not less than 65 mm. The minimum thickness of sections or plates which form the guides, is 10 mm.

4.2.8.8 Proper insulation is to be provided at connections or contact surfaces between steel and aluminium to avoid galvanic corrosion.

4.2.8.9 Removable bulkheads are to be equipped with a securing arrangement for preventing the bulkhead from floating, as necessary. Slot welding is carried out against a 50 ´ 8 mm steel flat bar or equivalent. Removable aluminium bulkheads are presumed constructed of a sea-water resistant alloy.

4.2.9 **Corrugated Aluminum Sections**

4.2.9.1 Corrugated aluminium shifting boards may be used instead of horizontal wooden boards. The maximum length between supports is not to be greater than that provided below:

$l = (k / h)\, (\, [\, I_A\, h\, h^{0.5}] / b)^{(1/3)}$ (m)

Where,

k = 0.60 for one longitudinal bulkhead
= 0.50 for two or more longitudinal bulkheads
= 0.40 for transverse bulkheads

h = Bulkhead height (m)

b = Board breadth (m)

I_A = Moment of inertia of board (cm^4)

4.2.9.2 Proper insulation is to be provided at connections or contact surfaces between steel and aluminium, in order to prevent galvanic corrosion.

4.2.9.3 Corrufated boards shall be made of seawater resistant aluminium.

4.2.9.4 Regarding the details the same rules as for bulkheads with horizontal wooden boards apply.

SECTION 5 PREVENTION OF ‘TWEEN DECK FLOODING

Contents

5.1 Tween Deck with Side Openings

5.1.1 Arrangement of Side Openings Leading to ‘tween deck (working deck)

5.1.1.1 Closing appliances and arrangement of openings in side which will normally be open when the vessel is at the fishing grounds, are to be in accordance with Sec 5.1.1.2 to Sec 5.1.1.5.

5.1.1.2 At the side and stern the doors in the vessel shall be limited in size and number to the minimum possible. The sill height is normally not to be less than 1000 mm. The doors with securing devices are to be designed with a strength equivalent to the structure in which they are fitted, and are to be so arranged that weathertight quick closing (approximately 15 second for side doors), can be easily executed by one member of the crew without the use of tools. This shall be possible also during black-out.

If a remote closing from the bridge arrangement is provided, a signal light is to be fitted at the port(s), warning automatically when closing is executed. To avoid injury when closing, TV monitoring of the door(s) or means of communication according to Sec 2.1.5.2 is to be arranged.

Clear signboard with the following text to be fitted:
“TO BE KEPT CLOSED WHEN NOT IN USED DURING FISHING”

5.1.1.3 Each opening for drainage by pumps from drainage wells is to be fitted with a type approved automatic non-return flap with manual means of closing operable from 1.5 m above the deck. The inboard opening shall be situated not lower than 0.02 Loa, or minimum 0.7 m above the maximum loaded waterline.

5.1.1.4 Drainage flaps leading directly overboard from drainage wells are to be limited to the minimum possible in size and number, and shall be flush with hull to avoid damage. Drainage flaps are to have vulcanised surfaces and be easy to flush clean. Drainage flaps are to be easily accessible for cleaning and survey.

Remote closing from the bridge shall be arranged, in addition to manual means of closing operable from 1.5 m above the deck. A panel on the bridge is to show which flaps are open/closed.

5.1.1.5 Inboard openings of garbage chutes for disposal of fish waste, are to be located minimum 0.7 m above the maximum loaded water line. The inboard end is to be fitted with a weathertight hinged cover and necessary number of securing devices. The outboard end is to be fitted with a watertight closeable non-return valve operable from 1.5 m above deck. The arrangement is to be easy to flush clean, and be easily accessible for survey.

5.1.1.6 Wall thickness of the steel plates between hull plating and closeable non-return valve is not to be less than 12.5 mm. However, if possible to get access for inspection and maintenance the thickness may be reduced to 10 mm.

5.1.2 Drainage of Tween Deck with Openings in Side

5.1.2.1 An effective drainage system with openings shall be arranged at the tween deck in accordance with 101 and 202 to 207.

5.1.2.2 Separate pumps shall be provided for drainage in drainage wells at side at the lowest position of the working deck. For vessels with a working deck of length greater than 9 m, drainage wells are to be fitted forward and aft. For working decks of length greater than B/2, drainage wells are to be fitted on both sides.

5.1.2.3 Drainage wells shall have a minimum volume as detailed below:

$V = (A_s\ l\ B)\ /\ 2$ (dm^3)

Where,

V = Volumne of drainage well (dm^3)
B = Breadth of vessel (m)
A_s = Area of side ports (m^2)
l = Length of working deck (m)

The volume shall in no case be less than 0.15 m^3, and the depth of each well is to be at least 0.35 metres.

5.1.2.4 Disposition of drainage wells shall ensure effective drainage and avoidance of clogging by fishing hooks and fish waste of pump suction.

5.1.2.5 Capacity of each bilge pump shall be the greatest of the following:

$Q = 3\ B\ A_s$ (m^3/ hr)
$Q = 1.25 \times Wd$ (m^3/ hr)

Where,

A_s = Area of side ports (m^2)
Wd = Available wash down capacity at each side (m^3/ hr)

5.1.2.6 Bilge pumps are to be designed to pump fish waste together with drainage water are to be fitted with manual start/stop. Outlet shall be in accordance with Sec 5.1.1.3.

5.1.2.7 A bridge alarm is to be provided and is to be activated when the drainage wells are full or when there is free water on the tween or working deck.

5.1.2.8 In addition to the arrangement described in Sec 5.1.2.2 to Sec 5.1.2.7, drainage flaps according to Sec 5.1.1.4 may be installed in the drainage wells if necessary. The freeboard shall not be less than to the lower edge of the drainage flap opening, or 0.35 m measured from the deck.

5.1.3 **Arrangement of Openings from Tween Deck to Other Spaces**

5.1.3.1 Closing appliances for openings from 'tween deck to spaces below deck, or to closed superstructure which is considered buoyant in the stability calculations, are to be in accordance with Sec 6.2.1.6 of this Chapter.

5.2 Enclosed Tween Deck

5.2.1 **Enclosed Tween Deck with Water Processing**

5.2.1.1 Arrangement of garbage chutes shall be in accordance with Sec 5.1.1.5.

5.2.1.2 Drainage from drainage wells is to be carried out by pumps. If the arrangement is based on separate pumps situated in each drainage well as in Sec 5.1.2.1 to Sec 5.1.2.7. the outlet shall be in accordance with Sec 5.1.1.3. The number and location of drainage wells shall be arranged so that satisfactory drainage is achieved. The capacity of drainage pumps shall be at least 1.25 times available wash-down capacity in m^3/h, for each side.

SECTION 6 FREEBOARD, OPENING AND CLOSING APPLIANCES

Contents

6.1 Freeboard

6.1.1 Freeboard

6.1.1.1 Draught marks shall be provided on each side of the vessel. The marks are to be fitted on the sides at midship corresponding to the approved draught with respect to strength and stability. The draught marks shall be in the form of horizontal lines (450 mm long, 25 mm in height) with the letters NV placed 25 mm above the lines (letter dimensions: height - 115 mm, breadth - 75 mm, thickness - 25 mm). The marks shall be permanent, and be painted in contrasting colour.

6.1.1.2 The freeboard measured from the loaded waterline to the surface of freeboard deck at side, shall in no circumstance be less than 0 mm.

6.1.1.3 If the freeboard deck surface outside of weathertight enclosed superstructure in any place is lower, measured to the design waterline, than at midship where the draught mark is placed, the minimum freeboard at midship shall be corrected accordingly, so that no part of exposed freeboard deck is lower than the loaded waterline.

6.1.1.4 Vessels with open connection to sea from fishing wells/tanks for live fish are to have the same freeboard for summer and winter. The freeboard is to be minimum 100 mm.

6.2 Openings and Closing Appliances

6.2.1 Sill Heights and Coaming, Closing Appliances, Freing Ports

6.2.1.1 Sill heights and coaming, closing appliances, freeing port areas, air pipes, ventilators, sanitary discharges etc. shall be in accordance with the requirements in Pt 4, Ch 6, except as otherwise specified in this subsection.

6.2.1.2 The height above deck of sills in those doorways, in companionways, erections and machinery casings which give direct access to parts of the deck exposed to the weather and sea shall be at least 600 mm on the freeboard deck and at least 300 mm on the superstructure deck subject to special consideration, where operating experience has shown justification, these heights, except in the doorways giving direct access to machinery spaces, may be reduced to not less than 380 mm and 150 mm, respectively.

6.2.1.3 Weathertight doors leading to spaces below freeboard deck and to enclosed superstructure included as buoyant in the stability calculations, are to be positioned as close to the vessel's centreline as possible. Weathertight doors are to have a standard equivalent to ISO 6042. Spraytight doors of a standard equivalent to ISO may be accepted as weathertight doors on vessels with service restriction **R2** and in general for doors in bulkheads which are facing aft and on doors on 'tween deck in enclosed superstructure.

6.2.1.4 The height hatchway coamings above deck shall be at least 600 mm on exposed parts of the freeboard deck and at least 300 mm on the superstructure deck.

6.2.1.5 Subject to special considerations and where operating experience has shown justification, the height of the hatchway coamings may be reduced, or the coamings omitted entirely, provided that the safety of the vessel is not thereby impaired. In this case, the hatchway openings shall be kept as small as practicable and the covers be permanently attached by hinges or equivalent means and be capable of being rapidly closed and battened down, or by equally effective arrangements.

6.2.1.6 Flush deck hatches used for catch of fish should normally be led to a tank or a watertight fish bin. The closing arrangement of the hatches are to be operated from deck.

6.2.1.7 Hatch covers are to be weather- or watertight, with gaskets and necessary securing devices. For hatch covers of more than 4 m^2, small hatch covers shall be installed as close to the vessel's centreline as possible for use during operation. Such hatch covers are to have securing devices also at the hinged side. Hinged hatch covers are to be securable in open position.

6.2.1.8 Coaming height and sill height for hatches and doors on working deck in enclosed superstructure and deckhouses where water are used in the working process are not to be less than 100 mm.

6.2.1.9 In vessels of 45 m in length and over, the height above deck of ventilator coamings, other than machinery space ventilator coamings, shall be at least 900 mm on the freeboard deck and at least 760 mm on the superstructure deck. In vessels of less than 45 m in length, the height of these coamings shall be 760 mm and 450 mm respectively.

6.2.1.10 In vessels of 45 m in length and over closing applicances need not be fitted to ventilators the coamings of which extend to more than 4.5 m above the freeboard deck or more than 2.3 m above the superstructure. In vessels of less than 45 m in length, closing appliances need not be fitted to ventilators the coamings of which extend to more than 3.4 m above the freeboard deck or more than 1.7 m above the superstructure deck.

6.2.1.11 Below the freeboard deck and in enclosed superstructure on freeboard deck, side scuttles with hinged deadlights are to be used.

6.2.1.12 Sidescuttles and windows may be accepted without deadlights in side and aft bulkheads of deckhouses located on or above the freeboard deck if satisfied that the safety of the vessel will not be impaired.

6.2.1.13 Windows and side scuttles prone to be damaged by fishing gear shall be suitably protected.

6.2.1.14 Side scuttles in ship sides, including outboard side of enclosed superstructure and deckhouses at ship sides, are not to be closer to the loaded waterline than 500 mm. Such side scuttles shall be equipped with hinged deadlights. Side scuttles closer to the loaded waterline than 1000 mm shall not be possible to open.

6.2.1.15 The freeing port area on each side of net bins and other short wells on deck with length less than 5 m, may be calculated using the following formula:

$A = 0.175\, l$

Where,

l = Length of well (m)

Wells of less than 3 m, the freeing port area may be specially considered. Covers of freeing ports are to be non-closeable nd hinged in upper edge.

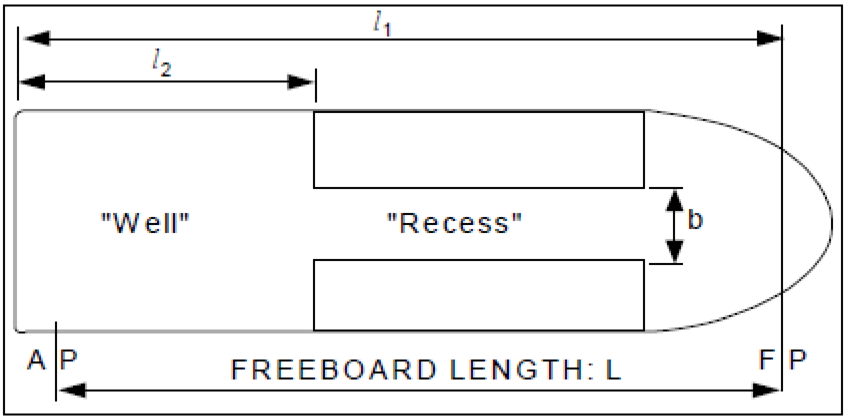


Fig 1 Parameters Used for Calculation of Freeing Ports

6.2.1.16 For non-watertight fish bins, a drainage system is required in order to prevent flooding of the working deck area.

6.2.1.17 Freeing ports in high bulwarks (more than 1 meter in height), or in sides of open superstructure, are not considered as sufficient for drainage of exposed freeboard deck (may be accepted for vessel with service notation **RE**). Open superstructure such as open forecastle, separate walls at side or other similar constructions are therefore not acceptable, unless the stability requirements of Sec 1.6 for water on deck are complied with, or if sufficient drainage is provided according to Sec 6.2.1.18.

6.2.1.18 For vessels where the sea may enter over the stern and flood the deck into a superstructure which is open in aft end, the freeing port area on each side is not to be less than required by the following formulas:

$A_{well} = (0.07\ l_2 + 0.04\ [h - 1.2]\ l_2)\ y_1\ y_2$ (m^2)

When the length of the bulward in the well is 20 m or less;

$A_{well} = ([0.7 + 0.035\ l_2] + 0.04\ [h - 1.2]\ l_2)\ y_1\ y_2$ (m^2)

$A_{Recess} = (0.07\ l_1\ [b / l_1]\ [1 - (l_2 / l_1)^2]\ y_1\ y_2$ (m^2)

Where,

h = Average height of bulwark aft of the open superstructure
y_1 = 0.50 for superstructure deck
= 1.00 for freeboard deck
y_2 = 1.50 for no shear
= 1.00 for suitable shear provided

Other parameters are defined in Fig 1.

6.2.1.19 Freeing ports over 300 mm in depth shall be fitted with bars spaced not more than 230 mm nor less than 150 mm apart or provided with other suitable protective arrangements. Freeing port covers, if fitted, shall be of approved construction. If devices are considered necessary for locking freeing port covers during fishing operations they shall be easily operable from a readily accessible position.

6.2.1.20 Poundboards and means for stowage of the fishing gear shall be arranged so that the effectiveness of freeing ports will not be impaired. Poundboards shall be so constructed that they can be locked in position when in use and shall not hamper the discharge of shipped water.

6.2.1.21 In vessels intended to operate in areas subject to icing, covers and protective arrangements for freeing ports shall be capable of being easily removed to restrict ice accretion. The size of openings and means provided for removal of these protective arrangements are to be considered.

SECTION 7 STABILITY AND BOW HEIGHT FOR VESSELS WITH CLASS NOTATION (N)

Contents

7.1 General

7.1.1 General

7.1.1.1 Vessels complying with the requirements for stability in paragraph 11 of the 1993 regulations of the Norwegian Maritime Directorate for FISKE- OG FANGSTFARTØY and the bow height requirements in Sec 7.2, may have the additional class notation (**N**).

7.2 Bow Height

7.2.1 Bow Height

7.2.1.1 The minimum bow height (m) measured vertically at the forward perpendicular from the loaded waterline to the exposed deck shall be:

$43\ L_{OA} + 310$; for vessels upto $L_{OA} = 24$ m
$48\ L_{OA} + 190$; for vessels with $L_{OA} = 24$ m and above

7.2.1.2 The loaded waterline is the summer load line parallel to the design waterline, for vessels of 50 gross tonnage and above.

7.2.1.3 The loaded waterline is a waterline parallel with the design waterline corresponding to a freeboard of 100 mm at midship, for vessels below 50 gross tonnage.

7.2.1.4 The required bow heights is considered as complied with, only when the height is measured from:

- Deck of weathertight enclosed forecastle with length of at least 0.1 L_{OA}, and with sheer in forecastle deck (with this minimum forecastle length) not greater than the sheer of the freeboard deck.

- The freeboard deck, having an approximately even sheer from midship to the forward perpendicular

With small or no sheer in freeboard deck, the length of weathertight enclosed forecastle may have to be increased.

SECTION 8 SPACES WITH REFRIGERATION INSTALLATIONS OF DIRECT EXPANSION TYPE

Contents

8.1 Refrigeration Plant

8.1.1 General

8.1.1.1 The refrigeration machinery room and the refrigeration system shall comply with the requirements in Rule Ch.7B Ch 7 .

8.2 Refrigerated Holds for Stowage of Frozen Fish / Fish Products

8.2.1 Access/ Exits

8.2.1.1 In holds where personnel may be engaged in stowing frozen fish products, the exit(s) shall be arranged so that escape is easy, preferably by inclined Stairs. The escapeway(s) shall be suited for carrying a disabled person out of the hold.

Frozen or cooled cargo chambers with direct expansion air coolers and with vertical access are if they are normally manned, such as on fishing vessels and on fish factory ships, to be fitted with permanent hoisting arrangements for removal of injured/unconscious crew members.

8.2.1.2 Doors for exits shall be open outwards.

8.2.1.3 Gas masks shall be placed close to the normal access to the hold, in case Ammonia (R717) is used as the refrigerant.

8.2.1.4 If the normal exit from the hold is through a space containing refrigeration equipment, eg. fish processing space, gas masks shall be available from inside the hold enabling personnel to escape. Alarm signals, optical and audible, shall be fitted inside the hold giving warning in case of refrigerant leakage in the adjacent space.

8.2.1.5 Access doors and -hatches shall either be operable from both sides or be fitted with catches to prevent inadvertent closing.

8.2.1.6 If air pipes for tanks or sea chests and water pipes are passing through freezing chambers or its insulation, they shall be arranged to prevent freezing.

8.2.1.7 Air, sounding and water pipes penetrating the tank top shall have substantial wall thickness in way of the insulation on the tank top.

8.2.1.8 All holds and air cooler rooms are each to be fitted with at least one conveniently located alarm call button.

8.2.2 Refrigeration Leakage Detection

8.2.2.1 A refrigerant leakage detection system shall be installed. For refrigerants in Group 1, except CO_2, an oxygen deficiency monitoring may be accepted in lieu of refrigerant gas detection.

8.2.2.2 In case the refrigerant is ammonia or CO_2, gas leakage detection shall be fitted. Alarm shall be triggered as follows:

Alarm at 150 PPM (Parts per million) for Ammonia (R717)
Alarm at 2000 PPM (Parts per million for CO2 (R744)

The gas detectors shall be suitable for use in the low temperature environment and shall be calibrated for same.

8.2.3 **Ventilation**

A fixed or portable type mechanical ventilation of the hold in case of a refrigerant leakage shall be made available.

8.3 Fish Processing Decks/ Spaces

8.3.1 **Access / Exit**

8.3.1.1 A minimum of two exits from the space shall be provided. In the case R717 is the refrigerant, the location of the exits shall be such that a possible refrigerant leakage will not block access to both exits.

8.3.1.2 Outwardly opening doors shall be provided for access/exits normally used.

8.3.2 **Ventilation**

8.3.2.1 Normal ventilation shall be separate for space and may be natural or mechanical.

8.3.2.2 Extraction type shall be provided if mechanical ventilation is installed.

8.3.2.3 Where R717 or R744 is beng used as the refrigerant, additional mechanical ventilation shall be available in case of leakage is detected. The ventilation capacity shall at least provide 30 airchanges per hour.

Starting of additional ventilation is to be automatically initiated in case of refrigerant leakage is detected. Ventilation outlets shall be located away from ventilation inlets to other spaces and away from areas where personnel is normally present.

8.3.2.4 The emergency stop arrangements for fans required by rules Pt.6 (Electrical Installation) shall be separate for the fans in Sec 8.3.2.3.

8.3.3 **Refrigerant Leakage Detection**

8.3.3.1 Gas detectors shall be installed for the detection refrigerant gas leakage. Detectors should be located at ventilation suction points and at suitable locations within the space. A minimum of 2 detectors per space is required. Alarm signals, optic and audible, shall be located within the space and in way of accesses to the space.

8.3.3.2 If the refrigerant is R717 gas detection should have 3 alarm levels:

Initial leakage detection at 150 PPM

Start ventilation and space evacuation at 350 PPM

De-energize non-Ex protected electrical equipment, stop refrigerant circulation pumps and close refrigerant supply and return valves required by Pt 7B Ch 7 at 5000 PPM.

Separate alarm indication in the navigation bridge shall be fitted.

8.3.3.3 If the refrigerant is CO2 (R744) alarm, automatic starting of ventilation and closing of refrigerant supply and return valves shall be executed at a concentration of: 2000 ppm.

8.3.3.4 For refrigerants in Group 1 except R744 oxygen deficiency alarm may be accepted as alternative to refrigerant gas detection.

8.3.4 Electrical Equipment

8.3.4.1 In case R717 is used as refrigerant all electrical equipment shall be Ex certified or arranged for automatic de-energizing in case leakage is detected as specified under Sec 8.3.3.1. Emergency lighting in the space and motors ventilation fans shall be Ex-certified and the fans of non-sparking design.

8.3.5 Personnel Protection

8.3.5.1 The following shall be provided if R717 is used as the refrigerant:

- Outside all access doors water screens and eye washes shall be provided. The water screens/eye washes shall be operable also under freezing conditions.

- Gas masks and hermetically sealed filters shall be available in a glass door case located outside each entrance to the space.

CHAPTER 5 OFFSHORE SERVICE VESSELS, TUGS AND SPECIAL SHIPS

CONTENTS

SECTION 1 INTRODUCTION

Contents

1.1 General

1.1.1 Introduction

The rules herein are applicable to offshore service, towing and pushing, and other specialised offshore and harbour services.

1.1.1.1 Scope

The scope of this chapter includes requirements regarding hull strength, system and equipment, stability and the relevant procedural requirements for the vessels as introduced. In addition, this chapter describes additional requirements on strength, stability and specific functions relevant for these vessels.

1.1.1.2 Objective

This chapter defines additional vessel design requirements supporting safe and reliable operation.

1.1.1.3 Application

The requirements shall be regarded as supplementary to those given for the assignment of main class.

Vessels complying with the different requirements of this chapter will be assigned class notations as described in Table 1.1.1.

Table 1.1.1 Notation and Section Reference

Notation	Section Reference
Offshore Service Vessel or Offshore Srevice Vessel +	Sec 2
Anchor Handling	Sec 3
Towing	Sec 3
Supply Vessel	Sec 4
AHTS	Sec 3 and Sec 4
SF	Sec 5
Standby Vessel or Standby Vessel (S)	Sec 6
Fire Fighter I or II or III	Sec 7
LFL and LFL*	Sec 8
Tug	Sec 9
Barge Barge for Deck Cargo Barge for Oil Barge for Liquified Gas Barge for Chemicals Barge Concrete	Sec 10

1.1.1.4 In addition to the above, notations Anchor Handling, Towing, Supply Vessel and AHTS shall comply with the requirments of Sec 2.

1.1.1.5 For vessels equally intended for more than one special duty may be assigned a combination of the class notations mentioned in Table 1.1.1.

1.2 Definitions

1.2.1 General

1.2.1.1 Symbols

L = Rule length (m)[1]
B = Rule breadth (m)[1]
D = Rule depth (m)[1]
T = Rule draught (m)[1]
C_B = Rule block coefficient[1]
V = Service speed (knots)[1]
s = Stiffener spacing (m)
s_s = Standard frame spacing (m)
= 0.48 + 0.002 L
= Maximum 0.61 m forward of collision bulkhead and aft of the after peak tank
l = Stiffner span (m)
k_m = Material factor depending on material strength group [2]

(1) For details refer Pt 3, Ch 1.
(2) For details refer Pt 3, Ch 1, Sec 2.

1.3 Documentation

1.3.1 General

1.3.1.1 Details related to additional class regarding design, arrangement and strength are in general to be included in the plans specified for the main class.

1.3.1.2 Additional documentation not covered by the main class is specified in appropriate sections of this chapter.

SECTION 2 OFFSHORE SERVICE VESSELS

Contents

2.1 General

2.1.1 Introduction

2.1.1.1 Requirments in this section apply to vessels designed specially for support services to offshore facilities and installations.

2.1.1.2 Scope

This section contains requirements to hull arrangement, systems and equipment, strength and stability applicable to offshore service vessels.

2.1.1.3 Objective

The objective includes the following:
- Provide design standard enabling safe and reliable offshore service operation
- Provide additional requirments enabling operation in harsh weather conditions

2.1.1.4 Application

Vessels built in compliance with the relevant requirements in A, B, C and D may be given the class notation **Offshore Service Vessel**.

If in addition the vessel complies with the additional requirements given in E, the notation may be extended to **Offshore Service Vessel +.**

Note:
*The extended notation **Offshore Service Vessel +** is recommended for vessels primarily to operate in harsh weather conditions like the North Sea*

Vessels built in compliance with the requirements in this section and requirements specified in Table 2.1.1 may be assigned the additional notations, as follows:

Table 2.1.1 Additional Class Notations

Additional Notation	Services	Requirments
Anchor Handling	Offshore service vessels intended for towing of floating objects in open waters and objects on sea bed in addition to subsurface deployment and lifting of anchoring equipment.	Sec 3
Towing	Offshore service vessels intended for towing of floating objects in open waters	Sec 3
Supply	Offshore service vessels intended for supply services to offshore units or installations.	Sec 4
AHTS	Multipurpose Offshore Service Vessels intended for towing of floating objects in open waters and objects on sea bed, subsurface deployment and lifting of anchoring equipment and supply services.	Sec 3 and Sec 4

2.1.1.5 Compliance with notations **Anchor Handling** and **Supply** qualifies for notation **AHTS**.

2.1.1.6 If the damage stability requirements in Sec 5 are satisfied in addition to the general requirements in Sec 2.4, then the additional notation **SF** may be given.

2.1.2 Documentation Requirments

2.1.2.1 Documentation requirements are detailed in Table 2.1.2 below:

Table 2.1.2 Documentation Requirments				
Component	**Document Type**	**Additional Description**	**(A)/(I)**	**Rule reference Section**
Independent cargo tanks and their supporting structures	Structural drawing	Including design loads and reaction force	(A)	E
Stowage racks and their supporting structures	Structural drawing		(A)	E
Windows	Arrangement plan	Including information on type of glass and deadlights	(A)	E
Note: (A) For Approval; (I) For Information				

2.2 Hull Arrangement and Strength

2.2.1 Ships Sides and Stern

2.2.1.1 Fenders along the longitudinal direction are normally to be fitted on the ship's sides at freeboard cargo deck and second deck above. The fenders shall extend not less than 0.02 L forward of the section where the deck has its full breadth.

Additional inclined fenders shall be arranged between the longitudinal fenders. The fenders may be omitted if the side shell scantlings are increased as specified in Sec 2.2.1.2.

2.2.1.2 Minimum thickness of side plating including bilge strake, upto second deck above freeboard deck shall be:

$$t = (s / s_s) ([4.50 + 0.05L] \ [k_m]^{0.5}) + 2.00$$
$$= 9.00 \text{ mm, minimum}$$

Where,
s / s_s = Not to be considered less than 1.00
L = Not be taken more than 90 m

Requirements as provided for side plating as in Pt 3 Ch 7 are also to be complied with as applicable.

In way of the fender area described insect 2.2.1.1, fenders can be omitted when the side plating is atleast twice that required above, for a breadth not less than 0.01 L, along the level of the freeboard deck and the second deck above.

2.2.1.3 The minimum section modulus of side longitudinals in any region is to be minimum 1.15 Z (cm3). Where Z is the general requirement as provided in Pt 3 Ch 7.

All frames up to second deck above freeboard deck, and forward of 0.2 L from F.P. up to forecastle deck, shall have end connections with brackets. Scallop welds shall not be used in connections between side frames and shell plating.

2.2.1.4 Flat part of nottom in way of stern shall be efficient stiffened.

2.2.2 Weather Deck for Cargo

2.2.2.1 The deck shall have scantlings based on a minimum cargo load of 1.5 t/m^2, in combination with 80% of the design sea pressure as specified for the main class. If the deck scantlings are based on cargo load exceeding 1.5 t/m^2, the notation **DK(+)** may be added. The design cargo load in t/m^2 will be given in the “Appendix to the classification certificate”. Cargo loads exceeding 4 t/m^2 need not be combined with sea pressure. For intermediate loads the percentage of the design sea pressure to be added shall be varied linearly.

For vessels less than 100 meters, the k factor given in Pt 3, Ch 7, Sec 2.1.1 shall be:

k factor = 1.50; Aft of 0.2L from AP and forward 0.2L from FP
k factor = 1.30; at other locations

2.2.2.2 Minimum deck plating thickness shall not be less than 8 mm.

2.2.2.3 In deck areas for heavy cargo units (eg. drilling rig anchors) the deck structure shall be adequately strengthened.

2.2.2.4 For the stowage of deck cargo, stow racks shall be provided on the deck. The stow racks shall be efficiently attached and supported.

The scantlings of the stow racks shall be based on a load not less than 6 A [kN], assumed to be evenly distributed on the stow rack on one side of the vessel.

Where A is the total deck area between stow racks (m^2).

The amximum allowable stress levels for the stow rack and supporting structure subjected bending, shear and combined effects shall be as below:

Bending stress, σ_b = 160 / k_m (N/mm^2)
Shear stress, τ = 90 / k_m (N/mm^2)
Von Mises stress, σ_{VM} = 200 / k_m (N/mm^2)

Where,
$\sigma_e = (\sigma_b^2 + 3\ \tau^2)^{0.50}$

2.2.2.5 Smaller hatches, air pipes, valves etc. shall be located outside stow racks, and shall be protected and adequately strengthened.

2.2.2.6 Scantlings of flush hatch covers in the cargo deck area shall be based on a load not less than the specific design cargo load.

2.2.3 Weathertight Doors

2.2.3.1 An arrangement for protecting the doors against deck cargo shall be provided wherever possible.

2.2.3.2 Scuttles or windows fitted in weathertight doors, shall comply with Pt 4, Ch 6, Sec 12.

2.2.4 Freeing Ports and Scuppers

2.2.4.1 Freeing ports areas in the side bulwarks on the cargo deck is at least to meet the requirements of Pt 4, Ch 6, Sec 13.

If an emergency exit is located in a recess, freeing ports should be located nearby.

Disposition of the freeing ports shall be carefully considered to ensure the most effective drainage of water trapped in pipe deck cargoes and in recesses at the after end of the forecastle. In such recesses appropriate scuppers with discharge pipes led overboard may be required.

2.3 Systems and Equipments

2.3.1 Steering Gear

2.3.1.1 The steering gear shall be capable of bringing the rudder from 35° on one side to 30° on the other side in 20 s, when the vessel is running ahead at maximum service speed.

2.3.2 Exhaust Outlets

2.3.2.1 Diesel engines exhaust outlets shall be provided with spark arrestors.

2.3.3 Anchoring Equipment

2.3.3.1 Vessels intended for anchoring close to offshore installations / fields , but without means for dynamic positioning, effective safety precautions have to be considered.

Note:
The safety precautions may consist of increasing the diameter and length of the chain cables above the minimum class requirements given in Pt.4, Ch 3. In such case, for operation in the North Sea or areas with similar environmental conditions, it is recommended to have the diameter of chain cables based on an equipment letter at least two steps higher than the corresponding vessel's equipment number and length of the chain cables 85% greater than the table value corresponding to the increased diameter.

2.4 Intact Stability

2.4.1 Stability Manual

2.4.1.1 This sub-section is applicable to vessels with a freeboard length, L_F of above 24.0 m.

2.4.1.2 The stability information presented in the required stability manual shall enable the master to assess with ease and certainty the stability of the vessel in different service conditions.

2.4.1.3 The following information shall be included in the stability manual:

- Capacities and center of gravity of all tanks and spaces intended for cargo and consumables.
- Free surface particulars of all tanks.
- Hydrostatic data and cross curves of stability
- Report on inclining test and determination of light ship data.
- Complete details on types, weights, centres of gravity and distribution of deck cargoes that can be carried within the limits as set out in Pt 8 Sec 4. Possible restrictions, such as plugging of pipes, shall be clearly stated.
- Towing instruction of the vessel, where applicable.
- Loading conditions including righting lever curvers and ccalculation of metacentric height GM including free surface corrections.
- Limiting VCG (vertical center of gravity above keel) curves or GM values for intact conditions and a curve showing the permissible area of operation.
- Still water bending moment and shear force limit curves.

2.4.2 Loading Conditions

2.4.2.1 The following loading conditions shall be considered and submitted to the Society:

- Vessel in fully loaded arrival condition with cargo as specified, but with 10% stores and fuel.
- Vessel in fully loaded departure condition with cargo distributed below deck and with deck cargo specified by position and weight, with full stores and fuel, corresponding to the worst service condition in which all stability criteria are met
- Vessel in ballast departure condition, without cargo but with full stores and fuel.
- Vessel in ballast arrival condition, without cargo but with 10% stores and fuel.
- Vessel in the worst anticipated operating condition
- If the vessel is equipped with towing gear, vessel in a typical condition ready for towing.

2.4.2.2 Loading Conditions - Assumptions:

The following assumptions shall be considered for calculating loading conditions:

- If in any loading condition water ballast is necessary, additional diagrams shall be calculated and shown in the stability manual
- If a vessel is fitted with cargo tanks, the fully loaded conditions as described in 201 shall be modified, assuming first the cargo tanks full and then the cargo tanks empty.
- In all cases when deck cargo is carried a realistic stowage weight shall be assumed and stated in the stability information, including the height of the cargo and its centre of gravity.
- Where pipes are carried on deck, a quantity of trapped water equal to a certain percentage of the net volume of the pipe deck cargo shall be assumed in and around the pipes. The net volume shall be taken as the internal volume of the pipes plus the volume between the pipes. This percentage shall be 30 if the freeboard amidships is equal to or less than 0.015 L and 10 if the freeboard amidships is equal to or greater than 0.03 L. For intermediate values of the freeboard amidships the percentage may be obtained by linear interpolation.
- Free surface for each type of consumable liquid shall be assumed for at least one transverse pair of tanks or a single centre line tank. The tank(s) to be considered are those where the effect of free surface is the greatest. The actual free surface effect may be applied.

2.4.2.3 For those vessels intended to operate in zones where icing is expected, this shall be included in the calculation of the stability. The vessel must in any service condition satisfy the stability criteria set out in Pt 8 including the additional weight imposed by the ice. Weight distribution shall be taken as at least 30 kg/m^2 for exposed weather decks, passageways and fronts of superstructures and deckhouses, and at least 15 kg/m^2 for projected lateral planes on both sides of the vessel above the waterline. The weight distribution of ice on un-composite structures such as railings, rigging, posts and equipment shall be included by increasing the total area for the projected lateral plane of the vessel's sides by 5%. The static moment of this area shall be increased by 10%.

2.4.3 Intact Stability

2.4.3.1 In addition to the stability criteria for main class the vessel shall comply with the requirements in Sec 9.5 in all towing conditions.

2.4.3.2 In the upright condition of the vessel the freeboard at the stern shall not be less than 0.005 L in any loading condition.

2.5 Enhanced Strength

2.5.1 Bulwark

2.5.1.1 Bulwark plating thickness shall not be less than 7 mm. Bulwark stays shall have a depth not less than 350 mm at deck. Stays shall be fitted on every second frame. Open rails shall have ample scantlings and efficient supports.

2.5.2 Weathertight Doors

2.5.2.1 Sill heights of weathertight door arrangements are in general to comply with Pt 4, Ch 6. Unprotected doors in exposed positions on a weather deck for cargo shall be made of steel.

2.5.2.2 Doors located in exposed positions at sides and front bulkheads, the requirements to sill heights apply one deck higher than given by Pt 4, Ch 6, Sec 2.

2.5.2.3 Doorways to the engine room and other compartments below the weather deck are, to be located at a deck above the weather deck, as far as practicable. Alternatively, two weathertight doors in series may be accepted.

2.5.2.4 For scuttles and windows installed in weathertight doors, shall comply with Sec 2.5.6.

2.5.3 Ship's Sides and Stern

2.5.3.1 If subjected to heavy loads while handling anchors for offshore floating units drilling rigs, the stern shall be adequately strengthened. The plate thickness adjacent to the stern roller and shark jaw shall not be less than:

$t = 10 + 0.20\,L$ (mm)

The deck adjacent to the stern shall be strengthened suitably. If a substantial sheathing is fitted on the deck, the requirement may be modified.

2.5.3.2 The thickness of the side plating up to forecastle deck shall not be less than as given in Sec 2.2.1.2.

2.5.3.3 Minimum section modulus of frames or side longitudinals upto second deck above the freeboard deck shall be:

$Z_1 = 1.50\,L\,s\,l\,k_m$ (cm^3)

$Z_1 = 2.50\,L\,s\,l\,k_m$ (cm^3); where fenders are not installed.

Minimum section modulus of main frames or tween deck frames in any region shall be as below:

$Z_{min} = 1.25\,Z$ (cm^3)

Where,
Z = General requirement as provided in Pt.3 Ch.1 Sec 7C and Pt.3 Ch.2 sec 6C
L = Rule length (m) but not greater than 90 m
l = Span of the member (m)
s = Spacing of the members (m)

The requirement for Z1 given above refers to frames, which have an inclination to the vertical (along the ship's depth) less than 15°. For greater inclinations the requirement given for Zmin shall be applied.

All frames up to second deck above freeboard deck, and frames forward of 0.2 L from F.P. up to forecastle deck, shall have end connections with brackets. Scallop welds shall not be used in connections between side frames and shell plating up to second deck above the freeboard deck.

2.5.3.4 In the ship sides up to second deck above freeboard deck, the section modulus of web frames and stringers shall not be less than:

Z_1 = 1.50 L S k_m (cm^3)

Z_1 = 2.50 L S k_m (cm^3); if fenders are not installed

However, the following shall be provided as a minimum:
Z_{min} = 1.25 Z (cm^3)
Z = General requirement in Pt 3, Ch 7, Sec 4.
S = Member span (m)
The web frames are assumed to have an effective end connection at both the ends.

2.5.4 Support of Heavy Components

2.5.4.1 Primary members of pillars and girders supporting deck cargo and equipment, foundations for separate cargo tanks, as well as supports of other heavy components, shall have scantlings based on the supported mass. The design loads shall not be less than as provided in the Table 2.5.1 below:

Table 2.5.1 Design Loads – Support of Heavy Components

Load Description	**Design Load**		
	L < 100 m		**L > 100 m**
	Aft of 0.2L from AP and forward of 0.2L from FP	**Between 0.2L and 0.8L**	
General	p = 20 q (kN/m^2)	p = 16 q (kN/m^2)	p = (g_0 + a_v) q (kN/m^2)
Vertical force alone	P_V =20 M (kN)	P_V =16 M (kN)	P_V = (g_0 + a_v) M (kN)
Transverse force alone	P_T = 7.50 M (kN)	P_T = 7.50 M (kN)	P_T = a_t M (kN)
Vertical + Transverse force	P_{VC} = 10.00 M (kN)	P_{VC} = 10.00 M (kN)	P_{VC} = g_0 M (kN)
Longitudinal force alone	P_L = 6.00 M (kN)	P_L = 6.00 M (kN)	P_L = al M (kN)
Vertical + Longitudinal force	P_{VC} = 20.00 M (kN)	P_{VC} = 20.00 M (kN)	P_{VC} = (g_0 + a_v)M (kN)

Where,
q = Deck cargo load (t/m^2)
M = Mass of equipment, heavy component etc (t)
a_v = Combined vertical accelerations as provided in Pt 3, Ch 5, Sec 2.6
a_t = Combined transverse accelerations as provided in Pt 3, Ch 5, Sec 2.7
a_l = Combined longitudinal acceleration as provided in Pt 3, Ch 5, Sec 2.8

Allowable stresses for the above girder shall be as below:

Bending Stress, σ_b = 160 / k_m (N/mm^2)
Shear Stress, τ = 90 / k_m (N/mm^2)

Von Mises Stress, σ_e = 200 / k_m (N/mm^2)
Where,
$\sigma_e = (\sigma_b^2 + 3 \tau^2)^{0.50}$

2.5.5 Deckhouses and End Bulkheads of Superstructures

2.5.5.1 Minimum section modulus of stiffeners and beam shall be:

$Z = 0.70\ s\ p\ l^2\ k_m$ (cm^3)
Where,
p = Design pressure (kN/m^2)
= a p_2, for exposed decks nd bulkheads
= 10.00 kN/m^2; for weather decks (minimum)
= 5.00 kN/m^2; for top of the wheelhouse (minimum)
= 8.00 kN/m^2; for accommodation decks, aft of 0.2L from AP and forward of 0.2L from FP.
= 6.50 kN/m^2; elsewhere
a = 2.00 for front bulkheads
= 1.20 for sides, aft end bulkheads and weather deck
p_2 = Design pressure as fiven in Pt 3, Ch 8, Sec 2.

2.5.5.2 Beams and stiffeners shall have end connections. Stiffeners on lower front bulkhead on weather deck forward shall have brackets at lower end.

2.5.5.3 Minimum plate thickness in deck houses and end bulkheads of superstructures shall ot be less than:

$t = c\ (t_0 + 0.02\ L)\ k_m^{0.50}$ (mm)
Where,
t_0 = 4.50 mm for deckhouse deck (in way of accommodation)
= 5.00 mm for sides and aft end bulkheads and weather decks elsewhere
= 6.00 mm for front bulkheads and weather deck forward of the lowest tier of the front bulkheads
c = 1.54 s
= 1.00 minimum

2.5.6 Windows and Side Scuttles

2.5.6.1 Side scuttles will normally not be accepted in the ship sides below 3rd tier forward of 0.1 L from forward perpendicular. Typical arrangements complying with the requirements given below are shown in Fig 2 and Fig 3.

Note:
Side scuttles below 3rd tier forward of 0.1 L from forward perpendicular may be accepted upon special consideration with respect to strength and position.

2.5.6.2 In front bulkheads of deckhouses and superstructures, windows will normally be accepted in third tier and higher, above the freeboard deck. In the first tier of the front bulkhead above the weather deck (forecastle deck) side scuttles only will be accepted. In the after end bulkhead of deckhouses and superstructures, in sides of deckhouses and of superstructures that are not part of the shell plating, windows will be accepted in second tier and higher, above the freeboard deck.

2.5.6.3 Deadlights hinged type shall be fitted to:

- Windows and side scuttles in all bulkheads of the first tier on the weather deck.
- Windows and side scuttles in the after end of bulkheads of superstructures and deckhouses, casings and companionways in the first and second tier above the freeboard deck

- All windows and side scuttles in front bulkheads of superstructures and deckhouses.
- Windows and side scuttles in the sides of deckhouses and superstructures up to and including the third tier above the freeboard deck.
- Side scuttles in the vessels hull (shell plating)

2.5.6.4 Deadlights fitted in the side of third tier may be portable if they are stored near by

- For tier four and above, unless it is the first tier above the forward weather deck, the deadlights may be portable if they are stored near by.
- In the second tier above the freeboard deck and higher, deadlights on windows may be arranged externally, provided there is easy and safe access for closing.
- Other deadlights shall be internally hinged.

2.5.6.5 Deadlights shall be provided for each type of window fitted on the front of a wheelhouse that is located on the forward part of the vessel, unless the wheelhouse is located on fifth tier (or above) and is at least two decks above the forward weather deck. For externally fitted deadlights an arrangement for easy and safe access shall be provided (eg. gangway with railing). The deadlights of portable type shall be stowed adjacent to the window for quick mounting. For the wheelhouse front windows, at least two deadlights shall have means for providing a clear view.

2.5.6.6 The strength of side scuttles with internally hinged deadlights and toughened glass panes shall comply with International Standard ISO 1751 as follows:

Type A (Heavy):
In the hull, in the sides of superstructures and in the front of superstructures and deckhouses (weather deck tier).

Type B (Medium):
In the after end of superstructures and in the sides and ends of deckhouses (except front in weather deck tier).

2.5.6.7 Toughened safety glass planes for windows shall have minimum thickness as provided below:

$t = (b / S)(p\,\beta)^{0.50}$ (mm)

Where,

p = Local sea pressure (kN/m^2) as provided in Sec 2.5.5.1
b = Smaller dimension of the glass pane (mm)
S = Safety factor from the Table 2.5.2.
β = Factor obtained from the Fig 1

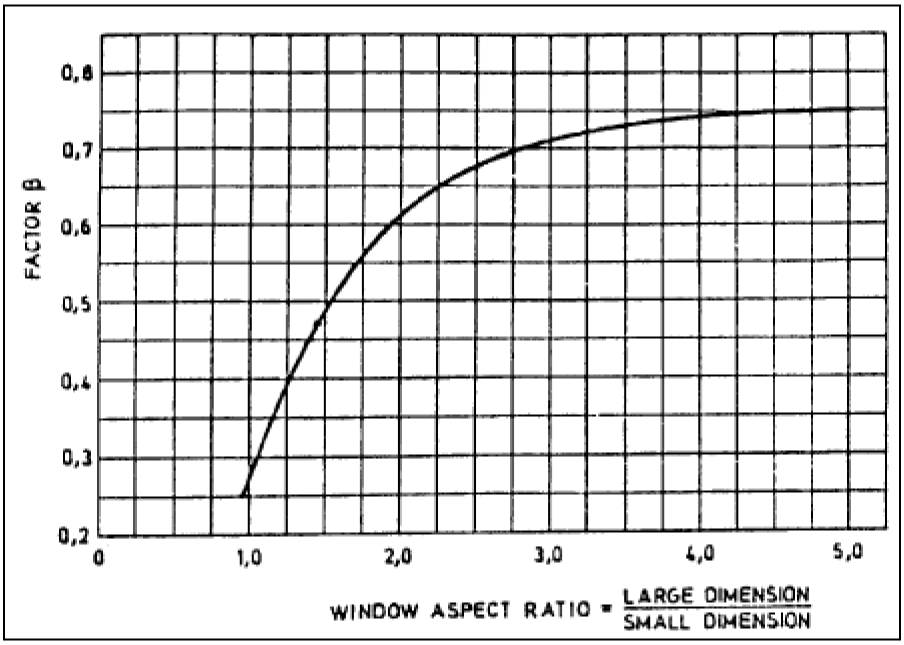


Fig 1 Curve for Factor β Based on Window Size Ratio

Minimum thickness of the window should not be taken less than 10mm.

When laminated glass panes are used, equivalent thickness according to formula given in Pt 4, Ch 6, Sec 12.2.3 is to be applied.

Table 2.5.2 Safety Factor (S)			
Window and tier	**2nd**	**3rd**	**4th and above**
Aft	100	150	200
Front or side	100	100	150

2.5.6.8 In case the design of windows is not in accordance with recognised international standards, such cases shall be especially approved by the Society. Drawings showing details of the frame design, its fixation and material specification shall be submitted for approval.

2.5.6.9 For large windows with the lower edge positioned at or less than 900 mm above the deck, provision of handrails at a level approximately 1 m above the deck s shall be considered when applicable.

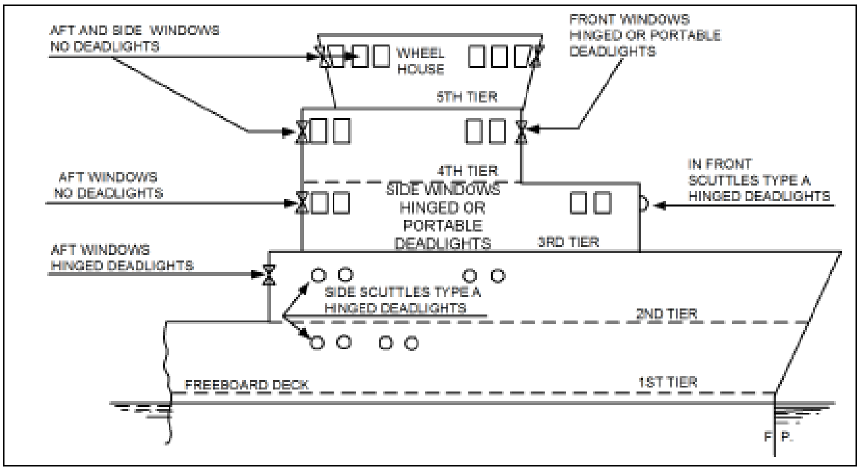


Fig 2: Side Scuttles and Windows in Supply Vessel with Complete Superstructure and Uppermost Forecastle

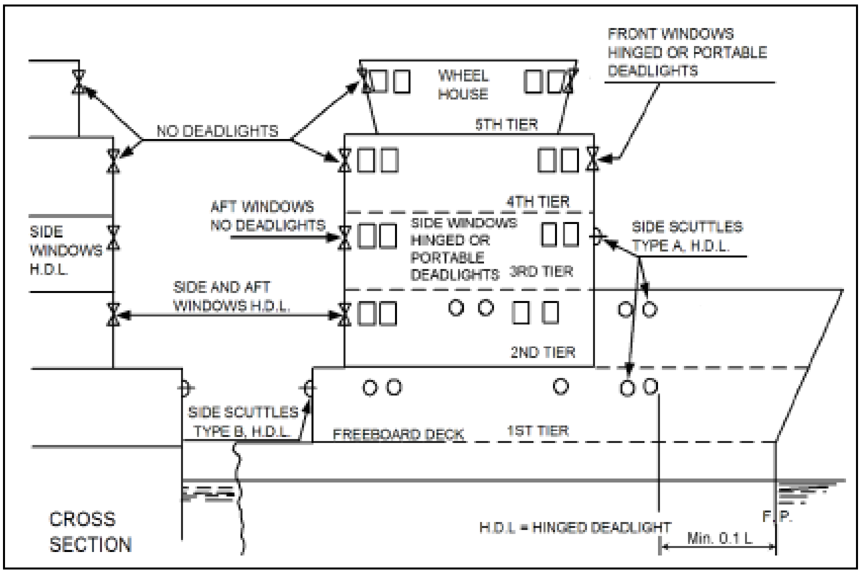


Fig 3: Side Scuttles and Windows in Supply Vessel with Forecastle Only

SECTION 3 OFFSHORE SERVICE VESSEL FOR ANCHOR HANDLING AND TOWING

Contents

3.1 General

3.1.1 Introduction

3.1.1.1 Requirements in this section apply to vessels intended for towing and anchor handling operations offshore.

3.1.1.2 Anchor handling operations implies towing of floating objects in open waters and objects on sea bed in addition to subsurface deployment and lifting of anchoring equipment.

3.1.1.3 Towing operations implies towing of floating objects in open waters.

3.1.1.4 Scope:

The following are covered in this section:

- Stability and watertight integrity
- Hull arrangement and supporting structures
- Design and testing requirements to towing and anchor handling equipment

The basic requrements as applicable for anchor handling/ towing vessels are provided in Sec 2.

3.1.1.5 Objective:

This section provides in detail a design standard for safe and reliable towing and anchor handling operation. The rules enable partially the user to specify the capacities of the equipment. Safety is maintained by enhanced focus on the actual performance and limitations.

3.1.1.6 Application:

Vessels with class notation **Offshore Service Vessel** intended for anchor handling operations built in compliance with the requirements in this section may be given the class notation **Anchor Handling**.

Vessels with class notation **Offshore Service Vessel** intended for towing operations built in compliance with relevant requirements in this section may be given the class notation **Towing**.

3.1.2 Defintions

3.1.2.1 Anchor handling winch:
The winch used for towing and anchor handling as described in Sec 3.1.1.2. The towing and anchor handling functions may be covered/fulfilled by dedicated drums on the winch(es).

3.1.2.2 Towing Winch:
Winch used for towing as detiled in Sec 3.1.1.3.

3.1.2.3 Towline
Towling is the rope used for towing. When used in the context of anchor handling it means work rope or any wire rope, rope or chain.

3.1.2.4 Shark jaw
An equipment used for securing the inboard end of towline.

3.1.2.5 Towing pins
They are pins for leaing and restraining the towline through the intended path.

3.1.2.6 Stern Roller
Rollers, fairleads or other equipment at the towline exit on the vessel (irrespective of location onboard), supporting the towline during lifting to avoid chafing and excessive bending, and arranged to facilitate the launch and recovery of rig anchors etc.

3.1.2.7 Bollard Pull
The maximum continuous pull obtained at static pull test on sea trial. The bollard test procedure is to be in line with Sec 9.1.5.

3.1.2.8 Reference Load (RL)
Reference load is defined as the value obtained from Table 3.1.1.

Table 3.1.1 Reference Loads	
Reference Load	**Bollard Pull (t)**
3.0 BP	BP < 40
(3.80 – [BP/50]) BP	40 ≤ BP ≤ 90
2.0 BP	BP > 90

3.1.3 Documentation Requirements

3.1.3.1 The following documents/ plans shall be submitted:

Table 3.1.2 Documentation Requirements				
Description		**Additional Description**	**(A/(I)**	**Ref. Rule Sec 3**
Anchor handling / towing arrangment	Arrangement plan	Including: -Towline paths showing extreme sectors and wrap on towing equipment -Towline points of attack -Maximum expected BP -Maximum design load for each component -Emergency release capabilities	(I)	C
Bollar Pull	Test procedure for quay and sea trial		(A)	A
Winch and other equipment	Test procedure for quay and sea trial		(A)	A
Anchor handling/ Towing winch	Design Criteria	Including: -RL and the expected maximum BP -Hoisting capacity, rendering and braking force of the winch -Release capabilities (response time and intended remaining holding force after release)	(I)	C
	Assembly or arrangement drawing		(I)	C
	Detailed drawing		(A)	C
	Design Analysis	Strength calculation of the drum with flanges, shafts with coupling, frameowkr and brakes.	(I)	C

	NDT Plan		(A)	A
Shark Jaw	Design Criteria	Including: -Maximum design load -Emergency release capabilities in operational and dead ship condition.	(I)	C
	Assembly or Arrangement drawings		(I)	C
	Detailed drawing		(A)	C
	Design Analysis		(I)	C
	NDT Plan		(A)	A
Towing Pins	Design Criteria		(I)	C
	Assembly or Arrangement drawings		(I)	C
	Detailed drawing		(A)	C
	Design Analysis		(I)	C
	NDT Plan		(A)	A
Foundation and support for stern rollwer, shark jaw, towing pins	Structural Drawing	Maximum applicable design loads to be included	(A)	B
Foundation support for anchor handling/ towing winch	Structural Drawing	The maximum force acting on the anchor handling winch shall be stated The maximum force acting on the towing winch shall be stated	(A)	B
Note: (A) For Approval; (I) For Information				

3.1.4 **Certification Requirments**

3.1.4.1 The following items need from INTLREG:
- Towing/ Anchor handling winch
- Tow hook
- Towing pins
- Shark jaw

3.1.4.2 The following items need from INTLREG:

- Winch drums and flanges
- Shafts for drums
- Shark jaw and towing pins with attachment
- Brake components

3.1.4.3 The following items need Works Material :
- Couplings
- Winch framework
- Gear shift and wheels

3.1.5 **Testing Requirements**

3.1.5.1 Major equipment (like winch etc) made mandatory in this Section shall be function tested according to approved procedure in order to verify the following:

- Proper function of the emergency operation modes, including emergency release and dead ship operations.
- Proper function of normal operation modes
- The ability for the arrangement and equipment to operate within the specified limitations, towline paths, towline sectors etc specified by the arrangement drawing

3.1.5.2 The winch shall be load tested during hoisting, braking, and pay out. Design loads to be applied. However, a maximum load equal to BP may be accepted if the winch is not of novel design or complex structure.

Bollard pull (BP) testing shall comply with the requirements as detailed in Sec 9.1.5.

3.2 Hull Strength

3.2.1 Deck Structure

3.2.1.1 Foundations and supports of towing pins shall have scantlings based on 2 times the specified maximum static working load.

3.2.1.2 Foundations and supports of winches for towing operation shall have scantlings based on 2.20 times the maximum bollard pull (BP) of the vessel.

3.2.1.3 Foundations and supports of winches intended for anchor handling functions shall have scantlings based on 1.5 times the specified maximum hoisting capacity or the macimum brake holding capacity of the winch whichever is greater.

3.2.1.4 Foundations and supports of stern roller shall have scantlings based on 2 times the specified maximum static working load as specified by the designer or 2 times the specified maximum hoisting capacity of the anchor handling winch whever is greater.

3.2.1.5 Foundations and support of shark jaw shall be based on 2 times the maximum static working loads as specified by the designer.

3.2.1.6 Allowable stress levels for the scantlings of the supporting structure are as detailed below:

Bending Stress, σ_b	$= 210 / k_m$	(N/mm^2)
Shear Stress, τ	$= 120 / k_m$	(N/mm^2)
Von Mises Stress, σ_e	$= 235 / k_m$	(N/mm^2)

Where,
$\sigma_e = (\sigma_b^2 + 3 \tau^2)^{0.50}$

3.2.2 Ship's Sides and Stern

3.2.2.1 When subjected to heavy loads when handling anchors, the stern shall be adequately strengthened. The plate thickness shall not be less than twice the basic requirement stated in Sec 2.2.1.2. The deck adjacent to the stern shall be strengthened accordingly. If a substantial sheathing is fitted on the deck, the requirement may be modified.

3.3 Anchor Handling and Towing Arrangement

3.3.1 General

3.3.1.1 Anchor handling and towing equipment shall meet the requirements in this Section. Alternatively, equipment complying with a recognized standard may be accepted upon special considerations provided such standard gives a reasonable equivalence to the requirements of this section and fulfils the intention.

3.3.1.2 Anchor handling and towing arrangement drawing with the content listed under Documentation Requirement in this Section shall be posted on the bridge.

3.3.1.3 Structural elements like cargo rails, bulwarks, etc. that may support the towline during normal operation, are to have a radius of bend sufficient to avoid damage to the towline.

3.3.1.4 The arrangement shall be such that the heeling moment arising when the towline is running in the athwart ships direction, will be as small as possible.

3.3.1.5 For the notation **Anchor Handling** the following items shall be installed onboard the vessel:

- Anchor Handling Winch
- Stern Roller
- Towing Pins
- Shark jaw

3.3.1.6 For the notation **Towing** either a towing winch or a tow hook shall be installed onboard.

3.3.1.7 The arrangement shall be such that the towline is led to the winch drum in a controlled manner under all foreseeable conditions (directions of the towline) and provide proper spooling on drum.

3.3.2 Materials for Equipment

3.3.2.1 Shark jaw and towing pins with attachment shall be made of rolled, forged or cast steel in accordance with Pt 2, Ch 2, Sec 4, Sec 5, Sec 6 or Sec 7.

3.3.2.2 For anchor handling and towing winch materials shall comply with relevant specifications given in Pt 2.

3.3.2.3 For forged and cast steel with minimum specified tensile strength above 650 N/mm2, specifications of chemical composition and mechanical properties shall be submitted for approval for the equipment in question.

3.3.2.4 Plate material in welded parts shall be of the grades as given in Pt 2 Ch 2 as relevant.

3.3.2.5 When minimum specified yield is above 0.8 times the minimum specified tensile strength, 0.8 times minimum tensile strength shall be used as minimum specified yield in calculations for structural strength as given in Sec 3.3.3.

3.3.3 Anchor Handling and Towing Winch

3.3.3.1 Control System

The control stands shall provide a safe and logical interface to the operator with operating levers returning to stop position when released and in addition provide a clear view to the drums. The anchor handling winch shall be capable of controlled operation during lowering and hoisting of anchors etc. both submerged and over the Stern Roller.

3.3.3.2 Monitoring System

A tow rope tension measuring device shall be fitted with thw winch.

3.3.3.3 Emergency Release

In all operation modes, the winch shall be designed to allow drum release in case of an emergency.

The release capabilities shall be as specified on arrangement drawing as required in Sec 3.3.1.2. The action to release the drum shall be possible locally at the winch and from a position at the bridge with full view and control of the operation. Identical means of equipment for the release operation to be used on all release stations.

In case of an an emergency release the winch brake shall be in normal function without delay. It shall always be possible to carry out the emergency release sequence (emergency release and/or application of brake), even during a black-out.

Control handles, buttons etc. for emergency release shall be protected against unintentional operation.

3.3.3.4 Structural strength of winch for anchor handling function

Winch for anchor handling function shall be capable of withstanding the maximum forces from hoisting, rendering and braking, including dynamic effects, without exceeding the following stress levels:

- Rendering load / load in towline when drum starts to roated in the opposite direction of the applied driving torque: 0.85 x Minimum specified yield
- Braking at relevant layer a specified in Sec 3.3.3.10: 0.67 x Minimum specified yield

- Hoisting including dynamic effect at relevant layer: 0.67 x minimum specified yield

Buckling and fatigue to be considered based on recognized standard or code of practice.

3.3.3.5 Structural strength for winch for towing function

The design and scantlings shall be capable of withstanding the RL without permanent deformations at relevant layer. Buckling and fatigue to be considered according to recognized standard or code of practice.

3.3.3.6 Winch intended for both functions shall meet requirements both in Sec 3.3.3.4 and Sec 3.3.3.5.

3.3.3.7 Drums

Minimum diameter of the rope drum for the steel wire rope shall be 14 times the maximum intended diameter of the rope. However, for all rope types, the rope bending specified by the rope manufacturer should not be exceeded. The drum design shall be carried out with due considerationto the relevant operations.

3.3.3.8 Towline attachment

A minimum of 3 dead turns of rope are assumed on the drum under normal operation to provide proper attachment. The end attachment of the towline to the winch barrel shall be of limited strength making a weak link in case the towline has to be run out.

3.3.3.9 Brake on drum intended for towing:

The brake is normally to act directly on drum and should be capable of holding the RL at inner layer. It shall be arranged for manual operation or other means for activation during failure of the power supply.

3.3.3.10 Brake on drum intended for anchor handling:

The brake is normally to act directly on drum. The bracke shall be capable of holding at least 1.25 times the maximum torque created from towline pull including dynamic effect. In addition, the brake shall be capable of stopping the rotation of the drum from its maximum speed.

The holding load / capacity of the winch shall not be affected by failure in the power supply and the brake shall be actuated at power failure if the load is not controlled by the winch motors or similar. Means shall however be provided for overriding such systems at any time.

3.3.3.11 Brake on drums intended for both functions shall meet requirements both in Sec 3.3.3.9 and Sec 3.3.3.10.

3.3.4 **Other Equipment**

3.3.4.1 The shark jaw shall be capable of sustaining the load defined on the arrangement drawing given in Sec 3.3.1.2 without exceeding a stress level of: 0.67 x minimum specified yield (Including dynamic effects)

3.3.4.2 The Towing Pins shall withstand forces and towline sectors defined on the arrangement drawing given in Sec 3.3.1.2 without exceeding a stress level of: 0.67 x minimum specified yield (Including dynamic effects).

3.3.4.3 If emergency release on shark jaw and towing pins is arranged, shall the capabilities be as specified on the arrangement drawing given in Sec 3.3.1.2.

3.3.4.4 If tow hook is installed, applicable requirements as in Sec 12 shall be complied with.

3.3.5 **Marking**

3.3.5.1 Equipment shall be marked to enable them to be readily related to their specifications and manufacturer. When an INTLREG product certificate is required, the equipment shall be clearly marked by the society for identification.

3.4 Stability and Watertight Integrity

3.4.1 **General Requirements**

3.4.1.1 For towing operations, stability to comply with applicable requirements in Sec 9.5.

SECTION 4 PLATFORM SUPPLY VESSELS

Contents

4.1 General

4.1.1 Introduction

4.1.1.1 Requirements in this section apply to vessels intend specifically for platform supply services.

4.1.1.2 Scope:

The section contains additional requirements to cargo handling arrangement and certification. Basis requirements for platform supply vessels are given in Sec 2.

4.1.1.3 Objectives

Objective of thi section to provide a vessel design standard ensuring a safe and reliable platform supply to offshore installations.

4.1.1.4 Application

Vessels with class notation **Offshore Service Vessel** built in compliance with the relevant requirements in this section may be given the class notation **Supply**.

4.1.2 Documentation Requirements

Plans and particulasr as detailed in the table below shall be submitted:

4.1.1 Documentation Requirments				
Description	**Document type**	**Additional Description**	**(A)/(I)**	**Rule Ref Sec 4**
Cement and dry mud	Piping diagram		AP	Sec 4.2
Liquid mud systems	Piping diagram		AP	Sec 4.2
Note: (A) For Approval; (I) For Information				

4.1.3 Certification Requirements

4.1.3.1 Cargo pumps for flammable liquids such as liquid mud, fuel oil and base oil shall be certified by the Society.

Note:
Other pumps in the cargo systems, including hydraulic power systems, need not to be delivered with the Society's certificate.

4.1.3.2 Valves for the cargo system shall be certified type. Manufactures certificate may be accepted at the discretion of the Society.

4.2 Cargo Handling Arrangement

4.2.1 General

4.2.1.1 Arrangements and the systems shall in general comply with the relevant requirements for main class given in Pt.5A (Piping system)

The redundancy requirement for cargo pumps as specified in Sec 4.3.1.2 are not applicable.

4.2.1.2 remote shut down devices capable of being activated from a dedicated cargo control location which is manned at the time of cargo transfer, shall be provided for the cargo pumps. Remote shut down shall also to be capable of being activated from at least one other location outside the cargo area and at a safe distance from it.

4.2.1.3 Segregation between cargo piping systems where cross-contamination causes safety hazards or marine pollution hazards shall be by means of spectacle flanges, spool pieces or equivalent. Valve segregation is not considered equivalent.

4.2.1.4 Those vessels intended for transportation of liquids with flashpoint below 60°C shall comply with Sec 8. Vessels that occasionally handle, store and transport recovered oil from a spill shall comply with Sec 10.

4.2.2 **Cement and Dry Mud Systems**

4.2.2.1 As far as practicable, the dry mud tanks and cement and piping systems are to be separated from the engine room. Where cement and dry mud tanks are situated in way of engine room, at least the upper parts of the tanks with hatches, pipe connections and other fittings, shall be segregated from the engine room by steel deck and bulkhead.

4.2.2.2 Where dry cargo and cement piping is led through the engine room, the wall thicknesses of the pipes shall not be less than given in Table 4.2.1. Pipe connections located in the engine room shall be welded as far as practicable. Necessary detachable connections shall be of such design that blow-out is prevented. The arrangement will be specially considered in each particular case.

4.2.2.3 Access doors between the engine room and spaces in which cement and dry mud systems are located, shall be provided with signboard stating that the doors shall be kept closed while the system is under pressure.

4.2.2.4 Dry mud and cement tanks shall be certified in accordance with the requirements for pressure vessels given in Pt.5A.

Table 4.2.1 Pipes for Dry Mud and Cement (Minimum Nominal Wall Thickness for Steel Pipes in Engine Room)

External diameter (mm)	Wall thickness (mm)
38.00 to 82.50	6.30
88.90 to 108.00	7.10
114.3 to 139.70	8.00
152.40 to 273.00	8.80

4.2.3 **Liquid Mud Systems**

4.2.3.1 Liquid mud carried onboard supply vessels shall have a flash point not lower than 60°C.

4.2.3.2 Means for relief of overflow shall be provided, example through a non-return valve fitted in a branch connection to the air pipe. The sectional area of the overflow pipe shall be at least twice that of the filling pipe.

SECTION 5 DAMAGE STABILITY FOR OFFSHORE SERVICE VESSELS

Contents

5.1 General

5.1.1 Classification

5.1.1.1 Vessels with a length L_F of 24 m and above complying with the requirements for intact stability given in Sec 2.4 and damage stability given in this section may be given the additional class notation **SF**, provided the Society upon consideration in each case finds these requirements to be appropriate for the vessel.

5.1.1.2 Examination and approval of stability documents carried out by National Authorities having equivalent intact and damage stability requirements (ie. Guidelines for the Design and Construction of Offshore Supply Vessels, 2006, IMO Res.MSC.235(82)) may be accepted as a basis for assigning the additional class notation **SF**.

5.1.1.3 In such cases the stability manual approved by the National Authorities shall be submitted as documentation of compliance with the rule requirements.

5.1.1.4 Cargo vessels which do not comply with the definition of “Offshore supply vessel” as set out in paragraph 1.2.1 of the IMO guidelines may not use compliance with additional class notation **SF** for exclusion of compliance with application of SOLAS Ch. II-1 as amended, Part B-1.

5.1.2 Documentation

5.1.2.1 The following particulars as detailed in Table 5.1.1 shall be submitted:

Table 5.1.1 Documentation Requirements

Description	Doc. Type	Additional Description	(A)/(I)	Rule Ref Sec 5
Damage stability	Preliminary damage stability calculation		(A)	Sec 5.2
Damage Stability	Final damage stability calculation	Not required in case of approved limit curves, or if approved lightweight data are not less favourable than estimated lightweight data	(A)	Sec 5.2
Internal Watertight Integrity	Internal watertight integrity plan		(A)	Sec 5.2
Note: (A) For Approval; (I) For Information				

5.1.2.2 Detailed description of stability documentation is given in Pt 8

5.2 Damage Stability

5.2.1 Damage Stability Manual

5.2.1.1 Damage stability manual shall contain the following information:

- Limiting VCG curves (centre of gravity above keel) or GM values for both intact and damage conditions and the resultant curve showing the permissible area of operation.

5.2.2 Damage Stability

5.2.2.1 The vessel shall comply with the damage stability requirements of IMO Res. MSC.235(82) (Guidelines for the Design and Construction of Offshore Supply Vessels, 2006)

SECTION 6 STANDBY VESSELS

Contents

6.1 General

6.1.1 Classification

6.1.1.1 Requirements herein apply to vessels especially designed to carry out rescue and standby services to offshore installations.

6.1.1.2 Vessels built in compliance with the requirements in A, B, C, D and E may be given the class notation **Standby Vessel**.

Note:
The flag administration may have requirements for the same items found in these rules. The most stringent one is to be followed.

6.1.1.3 If in addition the vessel complies with requirements on strengthening of the superstructure and deckhouses given in F, the notation may be extended to **Standby Vessel (S).**

Note:
*The notation **Standby Vessel (S)** is recommended for vessels primarily to operate in harsh weather conditions, eg. the North Sea.*

6.1.2 Documentation

6.1.2.1 The following documents/ plans shall be submitted for approval. Refer Table 6.1.1.

Table 6.1.1. Documentation Requirements

Document	Doc Type	Additional Description	(A)/(I)	Rule Ref.
Rescue areas	Arrangement Plan		(A)	Sec 6.3
Rescue and safety equipment	Safety Plan	Including rescue equipment	(A)	Sec 6.3, Sec 6.4
Towing arrangement	Arrangement Plan		(I)	Sec 6.1
Towing hook and towing winch supporting structure	Structural drawing	Maximum braking force of winch and breaking strength of the towline shall be stated (if applicable)	(A)	Sec 6.2
Towing hook and its release systems	Detailed drawing		(A)	Sec 6.2
Windows	Arrangement Plan	With information on type of glass, frames, including references to standards, and deadlights where applicable (for notation **Standby Vessel (S)** only)	(A)	Sec 6.6
Spaces for survivors	Arrangement Plan		(A)	Sec 6.3
Spaces for survivors	Calculation report	Capacity	(A)	Sec 6.3
Note: (A) For Approval; (I) For Information				

6.1.3 **Towing Arrangement**

6.1.3.1 Vessels fitted with means for emergency towing, the towing winch and or towing hook shall satisfy the requirements given in Sec 9.4.2.2, Sec 9.4.4.2 and Sec 9.4.5.2.

6.1.3.2 Vessels which are not built according to the Rules for **Tug**, **Towing**, **Anchor Handling** or **AHTS** notation, the towing wire and all connected parts shall have a minimum breaking load of 0.04 Ps (t), where Ps is the total power of the propulsion engines (kW).

6.1.3.3 All loose gear of the towing equipment, like shackles, rings, wire and ropes shall be delivered with a manufacturers test certificate.

6.1.4 **Safety Precaution**

6.1.4.1 Spark arrestors shall be provided at the exhaust outlet from diesel engines.

6.1.5 **Propulsion**

6.1.5.1 The vessel shall be fitted with 2 propulsion systems or similar capable of moving the vessel in the forward/aft direction.

6.2 Hull Arrangement and Strength

6.2.1 **General**

6.2.1.1 Minimum section modulus of the main and tween deck frames shall be:

$Z_1 = 1.25\,Z \quad (cm^3)$
Where,
Z = General requirements as provided in Pt 3, Ch 7.

All frames up to second deck above freeboard deck, and forward of 0.2 L from F.P. up to forecastle deck, shall have end connections with brackets.

6.2.1.2 Longitudinal fenders are normally to be fitted on the ship´s sides at freeboard cargo deck and second deck above. The fenders shall extend not less than 0.02 L forward of the section where the deck has its full breadth.

The breadth of the sheer strake at freeboard cargo deck shall not be less than:
$b = 5\,L + 800 \quad (mm)$

The minimum thickness at sheer strake in way of fenders shall be:
$t = (0.05\,L + 6.00)\,(s/s_s) \quad (mm)$

The ratio s/s_s shall not be taken as less than 1.0. If fenders are omitted, as for instance within the rescue zone, the above minimum thickness shall be increased by 50%, for a breadth not less than 0.01 L, along the level of the freeboard cargo deck and the second deck above.

If the vessel is not assigned with class notation **Offshore Service Vessel**, the side plating above the bilge, in way of the rescue zone, shall not be less than:

$t = (0.04\,L + 6.00)\,(s/s_s) \quad (mm)$
= 8.00 mm (minimum)

6.2.1.3 The minimum plating thickness of the exposed weather deck at the rescue zone, within at least 1.0 m from the ship side, shall be:

$t = (0.02 L + 6) + t_k$ (mm)

6.2.1.4 The minimum bulwark plating thickness shall be 7 mm. On the main weather deck the bulwark stays shall have a depth not less than 350 mm at deck and positioned at every second frame. Open rails shall have ample scantlings and efficient supports.

6.2.1.5 Scantlings of foundations and supports of towing winch and towing hook shall withstand a load 0.04 Ps (t), where Ps is the total power of the propulsion engines (kW).

Allowable stresses in the supporting structure resulting from bending moments and shearing forces calculated for the load given above are:

Bending Stress, $\sigma_b = 210 / k_m$ (N/mm^2)
Shear Stress, $\tau = 120 / k_m$ (N/mm^2)
Von Mises Stress, $\sigma_e = 235 / k_m$ (N/mm^2)

Where,
$\sigma_e = (\sigma_b^2 + 3 \tau^2)^{0.50}$

6.2.2 Freeing Ports and Scuppers

6.2.2.1 The area of the freeing ports in the side bulwarks on the cargo deck are at least to meet the requirements of Pt 4, Ch 6, Sec 13. The arrangement of the freeing ports shall be carefully considered to ensure the most effective drainage of water trapped on the weather deck.

6.3 Rescue Arrangement, Survivors' Accommodation and Safety Equipment

6.3.1 Rescue zone arrangement, equipment and facilities

6.3.1.1 Vessel shall be provided at each side with a rescue zone with minimum 8 m length. The area shall be clearly marked on the ship's side. Its location shall be sufficiently far away from the propellers and clear ofnany ship side discharges up to 2 m below the loaded waterline.

6.3.1.2 Access routes from the rescue zones to survivors' accommodation and to helicopter winch zone if provided shall have slip-resistant deck coating or wooden lining with surface treatment giving equivalent properties.

6.3.1.3 Ships side in way of the rescue zone shall be free of any obstruction, like for example, fenders.

6.3.1.4 Proper lighting shall be ensured along the rescue zone capable of providing minimum illumination level of 150 lux at the rescue zone and 50 lux at 20 m from the vessel.

6.3.1.5 In way of the rescue zone the deck area should preferably be free from air pipes, valves, smaller hatches etc. However, when this becomes impractical, proper arrangement shall be provided as protection against personnel injury.

6.3.1.6 Bulwarks or railings in way of the rescue zone shall be of a type easy to open or remove, to enable direct boarding on the deck.

6.3.1.7 A searchlight shall be available on each side and operated from the navigation bridge. The searchlights should be able to provide an illumination level of 50 lux in clear air, within an area not less than 10 m diameter, to a distance of 250 m.

6.3.1.8 Rescue zones at both sides shall be provided with a scrambling net made of corrosion resistant and non-slip material.

6.3.1.9 The vessel shall be provided with power assisted means capable of ensuring careful recovery of disabled persons from the sea.

6.3.1.10 A decontamination area equipped with a shower system shall be arranged for cleaning survivors and crew before entering the superstructure.

6.3.2 **Survivors Spaces**

6.3.2.1 A treatment room for casualities shall be arranged onboard, in addition a recovery room with berths, and enclosed space to accommodate survivors. These spaces shall be provided with lighting and means to control temperature and humidity suitable for the area of operation. The survivors may be accommodated in crew spaces, excluding sanitary rooms, treatment rooms, galley, wheelhouse, radio room, cabins for captain and two crew members.

The designed capacity of survivors shall be determined considering 0.75 m^2 per person. This includes free floor space and floor space with loose furniture, fixed seating and/or fixed beds. Other fixed furniture, toilets and bathrooms shall be excluded.

Doors and corridor giving access to the treatment room for casualties and recovery room shall be dimensioned to allow adequate transport of survivors by stretchers.

6.3.2.2 Sanitary facilities shall be available exclusively for the survivors. At least one installation comprising a toilet, a wash basin and shower shall be provided for each group of 50 survivors.

6.3.3 **Safety Equipment**

6.3.3.1 The vessel shall be equipped with at least one fast rescue boat of type complying with IMO MSC/ Circ.809, arranged and maintained to be permanently ready for use under severe weather conditions. The launching arrangement shall be a SOLAS approved type.

6.3.3.2 The following minimum safety equipment shall be provided when the vessel has a gross tonnage less than 500:

- One off SOLAS type approved lifejacket for each crew member plus 25% of the number of survivors for which the vessel is intended to carry.
- One off SOLAS type approved immersion suit for each crew member
- Six off lifebuoys, 4 being with a self-igniting light and buoyant line (SOLAS approved type)
- One off daylight signalling lamp
- One off line-throwing appliance with not less than four projectiles and four lines

6.4 Personal Care

6.4.1 **General**

6.4.1.1 Adequate equipment and medical supplies shall be provided in the treatment room, onbaord the vessel.

6.4.1.2 Treatment room equipment and medical stores should be arranged as required by local regulations or based on recognised standards.

Note:
The vessel shall be provided with blankets in sufficient quantity for the number of survivors for which the vessel is intended to carry.

6.5 Intact and Damage Stability

6.5.1 General

6.5.1.1 The vessel shall comply with intact stability requirements as given in Sec 2.4 and damage stability requirements as given in Sec 5.

6.6 Steel Deckhouses and Superstructures (Class Notation Standby Vessel (S))

6.6.1 Scantling for superstructures and deckhouses

6.6.1.1 Minimum section modulus of stiffeners and beams shall be:

$$Z = 0.70 \, s \, p \, l^2 \quad (cm^3)$$

Where,
p = Design pressure (kN/m^2)
= a p_2 for exposed decks and bulkheads
= 10.00 kN/m^2 for weather decks (minimum)
= 5.00 kN/m^2 for top of the wheelhouse (minimum)
= 8.00 kN/m^2 for accommodation decks, aft of 0.20L from AP and forward of 0.20L from FP and 6.50 kN/m^2 elsewhere
a = 2.00 for front bulkheads
= 1.20 for sides, aft end bulkheads and weather decks
p_2 = Design sea pressure as provided in Pt 3, Ch 8, Sec 2.1 and Pt 3, Ch 10, Sec 3.1 as applicable.
s = Spacing of member (m)
l = Span of member (m)

6.6.1.2 Effective end connections shall be ensured for the beams and stiffeners. These shall be connected by brackets. Stiffeners on lower front bulkhead on weather deck forward shall have brackets at lower end.

6.6.1.3 Minimum plate thickness in deckhouses and end bulkheads of superstructures shall be:

$$t = (0.02 L + t_0) \, c \, (k_m)^{0.50} \, (mm)$$

Where,
t_0 = 6.00 for front bulkheds and weather deck forward of the lowest tier of the front bulkhead.
= 5.00 for sides and aft end bulkheads and weather decks elsewhere
= 4.50 for deckhouse decks (in way of accommodation)
c = 1.54 s
= 1.00 minimum

6.6.2 Weathertight Doors

6.6.2.1 Sill heights and the arrangement of weathertight doors are in general to comply with Pt 4, Ch 6, Sec 2. Doors in exposed positions on the lowest weather deck and in lowest unprotected fronts and sides shall be of steel.

6.6.2.2 For doors located in exposed positions in sides and front bulkheads, the requirements to sill heights apply one deck higher than given by Pt 4, Ch 6, Sec 2.

6.6.2.3 Doorways to the engine room and other compartments below the weather deck are, to be located at a deck above the weather deck, as far as practicable. Alternatively, two weathertight doors in series may be accepted.

6.6.3 Windows and Side Scuttles

6.6.3.1 Arrangement of windows and scuttles shall comply with the requirements provided in Sec 2.5.6.

SECTION 7 FIRE FIGHTERS

Contents

7.1 General

7.1.1 Classification

7.1.1.1 Vessels complying with the requirements specified in this section may be given the class notation **Fire Fighter** with one or more of the following qualifiers **I**, **I+**, **II** or **III**.

7.1.1.2 For vessels not fully compliant with this section or not specifically built for the services intended to be covered by this section but which have special fire fighting capabilities in addition to their regular service, may be specially considered and reviewed under the intent of this section as they relate to fire fighting.

Such vessels, complying as a minimum Part I of this section, may be given the class notation **Fire Fighter Capability**. The standard applied, with relevant data on the extent of this special fire fighting capability will be entered into the "Appendix to the Class Certificate" and such special fire fighting systems will be subject to annual surveys.

7.1.2 Objectives

7.1.2.1 Requirments in this section apply to vessels intended for fighting fires onboard ships and on offshore and onshore structures. It is intended that these types of vessel shall act as additional fire-fighting stations, by providing water to combat fire and in support of ongoing rescue operations.

7.1.2.2 Class notation qualifiers of **I** and **I+** imply that the vessel has been built for early stage fire fighting and for support of rescue operations onboard or close to structures or ships on fire.

7.1.2.3 A vessel with **Fire Fighter** I notation shall be designed with active protection, giving it the capability to withstand higher heat radiation loads from external fires, to meet its objectives. In addition, the vessel includes a sufficient set of fire fighting equipment.

7.1.2.4 Other qualifiers of **I+** differentiates itself from **I** with a higher reliability and capability. In addition to active protection as named in Sec 7.1.2.2, the vessel shall have passive protection, giving it the capability to withstand the higher heat radiation loads also when the active protection fails. In addition, the vessel incorporates a longer throw length.

7.1.2.5 Other qualifiers of **II** and **III** imply that the vessel has been built for continuous fighting of large fires from a safe distance and for the cooling of structures on fire.

7.1.2.6 Qualifier **III** requires a significant water pumping capacity and more comprehensive fire fighting equipment when compared to the vessel with qualifier **II**.

7.1.2.7 If a vessel has been fitted with a fire fighting systems and equipment in accordance with the qualifiers II or III and has also been designed with passive and/or active heat radiation protection in accordance with the class notation I+ or I, then a combination of the two notations may be provided.

7.1.3 Scope

7.1.3.1 The class notation fire fighter includes the following:

- The vessels fire fighting ability

- Vessels stability and its ability to keep its position when fire fighting monitors are in operation
- Vessels passive and active heat radiation protection against external fire

7.1.3.2 Survivor rescue and recovery arrangements is not part of the Fire Fighter notations.

7.1.3.3 A detailed scope for the different qualifiers follows from the content of this chapter by an indication or a statement in wording to which qualifier the requirements applies to. Without such an indication or statement, the requirement is applicable for any qualifier.

Note:
*Sec 7.3.1, 'Active fire protection (Qualifiers **I** and **I+**)' indicates that the applicable paragraph is applicable for qualifiers **I** and **I+** only.*

7.1.4 Assumptions

7.1.4.1 Fire fighter class notations will be based on the assumption that the following has been complied with when operating the vessel as a fire fighter:

- The instructions laid down in the Operation Manual for fire fighting are being followed.
- The vessel will carry a sufficient quantity of fuel oil for continuous fire fighting operations, with all fixed water monitors in use for a period of not less than: 24 hours for qualifiers I and I+, and 96 hours for qualifiers **II** and **III**
- At least 30 minutes of foam forming liquid continuous foam production for the fixed foam monitors is stored onboard vessels with qualifier **III**
- At least 30 minutes of foam forming liquid continuous foam production by the mobile generator is stored in suitable containers onboard vessels with qualifiers **II** or **III**
- Crew operating the fire fighting systems and equipment has been trained in such operations, including the use of air breathing apparatus.
- Skill set of the cre is maintained by periodic exercises (drills)

7.1.5 Documentation Requirments

7.1.5.1 Refer Table 7.1.1 for documentation to be submitted for approval.

Table 7.1.1 Documentation Requirements

Description	**Documentation Type**	**Additional Description**	**Qualifier relevance**
Sea chest	System diagram	For fire fighting monitors	All
Structural fire protection arrangments	Structural fire protection drawing	Outer boundaries including external doors & windows.	**I+**
Fire fighting arrangments	Operation manual Maintenance manual	FIFI operation FIFI operation	All
Fire water supply and distribution arrangement	Piping diagram Capacity analysis Arrangement Plan		All

External surface protection water spraying fire extinguishing system	Fixed fire extinguishing system documentation		**I**, **I+**
Fire fighting vessel's fire extinguishing system	Structural drawing	Supporting structure for pumps, pump drivers and monitors.	All
Fire fighting vessel monitor water spraying fire extinguishing system	Fixed fire extinguishing system documentation	Including specification of height and length of throw. Including location of pumps, pump drivers, monitors, hose connections and hose stations	All
Portable foam generator	Specification	Foam generator and containers for storage of foam-forming liquid.	**II, III**
Fire-fighters outfit	Arrangement Plan		All
Breathing air compressor unit	Arrangement Plan		All
Flood light	Arrangment plan and Speficiation		All
Stability	Final stability manual		All

7.1.6 **Certification**

7.1.6.1 Certificates shall be required for the components shown in Table 7.1.2.

Table 7.1.2 Certificates Required

Components	**Product Certificate**	**Works Certificate**	**Test Report**
Fire fighting pumps and its prime mover	X		
Compressor for filling cylinders of air-breathing apparatus	X		
Pipes and valves		X	
Foam liquid suitable for intended use			X
Note: Definition of the certificates is provided in Pt.1 Ch.1			

7.1.7 **Testing**

7.1.7.1 Testing shall be carried out to verify that the vessel, fitted with fire fighting systems and equipment, is able to operate as intended and has the required capacities. The height and length of throw of the water monitors shall be demonstrated. The angle of list, with water monitors in operation in the most unfavourable position, shall also be measured.

7.1.7.2 For qualifiers **I** and **I+**, fire main capacities shall be tested as follows:

- Static pressure measured at the fire hydrant manifold shall be not less than 0.25 N/mm2 with four (4) jets of water from hoses simultaneously engaged to one of the fire hydrant manifolds required in Sec 7.7.1.

- Both water monitors shall be tested in operations simultaneously with the active heat radiation protection system in operation for not less than one (1) hour or until the temperature of the dedicated fire fighter pumps' prim-movers are stabilised.

7.1.7.3 For qualifier **II**, the number of hoses simultaneously engaged shall be not less than six (6) and for qualifier III not less than eight (8) for the test specified in Sec 7.1.7.2.

7.2 Basic Requirements

7.2.1 Operations Manual

7.2.1.1 Operation manual shall contain the following information in detail:

- Plan and record for periodically testing and drills (fire fighting)
- Line of responsibility and delegation of tasks
- Description of each fire fighting system and the equipment covered by the classification
- Safety precautions and start-up procedures
- Instructions for use, testing and maintenance of the fire fighting installations and the equipment (or may be only referred to)
- Instructions for operation of the vessel during fire fighting

7.2.2 Manoeuverability

7.2.2.1 Sufficient power for adequate manoeuvrability during fire fighting operations shall be ensured by providing adequate number of side thrusters and propulsion machinery.

7.2.2.2 Main propeller(s) and side thruster(s) shall be able to keep the vessel at a standstill in calm waters at all combinations of capacity and direction of throw of the water monitors, and the most unfavourable combination shall not require more than 80% of the available propulsion force in any direction.

7.2.2.3 If the system design is such that, in any operating combination, it will be possible to overload the power supply, a power management system shall be arranged. This system shall include alarm at 80% of available power and automatic action at 100% available power.

7.2.2.4 The operation of the side thruster(s) and the main propeller(s) shall be simple and limited to the adjustment of:

- Resultant thrust vector for the vessel
- Possible adjustment of the turning moment
- Possible adjustment of heading (gyro stabilised).

Operation shall be arranged at the workstation where the monitors are controlled.

7.2.2.5 It shall be visually indicated when this workstation has control. Failure in the control system shall initiate an alarm.

7.2.3 Floodlights

7.2.3.1 To ensure efficient operation of the vessel in darkness, at least two adjustable floodlights shall be fitted onboard, capable of providing an illumination level of 50 lux in clear air, within an area not less than 10 m diameter, to a distance of 250 m. The floodlights shall be of high pressure sodium vapour type or equivalent.

7.3 Protection of the Vessel Against External Heat Radiation

7.3.1 **Active Fire Protection (Notation Qualifier 1 and 1+)**

7.3.1.1 As a requirments for active fire protection the vessel shall be protected by a permanently installed water-spraying system. Water shall be applied by means of sprinkler nozzles, monitor nozzles and water shield nozzles or a combination thereof. Vertical sides of superstructures shall be protected by spray nozzles.

7.3.1.2 Fixed water-spraying system shall provide protection for all outside vertical areas of hull, superstructures and deckhouses including foundations for water monitors, essential external equipment for fire fighting operations and external life rafts and lifeboats and rescue boats. Water spray may be omitted for bulwark and rails.

7.3.1.3 Arrangement for the water-spraying system shall be such that necessary visibility from the wheelhouse and the control station for remote control of the fire fighting water monitors can be maintained while water spraying is activated.

7.3.1.4 Nozzles ad the pipelines shall be so arranged and protected that they will not be damaged during the operations for which the vessel is intended.

7.3.1.5 The fixed water-spraying system shall have a capacity not less than 10 litres per minute per m2 of the areas to be protected. For areas internally insulated to class A-60, however, a capacity of 5 litres per minute per m2 may be accepted.

7.3.1.6 For the fixed water-spraying system, the pumping capacity shall be sufficient to deliver water at the required pressure for simultaneous operation of all nozzles in the total system.

7.3.1.7 The pumps for the fire fighting water monitors may also serve the water-spraying system, provided the pump capacity is increased by the capacity required for the water spraying system. A connection with shut-off valve is then to be fitted between the fire main for the monitors and the main pipeline for the water spraying system. Such arrangements shall allow for separate as well as simultaneous operation of both the fire fighting water monitors and the water spray system.

7.3.1.8 The fixed water-spraying systems piping shall be protected against corrosion both externally and internally, by hot galvanizing or equivalent. Drainage plugs shall be fitted to avoid damages by freezing water.

7.3.1.9 Spray nozzles shall provide an effective and even distribution of water spray over the protected areas. The spray nozzles are subject to the Society's approval for their purpose.

7.3.2 **Passive Fire Protection (Notation Qualifier 1+ only)**

7.3.2.1 All of hull, superstructure, external doors and hatches shall be constructed of steel. Windows in boundary of superstructure/deckhouse, including bridge shall comply with A-0 class. In addition, the external platforms and exposed piping systems shall be of steel.

7.4 Water Monitor System

7.4.1 **Capacities**

7.4.1.1 Requirements for various class notation are provided in Table 7.4.1.

Table 7.4.1. Water Monitor System Capacities

Class Notation	**Fire Fighter 1 ,1+**	**Fire Fighter II**			**Fire Fighter III**	
Number of monitors	2	2	3	4	3	4
Capacity of each monitor (m^3 / hr)	1200	3600	2400	1800	3200	2400
Number of pumps	1 to 2	2 to 4			2 to 4	
Total pump capacity (m^3 / hr)	2400	7200			9600	
Length of throw (m)(1)	120	180	150	150	180	150
Height of throw (m)(2)	50	110	80	80	110	90
Fuel oil capacity (hours)(3)	24	96			96	

(1) For qualifier **I**, measured horizontally from the monitor outlet to the mean impact area. For **I+**, **II** and **III**, measured horizontally from the mean impact area to the nearest part of the vessel when all monitors are in satisfactory operation simultaneously.

(2) Measured vertically from sea level to mean impact area at a horizontal distance of at least 70 m from the nearest part of the vessel.

(3) Capacity for continuous operation of all monitors, to be included in the total capacity of the vessel's fuel oil tanks.

7.4.2 Arrangement

7.4.2.1 The monitors shall be capable of operating either forward or aft. The horizontal angular movement of each monitor shall be at least 90°, with minimum play across the vessels centre line of 30°. The necessary angular movement in the vertical direction is determined by the required height of throw of the water jet. The monitors shall be so positioned that they will have a free line for the water jet over the horizontal area covered.

7.4.2.2 At least two of the water monitors shall have a fixed arrangement making dispersion of the water jet possible.

7.4.2.3 The monitors shall be so arranged that the required length and height of throw can be achieved with all monitors operating simultaneously along the centre line of the vessel.

7.4.3 Monitor Control

7.4.3.1 Fire monitors shall be activated and manoeuvered remotely. The remote control station shall be arranged in a protected control room with a good general view.

Water hammer should be avoided and this should beconsidered in the design stage itself. Valve control shall not induce water hammer in the system.

7.4.3.2 Two independent control systems shall be arranged as a minimum such that a single failure will not disable more than 50% of the monitors installed. Failure in any remote control system shall initiate an alarm at the workstation from where the monitors are controlled.

7.4.3.3 The remote control station shall have open and closed indication of the remotely controlled valves.

7.4.3.4 Where an electrical control system is provided, each control unit shall be provided with overload and short-circuit protection, giving selective disconnection of the circuit in case of failure.

Where a hydraulic or pneumatic control system is provided, the control power units shall be duplicated.

7.4.3.5 Local and manual control shall be arranged in addition to the remote control for each monitor.

Note:
It is recommended that the local and manual control devices are automatically disconnected when remote operation is applied.

7.4.3.6 All shut-off and control equipment shall be clearly identified and marked.

7.5 Foam Monitor System (Notation Qualifier: III)

7.5.1 Capacities

7.5.1.1 The vessel shall be equipped with two foam monitors, each of a capacity not less than 5000 litres/minute with a foam expansion ratio of maximum 15 to 1; in addition to the water monitors.

7.5.1.2 Foam system and the arrangement and location of the monitors, shall give a height of throw at least 50 m above sea level when both monitors are used simultaneously with maximum foam generation.

7.5.1.3 When determining the necessary quantity of foam concentrate, the admixture is assumed to be 5%. The foam concentrate tank shall have capacity for at least 30 minutes of maximum foam generation from both foam monitors.

7.5.2 Arrangement

7.5.2.1 The same principles as detailed under Sec 7.4.2.1 shall be complied with.

7.5.2.2 A fixed type foam generating system shall be provided with separate foam concentrate tank, foam-mixing unit and pipelines to the monitors. The water supply to the system may be taken from the main pumps for the water monitors. In such cases it may be necessary to reduce the main pump pressure to ensure correct water pressure for maximum foam generation.

7.5.3 Monitor Control

7.5.3.1 The foam monitors shall be remotely controllable. This also concerns the operation of the valves necessary for control of water and foam concentrate. The remote control of the foam monitors shall be arranged from the same control room as the control of the water monitors and the control system shall comply with the same principles as given in D302 to D304. Local/manual control of each monitor is also to be arranged.

7.5.3.2 Remote control equipment and all shut off equipment shall be clearly identified and marked.

7.5.4 Monitor Design

7.5.4.1 The design of the foam monitors shall be approved by the Society.

7.6 Pumps and Piping

7.6.1 General

7.6.1.1 The water monitor and the associated system shall be so arranged such that the monotors will be able to deliver an even jet of water without any significan pulsations.

7.6.1.2 Requirements for pumping and piping systems given for systems covered by the main class, as well as the requirements for standard water extinguishing appliances and appliances for fire extinguishing on open decks given for main class, shall be complied with as far as applicable to systems fighting fires outside the vessel.

7.6.2 Pumps

7.6.2.1 The fire fighting system pumps and the machinery driving the pumps shall be adequately protected, and shall be so located that they will be easily accessible during operation and maintenance.

7.6.3 Seawater Inlets and Sea Chests

7.6.3.1 The seawater suctions provided for fire fighting pumps shall not be utilised for other purposes. The seawater suction valve, the pressure valve and the pump motor shall be operable from the same position. Valves with nominal diameter exceeding 450 mm shall be power actuated as well as manually operable.

7.6.3.2 When the water inlet valve is closed and the pressure valve is open, an interlock shall prevent start or engagement of the gear for the fire fighting pumps.

Warning by means of audible and visual alarm shall be provided as an alternative, if starting of the fire fighting pumps or engaging gears for the pumps is carried out with the inlet valve closed and the pressure valve open. This alarm shall be given at all control positions for the start or engagement of the gear for the fire fighting pumps.

7.6.3.3 Effective means for filling the water monitors' supply piping downstream of the pressure valves and up through the monitors whilst the pressure valves are in the closed position, shall be arranged.

7.6.3.4 Sea chests and seawater inlets shal be of a design ensuring an even and sufficient supply of water to the pumps. The location of the sea chests and seawater inlets shall be such that the water supply is not impeded by the ship's motions or by the water flow to and from bow thrusters, side thrusters, azimuth thrusters or main propellers.

7.6.3.5 Sea chest openings in the shell plating shall be fitted with strums. The design maximum water velocity through the strum holes is not to exceed 2 m/s.

7.6.4 Piping Systems

7.6.4.1 From pumps to the water monitors the piping shall be separate from the piping system to the hose connections required for the mobile fire fighting equipment.

7.6.4.2 At low delivery rates of the pumps, the piping system shall have arragements to avoid pump/s overheating.

7.6.4.3 Pump shall preferably be located below the waterline as far as practicable. Suctions lines shall be designed to avoid cavitations in the water flow. The lines are to be as short and as straight as practicable.

The net positive suction head (NPSH) for the pump system shall be designed according to the following formula:

NPSH available – 1 meter water column > NPSH required
An approved self priming system shall be provided for pumps located above water line.

Note:
NPSH available is the ship specific available net suction head (expressed in meter water column - mwc) as function of the elevation of the pump in relation to the waterline deduced for the pressure losses in the sea chest and supply piping up to the inlet flange of the pump. NPSH required is the net suction head (expressed in mwc) required by the pump in question in order to prevent cavitation.

7.6.4.4 Complete piping from seawater inlets to water monitors shall be internally protected against corrosion to a degree at least corresponding to hot galvanizing. Paint is accepted as external corrosion protection of piping exposed to weather.

Part of pipes passing through fuel oil tanks shall have thickness as for ballast pipes passing through fuel oil tanks in accordance with Pt.5A. Corrosion protection of the pipes within the tank shall be to the same level as the internal tank structure, while internal corrosion protection may be excluded for this part. A system for drainage the pipes within the fuel tank shall be arranged. Instruction shall be included in the operation manual for draining of these pipes upon completion of a fire fighting operation.

7.6.4.5 Layout of the piping shall be in accordance with good marine practice with large radius bends, and shall be satisfactorily protected against damage.

7.7 Mobile Fire Fighting Equipment

7.7.1 Fire Hydrant Manifold and Hoses for External use

7.7.1.1 Fire hydrant manifolds shall be provided on the port and starboard sides of the weather dec in addition to the fire hydrants required for onboard use. The hose connections shall therefore point outwards.

7.7.1.2 Fire fighting vessels with qualifiers **I** and **I+** shall have one fire hydrant manifold arranged on the port side and one on the starboard side, each with at least 4 hose connections.

7.7.1.3 Fire fighting vessels with qualifier **II** the number of additional hose connections at each of the fire hydrant manifolds positioned on the port and starboard sides shall be not less than six (6). For vessels with qualifier **III** the number is not less than eight (8).

7.7.1.4 In addition to the required number of hoses for onboard use, at least 8 x 15 m fire hoses of 50 mm diameter and 4 combined 16 mm jet and water spray nozzles shall be kept onboard in a readily available positions for vessels with qualifiers **I** and **I+**. For those with qualifier **II**, the number shall be increased to 12 hoses and 6 nozzles and for qualifier **III** to 16 hoses and 8 nozzles.

Table 7.7.1 Additional Hydrant Manifolds, Hose Connections and Nozzle Requirements

Qualifier	No of fire hydrant manifolds		No of hose connectio at each manifold	Total no of hose connections	Number of additional hoses (1)	Number of additional nozzles (2)
	Port	Stbd				
I, I+	1	1	4	8	8	4
II	1 or 2	1 or 2	6 3	12 12	12 12	6 6
III	1 or 2	1 or 2	8 4	16 16	16 16	8 8

(1) Length 15 m , 50 mm dia
(2) Combined 16 mm spray jet

7.7.1.5 The hydrant manifold manifold pressure shall be not less than 2.5 bar and maximum 5 bar when tested as described in Sec 7.1.7 with one length of hose fitted with a standard 16 mm nozzle fully open on each hose connection on one fire hydrant manifold.

7.7.1.6 Pumps for monitors and or water spray system may be used for supply of water to the fire hydrant manifolds required by Sec 7.7.1.1 providing the capacity is increased so that all connected consumers can be simultaneously served. In such case connections with shut-off valves shall be fitted between the fire main for the monitors and or water spray system in order to allow for separate as well as simultaneously operation of fire fighting water monitors and/or the water spray system as well as hoses connected the fire hydrant manifolds.

Further, valves to be arranged for independent supply to the fire hydrant manifolds without having the monitor and or the water spray in use.

7.7.1.7 Hoses and nozzles shall be of a design approved by the Society.

7.7.2 Foam Generator

7.7.2.1 Fire fighting vessels with qualifier **II** and **III** shall have a mobile high expansion foam generator with a capacity of not less than 100 m^3/minute for fighting of external fires.

7.7.2.2 The total storing capacity of foam-forming liquid shall be sufficient for 30 minutes continuous foam production. Foam-forming liquid shall be stored in containers, each of about 20 litres, suitable for mobile use.

7.8 Fire Fighters Outfit

7.8.1 Number and Extend of the Outfits

7.8.1.1 Four (4) sets of fire fighters outfits shall be provided in fire fighting vessel with qualifiers **I** and **I+**.

7.8.1.2 Six (6) sets of fire figthers outfit shal be provided in fire fighting vessel with qualifiers **II**. Eight (8) sets of fire figthers outfit shal be provided in fire fighting vessel with qualifiers **III**.

7.8.1.3 Each breathing apparatus shall have a total air capacity of at least 3600 litres including the spare cylinders. The extent of the fire fighter’s outfits shall be as specified for main class.

7.8.2 Location of the Firefighter’s Outfits

7.8.2.1 The firefighter's outfits shall be placed in at least two separate fire stations of which one shall have access from the open deck. The entrance to the fire station shall be clearly marked. The room shall be arranged for ventilation and heating.

7.8.2.2 The fire station shall be arranged such that all equipment will be easily accessible and ready for immediate use.

7.8.3 Compressed Air Supply

7.8.3.1 A high pressure compressor with accessories suitable for filling the cylinders of the breathing apparatuses, shall be installed onboard in the safest possible location. The capacity of the compressor shall be at least 75 litres/minute. The air intake for the compressor shall be equipped with a filter.

7.9 Stability and Watertight Integrity

7.9.1 **General Requirements**

7.9.1.1 For vessels with a length LF of 24 m and above, the stability shall be assessed when the water monitors are in operation at full capacity in the most unfavourable direction with respect to stability. A calculation showing the point of balance between the reaction forces from the water monitors and the forces from the vessel's propulsion machinery and its side thrusters shall be presented.

The monitor heeling moment shall be calculated based on the assumption in Sec 7.9.1.2. The criterion in Sec 7.9.1.3 shall be complied with.

7.9.1.2 Monitor Heeling Moment

The heeling force 'F' from the water monitor(s) shall be assumed in the transverse direction, based on full capacity as given in Table 7.4.1. Heeling arm 'a' of the monitor shall be taken as the vertical distance between the centre of side thruster(s) and the centre line of the monitor(s).

7.9.1.3 Criterion

Monitor heeling lever, calculated as F·a/displacement, shall not exceed 0.5 times the maximum GZ corresponding to maximum allowable VCG. If the maximum GZ occurs after 30°, the GZ at 30° shall be used instead of the maximum GZ.

Additional information on the monitor capacity, position, heeling force and moment as well as plotting the monitors' heeling lever on the GZ diagram of the most unfavourable loading conditions shall be included in the stability manual.

SECTION 8 OFFSHORE SERVICE VESSEL FOR TRANSPORTATION OF LOW FLASHPOINT LIQUIDS

Contents

8.1 General

8.1.1 Classification

8.1.1.1 Objective

This section defines the minimum requirements to vessels intended for transportation of liquids with flashpoint below 60°C in bulk to and from offshore installations.

8.1.1.2 Scope

The section includes requirements for arrangement and location of low flashpoint liquid tanks and spaces with low flashpoint liquid piping and installations, including requirements to entrances to such spaces.

Requirements to piping systems in cargo area, gas freeing, inerting and venting of cargo tanks, ventilation system within the cargo area, fire protection and extinction, electrical installations in hazardous areas, area classification, instrumentation and control system are included.

Operational instructions are required for approval.

8.1.1.3 Application

Requirements detailed herein are mandatory for vessels intended for transportation of liquids with flashpoint below 60°C in bulk to and from offshore installations and which are not assigned the class notations Tanker for Oil or Tanker for Chemicals.

Those vessels designed, built and equipped in compliance with the requirements of this section for carriage of liquids with flashpoint not lower than 60°C will be given the class notation **LowFP** (Low Flashpoint Liquids).

If the requirements for carriage of liquids with flashpoint below 43°C are complied with, the notation **LowFP *** will be given.

8.1.1.4 Cargoes intended to be carried in vessels to be built for class notation **LowFP** or **LowFP *** shall be specified for approval by the Society. The cargoes which may be carried will be stated in the “Appendix to the classification certificate”.

8.1.1.5 Vessels built for class notation **LowFP** or **LowFP *** are also to comply with the requirements in Sec 2.4 and Sec 5.

8.1.2 Assumptions

8.1.2.1 The classification of the vessel is based on the assumption that cargo handling operations are carried out in accordance with the approved instruction manual, refer Sec 8.9.

8.1.2.2 It is assumed that dry cargo and low flashpoint liquid cargo are not carried simultaneously unless one of the following conditions is satisfied:

- The cargo tanks are kept filled with inert gas and the cofferdams are kept filled with inert gas and monitored by a leakage detection system while the vessel is on dry cargo service.

- The cargo tanks are kept filled with inert gas and the cofferdams are filled with water while the vessel is on dry cargo service.

- The cargo tanks are kept filled with inert gas and the gas-concentration in the cofferdams is kept monitored by an automatic gas detection arrangement while the vessel is on dry cargo service.

- Dry cargo is carried aft and low flashpoint liquid cargo forward of the superstructure, or vice versa.

- The cargo has a flashpoint of not less than 43°C and is only carried within areas where it is known for certain that the ambient air temperature cannot rise to within 10°C below the flashpoint of the cargo

Operational assumptions corresponding to the above will be stated in the “Appendix to the classification certificate”.

8.1.3 **Defintions**

8.1.3.1 An area in which an explosive gas atmosphere is or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of electrical apparatus is termed as hazardous area. Hazardous areas shall be defined in compliance with Sec 8.8.

8.1.3.2 Liquids having flashpoint below 60°C is termed as cargo herein.

8.1.3.3 Cargo area is that part of the offshore support vessel where cargo and cargo vapours are likely to be present as defined in Sec 8.8.

8.1.4 **Documentation**

8.1.4.1 Details related to the additional class regarding design, arrangement and strength are in general to be included in the plans specified for the main class.

8.1.4.2 The documentation as detailed in Table 8.1.1 shall be submitted:

Table 8.1.1. Documentation Requirements

Description	Document	Additional Description	(A)/(I)
Cargo Piping System	Piping system		(A)
	Operation manual	Refer Sec 8.9	(A)
Inert Gas System	Piping system		(A)
	Control and monitoring system documentation		(A)
Cargo heating system	Piping system		(A)
Hazardous Area	Hazardous area classification drawing		(A)
Cargo area ventilation system	Ducting drawing		(A)
	Detailed drawing		(A)
Cargo tank pressure vacuum valves or high velocity vent valves	Data sheet		(I)
Hazardous areas - Electrical installation	Arrangemement Plan	Electrical equipment in hazardous areas. Where relevant, based on an approved 'Hazardous area classification drawing' where location of electric equipment in hazardous area is added (except battery room, paint stores and gas bottle store).	(I)

	Ex- installation table		(A)
	Maintenance manual	Electrical equipment in hazardous areas, Refer Sec 8.5.1.1.	(I)
	Schematic drawing- Electrical	Single line diagrams for all intrinsically safe circuits, for each circuit including data for verification of the compatibility between the barrier and the field components	(A)
Level monitoring system - Cargo tanks	Control and monitoring system documentation		(A)
Overflow protection system – Cargo tanks	Control and monitoring system documentation		(A)
Control and monitoring system- Pumps and cargo system valves	Control and monitoring system documentation		(A)
Hydrocarbon gas detection and alarm system (Fixed)	Control and monitoring system documentation	If applicable	(A)
	Arrangement plan		(A)
Cargo area leakage detection system	Arrangement plan	In cofferdams, if applicable	(A)
	Control and monitoring system documentation		(A)
Cargo tank deck fire extinguishing system	Fixed fire extinguishing system documentation	Refer Sec 8.14.5.	(A)
Exhaust systems	Arrangement plan	Including spark arrestors	(I)
Internal access	Arrangement plan	Refer Sec 8.2.1.2.	(A)
Note: (A) For Approval; (I) For Information			

8.1.4.3 When national authorities survey the vessel in accordance with the current requirements of the International Convention on Safety of Life at Sea (SOLAS), copies of the Cargo Ship Safety Construction Certificate and the Cargo Ship Safety Equipment Certificate shall be submitted by the ship-owner or building yard. This documentation will be considered as equivalent to a survey carried out by the Society.

8.1.5 Materials

8.1.5.1 Materials for structure used for tank construction, together with associated piping, valves, vents and their jointing materials, shall be suitable at the carriage temperature and pressure for the cargo to be carried, to the satisfaction of the Society.

8.1.6 Surveys and Testing

8.1.6.1 All systems covered by this section are to be function tested prior to assignment of class. This shall also include testing of the nitrogen system capacity to verify that it is in accordance with Sec 8.4.2.4.

8.1.7 Certification of Control and Monitoring System

8.1.7.1 Certification of various components shall be as detailed in Table 8.1.2.

Table 8.1.2 Certification Requirements		
Description	**Certification Type**	**Additional Description**
Control and monitoring System- Inert Gas	INTLREG product certificate	
Hydrocarbon gas detection and alarm system (Fixed)	INTLREG product certificate	
Level monitoring system- Cargo Tanks	INTLREG product certificate	
Overflow protection system- Cargo Tanks	INTLREG product certificate	
Control and monitoring system- Cargo pumps and valves	INTLREG product certificate	

8.2 Vessel Arrangement

8.2.1 Tank Arrangement

8.2.1.1 Within the accommodation area or engine room area, the cargo tanks shall not be arranged. Engine room and accommodation shall not be located above tanks or cofferdams.

8.2.1.2 The cargo tanks shall be surrounded by cofferdams if not bounded by bottom shell plating or pump room.

For safe access to and within tanks for low flashpoint liquids and adjacent cofferdams, horizontal hatches or openings to or within cargo tanks or cofferdams surrounding tanks for low flashpoint liquids are to have a minimum clear opening of 600 ´ 600 mm that also facilitates the hoisting of an injured person from the bottom of the tank/cofferdam. For access through vertical openings providing main passage through the length and breadth within cargo tanks and cofferdams surrounding tanks for low flashpoint liquids, the minimum clear opening shall not be less than 600 ´ 800 mm at a height of not more than 600 mm from bottom plating unless gratings or footholds are provided. Smaller openings may be accepted provided evacuation of an injured person from the bottom of the tank/cofferdam can be demonstrated.

Minimum horizontal distance between the tank side or pipes leading from the tank and the ship's shell shall be 760 mm.

8.2.1.3 Cargo tanks situated forward of the superstructure may extend to the deck plating, provided dry cargo is not handled in this area.

8.2.1.4 Cargo tanks for liquids with a flashpoint of not less than 43°C may extend to the ship's shell and the deck plating.

8.2.1.5 Other than fresh water and lubricating oil tanks, tanks for other purposes will be accepted as cofferdams for these tanks.

8.2.1.6 Spaces forward of the collision bulkhead (forepeak) and aft of the aftermost bulkhead (afterpeak) shall not be arranged as cargo tanks nor as cofferdams.

8.2.1.7 Cofferdams shall be arranged for water filling. The filling system shall not be permanently connected to the cofferdams.

8.2.1.8 Tanks on open deck may be approved after special considerations in each particular case.

8.2.1.9 Cargoes, which react in a hazardous manner with other cargoes or fuel oils, shall be segregated from such other cargoes or oil fuel by means of a cofferdam, pump room or tank containing a mutually compatible cargo.

8.2.2 Access and Openings- General

8.2.2.1 Machinery spaces, control stations, service spaces or accommodation shall not be located within the cargo area.

8.2.3 Access and Openings to Accommodation

8.2.3.1 Air inlets, entrances and openings to accommodation, service and machinery spaces and control stations are, in general, not to face the cargo area.

For vessels with cargo tanks aft of the superstructure, entrances, air inlets and openings facing the cargo area may be accepted provided they are situated at least 10 m from the nearest hazardous area.

The following provisions apply for such boundaries:

a. During loading/discharge operations doors shall be kept closed. Signboards shall be fitted.

b. Port lights or windows shall be of a non-opening type. Inside covers of steel or equivalent material shall be fitted in the first tier on main deck.

c. Ventilation inlets shall be installed as far as practicable from the nearest hazardous area (in no case less than 10 m.

8.2.4 Acces and Openings to Pump Room and Cargo Tanks

8.2.4.1 Cargo tanks and cofferdams surrounding cargo tanks shall have suitable access from open deck for cleaning and gas-freeing. Where cofferdams are provided over cargo tanks, small trunks are to be arranged to penetrate the cofferdam. The trunks shall be arranged for water filling.

8.2.4.2 From cargo tanks or cofferdams access opening to other spaces shall not be provided.

8.2.4.3 Entrance to pump room shall be from open deck.

8.2.4.4 A clear opening of minimum 600 x 600 mm shall be provided for access entrances and passages.

8.2.5 Chain Locker and Windlass

8.2.5.1 Chain locker shall ber arranged as a non-hazardous space.

8.2.5.2 Cable lifters, windlass and chain propes shall be situated outside hazardous areas.

8.2.6 Miscellaneous

8.2.6.1 Spark arrtors shall be provided at the exhaust outlets form combustion equipment.

8.2.6.2 Surface temperatures of equipment and piping in hazardous areas shall not exceed 220°C.

8.3 Cargo Area Piping System

8.3.1 General

8.3.1.1 Piping systems in cargo area shall comply with the requirements of Pt 7B,Ch 6. (…Chemical Carriers)

8.3.1.2 There shall be no permanent connection between piping systems in the cargo area and piping systems in the remainder of the vessel. For exemption refer Sec 8.3.3.

8.3.1.3 Separation may be achieved between non-permanent connections between piping systems in the cargo area and piping systems in the remainder of the vessel, by the use of one of the following arrangements:

- Blind flange valves
- Removing spool pieces or valves and blanking the ends of the pipes

Such arrangements shall not be located within a cargo tank or cofferdam.

For filling and drainage of cofferdams surrounding cargo tanks, non-permanent hose connections will be accepted.

8.3.1.4 The cofferdam boundaries shall not be penetrated at a level below the top of the cargo tanks.

Note:
Typically, hydraulics for pumps and valves, cables for instrumentation.

8.3.1.5 Bulkhead penetrations shall not utilise flanges bolted through the bulkhead.

8.3.1.6 Deck spills shall be kept away from accommodation and service areas through suitable precautionary means, such as a permanent coaming of suitable height extending from side to side or around loading and discharge stations.

8.3.1.7 Pipe tunnels, cofferdams and and cargo pump room shall have a separate drainage system connected to pumps or bilge ejectors situated entirely within the cargo area.

8.3.1.8 Bilge ejectors serving hazardous areas shall not be permanently connected to the drive water system.

8.3.1.9 Sounding pipes and air pipes led to the atmosphere shall be installed for cofferdams. The air pipes shall be fitted with flame screens at their outlets.

8.3.2 Cargo Piping System

8.3.2.1 The complete cargo piping system shall be entirely separate from all other piping systems on board and shall be located within the cargo area.

8.3.2.2 If the vessel is intended for cargoes, which react in a hazardous manner with other cargoes, they shall have separate pumping and piping systems, which shall not pass through other cargo tanks containing such cargoes unless encased in a tunnel.

8.3.2.3 Cargo piping shall not penetrate cargo tank boundaries below the top of the tank. However, penetrations below the top of the tank may be accepted provided that a remotely operated stop valve is fitted within the cargo tank served. Where a cargo tank is adjacent to a pump room, the remotely operated stop valve may be fitted on the cargo tank bulkhead on the pump room side.

8.3.2.4 Generation of static electricity is to be reduced by an effective arrangement of filling lines within cargo tanks, as an example, by reducing the free fall into the tank to a minimum.

8.3.2.5 Submerged pumps in cargo tank that are hydraulically powered (eg. deep well pumps), shall be arranged with double barriers, preventing the hydraulic system serving the pumps from being directly exposed to the cargo. The double barrier shall be arranged for detection and drainage of possible cargo leakages.

8.3.2.6 Relief valves with discharge to the suction line shall be provided for displacement pumps.

8.3.2.7 Efficient means shall be provided for stopping the pumps from the bridge or similar position facing the cargo area.

8.3.2.8 The transfer hose connecting coupling shall be of a type which automatically closes at disconnection (self-sealing type).

8.3.2.9 Means of quick-release of the transfer hose shall be provided, eg. by installation of a weak link assembly or by installation of a remotely controlled coupling. Quick release shall be capable of being actuated from the bridge.

8.3.3 **Cargo Heating System**

8.3.3.1 The temperature of the heating medium shall not exceed 220 0C and shall be compatible with the type of cargo.

8.3.3.2 The cargo heating system shall be arranged as a secondary system independent of other ship's services and not enter the engine room.

8.3.3.3 To isolate the heating or cooling systems for each tank, independent isolation valves shall be fitted (for each tank).

8.3.3.4 The heating circuit expansion tank shall be fitted with a gas detector or low level alarm and be vented to open air. For any heating system, means shall be provided to ensure that, when in any other but the empty condition, a higher pressure is maintained within the system than the maximum pressure head exerted by the cargo tank content on the system.

8.3.3.5 Cargo heating pipes shall not penetrate the cargo tank boundaries other than on the top of the tank.

Gas-Freeing, Inerting and Venting of Cargo Tanks

8.3.4 **Gas-freeing of Cargo Tanks**

8.3.4.1 Vapour is initially discharged in one of the following ways as part of the gas freeing operation:

- Gas freeing through outlets at least 2 m above the cargo tank deck level with a vertical efflux veloxity of at least 30 m/s maintained during gas freeing operation, or

- Gas freeing through at least 2m above cargo tank deck leel with a vertical efflux velocity of at least 20 m.s which are protected by suitable devise to prevent the passage of flame.

Note 1
When flammable vapour conventration at the outlet has been reduced to 30% of the lower flammable limit, gas freeing may therafter be continued at cargo tank deck level.

Note 2
Procedures to be included in the operation manual detailed in Sec 8.9.

8.3.5 Inerting of Cargo Tanks

8.3.5.1 Inerting of cargo tank s required as detailed in Sec 8.1.2.2.

8.3.5.2 In order to prevent the return of cargo vapour to any gas safe spaces, the inert gas supply line shall be fitted with two shut-off valves in series with a venting valve in between (double block and bleed valves). In addition a closable non-return valve shall be installed between the double block and bleed arrangement and the cargo tank.

These valves shall be located outside non-hazardous spaces and must function under all normal conditions of trim, list and motion of the ship.

The following conditions are applicable:

a) The operation of the valves shall be automatically executed. Signals for opening and closing shall be taken from the process directly, eg. inert gas flow or differential pressure.

b) An alarm for faulty operation of the valves shall be provided.

8.3.5.3 Where the connections to the hold spaces or to the cargo piping are non-permanent, two non-return valves may substitute the non-return devices required in Sec 8.4.2.2.

Note:
Connection of cargo tanks for inert gas padding are considered as permanent for the purpose of this requirement.

8.3.5.4 If the cofferdams are arranged for inert gas filling, the supply lines shall be protected from the return of cargo vapour via the tank padding supply lines with a double block and bleed arrangement.

8.3.5.5 Cargo discharge rate from tanks being protected shall be restricted to 80% of the inert gas capacity.

8.3.5.6 A low-pressure alarm shall be provided in the nitrogen supply line on the cargo tank side of any double block and bleed valves and pressure reduction units. In case pressure/vacuum alarms are fitted in each cargo tank as means to comply with redundant venting requirements, a separate low-pressure alarm is not required.

8.3.5.7 A high oxygen content alarm shall be provided at the location from where the cargo operation is controlled. The alarm is to be activated when the oxygen content in the inert gas supply exceeds 8%.

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

These separate compartment shall be treated as one of other machinery spaces with respect to fire protection.

8.3.6 **Cargo Tank Venting System**

8.3.6.1 Cargo tanks shall be provided with a breathing system for relief of pressure and vacuum. Such breathing shall be through P/V-valves (pressure/vacuum relief valves). The system shall comply with the requirements given in Ch.6 Sec.10 except that the height specified may be reduced to 2 m.

8.3.6.2 Cargoes, which react in a hazardous manner with other cargoes, shall have separate tank venting systems.

8.4 Ventilation System within the Cargo Area

8.4.1 **General**

8.4.1.1 Ventilation system shall comply with the requirements given in Ch.6 Sec.9 . The following requirements in Ch.6. Sec.9 B303 . may be relaxed after special consideration by the Society:

- The horizontal distance between exhaust outlets from cargo handling spaces and the ventilation inlets to non-hazardous spaces other than accommodation.

- The height of the exhaust outlets from cargo handling spaces

8.5 Fire Portection and Extinction

8.5.1 **Fire Protection**

8.5.1.1 In general, the vessel shall comply with the current requirements of the International Convention for the Safety of Life at Sea (SOLAS) for tankers. For vessels with cargo tanks aft of the superstructure and where the superstructure is situated at least 10 m from nearest hazardous area compliance with the provisions of SOLAS for cargo ships will be acceptable.

8.5.2 **Fire Extinction**

8.5.2.1 A fixed foam fire extinguishing system for protection of the cargo deck area shall be provided. Deck area to be simultaneously protected:

- Within 10 m radius from cargo loading/ unloading connection(s)
- Within 5 m radius from cargo breathing valves
- Withing 3m radius from tank openings, cargo pipe flanges and cargo valves

The deck area defined above shall be protected by either foam monitor(s) or nozzles or a combination of both. In case of monitors, nominal length of throw for coverage of the farthest extremity of the area protected by monitors shall be used.
Application rate shall not be less than the following:

- 5 litres/minute/m^2 with sufficient supply for at least 20 minutes, applicable for return mud or oil products for which class notation **LFL** shall be applicable.

- 10 litres/minute/m2 with sufficient supply for at least 20 minutes, applicable for products covered by the IBC Code or methanol or oil products for which class notation **LFL*** shall be applicable.

Water supply to the fixed foam fire extinguishing system shall be in addition to the water supply required for the vessels fire main. The foam concentrates shall be compatible with the cargo carried.

8.5.2.2 The vessel shall be provided at a readily available position, at cargo deck level, four portable foam applicator units with at least 8 portable 20 litre containers with foam concentrate, for use with water supplied by the vessels fire main.

8.5.2.3 In addition to those required by SOLAS Reg. II-2/10.10, tow fire fighters outfit shall be provided in addition.

8.5.2.4 Cargo pump rooms shall be protected by an approved fire extinguishing system. Fixed pressure water-spraying system and high expansion foam system may also be considered.

8.5.2.5 The deck foam system installed onboard shall be simple and capable of rapid operation. The main control station for the system shall be suitably located outside of the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fires in the areas protected. Start of the system should be supported by automatic sequential start of the system by activation of one single button. Foam monitors requiring manual operation shall be positioned outside of the protected area and be readily available in case of fire in the protected area. For pumps that also support other services such as ballast water; valves and pumps shall normally be in fire mode during transport of **LFL*** and in addition have remote control for switch-over to fire mode from the same position as the deck foam system operation controls in accommodation.

8.6 Electrical Installations in Hazardous Areas

8.6.1 General

8.6.1.1 Electrical installations in hazardous areas shall comply with the requirements given in Ch.6.

8.6.1.2 Only electrical equipment suitable for the relevant zone shall be installed in hazardous areas. Electrical equipment not suitable for the relevant zone with arrangements for disconnection will not be accepted.

8.7 Area Classification

8.7.1 General

8.7.1.1 For the selection of appropriate electrical apparatus and the design of suitable electrical installations, hazardous areas are divided into zones 0, 1 and 2.

8.7.2 Definitions

8.7.2.1 Hazardous area: Zone 0

The interiors of cargo tanks, slop tanks, any pipework of pressure-relief or other venting systems for cargo and slop tanks, pipes and equipment containing the cargo or developing flammable gases or vapours.

8.7.2.2 Hazardous area: Zone 1

The Zone 1 hazardous areas are as detailed below:

1. Cofferdams adjacent to cargo tanks
2. Hold spaces containing independent cargo tanks
3. Cargo pump rooms
4. Enclosed spaces above or adjacent to cargo tanks

5. Areas on open deck, or semi- enclosed spaces on deck, within 3 m of any cargo tank outlet, gas or vapour outlet, cargo manifold valve, cargo valve, cargo pipe flange, cargo pump-room ventilation outlets and cargo tank openings for pressure release provided to permit the flow of small volumes of gas or vapour mixtures caused by thermal variation.
6. Areas on open deck, or semi-enclosed spaces on open deck above and in the vicinity of any cargo gas outlet intended for the passage of large volumes of gas or vapour mixture during cargo loading, within a vertical cylinder of unlimited height and 6 m radius cantered upon the centre of the outlet, and within a hemisphere of 6 m radius below the outlet.
7. Areas on open deck, or semi-enclosed spaces on deck, within 1.5 m of cargo pump room entrances, cargo pump room ventilation inlet, openings into cofferdams or other zone 1 spaces
8. Areas on the open deck within spillage coamings surrounding cargo manifold valves and 3 m beyond these, up to a height of 2.4 m above the deck.
9. Compartment for cargo hoses
10. Enclosed or semienclosed spaces in which pipes containing cargoes are located.

Note:
Areas on open deck within 3 m of cargo tank access openings for ships with cofferdams towards deck are not defined as hazardous zones. Safety precautions related to the use of such access openings in connection with gas freeing are to be covered in the operation manual.

8.7.2.3 Hazardous area: Zone 2

1. Areas within 1.5 m surrounding open or semi-enclosed spaces of zone 1 as specified in 202, if not otherwise specified.

2. Spaces 4 m beyond the cylinder and 4 m beyond the sphere defined in Sec 1.8.2.2. (6).

3. Spaces forming an air-lock as defined in Ch.6 .

4. Areas on open deck over all cargo tanks and to the full breadth of the ship plus 3 m fore and aft of the forward-most and aft-most cargo tank bulkhead, up to a height of 2.4 m above the deck (the open deck over the cargo area will normally not be defined as a hazardous area when cofferdams are fitted above the cargo tanks).

8.7.2.4 Spaces with access or opening located in hazardous area shall have the same zone classification as the hazardous area.

8.8 Instrumentation and Control System

8.8.1 General

8.8.1.1 The control and control systems for pumps and cargo valves shall comply with the requirements given in Ch 5, Sec 9.2.

8.8.2 Level Gauging and Level Alarm

8.8.2.1 At least one level gauging device shall be installed in each cargo tank.
If only a single gauging device is fitted, it shall be arranged so that any necessary maintenance can be carried out while the cargo tank is in service. If this is not possible, means for manual sounding shall be provided.

8.8.2.2 Each cargo tank shall be fitted with a high level alarm giving alarm at 95% filling by volume. The alarm shall be activated by a level sensing device independent of the gauging device.

8.8.2.3 Cofferdams surrounding cargo tanks shall be fitted with leakage detection unless they are water filled when carrying low flashpoint liquids or fitted with gas detection. Alarms shall be provided at a manned control station.

8.8.3 **Gas Detection**

8.8.3.1 Portable gas measuring equipment shall be provided on board and consisting of at least two apparatus each measuring the following:

- Hydrocarbon content in the range 1 to 100% hydrocarbon gas by volume
- Oxygen
- Low hydrocarbun gas contents (0 to 100% **LEL**)

8.8.3.2 Gas detectors shall be installed in cofferdams surrounding cargo tanks unless they are water filled when carrying low flashpoint liquids or fitted with leakage detection. Alarm shall be provided at a manned control station.

8.8.3.3 Arrangements shall be made to facilitate measurement of the gas concentration in all tanks and other compartments within the cargo area.

Sampling points that are easily accessible shall be provided for closed gas detection of cargo tanks and inerted cofferdams from open deck. Where the atmosphere in the bottom part of cofferdams cannot be reliably measured using flexible gas sampling hoses, such spaces shall be fitted with permanent gas sampling lines.

8.8.3.4 A system for continuous monitoring of the concentration of hydrocarbon gases in cargo pump room shall be provided in accordance with SOLAS II-2 Reg.4.5.10.1.3.

8.8.3.5 Sequential sampling method is acceptable as long as it is dedicated for the pump room only, including exhaust ducts, and the sampling time is reasonably short.

8.9 Signboards

8.9.1 **General**

8.9.1.1 Signboards with text as shown below shall be provided at the doors to service spaces and accommodation areas:
TO BE KEPT CLOSED DURING HANDLING OF FLAMMABLE CARGO

8.9.1.2 Regarding electrical installation signboards, refer Ch 3, Sec 8.

8.10 Operational Instructions

8.10.1 **General**

8.10.1.1 All essential procedures for handling of flammable cargoes shall be prepared and documented in an operation manual. The operation manual is subject to approval and shall be kept on board.

8.10.1.2 The following shall be included in the operations manual, in general:

1. Ships Particulars
2. Cargo system particulars:
   - Tank layout/ capacities
   - Cargo handling system
   - Inert gas N2
   - Cargo tank heating
   - Cargo tank venting
   - Pump room ssafety (if applicable)
   - Crago tank instrumentation
   - Fire safety
   - Gas detection

3. Operations:
   - Assumptions
   - Loading
   - Voyage
   - Discharging
   - Cleaning and gas freeing (tank entry)
   - Cofferdam safety
   - Cargo area access plan
   - Gas detection
   - Pump room safety

4. Reference documents:
   - General arrangement
   - Capacity plan
   - pressure/ vacuum valves flow curves
   - Methanol/ special product cargo system
   - Nitrogen system
   - Hazardous zone
   - Cargo venting
   - Cargo area -Mechanical ventilation
   - Fire fighting
   - P&A manual (as applicable)
   - Bilge cargo area

8.10.1.3 The following instructions shall be included in the operation maual as relevant:

- Dry cargo shall not be handled in cargo area forward of the superstructure.
- Doors to accommodation and service spaces facing the cargo area shall be kept closed during cargo handling.
- Hydrocarbon gas measurements shall be carried out regularly

For vessels not satisfying the conditions in Sec 8.1.2.2, in addition:

- Low flashpoint liquid cargoes and dry cargoshall not be carried simultaneously
- Before the vessel enters dry cargo service, all cargo piping, tanks and compartments in the cargo area shall be cleaned and ventilated to the extent that the hydrocarbon gas content is less than 4% of LEL.

For vessel satisfying the requirements in Sec 8.4.2.1 and , in addition:

The following shall be complied with during carriage of dry cargo:

- Cargo tanks and piping shall be filled with inert gas and the O_2-content in the tanks shall not exceed 8% by volume

- Gas detection system in cofferdams surrounding the cargo tanks shall be function tested, or alternatively

- The cofferdams surrounding the cargo tanks shall be filled with inert gas and the O2-content shall not exceed 8% by volume and the leakage detection system shall be function tested, or alternatively

- The cofferdams surrounding the cargo tanks shall be filled with water.

SECTION 9 TUGS

Contents

9.1 General

9.1.1 Intoduction

9.1.1.1 The requirements in this section apply to vessels intended for towing services in harbour and open waters and pushing of floating structures.

9.1.1.2 Scope

The following topics are covered in this section:

- Stability and watertight integrity
- Hull arrangement and supporting structure
- Design and testing requirements of towing equipment

9.1.1.3 Objective

The objective is to provide design standards for safe and reliable towing operation of the vessel.

9.1.1.4 Application

Those vessels designed and built in compliance with the requirements speciied in this section may be gien the class notation **Tug**.

9.1.2 Definitons

9.1.2.1 Rope used for towing are termed towline.

9.1.2.2 The maximum continuous pull obtained at static pull test on sea trial is termed bollard pull.

9.1.2.3 The value obtained from Table 9.1.1 is termed the reference load:

Table 9.1.1 Reference Load

Reference Load	Bollard Pull (t)
3.00 BP	BP < 40
(3.80- BP/50) BP	40 ≤ BP ≤ 90
2.00 BP	BP ≥ 90

9.1.3 Documentation Requirements

9.1.3.1 The following as detailed in Table 9.1.2 shall be submitted:

Table 9.1.2 Documentation Requirements

Description	Doc Type	Additional Description	(A)/(I)	Rule Ref Sec 9
Towing Arrangement	Arrangement Plan	Shall include: -Maximum expected BP (bollard pull) -Maximum design load for each component -Emergency release capabilities -Towline paths showing	(I)	Sec 9.4

		extreme sectors and wrap on towing equipment towline points of attack		
Bollard Pull	Test procedure for quay and sea trial		(A)	Sec 9.1
Winch and other equipment	Test procedure for quay and sea trial		(A)	Sec 9.1
Towing Winch	Design criteria	Including: -RL and expected maximum BP -Hoisiting capacity, rendering and brake force of the winch -Release capabilities (response time and intended remaining holding force after release)	(I)	Sec 9.4
	Arrangement / Assembly drawing		(I)	Sec 9.4
	Detailed drawing		(A)	Sec 9.4
	Design analysis		(I)	Sec 9.4
	NDT plan		(A)	Sec 9.1
Towing Hook	Design criteria	Expected maximum BP to be stated.	(I)	Sec 9.4
	Arrangement / Assembly drawing		(I)	Sec 9.4
	Detailed drawing	Including emergency release mechanism.	(A)	Sec 9.4
	Design analysis		(I)	Sec 9.4
	NDT plan		(A)	Sec 9.1
Foundation and support structure for towing winch, tow hook etc.	Structural drawing	The RL and the expected BP shall be stated. Including foot print. Applicable for equipment with static force > 50 Kn or bending moment > 100 kNm	(A)	Sec 3.2 and Sec 9.4

9.1.4 Certification Requirements

9.1.4.1 INTLREG product certificates will be required for the following items:
-Towhook
-Towing winch

9.1.4.2 INTLREG material certifictes will be required for the items detailed below:

-Tow hook with attachment
-Winch drum and flanges
-Shafts for drum
-Brake components

9.1.4.3 Works material certificates are required for the following items:

-Gear shaft and wheels
-Winch framework
-Couplings

9.1.5 Testing Requirements

9.1.5.1 Winches, towhooks and other equipment made mandatory in this section shall be function tested according to approved procedure in order to verify the following:

- Correct function of normal operational modes
- Correct function of the emergency operation modes, including emergency release and deadship operation
- Stability for the arrangement and equipment to operate within the specified limitations, towline paths, towline sectors etc specified in the arrangement drawing.

9.1.5.2 The winch shall be load tested during hoisting, braking, and pay out. Design loads to be applied. However, a maximum load equal to BP may be accepted if the winch is not of novel design or complex structure.

9.1.5.3 The tow hook shall be load tested with a load equal to the bollard pull (BP) of the vessel.

9.1.5.4 Bollard Pull

The bollard pull (BP) of the vessel shall be verified by a special test approved by the Society. Based on the results of the test a Bollard Pull Certificate shall be issued.
BP testing procedure shall be as detailed in Sec 9.1.5.5.

The BP measure shall be entered in the register of vessels class under INTLREG as information.

The expected BP may be preliminarily applied for design approval purposes prior to sea trial. If sea trial reveals that the expected pull is significantly exceeded, such design approvals may have to be re-considered by the Society.

9.1.5.5 Bollard pull test procedure as detailed below shall be followed and possible deviations shall be recorded in the Bollard Pull Certificate:

1. Proposed bollard pull test programme shall be submitted to Society prior to testing.
2. During testing of continuous static bollard pull the main engine(s) shall be run a the manurfacturer's recommended maximum continuous rating (MCR).
3. While testing of overload pullm the main engines shall be run at the manufacturer's recommended maximum continuous rating that can be maintained for a minimum of one hour. The overload test may be omitted.
4. The propeller(s) installed while performing the test shall be the same propeller(s) used when the vessel is in normal operation.
5. All auxiliary equipment such as pumps, generators and other equipment, which are driven from the main engine(s) or propeller shaft(s) in normal operation of the vessel shall be connected during the test.
6. Vessel hall be trimmed at even keel or at a trim by stern not exceeding 2% of the vessel's length.
7. The vessel shall be able to maintain a fixed course for not less than 10 minutes while pulling as specified in items 2 or 3 above.
8. Test shall be performed with a fir win speed not exceeding 10 knots.
9. The co-current at the test location shall not exceed 1 knot.
10. Load cell used for the test shall be approved by INTLREG and be alibrated at least once a year. The accuracy of the load cell shal be +/- 2% within a temperature range and a load range relevant for the test.
11. An instrument giving a continuous read-out and also a recording instrument

recording the bollard pull graphically as a function of the time shall both be connected to the load cell.

12. Arrangement of bollard, towline and load cell shall ensure a force reading in horizontal direction by means of minimizing the influence from friction and force components in vertical direction.
13. The figure certified as the vessel's continuous static BP shall be the towing force recorded as being maintained without any tendency to decline for a duration of not less than 10 minutes.
14. Certification of BP figures recorded while running the engine(s) at overload, reduced r.p.m. or with a reduced or an increased number of engines or propellers operating can be given and noted on the certificate. The angular position of turn able propulsion devices shall be recorded.
15. Both the load cell reading, engine power, and other essential parameters shall be continuously available to the INTLREG surveyor.
16. The recorded load cell readings shall be made available to the INTLREG surveyor immediately upon completion of the test.

9.2 Hull Arrangement and Strength

9.2.1 Draught for Scantlings

9.2.1.1 The scantling of strength members shall be determined based on the ship's draught; the latter shall not be taken less than 0.85 D.

9.2.2 Fore Peak Structures

9.2.2.1 Those tugs designed to use the bow for pushing floating structures additional strength in the fore peak shall be in accordance with Sec 2.2.2.2, Sec 2.2.2.3, Sec 2.2.2.4.

9.2.2.2 Stringers shall be arranged forward of the collision bulkhead on the ship's side not more than 2 m apart. The stringers shall be connected to the collision bulkhead by brackets forming gradual transition to the bulkhead.

9.2.2.3 Stringer dimensions shall not be less than the following:

- Mean depth = 250 + 2.5 l L (mm)
- Thickness = 6.50 + 0.03 L (mm)
- Flange area = 0.15 l L (cm^2)

9.2.2.4 The frames shall be connected to the stringers by lugs or brackets at every frame.

9.2.2.5 Ships having large foreboady flare and only intended for towing, the general requirements given in Pt 3, Ch 7 + 25% may be applied.

9.2.3 Fenders

9.2.3.1 A substantial fender for the protection of the vessel's ship sides shall be fitted at deck level, extending the whole length of the vessel. Alternatively, an arrangement with loose fenders may be approved, if the upper part of the vessel's sides is additionally stiffened.

9.2.4 Machinery Casing and Emergency Exit

9.2.4.1 The scantlings of plating and stiffeners shall be at least 20% in excess of the requirements for main class for the exposed casing structure.

9.2.4.2 Skylights on uppermost continuous deck shall be arranged on a coaming not less than 900 mm in height. The scantlings shall be as for exposed casings.

9.2.4.3 Emergency exit shall be arranged from engine room to weather deck. The emergency exit shall be capable of being used at extreme angles of heel. The escape hatch on deck shall have a coaming height not less than 600 mm. The hatch cover shall have hinges arranged athwart ships, and shall be capable of being opened and closed (weathertight) from either side.

9.2.5 Companionways

9.2.5.1 Companionways to spaces below deck shall have sill heights not less than 600 mm, and shall have weathertight steel doors which can be opened and closed (weathertight) from either side.

9.2.6 Side Scuttles

9.2.6.1 Side scuttles are not allowed in the vessel's sides unless the distance from the lower edge of side scuttles to the design waterline is at least 750 mm. Side scuttles in the vessel's sides and in sides of any superstructures on freeboard deck shall be provided with internally fitted, hinged deadlights and shall satisfy the requirements to Type A (heavy) according to ISO Recommendation 1751. Fixed lights in skylights etc. shall have glasses of thickness appropriate to their position as required for side scuttles, and fitted with hinged deadlights which may be arranged on the weather side.

9.2.7 Deck Structure

9.2.7.1 Foundations and supports of towing pins shall have scantlings based on 2 times the specified maximum static working load.

9.2.7.2 Foundations and supports of towing winches shall have scantlings based on minimum 2.2 times the BP of the vessel.

9.2.7.3 Foundations and supports of towing hook shall have scantlings based on minimum 2.5 times the BP of the vessel

9.2.7.4 Allowable stress levels for the scantlings of the supporting structure resulting from bending moments and shearing forces calculated for the load given above shall be as provided below:

Bending Stress, σ_b	$= 210 / k_m$	(N/mm^2)
Shear Stress, τ	$= 120 / k_m$	(N/mm^2)
Von Mises Stress, σ_e	$= 235 / k_m$	(N/mm^2)

Where,
$\sigma_e = (\sigma_b^2 + 3 \tau^2)^{0.50}$

9.3 Systems and Equipment

9.3.1 Rudder Force

9.3.1.1 Design rudder force on which scantlings shall be based, shall be calculated as indicated for the main class. The speed of the ship, however, shall not be taken less than V = 10 knots.

9.3.2 Steering Gear

9.3.2.1 Steering shall be capable of bringing the rudder from 35° on one side to 30° on the other side in 20 s, when the vessel is running ahead at maximum service speed.

9.3.3 Anchoring and Mooring Equipment

9.3.3.1 Anchoring and mooring equipment for tugs corresponding to its equipment number, refer Pt 4, Ch 3, Sec 3.1. The term 2 B H in the formula may, however, be substituted by:

$2 (a B + \Sigma h_i b_i)$

Where
b_i= Breadth of the widest superstructure or deckhouse of each tier having a breadh greate than B/4.

9.4 Towing Arrangement

9.4.1 Design Standard

9.4.1.1 The equipment shall meet the requirements in this section. Alternatively, equipment complying with recognized standard may be accepted upon special considerations provided such specifications give reasonable equivalence to the requirements of this section and is fulfilling the intension.

9.4.1.2 Towing arrangement drawing together with the content listed under Documentation Requirement in this Section shall be posted on bridge.

9.4.2 General

9.4.2.1 Structural components such as cargo rails, bulwarks, etc that may support the towline during normal operation, are to have a radius of bend sufficient to avoid damage to the towline.

9.4.2.2 Vessel shall be installed with towing hook or towing winch suitable for its purpose. The towline point of attack is recommended to be located near the mid length of the vessel or other position suitable for the manoeuvrability. The arrangement shall be such that the heeling moment arising when the towline is running in the athwart ships direction, will be as small as possible.

9.4.2.3 Towing arrangement shall be such that the towline is led to the winch drum in a controlled manner under all foreseeable conditions (directions of the towline) and provide proper spooling on drum.

9.4.3 Materials for Equipment

9.4.3.1 Tow hook with attachment shall be made of rolled, forged or cast steel in accordance with Pt 2, Ch 2, Sec 4; Pt 2, Ch 2, Sec 5; Pt 2, Ch 2, Sec 6 and Pt 2, Ch 2, Sec 7.

9.4.3.2 Materials of towing winch shall comply with relevant specifications given in Pt 2.

9.4.3.3 For forged and cast steel with minimum specified tensile strength above 650 N/mm2, specifications of chemical composition and mechanical properties shall be submitted for approval for the relevant equipment.

9.4.3.4 Material of plates in welded parts shall be of the grades as given in Pt 2, Ch 2.

9.4.3.5 Where minimum specified yield is above 0.8 times the minimum specified tensile strength, 0.8 times minimum tensile strength shall be used as minimum specified yield in calculations for structural strength as given in Sec 9.4.5.

9.4.4 Tow Hook

9.4.4.1 Design and scantlings of the towing hook with attachment shall be capable of withstanding a load of minimum 2.5 times the BP without permanent deformations.

9.4.4.2 Tow hooks shall be provided with reliable release arrangement, so that in case of a critical situation, the towline can be immediately released regardless of angle of heel and of direction of towline. The releasing device shall be operable from the bridge.

9.4.5 Winch

9.4.5.1 Control System

For winches the control stands shall provide a safe and logical interface to the operator with operating levers returning to stop position when released and in addition provide a clear view to the drums.

9.4.5.2 Emergency Release

Winches shall be designed to allow drum release in case of an emergency in all operating modes. The release capabilities shall be as specified in the towing arrangement drawing.

The action to release the drum shall be possible locally at the winch and from a position at the bridge with full view and control of the operation. Identical means of equipment for the release operation to be used on all release stations.

After an emergency release the winch brakes shall be in normal function without delay. It shall always be possible to carry out the emergency release sequence (emergency release and/or application of brake), even during a black-out.

Emergency release bottons, control handles etc shall be protected against unintentional operation.

9.4.5.3 Structural Strength

Design and scantlings of the towing winch shall be capable of withstanding the RL without permanent deformations at relevant layer. Buckling and fatigue shall be considered according to recognized standards or code of practice.

9.4.5.4 Drum

Design of the drum shall be based on due consideration to the relevant operations.

The drum diameter for steel wire rope should not be less than 14 times the maximum intended diameter of the rope. However, for all rope types, the rope bending specified by the rope manufacturer should not be exceeded.

9.4.5.5 Towline Attachment

The end attachment of the towline to the winch barrel shall be of limited strength making a weak link in case the towline has to be run out.

A minimum of 3 dead turns of rope are assumed on the drum under normal operation to provide proper attachment.

9.4.5.6 Drum Brake

The brake is normally to act directly on drum and should be capable of holding the RL at inner layer. It shall be arranged for manual operation or other means for activation during failure of the power supply or control system.

9.4.6 **Marking**

Equipment shall be marked to enable them to be readily related to their specifications and manufacturer. When a INTLREG product certificate is required, the equipment shall be clearly marked by the society for identification .

9.5 Stability

9.5.1 General Requirements

9.5.1.1 Requirment in this section apply to vessels with length L_F of 24 m and above.

9.5.1.2 For vessels with a length L_F less than 24 m should as far as practicable comply with the requirements in this section. Other stability requirements may however be applied provided the Society upon consideration in each case finds these requirements to be appropriate for the vessel.

9.5.1.3 Stability of the vessel shall be assessed when the towing line is not in line with the vessel's longitudinal centre line. The towing heeling moment shall be calculated based on the assumption in Sec 9.5.1.4. The criterion in Sec 9.5.1.5 shall be complied with.

Note:
It is acceptable that compliance is demonstrated for actual loading conditions only. The approval will then be limited to the present loading conditions. These initial conditions shall also comply with the relevant intact and damage stability criteria before applying the heeling moment.

9.5.1.4 Towing Heeling Moment

Transverse heeling moment generated by the rudder and propulsion system with maximum thrust and rudder(s) hard over is assumed to act horizontally on the towline as a static transverse force derived from the maximum bollard pull. No vertical force is assumed.

A heeling lever curve as a function of the heeling angle shall be calculated as detailed below:

$$HL_\theta = (h\ F_{thr} \cos\theta) / (g\ \Delta)$$

Where,
h = Towing heeling arm taken as the vertical ditan between the center of the propeller(s) and the fastening point of the towline.
F_{thr} = BP C_T (kN)
BP = Continuous bollard pull measured in accordance with Sec 9.1.5.
C_T = Transverse thrust and rudder force reduction factor depending on the propulsion arrangement.

C_T shall be taken as not less than 0.6 for conventional single or twin propeller propulsion systems with rudders and fixed or no propeller nozzles. This value is increased to 0.7 for ships fitted with moveable nozzles.

C_T for single azimuth thrusters (‘Z-drives’) acting normal to the centreline and for cycloidal drives a value of 1.0 is to be applied.

C_T for two azimuth thrusters is to be taken as (1 + cos γ) / 2, where γ is the offset angle that occurs between the thruster jets when one unit is directed at a right angle to the ship's centreline and the other is directed so that its thrust jet tangentially intersects the nozzle of the first.

Any other values of C_T may be accepted if substantiated based on calcuations.

h = towing heeling arm taken as the vertical distance between the centre of propeller(s) and the fastening point of the towline
g = 9.81 (m/s^2)

Δ = Displacement of the loading condition (t). The displacement, LCG and VCG for the initial loading condition is assumed to remain unchanged.

If the vessel is intended to operate with additional transverse thrusters the heeling lever generated by the propulsion system shall be increased in proportion to the heeling moment generated by such thrusters.

9.5.1.5 Stability Criterion for Tugs

The residual area between the righting lever curve and the heeling lever curve calculated in accordance with Sec 2.5.1.4 shall not be less than 0.09 metre-radians. The area is determined from the first interception of the two curves to the angle of the second interception or the angle of down flooding, whichever is less.

Alternatively, the area under the righting lever curve shall not be less than 1.4 times the area under the heeling lever curve calculated in accordance with Sec 9.5.1.4. The areas are determined between 0° and the angle of the second interception or the angle of down flooding, whichever is less.

9.5.1.6 Stability Criteria for Ocean Tow

For ships intended only for towing operations where the towline is secured against transverse movement near the aft perpendicular the following criteria may be applied, refer Pt 8

The residual area between the righting lever curve and the heeling lever curve calculated in accordance with Sec 9.5.1.4 shall not be less than 0.055 metre-radians. The area is determined from the first interception of the two curves to the angle of the second interception or the angle of down flooding, whichever is less.

The static angle at the first interception shall not be more than 15°.

9.5.1.7 Additional Information

The vessel's stability manual shall contain additional information on the maximum bollard pull, the assumed location of the fastening point of the towline, heeling force and moment and identification of critical flooding points. The heeling lever curve shall be plotted on the GZ curve for all intended towing conditions.

SECTION 10 BARGES

Contents

10.1 General

10.1.1 Introduction

10.1.1.1 Objective

Requirements in this section form the minimum technical standard for barges.

10.1.1.2 Scope

The scope of this section includes arrangement, hull strength, hatches and deck openings, steering arrangement, equipment, machinery and electrical installations, drainage, and stability.

10.1.1.3 Barges intended to carry personnel, the scope also covers basic safety requirements. This includes life saving appliances, fire safety, power supply, and radio communication.

10.1.1.4 Application

Vessels constructed and equipped, surveyed and tested in accordance with the requirements of this section, will be assigned the class notation **Barge**.

10.1.1.5 INTLREG Rules for Ships Pt 2 and Pt 5 applies unless otherwise specified. Pt 3 is replaced by the requirements of this section.

10.1.1.6 A barge may be towed or pushed. For barge to be pushed, refer Ch 5 sect 9”Pusher Tug”).

10.1.1.7 Vessels built in compliance with the requirements as detailed in the Table 10.1.1 below shall be assigned the additional notations, as follows:

Table 10.1.1 Additional Notation - Barge

Class Notations		**Qualifier**		**Requirements**
Name	Description	Name	Description	
Barge	Barges are vessels without sufficient means of self propulsion for transit. Assistance from another vessel during transit or transportation services is ssumed[1]		Hull material: Steel	Sec 3.3
		For “C” [3]	Barge intended for carriage of Chemicals	
		For Deck Cargo [4]	Barge intended for carriage of cargo on deck only	NA[5]
		For Liquified Gas	Barge intended for carriage of liquified gas	Pt.7B Ch.18 (…Liquid gas Carrier)
		For Oil	Barge intended for carriage of oil	Ch 3.

Note:
(1) For vessels with limited means of self-propulsion an upper limit for barges/pontoons may normally be taken as machinery output giving a maximum speed less than V = 3 + L/50 knots, L not to be taken greater than 200 m.

(2) Barge made of concrete will be assigned the class notation Concrete Barge. The survey related class notation BIS is mandatory and requirement given in Pt 3, Ch 1, Sec 3.8 shall be complied with.
(3) "C" denotes th type of cargo for which the barge is classified, referring to specific type of liquid chemical. Example: **Barge for methanol**
(4) Deck cargo is an optional qualifier

10.1.2 Documentation Requirements

10.1.2.1 For class notation **Barge**, documentation shall be submitted as required by Pt 3, Ch 1. In addition, documentation shall be submitted as required by Table 10.1.2.

Table 10.1.2 Documentation Requirements- Notation Barge

Item	Doc Type	Additional Description	(A)/(I)
Towing arrangement	Arrangement Plan	Arrangement of towing line Fastening arrangement and details	(I)
Towing equipment support structures	Structural drawing	Including towing force, design loads and winch load footprint.	(A)
Note: (A) For Approval; (I) For Information			

10.1.2.2 Barges intended for carrying 36 persons or more the following additional following documentation shall be submitted as required in Table 10.1.3.

Table 10.1.3 Documentation Requirements- Barges carrying 36 persons or more

Item	Doc. Type	Additional Description	(A)/(I)
Safety General	Fire control plan		(A)
	Safety control plan		(A)
Structural fire protection arrangements	Structural fire protection drawings		(A)
	Penetration drawing		(A)
Fire detection and alarm systems	Control and monitoring system - Documentation		(A)
	Arrangement plan		(A)
Fire water system	Piping diagram		(A)
	Capacity analysis		(A)
	Arrangement plan		(A)
Fire extinguishing system (Fixed)	Fixed fire extinguishing system documentation		(A)
Escape routes	Escape route drawing		(A)
Ventilation systems	Ducting and instrumentation diagram (D&ID)		(A)
			(A)
Life saving appliances	Life saving arrangement plan		(A)
Note: (A) For Approval; (I) For Information			

10.2 Arrangement

10.2.1 Transverse Bulkheads

10.2.1.1 A collision bulkhead and an after end bulkhead shall be provided for all barges.

10.2.2 Bow Height

10.2.2.1 Minimum bow height requirement as provided in Pt.3 Ch.1 Sec.3 A900 or Pt.3 Ch.2 Sec.3 A900, may be dispensed with for such type of vessels.

Note:
For manned barges the requirement for bow height may clarified with the respective administration.

10.3 Hull Strength – Steel

10.3.1 Longitudinal Strength

10.3.1.1 The minimum midship section modulus within 0.4 L amidships about the horizontal neutral axis based on cargo or ballast condition shall be as provided below:

$Z = 1000 (M_s + M_w) / \sigma_l \quad (cm^3)$

Where,
M_s = Still water bending moment (kNm)
M_w = Wave bending moment (kNm)
= $-0.11\ C_W\ L^2\ B\ (C_B + 0.70)$ (kNm), Sagging
= $0.19\ C_W\ L^2\ B\ C_B$ (kNm), Hogging
C_W = As provided in Fig. 1
= Need not be taken greater than D/1.4

σ_l = $184/k_m$, for sea going condition with M_w as detailed below
= $140/k_m$, for special conditions as detailed in Sec 3.3.1.2.
k_m = Material factor as in Pt 3, Ch 2.
= 1.00 for NV-NS

10.3.1.2 For special harbour conditions (eg. transient states when moving heavy structures on board from end of barge) or when the wave heights are considered to be negligible, the wave bending moment may be taken zero when calculating Z in Sec 3.3.1.1. Correspondingly the most unfavourable M_S should be used in Sec 3.3.1.1. If M_S should occur outside 0.4 L amidships the actual section shall be considered.

The midship section modulus shall not be less than:

$Z = 0.95 (C_{WO}\ k_m)\ L^2\ B\ (C_B + 0.7) \quad (cm^3)$

Where,
C_{WO} = As detailed in Fig 1

10.3.1.3 The section modulus outside 0.4 L amidship, for ordinary barge will normally be satisfactory. In other cases it may be necessary to consider the section modulus in more detail along the ship length. In such cases the distribution of bending moments may be taken as outlined in Pt 3, Ch 5. Acceptable bending stresses at ends may be $85/k_m$ N/mm^2 and $65/k_m$ N/mm^2 for ordinary seagoing and special conditions, respectively.

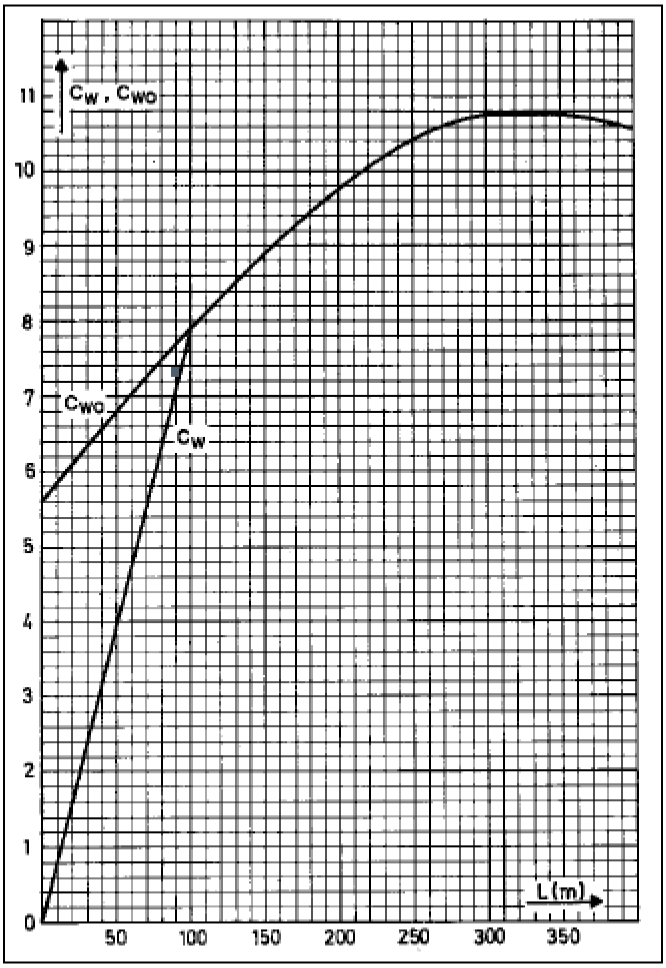


Fig 1 Wave Cefficients

10.3.1.4 Barges with restricted service, C_W and C_{WO} may be reduced as detailed in Table 10.3.1.

Table 10.3.1. Values of C_W and C_{WO}		
Class Notation	**Reduction**	
	Cw	**Cwo**
R0	None	None
R1	None	None
R2	10%	5%
R3	25%	13%
R4	40%	20%
Note: Regarding R0 to R4 refer Pt 1, Ch.1, Sec 4		

10.3.2 **Shear Strength**

10.3.2.1 Shear stresses ship sides and longitudinal bulkheads shall not exceed $110/k_m$ N/mm^2. The corresponding requirements to plating thickness of sides and longitudinal bulkheads may be found in Pt 3, Ch 5, Sec 4.

10.3.2.2 As an alternative to the calculation of plating thickness as outlined in Sec 3.3.2.1 the following approximate formula may be used:

$$\Sigma A \geq 0.10 (Q_s + Q_w) \quad (cm^2)$$

Where,

ΣA = Sum of effective shear areas of ship sides and bulkheads

Q_s = Still water shear force (kN)
Q_w = Wave shear force (kN)

Values and longitudinal distribution of Q_w may be found in Pt 3, Ch 5, Sec 2.2.

For special harbour conditions as detailed in Sec 3.3.1.2 may be accepted to use $Q_W = 0$.

Within 0.6 L amidships or in special areas due to conditions as referred to in 102 the values of ΣA_s shall be as detailed below:

$$\Sigma A_s \geq (2.70\ k_m)\ (LB)^{(1/3)} + \Sigma t_k$$

10.3.3 Local Strength

10.3.3.1 Minimum thickness required for bottom, side and deck plating due to lateral pressure is provided as below:

$$t = k\ s\ (p\ k_m)^{0.5} + t_k \quad \text{(mm)}$$

Where,
p = As detailed in Table 10.3.2.
t_k = Corrosion addition, refer Pt 3, Ch 2.
k = 1.50 for bottom and deck plating within 0.4 L when transverse stiffening and longitudinally stiffened deck plating inw ay of cargo area of vesels with class notation ESP.
= 1.30 Otherwise

10.3.3.2 Minimum thickness of bottom, side and deck plating shall be as provided below:

$$t = 5 + 0.04L\ k_m + t_k \quad \text{(mm)}$$

10.3.3.3 Minimum thickness of stiffeners and web plates shall be:

$$t = 5 + 0.02L\ k_m + t_k \quad \text{(mm)}$$

10.3.3.4 Buckling of plates and plate panel shall comply with Pt 3, Ch 13.

10.3.3.5 Minimum section modulus requirement for the local stiffeners and girders shall be:

$$Z = 83\ s\ p\ l^2\ k\ (1/\sigma) \quad (\text{cm}^3)$$

where,
l = Stiffener or girder span (m)
s = Stiffener or girder spacing (m)
k = $1 + 0.08\ t_k$
p = As provided in Table 10.3.2.
σ = Refer to relevant section in Pt 3.

10.3.3.6 Minimum web area of girder ends shall be as below:

$$A = 0.06\ s\ p\ l + 10\ h\ t_k \quad (\text{cm}^2)$$

Web area at the mid span shall not be less than 50% of the above area. Alternative the web area can be determined on the basis of direct strength calculation, refer Pt 3, Ch 13.

10.3.3.7 Minimum corrosion addition or internal members inside ballast tanks using fresh water from rivers and lakes shall be:

t_k = 2.00 mm within 1.50 m below weather deck tank or cargo hold top.
t_k = 1.00 mm otherwise.

Table 10.3.2 Design Pressures

Item	Location	Pressure p (kN/m^2)
Bottom	Bottom region	$10T + (k_s – 1.50)\ C_W$
Sides	Below waterline	$10h_0 + C_w\ (k_s – [1.50\ h_0/T])$
	Above waterline	$K_s\ (C_w – 0.67\ h_0)$ 10, minimum
Deck	Sea pressure	$0.80\ k_s\ (C_W – 0.67\ h_0)$ 10, minimum
	Cargo pressure	10 q (1 + k[0.35 – 0.0006L])

K = 1.30 at ends
= 0.80 within 0.70L midships. Linear interpolation at intermediate positions
k_s = 5.0 at ends
= 3.00 between 0.2L and 0.70L from aft end
= 8.00 at foreward end
h_0 = Vertical distance (m) from waterline at full drauth to the load point
q = Deck loading (t/m^2) and q not to be taken less than 0.70 t

If restricted service k may be reduced by the same percentage as C_W provided in Table 10.3.1. Reduction of C_W and k may also be considered if transporation is to take place under specified fair weather conditions.

Note:
If liquid cargo or ballast shall be carried the structure shall also be considered as tank structure.

10.3.4 Bottom Structure

10.3.4.1 Barge bottom structure may be built as single or double bottom. In case the vessel is arranged with a double bottom refer to requirements as detailed in Pt 3, Ch 6.

10.3.4.2 The double bottom height shall provide proper access to all the internal parts. The height however shall not be less than 650 mm.

10.3.4.3 Bottom structure of the barge shall be considered as a grillage system being supported by ship sides and/or bulkheads.

The structure is generally to be calculated for a net loading corresponding to p (bottom) given in Table 10.3.2. Acceptable stress levels may be as given for stiffeners in Pt 3, Ch 14, Sec 3.

10.3.4.4 In case the arrangement of the barge is such that the net loading specified in Sec 10.3.4.3 is considered to be unrealistic, reduced net loadings (ie sea pressure-cargo) according to specified loading conditions may be accepted. The reduced net loading should not be less than 50% of the full net loading given in Sec 10.3.4.3.

10.3.4.5 For barges with L > 100 m, the bottom shall be strengthened against slamming, refer Pt 3, Ch 6, Sec 8. In the formula for C2 the ballast draught T_{BF} may be substituted by full draught T.

10.3.5 Deck Structure

10.3.5.1 Incase a grillage system is adopted for the deck structure, direct strength calculations shall be made to verify that for the loading specified in Table 10.3.2 or other specified design loadings, the stresses comply with the levels given in Pt.3 Ch.8.

10.3.5.2 Provided that the deck is subjected to heavy point loads, plans shall be submitted showing the arrangement and position of loads as well as their magnitude.

It shall be specified if all loading points will be subject to loads simultaneously, or if there will be some alternative groupings of the loads. For reduction of dynamic loads, refer notes to Table 10.3.2 factor k.

10.3.5.3 It may be ensured that heavy point loads are preferably supported directly by bulkheads, but complying the with the relevant strength and buckling requirements.

10.3.5.4 Where decks are subjected to wheel loadings, the scantlings shall comply with requirements given in Ch 2, Sec 4.3.

10.3.5.5 Dry cargo barges where the cargo holds and the main deck are supported by cantilevers are to comply with requirements given in Ch 2, Sec 4.

10.3.6 Towing Arrangement

10.3.6.1 Towing components of tow hooks winches, brackets, padeyes with their supporting structure shall be capable of withstanding the breaking load P_b of the towline used for towing the barge.

10.3.6.2 The towline breaking load shall not be taken less than the towline minimum breaking strength provided in equipment table Pt 4, Ch 3, Table 3.3.1.

10.3.6.3 The allowable stress levels in the supporting structure resulting from bending moments and shearing forces calculated for the load P_b provided in Sec 10.3.6.1 or Sec 10.3.6.2 are provided below:

Bending Stress, σ_b $= 210 / k_m$ (N/mm^2)
Shear Stress, τ $= 130 / k_m$ (N/mm^2)
Von Mises Stress, σ_e $= 235 / k_m$ (N/mm^2)
Where,
$\sigma_e = (\sigma_b^2 + 3 \tau^2)^{0.50}$

10.3.7 Deckhouse

10.3.7.1 Deckhouse scanlings shall comply with Pt 3,Ch 10.

10.4 Hatches and Deck Openings

10.4.1 General

10.4.1.1 In barges the deck openings shall be provided with hatch coamings and covers as detailed in Pt 4, Ch 6. Minimum design pressure for hatch covers in dry cargo barges is 3.5 kN/m^2.

10.4.1.2 The closing arrangement of deck openings for barges with restricted service and high freeboard will be specially considered.

10.5 Steering Arrangement

10.5.1 General

10.5.1.1 If rudder is installed, the steering arrangement shall comply with the requirements given in Pt 4, Ch 2 as far as these rules are found to be relevant for barges.
A minimum speed of 8 knots shall be considerd for calculating the rudder force.

10.6 Equipment

10.6.1 General

10.6.1.1 Equipment as detailed in Pt 4, Ch 3, Table 3.3.1 are not required for unmanned barges.

10.6.1.2 Manned barges are required to carry equipment according to Pt 4, Ch 3, Table 3.3.1. However, the required total length of anchor chain cable may be reduced by 50%, based upon a special consideration of the intended service area of the vessel. In such cases a B will be given in brackets after the equipment letter for the vessel. Eg. F(B).

10.7 Machinery and Electrical Installations

10.7.1 General

10.7.1.1 Barges provided with machinery and electrical installation onboard shall comply with relevant requirments provided in Pt 5.

10.8 Drainage

10.8.1.1 Barges are normally to be provided with means for drainage of cargo holds, engine rooms and watertight compartments and tanks which give major contribution to the vessel's buoyancy and floatability.

10.8.1.2 The rules and principles for drainage of ship with propulsion machinery shall be complied with as far as practicable with exemptions as detailed below:

10.8.1.3 Barges that are manned shall be provided with a permanently installed bilge system with power bilge pumps. The bilge system shall have suctions in rooms mentioned in Sec 10.8.1.1.

Additional emergency bilge suction shall be provided in engine rooms.

Dry compartments in fore- and after peaks may be drained by effective hand pumps. Rooms situated on deck may be drained directly overboard.

10.8.1.4 Barges that are manned for unlimited service shall be equipped with two permanently installed bilge pumps. However manned barges with restricted service may have one bilge pump.

Ballast pumps may be used as bilge pumps. Where only one permanently installed bilge pump is installed, this pump shall not serve as fire pump.

10.8.1.5 Ballast systems shall comply with the requirements for ballast systems in ships. However, one ballast pump may be accepted.

Alternative methods for emptying ballast tanks, eg. by means of compressed air and bottom valves, may be accepted upon consideration in each case.

10.8.1.6 Drainage facilities shall be provided even in unmanned barges for compartments rooms mentioned in Sec 10.8.1.1.

For cargo holds the facilities shall be so arranged that drainage can be performed in loaded conditions, for instance by arranging ducts for portable pumps to bilge wells or piping from the connection point of the bilge pump to the bilge wells.

Other compartments which shall be drained by portable equipment shall be provided with suitable access openings for such equipment. Any engine room or pump room shall have bilge suctions to available pumps.

10.8.1.7 Barges that are unmanned may have portable bilge pumping equipment only, arranged with their own power supply. For barges for unlimited service such equipment shall be permanently installed.

For barges for restricted service the rules are based on the assumption that suitable bilge pumping equipment is available on board the barge or on board the towing / pushing vessel. This assumption will be included in the Appendix to the Classification Certificate to be issued for the barge.

10.9 Stability

10.9.1 Stability Requirements

10.9.1.1 Barges with a length of 24 m and above shall comply with the intact stability requirements according to Pt 8.

10.9.1.2 The alternative stability criteria as given in 2008 IS Code Part B Ch.2.2 may be applied for barges with class notation **Barge for Deck Cargo** or **Concrete Barge for Deck Cargo**.

10.10 Safety

10.10.1 General Requirements

10.10.1.1 The requirements in this sub-section are applicable for barges designed to carry 36 persons or more.

10.10.1.2 Builder or yard shall submit evidence of these topics being accepted by the respective Administration, in which the same will be also be acceptable to the Society.

10.10.1.3 Manned barges with less than 36 persons the requirements herein shall be reviewed on a case by case basis.

10.10.2 Fire Safety

10.10.2.1 The barge is to comply with the cargo ship fire safety requirements of Ch.II-2 of SOLAS 1974 as amended.

10.10.3 Life Saving Appliances

10.10.3.1 Barge shall comply with the requirements given in Part A and Section I of Part B of Ch.III of SOLAS 1974, as amended, and with the applicable provisions of the International Life-Saving Appliance (LSA) Code.

10.10.3.2 The barge shall carry one or more lifeboats complying with the requirement of section 4.6, 4.7, 4.8 and 4.9 of the LSA Code of such aggregate capacity on each side of the ship as will accommodate the at least 50% of all persons onboard.

10.10.3.3 Inflatable or rigid liferafts complying with the requirement of section 4.2 and 4.3 of the LSA Code, of such aggregate so that there will be survival craft on each side of the barge to accommodate all persons onboard.

10.10.3.4 In lieu of the requirement in Sec 10.10.3.2 and Sec 10.10.3.3, barges of less than 85 m in length or barges with appropriate damage stability as per SOLAS SPS Code, may carry on each side of the barge one or more liferafts complying with the requirement of section 4.2 and 4.3 of the LSA Code of such aggregate as will accommodate all persons onboard.

10.10.3.5 At least one rescue boat shall be carried onboard and complying with the requirement of section 5 of the LSA Code.

10.10.3.6 Personal life-saving appliances are to comply with requirements as detailed in SOLAS Reg.III/32

10.10.3.7 Survival craft embarkation and launching arrangement is to comply with requirements given in SOLAS Reg.III/33.

10.10.4 Power Supply

10.10.4.1 A minimum of two main generator sets are to be provided. The capacity shall be sufficient to maintain the barge in normal operational conditions with any one main generator out of operation.

10.10.4.2 The emergency source of power provided onboard shall be self contained. The emergency source of power and its associated equipment shall be located on or above the freeboard deck, and independent of the main electrical power required by Sec 10.10.4.1.

10.10.4.3 The requirements for a separate emergency source of power may be omitted for installations with two independent engine rooms when compliant with Pt.6 (Electrical Installation)

10.10.4.4 Upon failure of the main source of electric power, the emergency source of power shall be automatically connected to the emergency switchboard unless a transitional source of power is provided.

The emergency source of power shall be capable of supplying simultaneously the services listed below for at least 18 hours:

- Fire extinguishing system
- Fire detection and alarm system
- General alarm and communication systems
- Navigation and special purpose lights and warning systems including helicopter landing lights
- Emergency lighting for machinery spaces, control stations, alleyways, stairways, exits and elevators
- Emergency lighting for embarkation stations on decks and over sides
- Emergency lighting for stowage position(s) for firemen’s outfits
- Emergency lighting for helicopter landing decks

10.10.4.5 The transitional source of power, if required, shall be capable of supplying the services listed for at leased minutes 30 minutes:

- Emergency lighting
- General alarm and communication systems
- Fire detection and alarm systems

10.10.4.6 Electrical installation in general shall comply with relevant requirements as detailed in Pt.6 Electrical installation).

10.10.5 Radio Communication

10.10.5.1 Each barge is to be provided with a radiotelephone station complying with the provision of Chapter IV of SOLAS 1974 as amended and at least one emergency position-indicating radio beacon (EPIRB).

10.10.5.2 The radio station is to be subject to survey by the administration which issue the licence or its authorised representative before the radio station is put into service.

10.10.5.3 The radio station shall be surveyed once every 12 months, carried out by an officer of the Administration or its authorised representative, or by a qualified radio service engineer from a INTLREG approved local radio firm.

CHAPTER 6 CHEMICAL CARRIERS

CONTENTS

SECTION 1 GENERAL REQUIREMENTS

Contents

1.1 Classification

1.1.1. Application

1.1.1.1 The requirements in this chapter are applice to vessels intended for carriage of liquid chemicals in buk. The requirements heremin shall be considered as supplementary to those given in the main class.

1.1.1.2 Cargo handling and related machinery installations and their auxiliary systems, are to meet the same rule requirements as if they were considered to support a main function

1.1.1.3 The requirements of this chapter are considered to meet the requirements of the International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (IBC Code) and MARPOL 73/78 Annex II.

1.1.1.4 Cargoes covered by the classification in accordance with this chapter are considered to be those listed in IBC Code chapter 17 and 18 and the agreed additions given in the latest IMO MEPC.2/Circ.xx List 1. Nonhazardous cargoes except oil, are covered by the general requirements for main class unless otherwise stated.

1.1.1.5 Those chemical tankers which are also intended for oil carriage shall comply with the requirements in Ch 3.

1.1.1.6 Dry cargo (including vehicles and passengers) and liquid chemicals in bulk with flashpoint not exceeding 60°C is not permitted to be simultaneously carried for ships with class notations as stated in Sec 1.1.2.

1.1.1.7 Refer Pt 3 for vessels with cargo tanks intended for cargoes with specific gravity greater than 1025 kg/m^3.

1.1.1.8 Rules herein apply to ships intended for carriage of liquid chemicals in bulk with a flash point not exceeding 60°C (closed cup test), as well as ships heating its cargo to within 15°C or more of its flashpoint.

1.1.1.9 The requirements for other ships intended for carriage of liquid chemicals in bulk that are non-flammable or have a flashpoint exceeding 60°C, shall be specially considered.

1.1.2. Class Notations

1.1.2.1. Ships built according to Sec 1 to Sec 14 of this chapter may be assigned the class notation as provided below:

Tanker for Chemicals ESP or
Tanker for Chemicals

1.1.2.2. Ships built for carriage of cargoes not requiring full compliance with Sec 1 to Sec 14 may be assigned the class notation:

Tanker for C ESP or
Tanker for C or
Tanker for Chemicals with FP above 60ºC ESP or

Tanker for Chemicals with FP above 60ºC

The above shall be assigned to self propelled ships having integral tanks intended for carriage of liquid chemical in bulk according to IBC code.

1.1.2.3. For ships with the following class notation, the requirements shall be considered on a case by case depending on the nature of the cargo to be carried:

Tanker for C ESP or
Tanker for C or
Tanker for Chemicals with FP above 60ºC ESP or
Tanker for Chemicals with FP above 60ºC

1.1.3. Register Information

1.1.3.1. In the "Register of Vessels" with INTLREG, ships with the notations below may be given a series of letters and numbers describing technical features of the ship a described in Sec 1.1.3.2 to Sec 1.1.3.10.

Tanker for Chemicals ESP or
Tanker for Chemicals

1.1.3.2. Ship type

Damage stability shall be in accordance with IMO's IBC code nd shall be identified by one of the following notations: (Refer Sec 3.)

Ship type 1
Ship type 2
Ship type 3

1.1.3.3. Tank type (a) Refer Sec 1.4.

Tank types shall be identified as below:
a1: (Intergral tank, Type a1)
a2: (Integral tank, Type a2)
a3: (Independent tank, Type a3)
a4: (Independent tank, Type a4)

1.1.3.4. Materials of construction (**ssp**) and (**ss**)

Notation **ssp:**
Indicates cargo piping and all equipment in contact with cargo and cargo vapours is made of stainless steel.

Notation **ss**:
Notation **ss** indicates that the ship has one or more cargo tanks made of stainless steel, solid or clad, and that the pertaining cargo piping and all equipment in contact with cargo and cargo vapours is made of stainless steel.

1.1.3.5. Liquid level gauging device for cargo tanks (b): Refer Sec 13.

b1: Open device
b2: Restriced device
b3: Closed device

b4: Indirect device

1.1.3.6. Cargo Tank Vent System (**c**). Refer Sec 9.

Tank vent systems notation are as specified below:

c1: Open type vent system
c2: Tank vent system, outlet 6 m above deck
c3: Tank vent system, outlet B/3, minimum 6 m above deck, alternatively 3 m above deck and high velocity valves.

1.1.3.7. Ventilation system (**v**)

Note: Currently this notation is not in use

1.1.3.8. Cargo tank overflow control (**f**) refer Sec 13.

Overflow control systems notation for cargo tanks as specified below:
f1: High level alarm
f2: high- high level alarm

1.1.3.9. Cargo stipping efficiency (**str**) refer Sec 6.

Efficiency of the cargo stripping arrangements of a cargo tank and associated cargo piping notation as specified below:
str 0.075: Quantify of resiude not exceeding 0.075 m^3

Note:
*Notations for stripping efficiency according to previous MARPOL 73/78 Annex II requirements, were **str 0.3** and **str 0.1** for residue quantity not in excess of 0.3 m^3 and 0.1 m^3 respectively.*

1.1.3.10. Cofferdam (**k**) refer Sec 3

Cofferdam related notation **k** detailed as below:
k : Bunker tanks are separated from cargo tanks by cofferdam

1.1.3.11. Ship type and tank groups may be indicated in the “Register of Vessels” with INTLREG. This will, for a ship with cargo tanks of different technical standard, be limited to the groups with the lowest and highest technical standard, respectively.

Sample notation as below:
Ship type 3, a1, b2, c2, f1, str 0.075 and
Ship type 2, a2, b3, c3, f2, str 0.075
Combining above two, the notation in register shall be
Ship type 2, a1.2, b2.3, c 2.3, f1.2, str 0.075

Where more than one number is given in connection with a letter, all first and second numbers shall be combined, respectively.

1.2 Definitions

1.2.1 Terms

1.2.1.1 Accommodation Spaces:
Those used as public spaces such as, corridors, cabins, offices, lavatories, hospital, cinemas, games and hobby rooms, barber shops, 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.

1.2.1.2 Air lock:
An enclosed space for entrance between a hazardous area on open deck and a non-hazardous space, arranged to prevent ingress of gas to the non-hazardous space.

1.2.1.3 Boiling point:
The temperature at which a liquid exhibits a vapour pressure equal to the atmospheric barometric pressure.

1.2.1.4 Cargo area:
The part of the ship that contains cargo tanks, slop tanks, cargo pump rooms including pump rooms, cofferdams, ballast or void spaces adjacent to cargo tanks or slop tanks and also deck areas throughout the entire length and breadth of the part of the ship over the above mentioned spaces. Where independent tanks are installed in hold spaces, cofferdams, ballast or void spaces at the after end of the aftermost hold space or at the forward end of the forward-most hold space are excluded from the cargo area.

1.2.1.5 Cargo contro room (CCR):
The space in a ship used in the control of cargo handling operations.

1.2.1.6 Cargo handling spaces:
Includes cargo pump rooms and other enclosed spaces which contain fixed cargo handling equipment and smilar spaces in which work is performed on the cargo. It includes enclosed spaces containing cargo handling systems where cargo liquid, residue or vapour will be present during operation.

1.2.1.7 Cargo handling systems:
Includes piping systems in which cargo liquid, vapour or residue is transferred or likely to occur in operation and includes systems such as cargo pumping systems, cargo stripping systems, drainage systems within the cargo area, cargo tank venting systems, cargo tank washing systems, inert gas systems, vapour emission control systems and gas freeing systems for cargo tanks.

1.2.1.8 Cargo tank:
The liquid tight shell designed to be the primary container of the cargo. Cargo tanks include also slop tanks, residual tanks and other tanks containing cargo.

1.2.1.9 Cargo tank block:
The part of the ship extending from the aft bulkhead of the aftmost cargo tank and to the forward bulkhead of the forward most cargo tank, extending to the full beam of the ship, but not including the area above the deck of cargo deck.

1.2.1.10 Cargo pump room:
Any space that contains pumps and their accessories for the handling of the products covered by the IBC code.

1.2.1.11 Cofferdam:
Is the isolating space between two adjacent steel bulkheads or decks. The space may be a void space or ballast space.

1.2.1.12 Control stations:
Those spaces in which the ship's radio or main navigating equipment or the emergency source of power is located or where the fire recording or fire control equipment is centralised.

1.2.1.13 Design vapour pressure p_0 :
The maximum gauge pressure at the top of the tank which has been used in the design of the tank.

1.2.1.14 Flame screen:
A flame arrester, consisiting of a fine meshed wire gauze of corrosion resistant material.

1.2.1.15 Hazardous area
Area in which an explosive gas atmosphere is or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of electrical apparatus.

Hazardous areas are divided into Zone 0, 1 and 2 as defined below and according to the area classification specified in Sec 12.3.

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

Zone 1:
Area in which an explosive gas atmosphere is likely to occur in normal operation.

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

1.2.1.16 High velocity vent valve:
A cargo tank vent valve which at all flow rates, expels the cargo vapour upwards at a velocity of at least 30 m/s, measured at a distance equal to the nominal diameter of the standpipe above the valve outlet opening.

1.2.1.17 Hold space:
The space in which an independent cargo tank is situated.

1.2.1.18 Independent:
Piping or venting system, for example, is in no way connected to another system and that there are no provisions available for the potential connection to other systems.

1.2.1.19 Liquid cargo:
Is cargo with a vapour pressure below 2.75 bar absolute at 37.8°C.

1.2.1.20 Non-hazardous area
Area not considered to be hazardous.

1.2.1.21 Pressure Vacuum valve (P/V Valve)
The valve which keep the tank pressure within limits, ie the valve that prevents overpressure or under-pressure within appoved limits.

1.2.1.22 Pump room:
Any space located in the cargo area, containing pumps and their accessories for the handling of ballast and oil fuel.

1.2.1.23 Residual tank:
A designated tank for carriage of cargo residues and cargo mixtures typically transferred from slop tanks, cargo tanks and cargo piping. Residual tanks which are intended for this storage of cargo or cargo residue shall comply with the requirements for cargo tanks.

1.2.1.24 For the purpose of cargoes with high vapour pressure (refer IBC Code Chapter 15.14), reference temperature means the temperature corresponding to the vapour pressure of the cargo at the set pressure of the cargo tank pressure relief valve.

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

- Arrangement of two spectacle flanges in series with provisions for detecting leakage into the pipe between the two spectacle flanges.
- Removing spool pieces or valves and blanking the pipe ends

1.2.1.26 Service spaces:
These are spaces 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.

1.2.1.27 Slop tanks:
Tanks designated for the collection of tank draining, tank washing and other cargo mixtures. Slop tanks which are intended for the carriage of cargo liquid or cargo liquid residue shall comply with the requirements for cargo tanks.

1.2.1.28 Spaces not normally entered:
Such spaces include cofferdams, double hull spaces, duct keels, pipe tunnels, stool tanks, spaces containing cargo tanks and other spaces where cargo may accumulate.

1.2.1.29 Spark arrester:
This is a device which prevents sparks from the combustion in prime movers, boilers etc..from reaching the open air.

1.2.1.30 Designated tank decks are detailed below:

- Deck or part of deck within the cargo area, which is located lower than 2.4 m above a deck as described below.
- Deck or part of a deck that formthe top of a cargo tank
- The part of a deck upon which are located cargo tanks, cargo tank hatches, valves, pumps or other equipment intended for loading, discharging or transfer of the cargo.
- That part of a deck within the cargo area which is located lower than the top of a cargo tank.

1.2.1.31 Type of tanks:

Refer Sec 1.5.

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

1.2.1.33 Lining:
An acid-resistant material that is applied to the tank or piping system in a solid state with a defined elasticity property (IACS UI CC6 Rev.1).

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

1.3 Documentation

1.3.1 Documentation requirements

1.3.1.1 Documentatation as detailed in Table 1.3.1 shall be submitted by the builder.

1.3.1.2 Other plans, information or specifications may be required depending on the arrangement and the equipment used in each separate case.

Table 1.3.1 Documentation Requirements –Chemical Tankers

Description	**Doc Type**	**Additional Description**	**(A)/(I)**
Internal access	Ship structure access manual	Shall include details enabling verification of compliance with requirements to safe access to cargo tanks, ballast tanks, cofferdams and other spaces within the cargo area as required by IBC Code – Chapter 3.4	(A)
General arrangement	General Arrangement Plan	Shall include: 1) Doors, air locks, hatches, ventilating pipes and openings, hinged scuttles which can be opened, and other openings to non-	(I)

		hazardous spaces adjacent to the cargo area including spaces in and below the forecastle. 2) Cargo pipes and gas return pipes over the deck with shore connections including stern pipes for cargo discharge or pipes for bow loading arrangement. 3) Ventilating pipes and openings for cargo hatches, pump rooms and other hazardous areas. 4) Doors, hatches and any other openings to pump rooms and other hazardous areas. 5) Cargo hatches, butterworth hatches and any other openings to cargo tanks	
Hazardous area classification	Hazardous area classification drawing		(A)
Electrical equipment in hazardous area	Electrical schematic drawing	Single line diagrams (SLD) for all intrinsically safe circuits, for each circuit including data for verification of the compatibility between the barrier and the field components.	(A)
	Arrangement plan	Where relevant, based on an approved 'Hazardous area classification drawing' where location of electric equipment in hazardous area is added (except battery room, paint stores and gas bottle store).	(A)
	Maintenance manual	As detailed in Sec 12.	(A)
Ventilation systems for hazardous cargo areas	Ducting diagram		(A)
	Capacity analysis		(A)
	Detailed drawing	Rotating parts and casing of fans. Portable ventilators and drawing showing where and how these shall be fitted.	(A)
	Control and monitoring system documentation		(A)
Pollution prevention	Shipboard marine pollution emergency plan (SMPEP)	For ships with gross tonnage ≥ 150	(A)
	Piping diagram	Arrangement and location of underwater discharge outlet(s) including piping system connections to cargo system. Shall include calculations related to size.	(A)
	Procedure and arrangement plan	Developed in accordance with MARPOL, Annex II, Appendix 4 – Standard format for the procedures and arrangements manual.	(A)
	Procedure	Stripping test procedure	(A)

Cargo piping system	Piping diagram	Including cargo stripping system. For vacuum stripping systems details are to include termination of air pipes and openings from drain tanks and other tanks. For ships with cargo pumprooms specification of temperature monitoring equipment for cargo pumps and shaft penetrations shall be included in addition to arrangement of drainage of cargo pumps and piping on the pump room.	(A)
	Detailed drawing	Cargo pump(s)	(A)
	Material specification (Metals)	Declaration by yard on the materials in contact with cargo	(A)
	Operations manual	For Propylene Oxide cargo only. To include filling limit surveys.	(A)
Cargo handling arrangments	Detailed drawing	Gastight bulkhead stuffing boxes: Including details of lubrication arrangement and temperature monitoring.	(A)
Cargo pumps and remotely operated valves control and monitoring system	Piping diagram		(A)
	Control and monitoring system documentation	For ships with cargo pumprooms, specification of temperature monitoring equipment for cargo pumps and shaft penetrations shall be included.	(A)
Vapour return systems	Piping diagram		(A)
Cargo tanks gas-freeing systems	Piping diagram	Serving cargo tanks and cargo pipes. To include types of connections and location of gas-freeing outlets. For fixed gas freeing fan units location and means for prevention of backflow shall be included.	(A)
	Detailed drawing	For systems involving fixed gas freeing fan units, detailed drawings of rotating parts and casing of fans.	(A)
Cargo tank drying systems	Piping diagram	Only applicable for fixed systems.	(A)
Cargo tanks venting system	Piping diagram	Including settings of P/V-devices and type of gasfreeing outlets.	(A)
	Specifications	For P/V-valves, gas freeing covers and other flame arresting elements; Detail drawings, specification of maximum experimental safety gap (MESG), flow curves and references to type approval certificates.	(I)
Cargo tank level measurement system (Fixed)	Control and monitoring system documentation		(A)
	Arrangment plan	Type and location of level indicators shall be indicated.	(I)
Cargo tanks level	Control and monitoring system documentation		(A)

alarm system (Fixed)	Arrangment plan	Type and location of sensors shall be indicated, as well as location of audible and visible alarms	(I)
Cargo tanks pressure monitoring system (Fixed)	Control and monitoring system documentation	If required as a secondary means of cargo tank venting as per Sec.6.	(A)
	Arrangement plan	Type and location of sensors shall be indicated, as well as location of audible and visible alarms.	(I)
Cargo temperature monitoring system	Control and monitoring system documentation	As per the requirement detailed in Sec 7.	(A)
Cargo heating system	Piping diagram		(A)
Cargo tank	Protection cargo tank loction	Refer IBC code, chapter 2.	(A)
Bilge system	Piping diagram	As per the requirement detailed in Pt.5A (Piping system) but shall also include bilge and drainage piping systems serving (eg. pump rooms, cofferdams, pipe tunnels and other dry spaces) within cargo area. The drawing shall include arrangement for transfer of sludge /bilge water to slop tanks if installed. The drawing shall also include number and location of any bilge level sensors.	(A)
Ballast system	Piping diagram	As per the requirement detailed in Pt.5A (…Piping system) but shall also include ballast systems serving ballast tanks in the cargo area Diagram shall include piping arrangement for forepeak tank (if connected to the ballast system serving the cargo area) as well as details related to ballast treatment systems if installed. For ships with cargo pumprooms, specification of temperature monitoring equipment for ballast pumps and shaft penetrations shall be included.	(A)
Inert gas system	Piping diagram	Inert gas distribution to cargo tanks, ballast tanks and cargo piping. Shall include connections to cargo tank venting and vapour return systems.	(A)
	Piping diagram	-P/V breakers -Scrubbers -Double block and bleed arrangements -Non return valves Deck water seals	(A)
	Piping diagram	Piping systems serving the inert gas unit such as compressed air, exhaust gas, fuel supply, water supply and discharge piping.	(A)
	Operation manual	Refer Ch.8 and 11 of MSC/ Circ.353, as amended by MSC/ Circ.387.	(A)
Inert gas generator	Specification	In case installed. Also applicable for Nitrogen generators.	(A)

Inert gas control and monitoring system	Control and monitoring system documentation		(A)
Cargo tanks cleaning system	Piping diagram	The diagram shall include number of and location of cargo tank washing machines	(A)
	Shadow diagram	Applicable only for ETC notation.	(A)
	Arrangement plan	-Hand dipping and gas sampline arrangments. -Washing machines including installation and supporting arrangments.	(A)
Cargo cooling system	Piping diagram	If installed onboard	(A)
Flammable gas detection system	Arrangement plan	Details to include detectors, location of sampling points, call points / alarms and arrangement of sampling piping.	(A)
	Control and monitoring system documentation	Requirements applicable for permanent systems such as required for cargo pump rooms.	(A)
Decontamination shower and eye washer	Piping diagram	Shall include water supply and arrangement to prevent freezing.	(A)
	Arrangement Plan		(A)
Cargo tanks	Arrangement plan		(I)
	NDT plan		(A)
	Tank testing plan		(I)
	Material specification, metals	Applicable for stainless steel tanks and tanks with lining	(I)
	Structural drawing	Antifloatation arrangement and support details	(A)
	Strength analysis	Stress analysis for independent type tanks (a4 only)	(I)
Note: (A) For Approval; (I) For Information			

1.4 Certification

1.4.1. Certification Requirements

1.4.1.1 Components shall be certified as detailed in Table 1.4.1 below. The inert gas system requirements are detailed in Sec 16.

Table 1.4.1 Certification Requirements

Object	Certification Type	Additional Description
Strong points- Emergency towing	NV-P(..Pt 1 INTLREG	
	NV-M(..Pt 1 INTLREG)	
Fairleads- Emergency towing	NV-P(..Pt 1 INTLREG)	
	W-M(..Pt 1 INTLREG)	
P/V Valves, gas freeing valves and flame arrestors	NV-TA(..Pt 1 INTLREG)	
Cargo pumps	NV-P(..Pt 1 INTLREG)	Including stripping pumps

Gas freeing fans- Cargo tanks	NV-P(..Pt 1 INTLREG)	
Hazardous area- Ventilation fans	NV-P(..Pt 1 INTLREG)	Permanently installed fans
Hydrocarbon gas detection/ alarm system (Fixed)	NV-P(..Pt 1 INTLREG)	
Control and monitoring systems- Cargo valves and pumps	NV-P(..Pt 1 INTLREG)	
Level monitoring systems- Cargo tanks	NV-P(..Pt 1 INTLREG)	
Overflow protection alarm system- Cargo tanks	NV-P(..Pt 1 INTLREG)	
Pressure monitoring alarm system- Cargo tanks	NV-P(..Pt 1 INTLREG)	If required as a secondary mean of cargo tank venting as per Sec.5.
Temperature monitoring system- Cargo tanks	NV-P(..Pt 1 INTLREG)	If required as per Sec 13.2.4.
Portable gas detectors	TA (…Pt 1 Intelreg)	Refer Sec13
Associated electric motors and starters shall be certified as indicated in Pt.6(Electrical Installations) NV-P: INTLREG Product certificate NV-TA: INTLREG Type approval certificate (….Pt 1 to be updated on the same) TA: Type approval certificate (Pt 1 to be updated on the same) W-P: Works products certificate (Pt 1 to be updated on the same) NV-M: INTLREG Material certificate (.Pt 1 to be updated on the same) W-M: Works Material certificate (Pt 1 to be updated on the same)		

1.5 Tank Types

1.5.1. Integral Tanks (General)

1.5.1.1 These tanks form a part of ships hull and are influenced in the same manner and by the same loads which stress the adjacent hull structure.

1.5.1.2 Design vapour pressure p_0 generall not to exceed 0.25 bar. If, the hull scantlings are increased accordingly, p_0 may be increased ot a higher value but less than 0.70 bar.

1.5.2. Integral Tanks (Type a1)

1.5.2.1 Such integral tanks (Type a1) are built in such a way that the cargo is separated from the sea by a single skin.

1.5.3. Integral Tanks (Type a2)

1.5.3.1 Such integral tanks (Type a2) are built in such a way that the cargo is separated from the sea by a double skin.

1.5.3.2 The distance between the ship's shell plating (bottom and side) shall comply with the distances given in Sec 3.2.1.2 for Ship type 2 and Sec 3.2.1.3 for Ship type 3.

Note:
If a cargo tank is positioned adjacent to a sea chest, a loading restriction for

water reactive cargoes will be given on the International certificate of fitness for the carriage of dangerous chemical in bulk.

1.5.4. Independent Tanks (General)

1.5.4.1 Such independent tanks do not form a part of the ship's hull. An independent tank is built and installed in such a way that the influence on the tank by the hull's deformation and stresses is minimised. An independent tank does not contribute to the hull strength. An independent tank is normally to have longitudinally rigid fixture to the ship in only one transverse plane. Distance between tanks and hull: Refer Sec 4.1.1.

1.5.5. Independent Tanks (Type a3)

1.5.5.1 Such indpendents tanks (type a3) are self-supporting tanks with a design vapour pressure p_0 not exceeding 0.7 bar.

1.5.6. Independent Tanks (Type a4)

1.5.6.1 Such independent tanks (type a4) are self-supporting pressure vessels with a design vapour pressure higher than 0.7 bar and where the internal pressure is carried mainly as tensile membrane stresses in the tank skin (cylinders, spheres, etc.).

1.6 Filling Limits for Cargo Tanks

1.6.1. General

1.6.1.1 Tanks for liquid cargo shall be so loaded as to avoid the tank becoming liquid full during the voyage taking into consideration the highest temperature which the cargo may reach.

1.7 Signboards

1.7.1. References

1.7.1.1 The signboards are to be provided as detailed below:

- Regarding marking plates for independent tanks refer Sec 8.

- Regarding plates bolted to boundaries facing the cargo area and which can be opened for removal of machinery. These shall be fitted with signboard giving instructions that the plates shall be kept closed unless ship is gas-free, refer Sec 3.4.1.1.

- Regarding pumps and compressors shall not be started before the ventilation system in the electric motor room has been in operation for 15 minutes, refer Sec 10.2.3.2.

- Regarding opening of a lighting fitting. Before opening, its supply circuit shall be disconnected, refer Sec 12.6.1.1.

- Regarding ventilation to be in operation before lighting is turned on in the cargo pump room, refer Sec 12.6.1.2.

- Regarding portable electrical equipment supplied by flexible cables, refer Sec 12.6.1.3. This equipment shall not be used in areas where there is gas danger.

- Regarding welding apparatus. These shall not be used unless the working space and adjacent spaces are gas-free, refer Sec 1.6.1.4.

1.8 Cargo Information

1.8.1. General

1.8.1.1 Latest copy of International Code for Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk, provisions of this Code, shall be on board every ship covered by this Code.

1.8.1.2 Information shall be on board, and available to all concerned, giving the necessary data for the safe carriage of the cargo. Such information should include a cargo stowage plan to be kept in an accessible place, indicating all cargo on board, including each dangerous chemical carried:

1. Comprehensive description of the physical and chemical properties including reacticity necessary for the sfe containment of cargo.
2. In the event of leaks or spills, the action to be taken.
3. Countermeasure against accidental personal contact.
4. Fire-figthing procedures and fire-fighting media.
5. Procedure for cargo transfer, tank cleaning, gas-freeing and ballasting.
6. Those cargoes required to be stabilised or inhibited, the cargo should be refused if the certificate required by these paragrapths are not supplied.

1.9 Procedures and Arrangements Manual

1.9.1. General

1.9.1.1 The vessel shall be provided with a “Procedure and Arrangements Manual” (P&A Manual) developed for the ship in accordance with MARPOL, Annex II, Appendix 4- Standard Format for the Procedures and Arrangments Manual, and approved by Class.

1.9.1.2 Each vessel shall be fitted with equipment and arrangements indicated in its P&A Manual.

SECTION 2 MATERIALS AND HULL STRENGTH

Contents

2.1 General

2.1.1. Selection and Testing

2.1.1.1 Material requirements are provided in Pt.2 in detail.

2.1.1.2 INTLREG reserves the right to stipulate requirements of quality and propetties in each case for materials other than mild steel.

2.1.1.3 For stainless steel used for construction of cargo tanks for the carriage of particular cargoes, the content of molybdenum in the material shall not be less than 2.5% if type SS 316L or SS 316LN is specified.

2.1.1.4 Clad steel will be accepted if the requirements comply with standard industrial practice and IACS / IACS member society requirements are fulfilled. Acceptance of other linings necessary to protect the structural material will be specially considered.

2.1.1.5 Welding procedure tests and production weld tests requirements are detailed in Sec 5 and Sec 6.

2.1.1.6 For certain cargoes as specified in Sec 15 and the IBC Code Chapter 15, special requirements for materials apply.

2.2 Hull

2.2.1. General

2.2.1.1 Material of hull construction shall be in accordanc with the ordinary practice as provided in Pt 3, Ch 2.

2.3 Cargo Tanks

2.3.1. General

2.3.1.1 Materials for integral tanks and independent tanks type a3 may generally be selected in accordance with ordinary practice as given in Pt 3, Ch 2 for hull materials. Materials for independent tanks type a4 (pressure tanks) shall be pressure vessel steel in accordance with Pt 2, Ch 2, Sec 2.

2.4 Cargo Piping

2.4.1. General

2.4.1.1 Cargo pipes shall normally be of steel material. Other materials may be accepted for non-flammable chemicals. Grey cast-iron is not accepted as material of construction in cargo piping on ships with class notation **Tanker for Chemicals**.

2.4.1.2 Bodies of pump housings, valves and fittings shall be of cast steel, nodular cast iron as detailed in Pt 2.

2.4.1.3 Cargo steel pipes shall be tested accoding to relevant parts of Pt 2, Ch 2, Sec 17.

2.4.1.4 Liquid cargo and cargo vapour piping for tanks made of or protected by corrosion-resistant material shall be made of or protected by similar material.

Stainless steel cargo piping, the material shall be in accordance with a recognised standard. It is however recommended that the cargo piping is specified with a minimum content of molybdenum of 2.5%.

2.4.1.5 Reducers outboard of valves or manifold valves and distance pieces, which are connected directly to the cargo pipeline's shore connection on deck, shall be made of steel and of flanged type.

2.4.2. Documentation of Material Quality and Testing

2.4.2.1 Cargo piping system material shall be furnished with one of the following types of documentation according to Table 2.4.1.

2.4.3. Documentation of Material Quality and Testing

2.4.3.1 Cargo piping system materials shall be furnished with one of the following types of documentation according to Table 1.4.1..

NV Certificate, Works Certificate and Test Report are defined in Pt.1 Ch.1 Sec4 (…to be inlcued in Pt 1).

Table 2.4.1 Documentation of Material Quality and Testing

Description	**Material**	**Piping System**	**Nom dia (mm)**	**Documentation Type**		
				NV Certificate	**Work Cerificate**	**Test Report**
Cargo pipes and heating coils including fittings made from pipe		Pressure		X		
		Open ended			X	
Flanges and bolts						X
Bodies of valves and fittings, pump housings, source materials of steel expansion bellows, other pressure containing components not considered as pressure vessels	Steel, nodular cast-iron grade 1&2	Pressure	> 100		X	
		Pressure	≤ 100			X
		Open ended				X
	Copper alloys	Pressure	> 50		X	
		Pressure	≤ 50			X
		Open ended				X

2.5 Hull Strength

2.5.1. Emergency Towing

2.5.1.1 Emergency towing arrangements for chemical carriers of 20,000 tonnes deadweight and above shall comply with requirements in Ch 3. Sec 2.3.5.

2.5.2. Vertically corrugated bulkhead (No stool)

2.5.2.1 A lower stool is to be fitted for vertically corrugated bulkhead and moulded depth equal to or greater than 16 m. The inner bottom and hopper tank plating in way of corrugations is to be of at least the same material yield strength as the attached corrugation and Z-grade steel in accordance with Pt 2, Ch 1, Sec 1.11 shall be used or through thickness properties shall be documented. Brackets shall be arranged below inner bottom and hopper tank plating in line with corrugation webs as far as practicable.

2.5.3. Small Confined Spaces (within or adjacent to cargo taks)

2.5.3.1 Small confined spaces within or adjacent to cargo tanks are not acceptable, due to hazards related to reactivity of cargo. Railings, ladders and similar fittings within cargo tanks shall be of solid type, hollow profiles will not be accepted.

SECTION 3 SHIP ARRANGEMENTS

Contents

3.1 Cargo Tank Location

3.1.1 General

3.1.1.1 Cargo tanks for which **Ship type 1** is required shall be located at a minimum distance from the ship's side shell plating of B/5 or 11.5 m, whichever is less, measured inboard from the ship's side at right angle to the centre line at the level of the summer load line, and at a vertical distance from the moulded line of the bottom shell plating at centre line not less than B/15 or 6 m, whichever is less but not less than 760 mm from the shell plating.

3.1.1.2 Cargo tanks for which **Ship type 2** is required shall be located at a vertical distance from the moulded line of the bottom shell plating at centreline of B/15 or 6 m, whichever is less, but not less than 760 mm from the shell plating.

3.1.1.3 There are no restrictions in respect of cargo tank location, for **Ship Type 3**.

3.1.1.4 Except for **Ship type 1**, suction wells in cargo tanks may protrude into the double bottom below the boundary line defined by the distance given in 102 provided that such wells are as small as practicable and the protrusion below the inner bottom plating does not exceed 25% of the depth of the double bottom or 350 mm, whichever is less.

3.1.1.5 The protrusion of the suction well of independent tanks below the upper limit of bottom damage shall not exceed 350 mm, for vessels without double bottom.

3.2 Location and Separation of Spaces

3.2.1 General

3.2.1.1 At the aft end of cargo area, a cofferdam shall be provided. For spaces which may be approved as cofferdams, refer Sec 4.6.1.

3.2.1.2 Within the cargo tank block fuel oil tanks shall not be situated. Also fuel oil tank are not to extend into protective area of cargo tanks required by Sec 3. Such tanks may, however, be situated at forward and aft end of cargo area instead of cofferdams.

Ships which do not have bunker tanks arranged adjacent to cargo tanks, will get the letter **k** added to the series of letters and numbers given in the “Register of vessels classed with INTLREG”.

3.2.1.3 Category A machinery spaces and boiler spaces shall be positioned aft of the cargo area, but not necessarily aft of fuel oil tanks.

Machinery spaces other than those of category A may be permitted forward of the cargo area, when deemed necessary.

Machinery spaces shall not be located fully nor partly within the cargo area including within eg. pumprooms or other spaces approved as cofferdams, except as specified in Sec 4.2.1.3.

Machinery spaces other than those of category A that contain electrically driven equipment and systems required for cargo handling may upon special considerations be accepted located within the cargo area. Area classification requirements apply. Examples of such systems include hydraulic power units for cargo systems, nitrogen generators and dehumidification plants.

3.2.1.4 The cargo pump room lower portion may be recessed into machinery and boiler spaces to accommodate pumps, provided the deck head of the recess is in general not more than one-third of the moulded depth above the keel, except that in the case of ships of not more than 25 000 tons deadweight, where it can be demonstrated that for reasons of access and satisfactory piping arrangements this is impracticable, a recess in excess of such height may be permitted, though not exceeding one half of the moulded depth above the keel.

3.2.1.5 Accommodation spaces shall not be situated directly onto fuel oil bunker tanks adjacent to cargo tanks. Accommodation spaces and service spaces shall be positioned outside the cargo area, but not necessarily aft of fuel oil tanks.

3.2.1.6 Spaces mentioned in Sec 3.2.1.3 except machinery spaces of category A, may be positioned forward of the cargo area after consideration in each case.

Note:
Machinery spaces other than those of category A may be accepted located in forecastle spaces above forepeak tanks even if said forepeak tank is located adjacent to cargo tank. Bow thruster spaces cannot be located adjacent to cargo tanks (SOLAS Ch.II-2 Reg.4.5.1.3).

3.2.1.7 Incase installation of a navigation space above the cargo area is shown to be necessary, and it shall be separated from the cargo tank deck by means of an open space with a height of at least 2 m. Such navigation space shall only be for navigation purposes.

3.2.1.8 A permanent continuous coaming of minimum 100 mm high surrounding the cargo deck shall be provided to contain deck spills, which shall be kept away from accommodation and service areas and from discharge into the sea. In the aft corners of the cargo deck the coaming must be at least 300 mm high and extend at least 4.5 m forward from each corner and inboard from side to side. Scupper plugs of mechanical type are required. Means of draining or removing oil or oily water within the coamings shall be provided.

3.2.1.9 Where a corner-to-corner situation occurs between a non-hazardous space and a cargo tank, a cofferdam created by a diagonal plate across the corner on the non-hazardous side, may be accepted as separation. Such cofferdams shall be provided with arrangements for inerting, drainage, gas-freeing and inspection from open deck. Refer Sec 2.5.3.

3.2.1.10 Within the cargo area paint lockers shall not be located.

3.3 Arrangement of Entrances and Other Openings

3.3.1 Accommodation and Non-hazardous Spaces

3.3.1.1 Air inlets, entrances and openings to accommodation spaces, service spaces, control stations and machinery spaces shall not face the cargo area. They shall be located on the end bulkhead and or on the outboard side of the superstructure or deckhouse at a distance of at least L/25 but not less than 3 m from the end of the superstructure or deckhouse facing the cargo area. This distance, however, need not exceed 5 m.

The following shall be applicable, withint the limits specified above:

- Windows and sidescuttles shall be of the fixed (non-opening) type. Such windows and sidescuttles except wheelhouse windows, shall be constructed to A-60 class standard.

- Wheelhouse windows may be non-fixed and wheelhouse doors may be located within the limits as long as they are so designed that a rapid and efficient gas and vapour tightening of the wheelhouse can be ensured.

- Bolted plates for removal of machinery may be fitted. Such plates shall be insulated to A-60 class standard. Signboards giving instruction that the plates shall be kept closed unless the ship is gas-free, shall be posted on board.

- Sidescuttles according to Sec 3.3, in the first tier on the main deck shall be fitted with inside covers of steel or equivalent material.

3.3.1.2 Spaces not covered by Sec 3.3.1.3 (including cargo control rooms, stores) but located within accommodation, service and control stations spaces, may be permitted to have doors facing the cargo area. Where such doors are fitted, the spaces shall not have access to the spaces covered by Sec 3.3.1.3 and the boundaries of the spaces shall be insulated to A-60 class.

3.3.1.3 The following provisions apply for access and openings to non-hazardous spaces other than accommodation and service spaces:

a. Entrances from hazardous areas on the open deck shall normally not be arranged. If air locks are arranged such entrances may, however, be approved. Refer Sec 3.3.1.5 and Sec 3.3.1.6.

b. From hazardous spaces entrances shall not be arranged.

3.3.1.4 For the spaces mentioned in Sec 3.3.1.1, the ventilation inlets shall be located as far as practicable from gasdangerous zones, and in no case are the ventilation inlets nor outlets to be located closer to the cargo area than specified for openings in Sec 3.3.1.1.

3.3.1.5 Entrance through air locks to non-hazardous spaces shall be arranged at a horizontal distance of at least 3 m from any opening to a hazardous space containing gas sources, such as valves, hose connection or pump used with the cargo.

3.3.1.6 Where air locks are provided, it shall comply with the following:

- For requirements on ventilation of air locks refer Sec 10.

- Air locks shall be enclosed by gastight steel bulkheads with two substantially gas tight self-closing doors spaced at least 1.5 m and not more than 2.5 m apart. The door sill height shall comply with requirements given in Pt 4, Ch 6, but shall not be less than 300 mm.

- Air locks shall not be used for other purposes, for instance as store rooms. Air locks shall have a simple geometrical form. They shall provide free and easy passage, and shall have a deck area not less than 1.5 m^2.

- An audio visual alarm shall be triggered on both sides of the air lock to indicate if more than one door have been moved from the closed position.

3.3.2 Hazardous Spaces and Cargo Tanks

3.3.2.1 The entrances to pump room shall be from open deck.

3.3.2.2 Doors to hazardous spaces, situated completely upon the open deck, shall have as low a sill height as possible.

3.3.2.3 No hatches, openings for ventilation, ullage plugs or inspection openings shall be arranged in enclosed compartments for the cargo tanks.

3.3.3 Access to Spaces in Cargo Area (Cargo Tanks, Void Spaces, Other Spaces)

3.3.3.1 Void spaces, cargo tanks and other spaces in the cargo area shall be arranged so as to ensure adequate access for complete inspection.

3.3.3.2 Access to double bottom spaces may be through a cargo pump room, pump room, deep cofferdam, pipe tunnel or similar compartments, subject to consideration of ventilation aspects. Access to cofferdams, ballast tanks, cargo tanks and other spaces in the cargo area shall be directed from the open deck.

3.3.3.3 For access through horizontal openings, hatches or manholes, the dimensions shall be sufficient to allow a person wearing a breathing apparatus to ascend or descend without obstruction and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of the space. The minimum clear opening shall be not less than 600 mm × 600 mm.

3.3.3.4 For access through vertical openings, or manholes providing passage through the length and breadth of the space, the minimum clear opening shall be not less than 600 mm × 800 mm at a height of not more than 600 mm from the bottom shell plating unless gratings or other footholds are provided.

3.3.3.5 Under special circumstances, smaller dimensions than those specified in Sec 3.3.3.3 and Sec 3.3.3.4 may be approved, but at the descrition of the Society.

3.4 Protection of Crew

3.4.1 Arrangement

3.4.1.1 Bulwarks, gurad rails and arrangements for safe access to bow shall be arranged in accordance with Pt.3 (…Protection of crew). On tank deck open guard rails are normally to be fitted. Plate bulwarks, with a 230 mm high continuous opening at lower edge, may be accepted upon consideration of the deck arrangement and probable gas accumulation.

For safe access to bow, permanent constructed gangways of substantial strength and shall be constructed of fire resistant and non-slip material.

3.4.1.2 Insulation or mechanical shielding shall be provided for surfaces with a surface temperature above 60°C, if they are so located that crew may come in contact with them during normal operation or access.

3.5 Cargo Pump Rooms, Coofferdams, Pipe Tunnels

3.5.1 General

3.5.1.1 Ships certified for carriage of corrosive cargoes, pump room tank top arrangements shall be installed to deal with possible leakage from cargo pumps and valves in the pump room.

3.5.1.2 Under pumps and pipe connections, the floors or decks for acid shall have a lining or coating of corrosion-resistant material extending up to a minimum height of 500 mm on the bounding bulkheads or coamings. Hatches or other openings in such floors or decks should be raised to a minimum height of 500 mm.

3.5.1.3 Where cofferdams are provided they shall be of sufficient size for easy access to all parts. Minimum requirements to distance between bulkheads shall be in accordance with Sec 3.3.3, however not less than 600 mm.

3.5.1.4 Pump rooms and ballast tanks are also considered as coffer dams. Refer Sec 3.3.1.2.

3.5.1.5 Spacs surrounding independent tanks, are also normally considered as cofferdams.

3.5.1.6 Ample space for proper inspection of the pipes shall be available in pipe tunnels, and the pipes shall be situated as high as possible above the ship's bottom.

3.5.1.7 No connection between a pipe tunnel and the engine room, either by pipes or manholes, shall be acceptable in ships with integral tanks.

3.6 Diesel Enginers Driving Emegrency Fire Pumps (etc)

3.6.1 General

3.6.1.1 Non-hazardous area shall be used to house diesel engine drivn fire pumps etc.

3.6.1.2 Diesel engine exhaust pipe shall be provided with an effective spark arrester and shall be led out to the atmosphere at a s safe distance from hazardous areas.

3.7 Chain Locker and Windlass

3.7.1 General

3.7.1.1 Non-hazardous area shall be used to house the chain locker. Windlass and chain ppes also shall be located in a non-hazardous area.

3.8 Anodes, Washing Machines and Other Fittings in Tanks and Cofferdams

3.8.1 General

3.8.1.1 Washing machines, anodes and other permanently attached fittings/ units in tanks and cofferdams shall be well secured and fastened to the structure. These units shall be able to withstand sloshing in tanks, vibratory loads as well as other loads which are likely to be happen during service.

Note:
Construction materials in permanently attached units in tanks and cofferdams, shall be selected with due consideration to the contact spark-producing properties.

3.9 Slop Tanks

3.9.1 Arrangement

3.9.1.1 One or more slop tanks for storage of contaminated bilge water from cargo area and tank washings shall be provided. Means shall be provided to transfer contaminated water to on-shore slop tanks. Cargo tanks may be accepted as slop tanks.

Note:
In accordance with Reg.29 of MARPOL Annex I, a dedicated slop tank must be designated for ships also carrying oil as cargo.

3.10 Stowage of Cargo Samples

3.10.1 General

3.10.1.1 Samples which are to be retained on board, should be stowed in a designated space situated in the cargo area or, exceptionally, elsewhere subject to special approval.

3.10.2 Arrangement

3.10.2.1 Stowage space shall be as detailed below:

- Made of material fully resistant to the various liquids intended to be stowed.

Note:
Could be achieved by placing the bottled in leak tight bozed of resistant material or arranging a spill containment tray of resistant material in the bottom of the locker.

- Cell divided in order to avoid shifting of the bottles at sea.
- Provided with adequate ventilation arrangements.

3.10.2.2 Samples, which react with each other dangerously, shall not be stowed close to each other.

3.10.2.3 Samples shall not be retained on board longer than necessary.

SECTION 4 ARRANGEMENT IN HOLD SPACES

Contents

4.1 General

4.1.1 Distance Between Tanks and Hull

4.1.1.1 Sufficient and reasonable space for inspection and maintenance shall be ensured while finalising the distance between independent tanks and the distance between such tanks and parts of the hull.

Note:
The clear distance btween independent tanks and inner bottom shall generally ne not less than 400 mm. The clear distance between tanks and web frmaes should not be less than 50 mm. The clear distance between independent tanks and the inner edge of ordinary frmaes should not be less than 500 mm.

4.1.1.2 Distance btweel the ships shell and the independent tank shall not be less than 760 mm.

4.1.1.3 The vertical distance between independent tanks and the outer bottom shall not be less than B/15. Drainage sumps will be considered in each case.

4.2 Gas Pressure Relief Devices

4.2.1 Pressure/ Vacuum Relief Valves

4.2.1.1 Pressure and vacuum relief valves shall be provided in spaces for independent tanks which can be completely closed. The number and size of these valves shall be decided depending on size and shape of the spaces.

4.2.1.2 Valves shall normally open at a pressure of 0.15 bar above and below the atmospheric pressure.

4.3 Sealing Around Tanks

4.3.1 General

4.3.1.1 An effective and efficient sealing shall be provided where independent tanks extend above the upper deck. The sealing material shall be such that it will not deteriorate, even at considerable movements between the tanks and the deck.

Sealing shall be able to withstand all temperatures and environmental hazards which may be expected.

4.4 Earth Connections

4.4.1 General

4.4.1.1 For each tank at least two effective earth connections shall be provided between the tank and the hull.

SECTION 5 SCANTLING AND TESTING OF CARGO TANKS

Contents

5.1 Scantling of Cargo Tanks

5.1.1 Integral Tanks

5.1.1.1 The scantlings of integral tanks shall be in accordance with Pt 3.

Direct strength calculation principles shall comply with the requirements of Ch 3, Sec 2.

The minimum thickness requirements shall be considered on a case to case basis for materials other than mild steel.

5.1.2 Independent Tanks

5.1.2.1 The scantlings of independent tanks, constructed mainly of plane surfaces, shall be in accordance with relevant requirements given in Pt 3.

Tanks of pressure vessel configuration type (cylinders, spheres etc.) shall be in accordance with the requirements given in Ch.18(…Liquid gas carriers.)

5.2 Requirements for Testing of Welds and NDT

5.2.1 General

5.2.1.1 Non-destructive testing (NDT) of tank shell welds for chemical tankers with **Ship type 1** and **Ship type 2** notations shall be carried out as given in Table 5.2.1. For chemical tankers with **Ship type 3** notation, non-destructive testing shall be as for oil carriers.

5.2.1.2 Weld crossings and highly stressed connections shall be subjected to most of the testing

The Society may approve ultrasonic testing in lieu of or in addition to radiographic testing. Where such ultrasonic testing is carried out, the Society may require supplementary radiographic testing. Further, the Society may require ultrasonic testing in addition to radiographic testing. For surface crack detection magnetic particle testing is to be used for ferromagnetic materials and penetrant testing is to be used for nonferromagnetic materials. The quality of welds in steel is to comply with ISO 5817 quality level B.

5.2.2 Welding Procedure Tests

5.2.2.1 For independent tanks welding procedure test are required to be carried out.

5.2.3 Weld Production Tests

5.2.3.1 Weld production tests are required for independent tanks type **a4** (pressure tanks) and independent tanks **a3** (atmospheric), if of pressure vessel configuration ie. cylindrical, spherical.

The requirements for weld production testing are as for independent cargo tanks type C in Ch.18. (…Liquid gas carriers.)

Table 5.2.1 Non-Destructuive Testing of Tank Welds

Tank Type		**Non-destructive Testing**	
		Butt Welds [1] [4] Minimum extend of radiographic testing, % of total weld length	**Welds other than Butt Welds. Surface crack detection, % of total weld length**
Integral Tanks [2]	**a1**	1 %	[3]
	a2	2 %	[3]
Independent Tanks	**a3**	20 %	10%, Nozzles: 100%
	a4	Longitudinal welds: 100% Transverse welds: 10%	10%, Nozzles: 100%

Note:
[1]Butt welds of face plates and web plates of girders, stiffening rings etc. shall be radiographically tested as considered necessary.
[2]Guidance: Where double continuous fillet weld is used, full penetration weld at some points is recommended in order to reduce the possibility of leakage along the root of the fillet weld.
[3]The extent of surface crack detection will be decided on the basis of the visual inspection of the boundary welds. Normally this will be 2% to 5% of the total weld length.
[4]Ultrasonic testing may supplement or substitute radiographic testing in accordance with Sec 5.2.1.2.

SECTION 6 PIPING SYSTEMS IN THE CARGO AREA

Contents

6.1 Piping Systems- Not Used for Cargo

6.1.1 General

6.1.1.1 The piping systems serving the cargo area and the systems in the remainder of the ship shall not have any connections, except as specially permitted by this section.

Note:
Piping systems for hydraulic oil, fuel lines, compressed air, steam and condensate, fire and foam located in the cargo area are permitted to be connected to systems in the remainder of the ship, provided they are not permanently connected to cargo handling systems or have open ends in cargo tanks.

6.1.1.2 Compressed air, hydraulic oil piping system which serve systems within tanks or spaces that are not used for cargo shall not be led through cargo tanks.

6.1.1.3 Piping systems such as hydraulic oil serving systems within cargo tanks, shall be led to tanks from deck level and not penetrate boundaries between cargo tanks and tanks and compartments that do not contain cargo.

6.1.1.4 All pipings led from machinery spaces into the cargo area shall be provided with means to preserve the integrity of the machinery space bulkhead.

6.1.1.5 The heating systems temperature in the cargo area shall not exceed the temperature determined by the required temperature class of the equipment as specified for the cargoes to be carried or 220°C, whichever is less.

6.1.1.6 Hazardous spaces (including any compartment or tank, cofferdams or void) within the cargo area shall only be drained by bilge pumps or ejectors located within the space itself or within a space with an equivalent hazard.

6.1.1.7 Pipe tunnels shall be drained from the cargo pump room or an equivalent hazardous space.

6.1.1.8 Piping systems such as ballast and other piping such as sounding and vent piping to ballast tanks shall not pass through cargo tanks.

6.1.2 Cargo Pump Rooms

6.1.2.1 Two options for drainage shall be provided, one of which shall be operable from open deck. One ejector with two sources of supply will be accepted.

6.1.2.2 For the drainage of the cargo pump rooms, bilge pump or ejector independent of the cargo pumps shall be fitted.

6.1.2.3 Bilge pipes in a crago pump room shall not be led into engine room.

6.1.3 Pipe Tunnels and Cofferdams

6.1.3.1 Pipe tunnels and cofferdams shall be provided with sounding pipes and with air pipes led to the atmosphere. For ships carrying flammable cargoes, the air pipes shall be fitted with flame screens at their outlets.

6.1.3.2 Permanent means for bilge drainage shall be provided for pipe tunnels, cofferdams, voids and other dry compartments below main deck and within the cargo area.

Note:
Portable draining arrangments may be accepted for voids, located at main deck level with direct access from open deck (eg. transverse upper stool spaces). Arrangements where the use of the portable drainage equipment requires entry into the void will not be accepted.

6.1.4 Spaces for Independent Tanks

6.1.4.1 Spaces with independent tanks shall be connected to a bilge system.

6.1.4.2 The capacity is normally to be such that the requirements detailed in Pt.5A (…Piping system) are complied with. However, these requirements may be reduced by 50%, when the volume of the tanks is more than 75% of the total volume of the space.

6.1.4.3 Pipe connections shall be so arranged that cargo cannot be pumped into the spaces due to incorrect operation of valves etc. Cargo pumps may be accepted for bilge system purposes to spaces for independent tanks when the pumps are so arranged that they effectively can be used for this purpose. The necessary pipe connection between cargo pumps and the space around the tanks shall not penetrate any part of tank walls situated in closed spaces or lower than the liquid level to maximum filling of the tank.

6.1.5 Ballast Systems

6.1.5.1 Filling or discharge of tanks within cargo area with ballast shall be carried out from the cargo pump room, a similar hazardous space or from inside ballast tanks, except as permitted by Sec 6.1.5.2.

6.1.5.2 Ballast lines, vent lines, pumps and other similar equipment serving permanent ballast tanks should be independent of similar equipment serving cargo tanks and from cargo tanks themselves. Discharge arrangements for permanent ballast tanks sited immediately adjacent to cargo tanks should be outside engine room and accommodation spaces. Filling arrangements may be in the engine room provided that such arrangements ensure filling from tank deck level and non-return valves are fitted.

6.1.5.3 Filling of ballast in cargo tanks may be arranged from deck level by pumps serving permanent ballast tanks, provided that the filling line has no permanent connection to cargo tanks or piping and that non-return valves are fitted.

6.1.5.4 The formation of static electricity is to be minimised by proper arrangement of filling lines to permanent ballast tanks, ie by reducing the free fall into the tank to a minimum.

6.1.5.5 Seawater suction to permanent ballast tanks shall not be arranged in the same sea chest as used for discharge of ballast water from cargo tanks, refer Sec 6.2.3.5 in addition.

Note:
Discharge of ballast water from cargo tanks shall be arranged at the opposite side of sea water suction.

6.1.5.6 Forward of cargo area, the lines from engine room to ballast tanks shall be carried outside cargo tanks.

6.1.5.7 For details of the requirements to drainage o ballast tanks, refer Pt.5A (…Piping systems) .

6.1.5.8 Ballast water treatment systems are to comply with the safety requirements of Pt.5A (…Ballast water management) .

6.1.6 Forepeak Ballast Tank

6.1.6.1 Ballasting of the forepeak tank may be carried out with the system serving ballast tanks within the cargo area, provided:

- Forepeak tank is considered hazardous.
- Means are provided, on the open deck, to allow measurement of flammable gas concentrations within the tank by a suitable portable instrument.
- The air pipes shall be located on open deck. The hazardous zone classification in way of the air pipe shall be in accordance with Sec 12.
- The access to the forepeak and the sounding arrangements are directly from open deck. In case the forepeak tank is separated by cofferdams from the cargo tanks, an access through a gas tight bolted manhole located in an enclosed space may be accepted. In that case, a warning sign shall be provided at the manhole stating that the tank may only be opened after it has been proven to be gas free or the electrical equipment which is not certified safe in the enclosed space, is isolated.

6.1.7 Fuel Oil Tanks

6.1.7.1 Fuel oil bunker tanks situated at forward or aft end of the cargo area may be connected directly to pumps in the engine room. The pipes shall not pass through cargo tanks.

6.2 Piping Systems - For Cargo

6.2.1 General

6.2.1.1 Complete cargo piping and pumps shall be provided for the cargo tanks and positioned within the cargo area, except for bow and stern loading systems complying with Sec 6.5.

Steam and water systems shall be connected to the cargo piping only by non-permanent means, and be fitted with a non-return valve in the cargo area upstream of the first outlet branch.

Cargo piping system shall be entirely separate from all other piping systems on board.

Regrding piping for ventilation or inerting purposes, refer Sec 9.

6.2.1.2 Dimensioning of the cargo piping system shall be in compliance with Pt.4 Ch.6 Sec.9. The design pressure p is the maximum working pressure to which the system may be subjected. Due consideration shall be given to possible liquid hammer in connection with the closing of valves.

The minimum design pressure for cargo piping system shall be considered as 10 bar. For ships designed for the carriage of high density cargo, including partially loaded tanks, the design pressure shall take into account the density of such cargo.

Note:
Maximum pressure will occur with the cargo pump running at full speed against closed manifold valve, when pumping cargo with the maximum design density (regardless of cargo tank filling limitations).
As an alternative to increased design pressure when carrying high density cargo, a pressure monitoring system which automatically prevents the design pressure from being exceeded may be accepted. The system shall activate an alarm at the cargo control station. The system shall not impair the operation of ballast and bilge pumps connected to the cargo pump power supply system.

6.2.1.3 The cargo piping shall be joined by butt welding with a minimum of flange connections. Where flanges are used they shall comply with the following:

- Flange connections in piping systems constructed of materials other than mild steel, will be especially considered.
- Flange types A, B and C will be accepted in piping systems with design pressure $p \leq 16$ bar.
- Flange types A and B will be accepted in piping systems with design pressure $p > 16$ bar. Refer Pt.5A (Piping Systems).

6.2.1.4 All cargo piping shall be electrically bonded to the ship's hull and the resistance to earth from any point in the piping system shall not exceed 10^6 Ω.

Piping sections not permanently connected to the hull, shall be electrically bonded to the hull by bonding straps.

Fix points may be considered as an effective bonding.

Distance pieces and reducers in way of manifold valves, refer Sec 2.4.1.5.

6.2.2 Cargo Pumps

6.2.2.1 Two independently driven cargo pumps shall be installed to the system for cargo handling.

6.2.2.2 Where cargo tanks are equipped with independent pumps (eg. deep well pumps), the installation of one pump per tank may be approved in tankers. Satisfactory facilities shall be provided for emptying the tanks in case of failure of the regular pump.

6.2.2.3 Cargo pumps submerged in cargo tanks and hydraulically powered (eg. deep well pumps), shall be arranged with double barriers, preventing the hydraulic system serving the pumps from being directly exposed to the cargo. The double barrier shall be arranged for detection and drainage of possible cargo leakage.

6.2.2.4 Cargo pumps shall be certified as required by Sec 1, Table 1.4.1. For electrically driven pumps, associated electric motors and motor starters shall be certified as required by Pt. 6 (…Electrical). For steam driven pumps, steam turbines shall be certified in accordance with Pt.5A (…Piping systems). For hydraulically driven pumps, hydraulic pumps shall be certified in accordance with Pt.5A (…Piping systems???).

6.2.2.5 Gastight glands shall be fitted where machinery in cargo pump room or other hazardous spaces are driven by shafting passing into the pump room through bulkheads or deck plating. The glands shall be efficiently lubricated and shall be constructed so as to reduce the risk of overheating. The glands shall be visible and easily accessible.

Parts which may accidentally come into contact if the seal is badly aligned or if a bearing is damaged, shall be of such material that no spark will occur. If an expansion below is fitted, it shall be hydraulically pressure tested.

6.2.2.6 Relief valves with discharge to the suction line shall be provided for displacement pumps.

6.2.2.7 The cargo pump shall be capable of being stopped from an easily accessible position outside the pump room.

6.2.3 General Design and Arrangement

6.2.3.1 Valves or branch pieces, which connect the cargo pipeline's shore connection on deck, and cargo piping shall be supported with due regard to load stresses.

6.2.3.2 Expansion elements shall be provided in the cargo piping system as necessary. The elements shall not be of the sliding type.

6.2.3.3 The formation of static electricity is to be minimized by proper arrangement of filling lines to cargo tanks, Eg. by reducing the free fall into the tank to a minimum.

6.2.3.4 The discharge of ballast water from cargo tanks shall be arranged in such a way as to prevent the ballast water from being drawn into sea suctions for other pipe systems, eg. cooling water systems for machinery.

6.2.3.5 Cargo piping systems shall not be installed under deck between the outboard side of the cargo containment spaces and the skin of the ship, unless clearances required in Sec 6.2.3.5 are maintained. This requirement does not apply when damage to the pipe would not cause release of cargo.

6.2.3.6 Provisions shall be made for proper drainage of cargo lines.

6.2.3.7 Runs of cargo piping, located below the weather deck, may run from the tank they serve and penetrate tank bulkheads or boundaries common to adjacent (longitudinally or transversely) cargo tanks, ballast tanks or empty tanks or pump rooms, provided that inside the tank they serve, the runs are fitted with a stop valve operable from the weather deck.

Where a cargo tank is adjacent to a pump room the stop valve operable from the weather deck may be situated on the tank bulkhead on the pump room side, as an exception, provided an additional valve is fitted between the bulkhead valve and the cargo pump.

Where penetrations occur in other dry compartments such as voids, cofferdams and pipe tunnels, a totally enclosed hydraulically operated valve located outside the cargo tank may however be accepted provided that:

- The valve is fitted to the bulkhead to the cargo tank served.
- The valve is specifically designed to prevent leakage in way of valve glands into the space where the valve is located.
- The valve is not located within the damage area as determined by damage stability requirements.
- The valve is operable from a manned control station on or above weather deck.
- The space in which the valve is located is provided with means for detection of leakages.
- The space in question is arranged for containing leakages from the cargoes carried.

6.2.3.8 Inside the pipe tunnels the various runs of cargo piping are also to comply with the requirements in Sec 6.2.3.7 and Sec 6.2.3.10. The tunnel shall not have any other openings except to the weather deck and the pump room.

6.2.3.9 Cargo piping passing through bulkheads shall not utilise flanges bolted through the bulkhead.

6.2.3.10 Where a pump serves more than one tank, in any pump room, a stop valve shall be fitted in the line to each tank.

6.2.3.11 At each cargo hose shore connection, a stop valve shall be fitted.

6.2.3.12 A manually operated stop valve, shall be fitted on each tank filling and discharge line, located near the tank penetration. If individual deep-well pumps are installed, a stop valve at the tank is not required on the discharge line.

6.2.3.13 Cargo lines shall be provded with efficient means for gas-freeing.

6.2.3.14 The controls necessary during transfer and or transport of cargoes other than in pump rooms which have been specially dealt with shall not be located below the weather deck.

6.2.3.15 In case of pressure type independent cargo tanks, all pipe connections shall be above the liquid level.

6.2.3.16 From cargo deck, drip trays etc. the drainage sytems are to be arranged for transfer to cargo or slop tanks. Connections to cargo and slop tanks shall be arranged for separation by spool pieces or similar and are to be provided with means for prevention of backflow of vapour.

6.2.3.17 Ships that are to be certified for simultaneous carriage of cargoes, residues of cargoes or mixtures which react in a hazardous manner with other cargoes, residues or mixes onboard, shall have separate cargo tank venting systems as well as separate cargo handling systems which shall not pass through other cargo tanks containing such cargoes, residues or mixes. Means for separation shall be located outside cargo tanks, in open air and shall consist of spool pieces or similar.

Note:
For information regarding incompatibility of cargoes and mixes, reference is made to USCG 46 CFR part 150 Compatiblity of cargoes.

6.2.4 Pressure Indication

6.2.4.1 Outside of the pump room a pump discharge pressure gauges shall be provided.

6.2.5 Welding Procedure Tests

6.2.5.1 Cargo piping of austenitic stainless steel are to be subjected to welding procedure tests.

6.2.5.2 Requirements are as detailed in Pt 2, Ch 3, Sec 1.1.4, except that Charpy tests are not required for austenitic stainless steel.

6.2.5.3 If previous welding procedure tests for similar material, thicknesses and welding positions are satisfactorily documented then special welding procedure tests will not be required.

Note:
To comply with the requirements for passing radiographic testing of welding of butt joints on stainless steel pipes, it is strongly recommended that welding is carried out with nitrogen or argon as backing-gas inside piping.

6.2.6 Testing

6.2.6.1 Radiographic testing covering at least 10% of the butt weld in cargo piping connection is to be carried out, when steel pipes are used. This percentage may be increased as found necessary by the Surveyor. The quality of the welds in steel shall comply with ISO 5817 quality level B.

6.2.6.2 Hydrostatic testing of cargo piping shall be carried out in the presence of the Surveyor to a test pressure = 1.5 × the design pressure.

Provided that the hydrostatic testing of separate lengths of piping, valves, expansion elements etc. has been carried out prior to the installation on board, a tightness test only is required after completion of the installation onboard.

6.2.6.3 Hydrostatic testing of pump housings on submerged pumps will normally not be required.

However, cargo pumps and associated pump risers shall be hydrostatically tested to 1.5 times the design pressure, with a minimum of 14 bar. For centrifugal pumps the maximum pressure shall be the maximum pressure head on the head-capacity curve. For displacement pumps the design pressure shall not be taken less than the relief valve opening pressure.

6.2.6.4 Pump capacities shall be checked with the pump running at design condition (rated speed and pressure head, viscosity, etc.). Capacity test may be dispensed with for pumps produced in series when previous satisfactory tests have been carried out on similar pumps.

6.2.6.5 For centrifugal pumps having capacities less than 1000 m^3/h, the pump characteristic (head-capacity curve) shall be determined for each type of pump. For centrifugal pumps having capacities equal to or greater than 1000 m^3/h, the pump characteristic shall be determined over a suitable range on each side of the design point, for each pump.

6.2.6.6 Special survey arrangments for testing of pumps may be agreed upon with the Surveyor.

6.3 Stripping of Cargo Tank and Cargo Lines

6.3.1 General

6.3.1.1 The piping arrangement and pumping shall ensure that the amount of residues in each cargo tank and its associated piping, is not in excess of 75 litres (Cargo stripping performance str 0.075).

6.3.1.2 The verification of the above residue quantity shall be through actual testing with water and in accordance with an approved test procedure. Reference is made to MARPOL 73/78 Annex II, Appendix 5.

6.4 Discharge of Contaminated Water

6.4.1 Location of Discharge Outlet

6.4.1.1 For discharge of cargo contaminated water an outlet located below the waterline in vicinity of the turn of the bilge shall be arranged within the cargo area.

6.4.1.2 The outlet(s) shall be located such that the cargo contaminated discharges will not enter the ship's seawater intakes.

6.4.2 Sizing of the Discharge Outlet

6.4.2.1 The internal diameter of the outlet shall not be less than:

$D = Q_D / 5L$

where,

Q_D = Discharge rate (m^3/h)

L = Distance of outlet from forward perpendicular (m)

In the case of angled outlets only the velocity component of the discharge perpendicular to the ship's shell plating need to be considered when determining Q_D.

The discharge rate assumed as the basis for outlet(s) sizing shall not be taken less than the aggregate throughput of the washing machines in anyone tank.

6.4.3 Cargo Record Book and SMPEP

6.4.3.1 All ships having a Certificate of Fitness (COF) for the carriage of liquid substances as listed in the IBC Code Chapter 17 and 18, shall have on board a Cargo Record Book according to MARPOL 73/78, Annex II Appendix 2.

6.4.3.2 All ships having a Certificate of Fitness (COF) for the carriage of liquid substances as listed in the IBC Code Chapter 17 and 18, shall carry on board a Shipboard Marine Pollution Emergency Plan (SMPEP) according to MARPOL 73/78 Annex II, Reg. 17.

6.5 Stern Loading and Unloading Arrangements

6.5.1 General

6.5.1.1 Cargo piping may be installed to permit stern loading and unloading, subject to the approval of the Society. Portable arrangements will not be permitted.

6.5.1.2 Stern loading and unloading lines shall not be used for the transfer of products required to be carried in **Ship type 1** ships. Stern loading and unloading lines shall not be used for the transfer of cargoes emitting toxic vapours required to comply with Sec 9.2.4, unless specifically approved by the Society.

6.5.2 Piping Arrangement

The following shall be applicable in addition to the requirements detailed in Pt.5A (Piping systems)

- A shut-off valve and a blank flange shall be fitted for the shore connection.

- The piping shall be full penetration butt welded, and fully radiographed. Flange connections in the piping shall only be permitted within the cargo area and at the shore connection.

- The piping outside the cargo area shall be fitted at least 760 mm inboard on the open deck. Such piping shall be clearly identified and fitted with a shut-off valve at its connection to the cargo piping system within the cargo area. At this location, it shall also be capable of being separated by means of a removable spool piece and blank flanges when not in use.

- Spray shields shall be provided at the connections specified in Sec 6.1 as well as collecting trays of sufficient capacity with means for the disposal of drainage.

- The piping shall be self-draining to the cargo area and preferably into a cargo tank. Alternative arrangements for draining the piping may be accepted by the Society.

- Arrangements shall be made to allow such piping to be purged after use and maintained gas-safe when not in use. The vent pipes connected with the purge shall be located in the cargo area. The relevant connections to the piping shall be provided with a shut-off valve and blank flange.

- If the stern line is used for unloading the stripping requirements in C shall be complied with. The stripping requirements shall be verified through a stripping test using the stern line.

6.5.3 Accommodation Entrances

6.5.3.1 Air inlets, entrances and openings to accommodation, service and machinery spaces and control stations shall not face the cargo shore connection location of stern loading and unloading arrangements. They shall be located on the outboard side of the superstructure or deckhouse at a distance of at least 4% of the length of the ship but not less than 3 m from the end of the house facing the cargo shore connection location of the stern loading and unloading arrangements. This distance, however, need not exceed 5 m.

Sidescuttles facing the shore connection location and on the sides of the superstructure or deckhouse within the distance mentioned above shall be of the fixed (non-opening) type. In addition, during the use of the stern loading and unloading arrangements, all doors, ports and other openings on the corresponding superstructure or deckhouse side shall be kept closed. Where, in the case of small ships, compliance with Sec 3.3.1.3 and this paragraph is not possible, the Society may approve relaxations from the above requirements.

6.5.3.2 The following shall be shielded from any spray which may come from a burst hose or connection.

- Air pipes
- Openings to enclosed spaces not listed in Sec 6.5.3.1.

6.5.3.3 Escape routes shall not terminate within the coamings required by Sec 6.5.3.4 or within a distance of 3 m beyond the coamings.

6.5.3.4 To keep any spills on deck and away from the accommodation and service areas, continuous coamings of suitable height shall be provided.

6.5.4 Electrical Equipment – Fire Fighting

6.5.4.1 Electrical equipment within the coamings required by Sec 6.5.3.4 or within a distance of 3 m beyond the coamings shall be in accordance with the requirements of Sec 12.

6.5.4.2 Provision shall be made for the remote shutdown or cargo pumps from the cargo shore connection location. Means of communication between the cargo control station and the cargo shore connection location shall be provided and certified safe, if necessary.

6.5.4.3 Ships installed with stern loading and unloading arrangements shall be provided with one additional foam monitor meeting the requirements of Sec 11.2.2.8 and one additional applicator meeting the requirements of Sec 11.2.2.11. The additional monitor shall be located to protect stern loading and unloading arrangements. The area of the cargo line aft of the cargo area shall be protected by the above mentioned applicator.

6.6 Cargo Hoses

6.6.1 General

6.6.1.1 Cargo hoses (both liquid and vapour) used in cargo transfer shall be compatible with the cargo and suitable for the cargo temperature.

6.6.1.2 Cargo hoses that are subject to tank pressure or the discharge pressure of pumps shall be designed for a bursting pressure not less than 5 times the maximum pressure the hose will be subjected to during cargo transfer.

6.6.1.3 Cargo hoses, each type, complete with end-fittings, shall be prototype-tested at a normal ambient temperature with 200 pressure cycles from zero to at least twice the specified maximum working pressure. After this cycle pressure test has been carried out, the prototype test shall demonstrate a bursting pressure of at least 5 times its specified maximum working pressure at the extreme service temperature. Hoses used for prototype testing shall not be used for cargo service.

Thereafter, before being placed into service, each new length of cargo hose produced shall be hydrostatically tested at ambient temperature to a pressure not less than 1.5 times its specified maximum working pressure but not more than two-fifths of its bursting pressure. The hose shall be stencilled or otherwise marked with the date of testing, its specified maximum working pressure and, if used in services other than the ambient temperature services, its maximum and minimum service temperature as applicable. The specified maximum working pressure shall not be less than 10 bar gauge.

SECTION 7 CARGO HEATING ND COOLING ARRANGEMENTS

Contents

7.1 Cargo Heating

7.1.1 General Requirements

7.1.1.1 The requirements for thermal oil, hot water systems and steam systems given in Pt.5A (Piping systems) apply, with additional requirements given in this section.

7.1.1.2 Compatibility of the heating and cooling medium for the intended cargo shall be ensured.

7.1.1.3 The heating or cooling systems shall be provided with valves to isolate the system for each tank and to allow manual regulation of flow.

7.1.1.4 For any heating or cooling system, means shall be provided to ensure that, when in any other but the empty condition, a higher pressure is maintained within the system than the maximum pressure head exerted by the cargo tank content on the system.

7.1.1.5 Pipes for cargo heating and cooling shall not penetrate the cargo tank boundaries other than on the top of the tank.

7.1.1.6 Efficient means shall be provided for measuring the cargo temperature. When overheating or overcooling could result in a dangerous condition, temperature alarm shall be provided. The means for measuring the cargo temperature shall be of restricted or closed type, respectively, when a restricted or closed gauging device is required for individual substances as shown in the IBC Code Ch.17 column j.

Note:

- *A closed temperature measuring device is subject to the definition for a closed gauging device in Sec 13.2.1, eg. a remote thermometer of which the sensor is installed in the tank.*
- *A restricted temperature measuring device is subject to the definition for a restricted gauging device in Sec 13.2.1, eg. a portable thermometer lowered inside a gauge tube of the restricted type.*

7.1.1.7 The heating or cooling media shall operate as detailed below, when products with a significant toxic hazard (IBC Code Ch.17 column o refers to Ch. 15.12, 15.12.1 or 15.12.3) are being heated or cooled:

- In a system external to the tanks or
- In a circuit dependent of other services, if the condensate is not returned to the engine room or
- In a circuit independent of other ships services, except for another cargo heating or cooling system, and not enter the engine room, or
- In a circuit where the medium is sampled to check for the presence of cargo before it is recirculated to other ship's services or into the engine room. The sampling equipment shall be located within the cargo area and be capable of detecting the presence of any toxic cargo being heated or cooled

Note:
Suitability of sampling method must be documented for each product.

7.1.1.8 In case hot water system or thermal oil is being re-circulated into the engine room, the system must comply with the following additional requirements:

- Pressurized expansion tanks may be considered.
- Expansion tanks shall be installed with high and low level alarms
- Expansion tanks shall be installed with detection of flammable cargo vapours.
- The sytem is so arranged that positive pressure in the heating coil within a cargo tank shall be at least 3 m water column above the ststic head of the cargo when circulating pump is not in operation. The specific gravity of cargo and the maximum P/V-valve setting must be taken into account.

7.1.1.9 The cargo tank heating coil supply and return pipes shall be arranged for blank flanging outside the engine or boiler room.

7.1.1.10 For carriage of heat sensitive products, heating coils fitted in tanks (IBC Code Ch.17 column refers to Ch. 16.6.2), shall be arranged for blank flanging at each tank.

7.1.1.11 Temperature of the heating medium is normally not to exceed 220°C. If cargoes with an auto-ignition temperature lower than 220°C are carried, the heating medium temperature shall be adjusted accordingly, during transfer of cargo.

7.1.1.12 The condensate from cargo heating systems shall not be used for feed water for main boilers.

7.1.1.13 Heating coils shall be tested according to the non-destructive testing requirement listed in Pt. 5A (…Piping systems).

7.1.2 Heating of Cargoes with Temperatures above 800C

7.1.2.1 A built in redundancy shall be provided for heating plants for cargoes with temperatures above 80°C. Redundancy is required for boilers/thermal oil heaters, heat exchangers, heating coil circuits as well as active components (eg. circulation pumps). Failure of a redundant component is not to reduce the installed heating capacity by more than 50%.

7.1.2.2 Pumps and valve systems shall be suitable for the type of cargo to be transported.

7.1.2.3 In each cargo tanks, temperature gauges shall be arranged enabling the monitoring of temperature at bottom, middle and top of tanks.

7.1.2.4 For cargoes requiring heating above 120°C, heating arrangement shall be provided for cargo pumps, P/V-valves (if fitted), automatic vent heads (if fitted) and cargo lines.

7.2 Cargo Cooling System

7.2.1 General

7.2.1.1 Any cargo cooling system required to be installed shall be arranged in accordance with the requirements in Ch 18(…Liquid Gas Carriers). In addition, the cooling system shall comply with the requirements as detailed in Pt.5A(Piping Systems) to the extent these are applicable.

Note:
Only the safety requirements and requirements to environmental protection referred to in rules are applicable when a cargo cooling sysem is not required to be installed.

SECTION 8 MARKING OF TANKS, PIPES AND VALVES

Contents

8.1 General

8.1.1 Marking Plates

8.1.1.1 Corrosion resistant material shall be used for the manufacture of marking plates, and shall be permanently fixed to valve handles, flanges or similar parts. Markings, bolt holes, etc. in the tanks themselves shall be avoided.

8.1.1.2 The lettering shall be impressed on the marking plate in letters of at least 5 mm height. The marking plates shall be placed in easily visible positions and shall not be painted.

8.1.2 Pipelines

8.1.2.1 Pumps, valves and pipelines shall be distinctively marked to identify the service and tanks which they serve. General remarks regarding marking of valves are given in Pt.5A (Piping systems).

8.1.3 Marking of Indepndent Tanks

Each of the independent tanks shall have marking plate providing the following information as relevant:

- Tank No
- Cargo type
- Design vapour pressure (bar)
- Maximum cargo density (kg/m3)
- Capacity of tank (m3) 98% filled
- Test pressure (bar)
- Name of builder
- Year of construction
- Marking plate may also be used for the necessary marking of identification

Note:
For defintiions of design vapour pressure, test pressure etc refer Sec 1.2.

SECTION 9 GAS FREEING AND VENTING OF CARGO TANKS

Contents

9.1 Gas Freeing of Cargo Tanks

9.1.1 General

9.1.1.1 Cargo tanks shall be provided with efficient means for gas freeing.

The arrangement for gas freeing cargo tanks shall be such as to minimize the hazards due to the dispersal of flammable or toxic vapours in the atmosphere and to flammable or toxic vapour mixtures in a cargo tank.

The cargo tank ventilating system shall be used exclusively for ventilating purposes. Connection between cargo tank and pump room ventilation will not be accepted.

9.1.1.2 Gas freeing operations shall be carried out such that vapour is initially discharged in one of the following ways:

1. Through the vent outlet specified in Sec 9.2.3 or Sec 9.2.4; or

2. Through outlets at least 2 m above the cargo tank deck level with a vertical efflux velocity of at leat 30 m/s maintained during the gas freeing operation; or

3. Through outlets at least 2 m above cargo tank deck level with a vertical efflux velocity of at least 20 m/s which are protected by an approved device to prevent the passage of flame; or

4. For ships required to be inerted when carrying flammable chemicals, before gas-freeing with air, the cargo tanks shall be purged with inert gas through outlets pipes having a cross sectional area such that an exit velocity of at least 20 m/s can be maintained when any three cargo tanks are being simultaneously supplied with inert gas. This outlet shall be at least 2 meters above deck level and purging of cargo tanks shall be continued until the concentration of hydrocarbon or other flammable vapours are reduced to less than 2% by volume.

9.1.1.3 Ventilating and gas-freeing systems that are permanently installed, with non-permanent connections to cargo tanks or cargo piping, shall comply with the following:

- Non-sparking type fans shall be used and certified in accordance with Sec 10.1.2.
- Where the fans are located in a non-hazardous space, the air supply piping from the fan shall have an automatically operated shut-off valve and a non-return valve in series.
- The valves shall be located at the bulkhead where the air supply piping leaves the non-hazardous space, with at least the non-return valve on the outside.
- The shut-off valve shall open after the fans are started, and close automatically when the fans stop.

9.1.1.4 Between an inert gas plant or ventilating plant and cargo piping systems permanent pipe connections will normally not be accepted.

9.2 Tank Venting System

9.2.1 General

9.2.1.1 The term “pressure relief valve” denotes a safety valve which opens at a given internal pressure above atmospheric pressure. The term “vacuum relief valve” denotes a safety valve which opens at a given internal pressure below atmospheric pressure. The term “P/V” valves are meant combined pressure/ vacuum relief valves.

9.2.1.2 The maximum permissible loading and unloading rates for each tank or group of tanks consistent with design of the venting systems shall be provided to the master of the vessel.

9.2.1.3 The cargo venting system shall be so designed that, taking into account the density of the cargo vapour mixture, the pressure drop in the cargo tank venting system due to the gas flow rates corresponding to the maximum design loading and discharge rate does not exceed the design vapour pressures of the tank. The pressure drop shall include the pressure drop across the P/V-valve and/or other flame arresting elements for the gas flow corresponding to the maximum design loading and discharge rate.

As a minimum any P/V-valve fitted to a cargo tank shall have a capacity for the relief of full flow overpressure of not less than 125% of the gas volume flow corresponding to the maximum design loading rate for each tank. The P/V-valve capacity for the relief of underpressure must be not less than the gas flow corresponding to the maximum design discharge rate for each tank.

Note:
USCG Vapour emission control systems (VECS):
Note that for ship intended to comply with USCG regulations, the maximum allowable liquid loading rate when loading with vapour return will be determined by the capacity of the P/V-valves fitted to each tank. Under USCG regulations the P/V-valve capacity must take into account the vapour growth rate (min. 1.25) and the air vapour density (min. recommended 3.6 kg/m^3) of the cargo to be carried.

For ships provided with eg. an in-line P/V-breather valve in connections to common cargo tank venting system or between such a system and the mast riser outlet, the opening pressure of this P/V-breather valve shall be taken into account in the pressure drop calculations required by the USCG. However, if the P/V-breather valve can be isolated during vapour return and procedures for same is included in the VECS operation manual, the opening pressure need not be taken into account.

Venting systems in tanks as described in 200 to 400 below, shall be provided in accordance with IBC Code Ch.17 column g.

9.2.1.4 Tank venting shall comply with Sec 9.2.3 for carriage of IBC Code Ch 18 products with flash point not exceeding 60^{o}C.

9.2.1.5 Any spool piece or similar means of separation provided in, or connected to a tank venting systems shall be so arranged so that mounting or dismantling does not imply exposure to cargo vapour. ie isolation valves will normally be required.

9.2.2 Tank Venting System (Type c1 Open)

9.2.2.1 An open tank venting system is applicable for some particular products. The height of cargo tank vent outlets shall comply with load line requirements, including requirements to automatic vent heads.

9.2.2.2 Venting systems consists of individual vents from each tank or the vents from each individual tank may be connected to a common header. Due regard is however to be paid to requirements to separation of piping systems.

9.2.2.3 Shut-off valves or other means of isolation shall not be fitted in cargo tank venting lines, unless alternative means are provided to prevent the tank being isolated from atmosphere.

9.2.3 Tank Venting System (Type c2 - Controlled)

9.2.3.1 The tanks shall have arrangement for pressure/ vacuum relief during voyage and venting during loading and unloading with closed tank hatch covers.

9.2.3.2 To limit the pressure or vacuum in the tank, pressure vacuum relief valves shall be fitted to each tank. The opening pressure of the vacuum relief valves is normally not to be lower than 0.07 bar below atmospheric pressure.

The venting system may consist of individual vents from each tank or the vents from each individual tank may be connected on the pressure side of the P/V-valve to a common header. Due regard is in that case to be paid to cargo segregation.

9.2.3.3 Shut-off valves shall not be be fitted neither above nor below P/V valves, unless alternative means of controlled venting are provided to prevent the tank being isolated from atmosphere.

9.2.3.4 Redundancy shall be ensure for the venting system for the relief of full flow overpressure and vacuum. Any one of the following arrangements may be accepted:

- Pressure sensors fitted in each individual cargo tank, and connected to an alarm system. The setting of the over-pressure alarm shall be above the pressure setting of the P/V-valve and the setting of the underpressure alarm shall be below the vacuum setting of the P/V-valve. The alarm settings are to be within the design pressures of the cargo tanks. The settings are to be fixed and not arranged for blocking or adjustment in operation, unless the ship is approved for carrying P/V-valves with different settings.

- Two P/V-valves fitted to each individual cargo tank, without means for isolation, each with a capacity as required by Sec 9.2.1.5.

Refer Sec 13 for details on high level alarms, overflow systems etc.

Note:
In case the pressure sensors required are also used for USCG vapour return purposes, then the system is to be provided with multiple fixed settings. Eg. for ships where inerting is not mandatory, the system is to be provided with mode selection so that the vapour return alarms are blocked except when the ship is loading with vapour return.

9.2.3.5 P/V valves shall be located on open deck and shall be of a type which allows the functioning of the valve to be easily checked.

9.2.3.6 When carrying cargoes that may casue clogging, the P/V valves and automatic vent heads shall be provided with arrangement for heating.

9.2.3.7 The intake openings of vacuum relief valves shall be located at least 1.5 m above tank deck, and shall be protected against the sea. The arrangement shall comply with the requirements in Pt 4, Ch 6.

9.2.3.8 Vent outlets of cargo tanks shall be situated not less than 6 m above the weather deck or above the fore and aft gangway, if fitted within 4 m of the gangway. The vent height may be reduced to 3 m above the deck or fore and aft gangway as applicable, provided high velocity vent valves of an approved type with an exit velocity of at least 30 m/s, are fitted.

The vent exits are also to be arranged at a distance of at least 10 m from the nearest air intake or opening to accommodation and service spaces and ignition sources. The vapour discharge shall be directed upwards in the form of unimpeded jets.

9.2.3.9 Vapour outlets for tanks to be used for cargoes with flashpoint not exceeding 60°C shall be provided with devices tested and approved according to IMO MSC/Circ.677 as amended by MSC/Circ.1009, to prevent the passage of flame into the cargo tanks. Due attention shall be paid in the design of P/V valves, 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. Provisions shall be made that the system and fittings may be inspected, operationally checked, cleaned or renewed as applicable.

9.2.3.10 Gas freeing covers, P/V valves and other flame arresting elements must also comply with the requirements to maximum experimental safety gap (MESG) corresponding to the gas group required for each cargo in column I" of Ch.17 of the IBC code (IMO MSC.1/Circ.1324 amending IMO MSC Circ.677).

Note:
For ships carrying cargoes requiring gas group IIA: MESG is 0.9 mm (oil tanker standard).
For ships carrying cargoes requiring gas group IIB: MESG is 0.65 mm.
For ships carrying cargoes requiring gas group IIC: MESG is 0.28 mm.

9.2.3.11 The vent system shall be sized, allowing for flame screens, if fitted, to permit loading at a design rate without overpressuring the tank. Specifically, under conditions in which a saturated cargo vapour is discharged through the venting system at the maximum anticipated loading rate, the pressure differential between the cargo tank vapour space and the atmosphere shall not exceed the design vapour pressure of the tank, or, for independent tanks, the maximum working pressure of the tank.

9.2.3.12 The venting system shall be connected to the highest point of each cargo tank and vent lines shall be selfdraining under all normal operating conditions of list and trim. Where it is necessary to drain venting systems above the level of any P/V valve, capped or plugged drain cooks should be provided.

9.2.3.13 It is to be ensured that the liquid head in any tank does not exceed the test head of that tank; overflow control systems or spill valves, together with gauging devices and tank filling procedures may be accepted for this purpose.

Note:
Where the means of limiting cargo tank overpressure includes an automatic closing valve, the valve shall comply with Sec 9.2.4.

9.2.4 Tank Venting System (Type c3 - Controlled Venting for Toxic Products)

9.2.4.1 This type of venting system is required for products for which IBC Code Ch.17 column o refers to Ch. 15.12 or parts thereof. The requirements of Sec 9.2.3 apply with the additions given in Sec 9.2.4.2, Sec 9.2.4.3 and Sec 9.2.4.4.

9.2.4.2 The opening pressure of pressure relief valve and vacuum relief valves are as detailed below:

- Pressure relief valves:
  0.20 bar above atmospheric pressure.

- Vacuum relief valves:
  Normally not to be lower than 0.07 bar below atmospheric pressure.

9.2.4.3 Gas outlets are normally to be at a minimum height of B/3 or 6 m, whichever is greater above the weather deck, or in the case of a deck tank the access gangway, where B = ship's moulded breadth. Further, the outlets shall not be less than 6 m above the fore and aft gangway if fitted within a horizontal distance of 6 m from the gangway.

Height of the vent may be reduced to 3 m above the deck or fore and aft gangway as applicable provided high velocity vent valves of an approved type, directing the vapour and air mixture upwards in an unimpeded jet with an exit velocity of at least 30 m/s, are fitted.

The gas outlets shall be situated at a horizontal distance of at least 15 m from air intakes, port holes or doors to accommodation and service spaces.

For ships with length less than 90 m, smaller distances may be accepted.

9.2.4.4 Pipe connections with associated valves for returning the expelled gases ashore during loading shall be provided.

SECTION 10 MECHANICAL VENTILATION IN THE CARGO AREA OUTSIDE THE CARGO TANKS

Contents

10.1 System Requirements

10.1.1 General

10.1.1.1 Ventilation systems within the cargo area shall be independent of other ventilation systems. Any ducting used for the ventilation of hazardous spaces shall be separate from that used for the ventilation of non-hazardous spaces.

10.1.1.2 Air inlets for non-hazardous enclosed spaces shall be taken from non-hazardous areas at least 1.5 m from the boundaries of any hazardous area.

Air inlets for hazardous enclosed spaces shall be taken from areas which, in the absence of the considered inlet, would be non-hazardous.

Wherever the inlet duct passes through a more hazardous space, the duct shall have over-pressure relative to this space, unless mechanical integrity and gas-tightness of the duct will ensure that gases will not leak into it.

10.1.1.3 Air outlets from non-hazardous spaces shall be located outside hazardous areas.

10.1.1.4 Air outlets from hazardous enclosed spaces shall be located in an open area which, in the absence of the considered outlet, would be of the same or lesser hazard than the ventilated space.

10.1.1.5 Within the cargo area ventilation ducts for spaces shall not be led through non-hazardous spaces.

10.1.1.6 Overpressure type ventilation shall be arranged for non-hazardous enclosed spaces. Hazardous spaces shall have ventilation with underpressure relative to the adjacent less hazardous spaces.

10.1.1.7 Ventilation fans of gas safe spaces shall have its starters within the cargo area shall be located outside this area or on open deck.

If electric motors are installed in such spaces, the ventilation capacity shall be suitably high enough to prevent the temperature limits specified in Pt.6 (Electrical installations), from being exceeded, taking into account the heat generated by the electric motors.

10.1.1.8 At the outside opening of ventilation ducts, wire mesh protection screens of not more than 13 mm square mesh shall be fitted.

Where fans are installed in ducts, protection screens are also to be fitted inside of the fan to prevent the entrance of objects into the fan housing.

10.1.1.9 Spare parts for fans shall be carried onboard. Normally one motor and one impeller is required for each type of fan serving spaces in the cargo area.

10.1.1.10 For spaces in the cargo area, the ventilation inlets and outlets that are required to be continuously mechanically ventilated at sea, shall be located so that they are operable in all weather conditions. This implies that they shall be arranged at a height above deck as required in Pt.3 Ch.3 Sec.6 H, as a ventilator not requiring closing appliances.

Note:

Spaces such as nitrogen rooms, cargo heater rooms and deck trunks containing cargo piping and cargo heaters may however require continuous ventilation also at sea. Spaces such as cargo pumprooms, ballast pumprooms and ballast water treatment spaces do normally not require continuous mechanical ventilation at sea.

10.1.2 Fans Serving Hazardous Spaces

10.1.2.1 Those fans serving hazardous spaces shall be certified as required by Table 1.4.1. Associated electric motors and motor starters shall be certified as required by Pt.6 (Electrical Installations)

Note:
Recommend that such fans comply with the requirements as detailed in EN13463-1, EN13463-5 and ENI14986.

10.1.2.2 Motors of electric fans shall not be installed in ventilation ducts for hazardous spaces.

10.1.2.3 Fans for hazardous spaces shall be designed with least possible risk of spark generation.

10.1.2.4 Minimum safety clearances between the casing and rotating parts shall be such as to prevent any friction with each other.

The radial air gap between the impeller and the casing is not to be less than 0.1 of the diameter of the impeller shaft in way of the bearing, but not less than 2 mm. It need not be more than 13 mm.

10.1.2.5 Spark proof materials and materials with antistatic properties shall be used for the manufacture of part of the rotating body and of the casing.

The installation on board of the ventilation units shall be such as to ensure the safe bonding to the hull of the units themselves. Resistance between any point on the surface of the unit and the hull, shall not be greater than 10^6 Ω.

The following combinations of materials and clearances used in way of the impeller and duct are considered to be non-sparking:

- Impellers and housing of austenitic stainless steel;
- Impellers and housing of non-frrous materials;
- Impellers and or housing of non-metallic material, due regard being padi to the emimination of static electricity;
- Any combination of ferrous (including austenitic stainless steel) impellers and housing with not less than 13 mm tip design clearance;
- Impellers of aluminium alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non-ferrous materials is fitted in way of the impeller, due regard being paid to static electricity, reliability of the arrangement for securing of the ring to the housing and corrosion between ring and housing.

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

10.2 Ventilation Arrangement and Capacity Requirements

10.2.1 General

10.2.1.1 Ventilation plant capacity shall normally be based on the total volume of the room. An increase in required ventilation capacity may be necessary for rooms having a complicated form.

10.2.1.2 An audible and visual alarm shall be activated in a permanently manned control station, in case of failure of a required fixed mechanical ventilation system in that space.

10.2.2 Non-hazardous Spaces

10.2.2.1 An air lock shall be provided between non-hazardous spaces with opening into a hazardous area, and be maintained at an overpressure relative to the external hazardous area. The following air lock arrangements shall be accepted:

1. Air lock Without Independent Mechanical Ventilation:

a) Air lock shall be arranged in accordance with Sec 3.2.1.6 and Sec 3.2.1.7.
b) Air lock shall be connected to the ventilation system required for the protected space and maintained with an overpressure in the space relative to the external hazardous area.
c) The air lock that protects the non-hazardous space shall be arranged with an independent mechanical ventilation system, maintaining an overpressure in the space relative to the external hazardous area.
d) The relative overpressure or air flow is to be continuously monitored and so arranged that in the event of ventilation failure, an audible and visual alarm is activated in a permanently manned control station and the electrical supply to all equipment (not of the certified safe type) is to be automatically disconnected. If the equipment in the protected space is suitable for operating in a zone 2, manual programmed disconnection may be accepted in lieu of automatic disconnection.
e) Wherever the pressure is monitored by air flow, an alarm (audible and visual) shall be released on both sides of the air lock to indicate if more than one door has been moved from the fully closed position.
f) Priot to energising any electrical installations not certified safe during initial start-up or after loss of overpressure ventilation, the following is required:

- The protected space shall be confirmed pressurised.
- The overpressure ventilation system shall be arranged for pre-purging (at least 5 air changes) or confirmation by gas measurements that the space is non-hazardous.

2. Air lock With Independent Mechanical Ventilation:

a) Air lock shall be arranged in accordance with Sec 3.2.1.6 and Sec 3.2.1.7.

b) Air lock shall be provided with independent mechanical ventilation maintaining an overpressure in the space relative to the external hazardous area.

c) The air lock that protects the non-hazardous space shall be arranged with an independent mechanical ventilation system, maintaining an overpressure in the space relative to the external hazardous area.

d) The relative overpressure or air flow is to be continuously monitored and so arranged that in the event of ventilation failure, an audible and visual alarm is to be activated in a permanently manned control station. If the pressurization cannot be restored for an extended period or if the gas concentration is detected to above 30% LEL or above, manual programmed disconnection of power supply to electrical equipment not suitable for operation in the relative hazardous area is required.

e) Wherever the pressure is monitored by air flow, an audible and visual alarm shall be released on both sides of the air lock to indicate if more than one door has been moved from the fully closed position.

f) Prior to energising any electrical installations not certified safe during initial start-up or after loss of overpressure ventilation, the following is required:

- The protected space shall be confirmed pressurised.
- The overpressure ventilation system shall be arranged for pre-purging (at least 5 air changes) or confirmation by gas measurements that the space is non-hazardous.

10.2.2.2 Machinery necessary for maintaining main functions, as well as safety systems such as the emergency generator and emergency fire pumps, shall not be located in spaces where automatic disconnection of electrical equipment is required.

Note:
Equipment suitable for operating in a zone 1, is not required to be disconnected. Certified flameproof lighting may have a separate disconnection circuit.

10.2.3 Cargo Handling Spaces

10.2.3.1 An effective and permanent mechanical ventilation system shall be installed capable of circulating sufficient air to give at least 30 air changes per hour. Extraction from above and below floor plates shall be possible, with the following arrangement of exhaust trunking:

- An emergency intake located 2 m above the pump room lower grating. This emergency intake would be used when the lower intakes are sealed off due to flooding in the bilges. The emergency intake is to have a damper fitted, which can be remotely opened from the exposed main deck in addition to local opening and closing arrangement at the lower grating.

- In the pump room bilges just above the transverse floor plates or bottom longitudinals, so that air can flow over the top from adjacent spaces

  For carriage of certain products, increased ventilation rates are required. Refer Sec 15.1.11.

10.2.3.2 Spaces such as pump rooms, compressor rooms and other cargo handling spaces ventillation systems shall be in operation when pumps or compressors are working. Warning notices to this effect shall be placed in an easily visible position near the control stand.

10.2.3.3 Exhaust outlest shall discharge upwards and shall be situated at least 4 m above tank deck and at least 10 m in the horizontal direction from ventilation inlets to the accommodation and other gas safe spaces.

10.2.3.4 When the space is dependent on ventilation for its area classification, the following requirements apply:

1. During initial start-up, and after loss of ventilation, the space shall be purged (at least 5 air changes), before connecting electrical installations which are not certified for the area classification in absence of ventilation.
2. Proper monitoring of the ventilation shall be carried out.
3. The following shall be applicable in the event of ventilation failure:

- An audio visual alarm shall be activated at a manned location
- Electrical installations shall be disconnected if ventilation cannot be restored for an extended period.
- Immediate action shall be taken to restore ventilation.

Disconnections shall be made outside the hazardous areas, and be protected against unauthorised reconnection, eg. by lockable switches.

Note:
Intrinsically safe equipment suitable for Zone 0, is not required to be switched off. Certified flameproof lighting, may have a separate switch-off circuit.

10.2.4 Other Hazardous Spaces Normally Entered

10.2.4.1 Other enclosed spaces, such as pump rooms below deck not covered by 300, where access may be necessary for normal operation and maintenance, shall be provided with a mechanical ventilation system giving at least 20 air changes per hour.

10.2.4.2 Spaces such as cargo handling gear lockers, cargo sample lockers etc situated on or above cargo deck level may be accepted with natural ventilation only.

10.2.5 Spaces Not Normally Entered

10.2.5.1 Spaces detailed in Sec 1.2.1 shall be arranged for gasfreeing. Where necessary, owing to the arrangement of the spaces, necessary ducting shall be permanently installed in order to ensure safe and efficient gasfreeing.

10.2.5.2 Permanent or portable mechanical ventilation system shall be provided, capable of circulating sufficient air to the compartments concerned. Where a permanent ventilation system is notprovided, approved means of portable mechanical ventilation shall be provided. For permanent installations the capacity of 8 air changes per hour shall be provided and for portable systems the capacity of 16 air changes per hour. Fans or blowers shall be clear of personnel access openings, and shall comply with Sec 10.1.2.

SECTION 11 FIRE PROTECTION AND EXTINCTION

Contents

11.1 General

11.1.1 Application

11.1.1.1 As specified in Ch 3, Sec 7.1.1, the fire safety measure in SOLAS related to tankers in general, shall apply depending on flag state authorization.

11.1.1.2 The applicable fire safety measures for chemical tankers are specified in Sec 11.2 below and in Sec 6.5.

11.2 Fire Extinguishing

11.2.1 Fire Extinguishing in Cargo Area

11.2.1.1 For all products carried by the vessel, compatible fire extinguishing equipment shall be provided. Fire extinguishing media considered to be suitable for certain products, are indicated in the IBC Code Ch.17 column l.

11.2.2 Deck Fire Extinguishin System in Cargo Area

11.2.2.1 Ships with class notation **Tanker for Chemicals** or **Tanker for C** for dedicated chemical cargoes, except those engaged solely in the transport of non-flammable products, shall be fitted with a fixed deck foam fire-extinguishing system in accordance with the following requirements. Ships which are dedicated to the carriage of specific cargoes may, however, be protected by alternative provisions to the satisfaction of the Society when they are equally effective for the products concerned as the deck foam system required for the generality of flammable cargoes.

Note:
The term “ships which are dedicted to the carriage of specific cargoes” means vessels which are dedicted to the carriage of a restricted number and type of cargoes.

11.2.2.2 Ships intended to carry flammable products with flash point exceeding 60°C the requirements as specified for oil tankers in Ch 3, Sec 7.1.1 shall be applied in lieu the regulations of this section.

11.2.2.3 A single type of foam concentrate only shall be supplied, and it shall be effective for the maximum possible number of cargoes intended to be carried. For other cargoes for which foam is not effective or is incompatible, additional arrangements to the satisfaction of the Society shall be provided. Basic protein foams shall not be used.

11.2.2.4 The foam system and arrangements shall be capable of delivering foam to the entire cargo tank area as well as into any cargo tank, the deck of which is assumed to be ruptured.

11.2.2.5 The main control station for the system shall be suitably located outside of the cargo tank area, adjacent to the accommodation spaces and readily accessible and operable in the event of fires in the areas protected. The deck foam system shall be capable of simple and rapid operation.

11.2.2.6 Form solution supply rate shall not be less than the greater of the following:

a) 2 l/m^2 minute of the cargo deck area, where cargo deck area means the maximum breadth of the ship times the total longitudinal extent of the cargo tank spaces,

b) 20 l/m^2 minute of the horizontal sectional area of the single tank having the largest such area,

c) 10 l/m^2 minute of the area protected by the largest monitor, such area being entirely forward of the monitor, but not less than 1250 l/minute. For ships of less than 4000 tons deadweight, the minimum capacity of the monitor shall be to the satisfaction of the Society.

11.2.2.7 Type approved foam concentrate shall be used, and delivered with a declaration of conformity and a declaration of the main characteristics (sedimentation, pH-value, expansion ratio, drainage time and volumetric mass and date of production).

11.2.2.8 Fluorine protein (that are alcohol resistant) based foam concentrates is subjected to a chemical stability test with acetone before pouring into foam tank and a new chemical stability test after installation onboard (preferably as long as possible but not less than after 14 days after installation onboard).

The sample shall be collected and test shall be witnessed by the INTLREG Surveyor.

Note:
For test programme and requirements refer INTLREG Type Approval Program (included in INTLREG Part).

11.2.2.9 At least 30 minutes of foam generation shall be ensured by the quantity of foam concentrate provided onboard, when using solution rates stipulated in Sec 11.2.2.6 (a), (b) and (c), whichever is the greater.

11.2.2.10 Monitors and foam applicators shall be used to apply the foam from the fixed foam system. At least 50% of the foam rate required in Sec 11.2.2.6 (a) or (b) shall be delivered from each monitor. The capacity of any monitor shall be at least 10 l/minute of foam solution per square metre of deck area protected by that monitor, such area being entirely forward of the monitor. Such capacity shall be not less than 1250 l/minute. The minimum capacity of the monitor shall be to the satisfaction of the society for ships of less than 4 000 tons deadweight.

11.2.2.11 The distance from the monitor to the farthest extremity of the protected area forward of that monitor shall be not more than 75% of the monitor throw in still air conditions.

11.2.2.12 The foam applicator’s monitor and hose connection shall be situated both port and starboard at the poop front or accommodation spaces facing the cargo tanks.

11.2.2.13 The number of foam applicators provided shall be not less than four. The number and disposition of foam main outlets shall be such that foam from at least two applicators can be directed to any part of the cargo tank deck area.
Foam applicators shall be provided for flexibility of action during fire-fighting

operations and to cover areas screened from the monitors. The capacity of any applicator shall be not less than 400 l/minute and the applicator throw in still air conditions shall be not less than 15 m.

11.2.2.14 Valves shall be provided in the foam main, and in the fire main where this is an integral part of the deck foam system, immediately forward of any monitor position to isolate damaged sections of those mains.

11.2.2.15 Operation of a deck foam system at its required output shall permit the simultaneous use of the minimum required number of jets of water at the required pressure from the fire main.

11.2.2.16 Portable fire extinguishing equipment of appropriate types for the products to be carried shall be provided and kept in good operating order.

11.2.2.17 All sources of ignition shall be excluded from spaces where flammable vapours may be present, except as permitted in Sec 12.

11.2.2.18 When the alternative deck fire extinguishing system permitted under Sec 11.2.2.1 is a fixed dry chemical powder fire extinguishing system, the system shall comply with Part 5A/Ch 13).

11.2.3 Fire Extinguishing in Cargo Pump Rooms

11.2.3.1 A fixed carbon dioxide fire extinguishing system in the cargo pump room are to be installed in ships with the class notation **Tanker for Chemicals**, as specified in Sec 11.2.3.2 to 11.2.3.4 below.

For ships with class notation **Tanker for C** for dedicated chemical cargoes, refer Sec 11.2.3.7.

11.2.3.2 The carbon dioxide fire extinguishing system for the cargo pump room shall comply with the requirements in Part 5A/Ch 13

11.2.3.3 The amount of gas carried shall be sufficient to provide a quantity of free gas equal to 45% of the gross volume of the cargo pump room in all cases.

11.2.3.4 A notice shall be exhibited at the controls stating that the system in only to be used for fire extinguishing and not inerting purposes due to the electrostatic ignition hazard.

11.2.3.5 For ships which are dedicated to the carriage of specific cargoes, the cargo pump rooms shall be protected to the satisfaction of the Society.

Note:
The term “ships which are dedicated to the carriage of specific cargoes”, means ships which are dedicated to the carriage of a restricted number of cargoes.

11.2.3.6 A fire-extinguishing system consisting of either a fixed pressure water spray system or a high expansion foam system could be provided for the cargo pump room if it can be adequately demonstrated to the Society that cargoes will be carried which are not suited to extinguishment by carbon dioxide. The Appendix to Classification Certificate will reflect this conditional requirement.

11.2.3.7 Cargo pump rooms shall not be provided with steam smothering system.

SECTION 12 AREA CLASSIFICATION AND ELECTRICAL INSTALLATIONS

Contents

12.1 General

12.1.1 Application

12.1.1.1 The requirements in this section are additional to those given in Pt.6 (...Electrical Installations) and apply to tankers with the class notations **Tanker for Chemicals**. The requirements may be made wholly or partly valid also for tankers for dedicated chemical cargoes (**Tanker for C**) in some cases.

12.1.1.2 For the carriage of cargoes with flash point above 60°C, the requirements for the tanker will be specially considered on a case by case basis. Refer Sec 12.3.3.

12.1.2 Insulation Monitoring

12.1.2.1 Insulation fault

Device(s) for continuously monitoring the insulation earth shall be installed for both insulated and earthed distribution systems. An audible and visual alarm shall be given at a manned position in the event of an abnormally low level of insulation resistance and or high level of leakage current.

12.2 Electrical Installations in Hazardous Areas

12.2.1 General

12.2.1.1 Hazardous areas in general shall be free from any electrical equipment and wiring. Where essential for operational purposes, the arrangement of electrical installations in hazardous areas shall comply with Pt.6 (…Electrical Installation), based on area classification as specified in Sec 12.3.

In addition, installations as specified in Sec 12.2.1.2 are accepted. Except as specified in Sec 12.2.1.2 and Sec 12.3.3. operational procedures are not acceptable as an equivalent method of ensuring compliance with these rules.

In hazardous areas the electrical equipment installed shall, as a minimum, comply with the requirements to gas group IIA and temperature class T3.

Note:
For chemical tankers the requirements to gas group and temperature class are specified for each cargo in columns i' and ii'' of Ch.17 of the IBC code.

For advanced stainless steel chemical tankers, selecting equipment complying with requirements to gas group IIB and temperature class T4 should be considered.

12.2.1.2 Applicble at Zone 1

Impressed current cathodic protection (ICCP) equipment, electric depth-sounding devices and log devices are accepted provided the following is complied with:

- Cables are to be installed in steel pipes with gas-tight joints up to the upper deck.

- Such equipment shall be of gas-tight construction or be housed in a gas tight enclosure.
- Corrosion resistant pipes, providing adequate mechanical protection, shall be used in compartments which may be filled with seawater (e.g. permanent ballast tanks)
- Wall thickness of the pipes shall be as for overflow and sounding pipes through ballast or fuel tanks, in accordance with Pt.5A C (Piping Systems).

12.2.1.3 For certain cargoes according to IBC Code Ch.15 and Ch.17, additional requirements may be applicable.

12.2.1.4 The materials used for electrical equipment shall:

- Be corrosion resistant against the liquids or gases they are likely to be exposed onboard the vessel.
- Not react dangerously with the cargo liquids or gases to which they may be exposed.

12.3 Area Classification

12.3.1 General

12.3.1.1 The objective of the area classification is to allow the selection of electrical appliances be able to operate safely in these areas. Area classification is a method of analysing and classifying the areas where explosive gas atmospheres may occur.

12.3.1.2 In order to facilitate the selection of appropriate electrical appliances and the design of suitable electrical installations, hazardous areas are divided into zones 0, 1 and 2 according to the principles of the standards IEC 60079-10 and IEC 60092-502.

For tankers classification of areas and spaces, are detailed in Sec 12.3.2 and Sec 12.3.3, based on IEC 60092-502.

12.3.1.3 The principles of the IEC standards shall be applied to the areas and spaces as relevant. Areas and spaces other than those classified in Sec 12.3.2 and Sec 12.3.3, shall be subject to special consideration.

12.3.1.4 Ventilation may govern the area classification of a space as specified in IEC 60092-502, Table 1. Requirements to such ventilation are given in Sec 10.2.3.4.

12.3.1.5 By means of over pressure, a space with opening to an adjacent hazardous area on open deck, may be made into a less hazardous or non-hazardous space. Requirements to such pressurisation are given in Sec 10.2.2.1 to Sec 10.2.2.2.

12.3.1.6 The ventilated space and the ventilation ducts shall have the same area classification.

12.3.1.7 With the exception of spaces arranged in accordance with Sec 10.2.2.1, space having an opening into a hazardous area or space, having a more severe hazardous zone classification, will be considered to have the same hazardous zone classification as the zone it has an opening into.

Note:
As per Sec 3.3.1.3 a non-hazardous space will not be accepted with opening into a hazardous space. Openings are considered to be any access door, ventilation inlets or outlets or other boundary openings. Bolted plates that are normally closed and only opened when area has been confirmed gas free may be accepted.

12.3.2 Tankers for Carriage of Products with Flashpoint Not Exceeding 600C

12.3.2.1 Hazardous area: Zone 0

The interiors of cargo tanks, slop tanks, any pipework of pressure-relief or other venting systems for cargo and slop tanks, pipes and equipment containing the cargo or developing flammable gases or vapours.

12.3.2.2 Hazardous area: Zone 1

Zone 1 hazardous areas shall include the following:

1. Void spaces and cofferdams adjacent to, above or below integral cargo tanks
2. Hold spaced containing independent cargo tanks
3. Tanks such as ballast tanks or any other tanks adjacent to cargo tanks
4. Cargo handling spaces and cargo pump rooms
5. Enclosed or semi-enclosed spaces, immediately above cargo tanks (for example, between decks) or having bulkheads above and in line with cargo tanks bulkheads, unless protected by a diagonal plate acceptable to the appropriate authority.
6. Spaces (other than cofferdam) adjacent to and below the top of a cargo tanks (for example, trunks, passageways pump rooms, ballast treatment spaces and hold spaces).
7. Areas on open deck, or semi- enclosed spaces on deck, within 3 m of any cargo tank outlet, gas or vapour outlet (Refer note), cargo manifold valve, cargo valve, cargo pipe flange, cargo pump-room ventilation outlets and cargo tank openings for pressure release provided to permit the flow of small volumes of gas or vapour mixtures caused by thermal variation.

   Note: Such areas are, for example, all areas within 3 m of cargo tank hatches, sight ports, tank cleaning openings, ullage openings, sounding pipes, cargo vapour outlets.

8. Areas on open deck, or semi-enclosed spaces on open deck above and in the vicinity of any cargo gas outlet designed for the passage of large volumes of gas or vapour mixture during cargo loading and ballasting or during discharging, within a vertical cylinder of unlimited height and 6 m radius cantered upon the centre of the outlet, and within a hemisphere of 6 m radius below the outlet.
9. Areas on open deck, or semi-enclosed spaces on deck, within 1.5 m of cargo pump room entrances, cargo pump room ventilation inlet, openings into cofferdams or other zone 1 spaces.
10. Areas on the open deck within spillage coamings surrounding cargo manifold valves and 3 m beyond these, up to a height of 2.4 m above the deck.
11. Areas on open deck over all cargo tanks (including ballast tanks within the cargo tank area) where structures are restricting the natural ventilation and to the full breadth of the ship plus 3 m fore and aft of the forward-most and the aft-most cargo tank bulkhead, up to a height of 2.4 m.

12. Compartment for contaminated cargo equipment and cargo hoses.
13. Enclosed or semi-enclosed spaces in which pipes containing liquid cargoes or cargo vapour are located.

12.3.2.3 Hazardous area: Zone 2

Zone 2 hazardous areas shall include the following:

1. Areas within 1.5 m surrounding open or semi-enclosed spaces of zone 1 as specified in Sec 12.3.2.2, if not otherwise specified in this standard.
2. Spaces 4 m beyond the cylinder and 4 m beyond the sphere defined in Sec 12.3.2.2 (8).
3. The spaces forming an air-lock as defined in Sec 1.2.1.2 and Sec 3.3.1.5 and Sec 3.3.1.6.
4. Areas on open deck extending to the coamings fitted to keep any spills on deck and away from the accommodation and service areas and 3 m beyond these up to a height of 2.4 m above deck.
5. Areas on open deck over all cargo tanks (including all ballast tanks within the cargo tank area) where unrestricted natural ventilation is guaranteed and to the full breadth of the ship plus 3 m fore and aft of the forward-most and aft-most cargo tank bulkhead, up to a height of 2.4 m above the deck surrounding open or semi-enclosed spaces of Zone 1.
6. Spaces forward of the open deck areas to which reference is made in Sec 12.3.2.2 (11) and Sec 12.3.2.3 (5), below the level of the main deck, and having an opening on to the main deck or at a level less than 0.5 m above the main deck, unless:

a. The entrances to such spaces do not face the cargo tank area and, together with all other openings to the spaces, including ventilating system inlets and exhausts, are situated at least 10 m horizontally from any cargo tank outlet or gas or vapour outlet; and
b. Spaces are mechanically ventilated.

7. Forepeak ballast tanks, if connected to a piping system serving ballast tanks within the cargo area. Refer Sec 6.1.6.
8. Ballast pump rooms or ballast treatment spaces which are not located adjacent to cargo tanks, but which could contain contaminated ballast water from ballast tanks located adjacent to cargo tanks.

Note:
Spaces containing ballast pumps or treatment systems only used for filling of ballast tanks and are provided with means for prevention of backflow are not considered hazardous. Refer however Pt.5A Ch 9 sect 4 (Ballast water management) regarding ballast treatment systems generating explosive gases.

12.3.3 Tankers for carriage of products with flashpoint exceeding 60°C

12.3.3.1 Unheated cargoes and cargoes heated to a temperature below and not within 15°C of their flashpoint.

Hazardous Area: Zone 2
The interiors of cargo tanks, slop tanks, any pipework of pressure-relief or other venting systems for cargo and slop tanks, pipes and equipment containing the cargo.

12.3.3.2 Cargoes heated above their flashpoint and cargoes heated to a temperature within 15°C of their flashpoint.
The requirements of Sec 12.3.2.2 are applicable.

Note:
It is acceptable that an operational limitation is inserted in the Appendix to the Class Certificate specifying that the ship is approved on the condition that cargo is not heated to within 15°C of its flashpoint.

12.3.4 Tankers for carriage of products (eg. acids) reacting with other products/materials to evolve flammable gases

12.3.4.1 Hazarodus areas: Zone 1

Areas as specified in Sec 12.3.2.1, Sec 12.3.2.2 (4) and Sec 12.3.2.2 (12).

12.3.4.2 Hazarodus areas: Zone 2

1) Areas of 1.5 m surrounding openings of zone 1 spaces as specified in Sec 12.3.4.1, if not otherwise specified in the rules.
2) Areas specified in Sec 12.3.2.2 (1), Sec 12.3.2.2 (2), Sec 12.3.2.2 (3), Sec 12.3.2.2 (6) and Sec 12.3.2.2 (13).
3) Areas as specified in Sec 12.3.2.2 (7) and Sec 12.3.2.2 (10) but with the distances of 2.4 m and 3 m reduced to 1.5 m, and areas as specified in Sec 12.3.2.2 (8) but with the distance of 6 m reduced to 3 m.

12.4 Inspection and Testing

12.4.1 General

12.4.1.1 Prior to the electrical installations in hazardous areas put into service or considered ready for use, they shall be inspected and tested. All equipment, cables, etc. shall be verified to have been installed in accordance with installations procedures and guidelines issued by the manufacturer of the equipment, cables, etc., and that the installations have been carried out in accordance to Pt.6(Electrical installations).

12.4.1.2 All spaces that are protected by pressurization shall be examined and tested that the purging can be effected. Purge time at minimum flow rate shall be documented. Required shutdowns and / or alarms upon ventilation overpressure falling below prescribed values shall be tested.

Spaces where area classification depends on mechanical ventilation it shall be tested that ventilation flow rate is sufficient, and that and required ventilation failure alarm operates correctly.

12.4.1.3 Equipment for which safety in hazardous areas depends upon correct operation of protective devices (for example overload protection relays) and or operation of an alarm (for example loss of pressurisation for an Ex(p) control panel) it shall be verified that the devices have correct settings and / or correct operation of alarms.

12.4.1.4 Equipmemt where interlocking and shutdown arrangements are required (such as for submerged cargo pumps), they shall be tested.

12.4.1.5 All intrinsically safe circuits shall be verified to ensure that the equipment and wiring are correctly installed.

12.4.1.6 Verification of the physical installation shall be documented by yard. The documentation shall be available for the Society's surveyor at the site.

12.5 Maintenance

12.5.1 General

12.5.1.1 The maintenance manual referred, shall be in accordance with the recommendations in IEC 60079-17 and 60092-502 and shall contain necessary information on:

- Overview of classification of hazardous areas, with information about gas groups and temperature class
- Register of inspections, with information about date of inspections and name(s) or person(s) who carried out the inspection and maintenance work.
- Inspection routines with information about detailing level and time intervals between the inspections, acceptance/rejection criteria.
- Records sufficient to enable the certified safe equipment to be maintained in accordance with its type of protection (list and location of equipment, technical information, manufacturer's instructions, spares etc.)

12.5.1.2 Inspection and maintenance of installations shall be carried out only by experienced personnel whose training has included instruction on the various types of protection of apparatus and installation practices to be found on the vessel. Appropriate refresher training shall be given to such personnel on a regular basis.

Updated documentation and maintenance manual, shall be kept onboard, with records of date and names of companies and persons who have carried out inspections and maintenance.

12.6 Signboards

12.6.1 General

12.6.1.1 In hazardous areas where electric lighting is provided, a signboard at least 200 × 300 mm shall be fitted at each entrance to such spaces with text as below:

**BEFORE A LIGHTING FITTING IS OPENED
ITS SUPPLY CIRCUIT IS
TO BE DISCONNECTED**

A signboard with the same text can be fitted at each individual lighting fitting.

12.6.1.2 Where electric lighting is provided in spaces where the ventilation must be in operation before the electric power is connected, a signboard at least 200 × 300 mm shall be fitted at each entrance, and with a smaller signboard at the switch for each lighting circuit, with the following text:

**BEFORE THE LIGHTING IS TURNED ON
THE VENTILATION MUST BE
IN OPERATION**

12.6.1.3 Signboard with following text shll be fitted at each socket-outlet, where socket-outlets are installed in cargo area or adjacent area:

**PORTABLE ELECTRICAL EQUIPMENT SUPPLIED
BY FLEXIBLE CABLES
IS NOT TO BE USED IN AREAS WHERE THERE IS
GAS DANGER**

Alternatively, signboards of size approximately 600 × 400 mm, with letters of height approximately 30 mm, can be fitted at each end of the tank deck.

12.6.1.4 Where socket-outlets for welding apparatus are installed in areas adjacent cargo area, the socket outlet shall be provided with a signboard with the following text:

**WELDING APPARATUS NOT TO BE USED UNLESS
THE WORKING SPACE
AND ADJACENT SPACES ARE GAS-FREE.**

SECTION 13 INSTRUMENTATION AND AUTOMATION

Contents

13.1 General Requirements

13.1.1 General

13.1.1.1 The requirements in this chapter are additional to those provided in Pt.6 Ch.8 (…Control and monitoring systems), regarding instrumentation and automation, including computer based control and monitoring.

Control and monitoring systems shal be certified according the requirments list in Sec 1.4, Table 1.4.1.

13.1.1.2 Cargo temperature and pressure remote reading system shall not allow the cargo or vapour to reach gas safe spaces. Direct pipe connections will not be accepted.

13.1.1.3 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 shall be concentrated in one control position.

13.1.1.4 Ships arranged with cargo pump room, carrying chemicals with flashpoint not exceeding 60°C, shall comply with the requirements for pump room safety as given in Sec 13.2.9 and Ch 3, Sec 6.2.3.2 and Ch 3, Sec 9.2.1.2 and Sec 13.2.1.3.

13.2 Alarms, Indication and Recording Systems

13.2.1 Level Gauging of Cargo Tanks

13.2.1.1 “Gauging device” means an arrangement for determining the liquid level in cargo tanks. Considering of the hzard and physical proplerties of each cargo shall provided the bsis for election one of the following types.

- Open: Type **b1**
  A method which utilises an opening in the tank and directly exposes the operator to the cargo or its vapours. Examples of this type are ullage openings and gauge hatches.

- Restricted: Type **b2**
  A device which penetrates the tank and which, when in use, permits a limited quantity of cargo vapour or liquid to be expelled to the atmosphere. When not in use, the device is completely closed. Examples of this type are rotary tube, fixed tube, slip tube and sounding pipe.

- Closed: Type **b3**
  A permanently installed device which penetrates the tank, but which is part of a closed system which keeps the cargo containment system completely sealed off from the atmosphere. Examples of this type are sight glasses, pressure cells, float-tape systems, electronic or magnetic probe.

- Indirect: Type **b4**
  A device which does not penetrate the tank shell or is independent of the tank and which makes use of an indirect measurement for determining the amount of cargo. Examples are weighing of cargo, pipe flow meter.

13.2.1.2 Each cargo tank shall be provided with at least one liquid level gauging device. Type of gauging devices required for the individual cargoes are shown in the IBC Code Ch.17 column j.

13.2.1.3 A closed gauing devise shall be provided with shut-off valves situated as close as possible to the tank, if it is not mounted directly on the tank.

13.2.2 Overflow Control

13.2.2.1 Arrangements as described below shall be provided according to the IBC Code Ch.17 column o (references to 15.19.6 corresponds to **f1**, references to 15.19 corresponds to **f2**).

13.2.2.2 Type **f1**: Visual and audible high level alarm shall be fitted in the cargo tank

This shall be able to be function tested from the outside of the tank and is also to be independent of the level gauging device required in Sec 13.2.1.2 and the high-high level alarm required in Sec 13.2.2.3.

13.2.2.3 Type **f2**: In addition to the high level alarm as described in Sec 13.2.2.2, a high-high level alarm shall be fitted. The high-high level alarm shall be independent of the high level alarm and the level gauging device.

13.2.3 Vapour Detection

13.2.3.1 Ships carrying toxic and/or flammable cargoes (refer IBC Code Ch.17 column k) shall be equipped with at least two instruments designed and calibrated for testing for the specific vapours in question. If such instruments are not capable of testing for both toxic concentrations and flammable concentrations, then two separate sets of instruments shall be provided.

13.2.3.2 Portable or fixed type vapour detection instrument is to be provided. If a fixed system is installed, at least one portable instrument shall be provided.

13.2.3.3 In the case of portable instruments being used, provisions shall be made to facilitate easy measurements, and where necessary fitting of guide tubes to enable gas sampling hose to be easily lead to the space to be tested.

13.2.4 Cargo Temperature Measurement

13.2.4.1 Means for measuring the cargo temperature shall be provided. Tanks intended for carriage of cargoes requiring cargo level gauging systems type **b2**, **b3** or **b4**, shall be provided with a temperature measuring system providing a gas segregation equivalent to the gauging systems required.

13.2.5 Hold Leakage Alarm

13.2.5.1 Cargo pump rooms, spaces containing cargo piping, hold spaces containing independent cargo tanks, as well as pipe tunnels and dry spaces adjacent to cargo tanks that are normally entered (including ballast pumprooms) shall be provided with level alarms for detection of leakage. The alarms shall be audible and visual and are to be activated at a permanently manned control station.

13.2.6 Computer (PLC) Based Systems for Cargo Handling

13.2.6.1 Local control of cargo handling systems independent of computer controlled systems will be required.

13.2.7 Centralised Cargo Control

13.2.7.1 If the cargo and ballast systems of the ship is built and equipped, surveyed and tested in accordance with the requirements in , may be given the additional class notation **CCS**.

13.2.8 Integrated Cargo and Ballast Systems

13.2.8.1 To enhance the safety of tankers, the operation of cargo and/or ballast systems may be necessary, under certain emergency circumstances or during the course of navigation. As such, measures are to be taken to prevent cargo and ballast pumps becoming inoperative simultaneously due to a single failure in the integrated cargo and ballast system, including its control and safety systems.

13.2.8.2 Integrated cargo and ballast systems meaning any integrated hydraulic and/or electric system used to drive both cargo and ballast pumps (including active control and safety systems and excluding passive components, eg. piping), are to be designed and constructed as detailed below:

1. Emergency stop circuits of the cargo and ballast systems are to be independent from the circuits for the control systems. A single failure in the control system circuits or the emergency stop circuits are not to render the integrated cargo and ballast system inoperative
2. Manual emergency stops of the cargo pumps are to be arranged in a way that they are not stop the power pack making ballast pumps inoperable.
3. Backup power supply shall be provided for the control systems, which may be satisfied by a duplicate power supply from the main switch board. The failure of any power supply is to provide audible and visible alarm activation at each location where the control panel is fitted.
4. In the event of failure of the automatic or remote control systems, a secondary means of control is to be made available for the operation of the integrated cargo and ballast system. This is to be achieved by manual overriding and or redundant arrangements within the control systems.

13.2.9 Gas Detection in Cargo Pump Room for Flamamable Liquids with Flashpoint Not Exceeding 600C

13.2.9.1 A continuous monitoring system of the concentration of flammable vapours shall be fitted according the the IBC code 11.1.4 also taking into account the requirements of Ch 3, Sec 9.6.1.

13.2.9.2 Sequential sampling is acceptable as long as it is dedicated for the pump room only, including exhaust ducts, and the sampling time is reasonably short.

Note:
Suitable positions may be the exhaust ventilation duct and lower parts of the pump room above the floor plates.

SECTION 14 TEST AFTER INSTALLATION

Contents

14.1 General

14.1.1 Application

14.1.1.1 As far as practicable, the tests shall be performed at the building yard. All systems covered by this chapter shall be tested in operation.

14.1.1.2 The remaining function tests, which cannot be carried out without cargo on board, may be carried out in connection with the first cargo loading and transport with a representative cargo.

SECTION 15 ADDITIONAL REQUIREMENTS FOR CERTAIN CARGOES

Contents

15.1 General Requirments

15.1.1 Application

15.1.1.1 The requirements are mainly of constructional nature or of a nature affecting both construction and operation. Specific operational requirements for some of the products are given in the IBC Code. It is assumed that the operational requirements are complied with during operation of the ship.

The requirements of this section are applicable where specific reference is made in the IBC Code Ch.17 column o to corresponding parts of the Code.

15.1.2 Material of Construction

15.1.2.1 The tanks and associated pipelines, valves, fittings and other items of equipment which may come in contact with the cargo, are to be constructed of stainless steel unless fitted with an approved lining, when cargo tanks are intended for carriage of acids/corrosive products, which in the IBC Code Ch.17 column o have a reference to 15.11 (or to 15.11.2 or .3)

15.1.3 Segregation of Cargo from Bunker Tanks

15.1.3.1 In tanks adjacent to bunker tanks, the products detailed in IBC Code Ch 17 column o have a reference to 15.12 or 15.12.3 shall not be carried.

15.1.4 Separate Piping Systems

15.1.4.1 Relevant cargo products in the IBC Code Ch.17 column o have a reference to 15.12 or 15.12.3, shall be carried in tanks with separate piping systems and with vent systems separate from tanks containing other products.

Separation of piping systems shall be by spool pieces or similar arrangements enabling visual confirmation of the status of the separation. The requirements to separation of piping systems applies to any cargo handling systems common to and connected to tanks or piping conveying cargo liquid or vapour. Examples of such systems are tank washing systems, inert gas systems, vapour return systems, fixed gas-freeing and drying systems, stripping systems and cargo pipe drainage systems.

15.1.5 Cargo Contamination

15.1.5.1 Water shall not be allowed to contaminate products which in the IBC Code Ch.17 column o have a reference to 15.16.2. In addition, the following provisions apply:

- The air inlets to pressure/vacuum relief valves (P/V valves) of tanks containing this cargo shall be situated at least 2 m above the weather deck.
- Steam or water shall not be used as the heat transfer media in a cargo temperature control system.
- This cargo shall not be carried in tanks adjacent to permanent ballast or water tanks unless the tanks are empty and dry.
- This cargo shall not be carried in tanks adjacent to sea chests, slop tanks, cargo tanks containing ballast or slops or other cargoes containing water which may react in a dangerous manner. Pumps, pipes or vent lines serving such

tanks shall be separate from similar equipment serving tanks containing this cargo. Pipelines from slop tanks or ballast lines shall not pass through tanks containing this cargo unless in a tunnel.

15.1.6 Inert Gas

15.1.6.1 In the IBC Code Ch.17 column h, for the products that are assigned "Inert", the cargo tank vapour space and associated piping systems shall be filled and maintained with a gas (inert) which will not support combustion and which will not react with the cargo.

15.1.6.2 Unless a shore supply of inert gas is available, an adequate supply of the same for use in filling and discharging shall be installed and stored onboard.

Sufficient inert gas shall be available on the ship to compensate for normal losses during transportation, in addition.

15.1.6.3 The inert gas system on board the ship shall be able to maintain at least 0.07 bar over-pressure within the containment system at all times. In addition, the inert gas system shall not raise the cargo tank pressure to more than the tank's relief valve setting.

15.1.6.4 Effective means for monitoring ullage spaces containing a gas blanket to ensure that the correct atmosphere is being maintained.

15.1.6.5 With flammable cargoes inerting arrangements shall be such as to minimise the creation of static electricity during the admission of the inerting media.

15.1.7 Moisture Control (Drying)

15.1.7.1 Relevant cargo products in the IBC Code Ch.17 column h are assigned "Dry", the cargo tank vapour space and associated piping systems shall be filled and maintained with a moisture free gas or vapour which will prevent the access of water or water vapour to the cargo. For the purpose of this paragraph, “moisture free” gas or vapour is that which has a dewpoint of -40°C or below at atmospheric pressure.

15.1.7.2 Where dry nitrogen is used as the medium, similar arrangements for supply of the drying medium shall be made as required in Sec 15.1.6.2 and Sec 15.1.6.5 above. Where drying agents are used as the drying medium on all air inlets to the tank, sufficient media shall be carried for the duration of the voyage taking into consideration the diurnal temperature range and the expected humidity

15.1.8 Cargo Pumps in Tanks

15.1.8.1 Relevant cargo products in the IBC Code Ch.17 column o have a reference to 15.18, cargo pumps shall be located in the cargo tank or the cargo pump room shall be located on the weather deck level. Special consideration by the Society is required for other locations of the pump room.

15.1.9 Products not to be exposed to excessive heat

15.1.9.1 Relevant cargo products in the IBC Code Ch.17 column o have a reference to 16.6 or 16.6.3, are due to their heat sensitive nature, not to be carried in uninsulated deck tanks.

15.1.9.2 Relevant cargo products in the IBC Code Ch.17 column o have a reference to 16.6 or 16.6.4, are due to their heat sensitive nature, not to be carried in deck tanks.

15.1.10 Cargo Pump Temperature Sensors

15.1.10.1 Relevant cargo products in the IBC Code Ch.17 column o have a reference to 15.21, temperature sensors shall be used to monitor cargo pumps located in pump rooms, to detect overheating due to pump failure.

15.1.11 Increased ventilation of cargo handling spaces

15.1.11.1 Relevant cargo products in the IBC Code Ch.17 column to have a reference to 15.17, the ventilation system as described in Sec.10 B301, shall have a capacity of at least 45 air changes per hour. The ventilation exhaust outlets shall be situated at least 10 m from ventilation inlets to the accommodation and other non-hazardous spaces and at least 4 m above the tank deck.

15.2 Additional Requirements for Certain Groups of Product

15.2.1 Acids

15.2.1.1 Source of ignition including electric equipments are not permitted in enclosed spaces adjacent to cargo tanks, except as specified in Sec 12.

15.2.1.2 Shell plating of the ship shall not form any boundaries of tanks containing mineral acids.

15.2.1.3 For carriage of acids the materials of construction of the tanks shall be approved on a case by case basis.

15.2.1.4 Proposals for lining steel tanks and related piping systems with corrosion-resistant materials may be considered by the Society. The elasticity of the lining shall not be less than that of the supporting boundary plating. For definition of lining refer Sec 1.2.

15.2.1.5 The plating thickness shall take into account the corrosiveness of the cargo, unless the tanks are constructed completely of corrosion-resistant materials or fitted with an approved lining.

15.2.1.6 The loading and discharge manifold connection flanges shall be provided with shields which may be portable to guard against the danger of the cargo being sprayed. Drip trays shall be provided to guard against leakage on to the deck.

15.2.1.7 Efficient means fo detecting leakage of cargo into adjacent spaces shall provided.

15.2.1.8 Bilge pumping arrangements and drainage arrangements in pump rooms shall be of corrosion resistant materials.

15.2.2 Products With Vapour Pressure Greater than 1.013 bar at 37.8°C

15.2.2.1 Provisions shall be made to maintain the temperature of the cargo below its boiling point at atmospheric pressure, unless the tank is designed to withstand the vapour pressure of the cargo.

15.2.2.2 During loading of cargo, proper connection with valves for returning gas ashore shall be provided.

15.2.2.3 A pressure gauge indicating the pressure in the vapour space above the cargo shall be provided in each tank.

15.3 Additional Requirements for Certain Chemicals

15.3.1 Ammonium Nitrate Solution (93% of less)

15.3.1.1 For relevant requirements refer to the IBC Code 15.2

15.3.2 Carbon Disulphide

15.3.2.1 For relevant requirements refer to the IBC Code 15.3

15.3.3 Diethyl Ether

15.3.3.1 Natural ventilation shall be provided for the voids around the cargo tanks while the vessel is under way, unless inertedAll blowers shall be of non-sparking construction if a mechanical ventilation system is installed. Mechanical ventilation equipment shall not be located in the void spaces surrounding the cargo tanks.

15.3.3.2 Ensure that the settings of the pressure relief valve not less than 0.20 bar.

15.3.3.3 For discharging cargo from pressure vessel tanks, the inert gas displacements technique may be used, provided the cargo system is designed for the expected pressure.

15.3.3.4 Electrical equipment other than approved lighting fixtures shall not be installed in enclosed spaces adjacent to cargo tanks. Lighting fixtures shall be approved for use in diethyl ether vapours. The installation of electrical equipment on the weather deck shall comply with the requirements of Sec 12.

15.3.3.5 Provisions shall be made to avoid any ignition source and/or heat generation in the cargo area, in view of the fire hazard.

15.3.3.6 Pumps may be used for discharging cargo provided that they are of a type designed to avoid liquid pressure against the shaft gland or are of a submerged type and are suitable for use with the cargo.

15.3.3.7 Provisions shall be made to maintain the inert gas pad in the cargo tank during loading, unloading and during transit.

15.3.4 Hydrogen Peroxide Solutions (60% but not over 70% by mass)

15.3.4.1 For relevant requirements refer to the IBC Code 15.5.1.

15.3.5 Hydrogen Peroxide Solutions (over 8% but not over 60% by mass)

15.3.5.1 For relevant requirements refer to the IBC Code 15.5.2 and 15.5.3.

15.3.6 Phosphorus (White or Yellow)

15.3.6.1 For relevant requirements refer to the IBC Code 15.5.7.

15.3.7 Propylene Oxide and Mixtures of Ethylene Oxide/ Propylene Oxide (with ethylene oxide content of not more than 30% by weight)

15.3.7.1 Under the provision of this section, propylene oxide transported shall be acetylene free.

15.3.7.2 Propylene oxide tanks shall be of steel or stainless steel construction.

15.3.7.3 Materials:

1. All flanges, valves, fittings and accessory equipment shall be of a type suitable for use with propylene oxide and shall be constructed of steel or stainless steel or other material acceptable to the Society. The chemical composition of all material used should be submitted for approval prior to fabrication. Discs or disc faces, seats and other wearing parts of valves shall be made of stainless steel containing not less than 11% chromium.

2. All gaskets used in the system shall be constructed of materials which do not react with, dissolve in or lower the auto-ignition temperature of these products and which are fire resistant and possess adequate mechanical behaviour. The surface presented to the cargo shall be polytetrafluoroethylene (PTFE) or materials giving a similar degree of safety by their inertness. Spirally-wound stainless steel with a filler of PTFE or similar fluorinated polymer will be accepted.

3. Packing and insulation, if used, shall be of a material which does not react with, dissolve in, or lower the auto-ignition temperature of these products.

4. Materials detailed below are generally found unsatisfactory for gaskets, packing and similar uses in containment systems for these products and would require testing before being approved:

- Mineral wools and materials containing oxides of magnesium
- Natural rubber or neoprene if it contacts propylene oxide

15.3.7.4 In the liquid cargo and vapour lines threaded joints are not permitted.

15.3.7.5 Filling and discharge piping shall extend to within 100 mm of the bottom of the tank or any sump pit.

15.3.7.6 Containment System:

1. A valved vapour return connection shall be installed in the containment system for a tank containing these products.

2. The products shall be loaded and discharged in such a manner that venting of the tanks to atmosphere does not occur. If vapour return to shore is used during tank loading, the vapour return system connected to a propylene oxide containment system for these products shall be independent from all other containment systems.

3. The pressure in the cargo tank must be maintained above 0.07 bar gauge during discharging operations.

15.3.7.7 Facilities shall be provided for sampling the tank contents without opening the tank to the atmosphere. Tanks carrying these products shall be vented independently of tanks carrying other products.

15.3.7.8 The cargo may be discharged only by deepwell pumps, hydraulically operated submerged pumps, or inert gas displacement. Each cargo pump shall be arranged to ensure that the oxide does not heat significantly if the discharge line from the pump is shut off or otherwise blocked.

15.3.7.9 Cargo hoses used for transfer of these products shall be marked as below:

FOR ALKYLENE OXIDE TRANSFER ONNLY

15.3.7.10 Enclosed spaces such as void spaces, cargo tanks etc. adjacent to an integral gravity cargo tank, shall either contain a compatible cargo or be inerted by injection of a suitable inert gas. Any enclosed space in which an independent cargo tank is located shall be inerted. Such inerted spaces and tanks shall be monitored for propylene oxide and oxygen. The oxygen content of these spaces shall be maintained below 2%.

15.3.7.11 Air should never be allowed to enter the carog pump or piping system while these products are contained within the system.

15.3.7.12 Before disconnecting shore-lines, the pressure in liquid and vapour lines shall be relieved through suitable valves installed at the loading header. Ensure that the liquid and vapour from these lines shall not be discharged to atmosphere.

15.3.7.13 Propylene oxide may be contained in pressure tanks (**a4**) or in independent (**a3**) or in integral (**a2**) gravity tanks.

Ethylene oxide/propylene oxide mixtures shall be carried in independent gravity tanks (**a3**) or in pressure tanks (**a4**). Tanks shall be designed for the maximum pressure expected to be encountered during loading, conveying and discharging cargo.

15.3.7.14 Tanks:

1. Cargo tanks with a design pressure less than 0.6 bar gauge and tanks for the carriage of ethylene oxide/ propylene oxide mixtures with a design pressure less than 1.2 bar gauge shall have a cooling system to maintain the propylene oxide below the reference temperature (Refer Sec 1.2.1.19).

2. The refrigeration requirement for tanks with a design pressure less than 0.6 bar gauge may be waived by the Society for ships operating in restricted areas or in voyages of restricted duration and account may be taken in such

cases of any insulation of the tanks. The area and times of year where and for which such carriage would be permitted will be included in the conditions of carriage in the Appendix to the classification certificate.

Note:
For ships subject to USCG compliance, reference is also made to additional USCG requirements given in 46 CFR 153.370, 153.371 and 153.438.

15.3.7.15 Cooling

1. The provided cooling system shall maintain the liquid temperature below the boiling temperature at the containment pressure. At least two complete cooling plants automatically regulated by variations within the tanks shall be provided. Each cooling plant shall be complete with the necessary auxiliaries for proper operation. The control system is also to be capable of being manually operated. An alarm shall be provided to indicate malfunctioning of the temperature controls. The capacity of each cooling system shall be sufficient to maintain the temperature of the liquid cargo below the reference temperature (Refer Sec 1.2.1.19) of the system.
2. An alternative arrangement may consist of three cooling plants, any two of which shall be sufficient to maintain the liquid temperatures below the reference temperature.
3. Cooling media which are separated from the products by a single wall only shall be non-reactive with the propylene oxide.
4. Propylene oxide compression shall not be used in the cooling system installed.

15.3.7.16 Pressure relief valve settings:

Pressure tanks for the carriage of propylene oxide:
Setting shall not be less than 0.2 bar gauge, nor greater than 7.0 bar gauge .

Pressure tanks for the carriage of propylene oxide/ethylene oxide mixtures:
Setting shall not be less than 0.2 bar gauge, nor greater than 5.3 bar gauge

15.3.7.17 Piping

1. Piping system for these products shall be completely separate from piping systems for all other tanks, including empty tanks, and from all cargo compressors. If the piping system for the tanks to be loaded is not independent as defined in Sec 1.2.1.18, the required piping separation shall be accomplished by the removal of spool pieces, valves, or other pipe sections, and the installation of blank flanges at these locations. The required separation applies to any other possible connections such as common tank washing systems, inertgas systems, vapour return systems, fixed gas freeing and drying systems, stripping systems and cargo pipe drainage systems.

2. Transportation of such products shall only be carried out based on cargo handling plans that have been approved by the Society. Each intended loading arrangement shall be shown on a separate cargo handling plan. Cargo handling plans shall show the entire cargo piping system and the locations for installation of blank flanges needed to meet the above piping separation requirements. A copy of each approved cargo handling plan shall be maintained on board the ship.

Note:
When a ship carries propylene oxide or mixtures of ethylene oxide and propylene oxide under IMO's Certificate of Fitness, the Administration or delegated body issuing the certificate will be required to include a reference to the approved cargo handling plans in the certificate.

3. Prior to loading of propylene oxide, certification verifying that the required piping separation has been achieved shall be obtained from a representative of the Society and carried on board the ship. Each connection between a blank flange and pipeline flange shall be fitted with a wire and seal by the Society's representative to ensure that inadvertent removal of the blank flange is impossible.

15.3.7.18 For each cargo tank, the maximum allowable filling limits shall be indicated for each loading temperature which may be applied and for the applicable maximum reference temperature, on a list to be approved by the Society. A copy of the list shall be permanently kept on board by the master.

15.3.7.19 A suitable protective padding of nitrogen gas shall be ensured while the cargo is carried in the tank. An automatic nitrogen make-up system shall be installed to prevent the tank pressure falling below 0.07 bar gauge in the event of product temperature fall due to ambient conditions or maloperation of refrigeration systems. Nitrogen of acceptable purity shall be used for padding. Sufficient nitrogen shall be available on board to satisfy the demand of the automatic pressure control.

15.3.7.20 The vessel shall have an effective nitrogen system and shall be capable of inerting the tank vapour space to an oxygen content of less than 2% prior to loading and maintaining this content during the voyage.

15.3.7.21 Where loading and unloading operations are conducted an effective waterspray system shall be provided in that area. The arrangement and capacity shall be such as to blanket effectively the area surrounding the loading manifold and the exposed deck pipework associated with product handling. The arrangement of piping and nozzles shall be such as to give a uniform distribution over the entire area protected at a discharge rate of 10 l/m^2/minute. Remote manual operation should be arranged such that remote starting of pumps supplying the water spray system and remote operation of any normally closed valves in the system can be carried out from a suitable location outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the areas protected. The water-spray system shall be capable of both local and remote manual operation and the arrangement shall ensure that any spilled cargo is washed away. Additionally, a water hose with pressure to the nozzle, when atmospheric temperatures permit, shall be connected ready for immediate use during loading and unloading operations.

Note:
Ships subjected to USCG compliance, reference is also made to additional USCG requirements to such systems given in 46 CFR 153.530.

15.3.7.22 At the manifold for each cargo hose connection used during cargo transfer, a remote operational, controlled closing-rate shut-off valve shall be provided.

15.3.8 Sulphuric Acid:

15.3.8.1 Unlined mild steel tanks shall be acceptable for the carriage of sulphuric acid as detailed below:

- 78% (60° Be) or higher with or without an inhibitor, provided the corrosive effect on mild steel at 25°C is not higher than that of 96% (66° Be) commercial sulphuric acid.
- 96% (66° Be) or higher concentrations.
- Spent sulphuric acid from industrial processes, provided the corrosive effect is not higher than that stated above.

15.3.8.2 Other qualities and concentrations of sulphuric acid other than stated in Sec 15.3.8.1 shall be carried in tanks lined or made from suitable acid-resistant materials. These will be subject to special consideration by the Society.

15.3.8.3 Cargo pipings, pumps and valves made from nodular cast iron, will be accepted for the following sulphuric acids:

- 65% (51.7° Be) or higher concentrations
- Spent sulphuric acid from industrial processes, provided the corrosive effect is not higher than that stated above.

15.3.8.4 Vent pipes and P/V valves from the cargo tank shall be made of or protected by acid-resistant materials. Vent pipes to unprotected cargo tanks shall extend about 50 mm into the tank.

15.3.8.5 Below pump glands and at shore connections, drip pans shall be provided.

15.3.8.6 Bilge pump and piping system in pump rooms shall be made of or lined with corrosion-resistant material.

15.3.9 Liquid Sulphur

15.3.9.1 Cargo tank ventilation shall be provided to maintain the concentration of H_2S below one half of its lower explosive limit (LEL) throughout the cargo tank vapour space for all conditions of carriage, ie. below 1.85% by volume.

15.3.9.2 Ventilation failure alarms shall be provided, where mechanical ventilation systems are used for maintaining low gas concentrations in cargo tanks.

15.3.9.3 The ventilation systems shall be designed and arranged to preclude depositing of sulphur within the system.

15.3.9.4 Entry of water, sulphur or cargo vapour shall be prevented through effectively designed and fitted openings to void spaces adjacent to cargo tanks.

15.3.9.5 Effective connections to enable sampling and analysis of vapour in void spaces shall be provided

15.3.9.6 In order to ensure that the temperature of the sulphur does not exceed 155°C, an automatic temperature control system for the cargo shall be installed.

A high temperature alarm shall be fitted in the tanks.

15.3.10 Alkyl Nitrates (C_7 – C_9)

15.3.10.1 To prevent the occurance of self-sustained, exothermic decomposition reaction, the cargo shall be carried at a temperature below 100^0C.

15.3.10.2 The cargo may not be carried in independent pressure tanks (a4) permanently affixed to the ship's deck unless:

1. The tanks are sufficiently insulated from fire, and
2. The ship has a water deluge system for the tanks such that the cargo temperature is maintained below 100°C and the temperature rise in the tanks does not exceed 1.5°C/hour for a fire of 650°C.

SECTION 16 INERT GAS SYSTEMS

Contents

16.1 General

16.1.1 Application

16.1.1.1 Chemical tankers of 8000 tonnes dwt and above, constructed on or after 1 January 2016 shall be fitted with a fixed inert gas system. Requirements given for inert gas plants in the FSS Code Ch.15 as amended by IMO Res. MSC.367(93) shall apply.

Chemical tankers when transporting oil with flashpoint not exceeding 60°C shall comply with the inert gas requirements of SOLAS Reg. II-2/4.5.5.

Ch.15 of the FSS code as amended by IMO Res. MSC.367(93) have been included in Table 16.3.1.

SOLAS II-2 Reg.16 as amended by IMO Res. MSC.365(93), specifies that for chemical tankers, when carrying flammable chemicals, the application of inert gas, may take place after the cargo tank has been loaded, but before commencement of unloading and shall continue to be applied until that cargo tank has been purged of all flammable vapours before gas-freeing. Only nitrogen is acceptable as inert gas under this provision. For ships that intend to apply this option, nitrogen generators with capacity of 125% of the maximum discharge rate must be installed.

16.1.2 Documentation Requirements

16.1.2.1 Documentation in accordance with Ch 3, Sec 11 shall be submitted for approval.

16.2 Materials, Arrangement and Design

16.2.1 General

The requirements of Ch 3, Sec 11 shall be applicable for the inert gas systems to the extent these are applicable. Certification requirements for components in nitrogen inert gas systems based on separation of air are given in Table 16.2.1..

Alternative solutions to specific requirements in above rules may be accepted as follows:

1. Water seals as required by Ch 4, Sec 11.3.6.2 may be replaced by an alternative arrangement consisting of two automatically operated shut-off valves in series with a venting valve in between (double block and bleed). The following shall be applicable:

    - The valve operation shall be automatically executed. Signals for opening and closing shall be taken from the process directly, eg. inert gas flow or differential pressure. An arrangement where nitrogen supply directly from the process is used to control the valves (maintain block valves open and bleed valve closed) may be accepted, provided the nitrogen supply pressure is higher than the pressure setting of the cargo tank P/V-valves and provided the valves automatically return to safe position in the event of loss of nitrogen supply.
    - Position indication for the valves shall be provided. An alarm for faulty operation of the valves shall be provided, eg. the operational status of “Blower stop” and “Supply valve(s) open” is an alarm condition.

2. A lower capacity of the system than that required by Ch 3, Sec 11.4.1 may be accepted on the condition that the cargo discharge rate from tanks being protected is restricted to 80% of the inert gas capacity. An entry to this effect will be made in the Appendix to the Classification Certificate.

16.2.2 Production of inert gas by other means other than combustion of hydrocarbons may be accepted upon special considerations by the Society.

16.2.3 Inert gas systems based on other means than combustion of hydrocarbons

16.2.3.1 The requirements of Sec 16.2.3 are specific for the gas generator system and apply when inert gas is produced by passing compressed air through hollow fibres, semi-permeable membranes or adsorber materials.

16.2.3.2 At least two air compressore shall be provided to the system.

16.2.3.3 To remove free water, particles and traces of oil from the compressed air, a feed air treatment system shall be installed.

16.2.3.4 Nitrogen generator and air compressor may be installed in the engine room or in a separate compartment. The separate compartment can also be positioned in the cargo area subject to hazardous zone considerations. When installed in a separate compartment, the compartment shall be treated as one of other machinery spaces with respect to fire protection.

16.2.3.5 Where a separate compartment is provided, it shall be fitted with an independent mechanical extraction ventilation system, providing 6 air changes per hour. Two oxygen sensors (low oxygen alarms) shall be fitted and give audible and visual alarm outside the door. Such compartment is to have no direct access to accommodation spaces, service spaces and control stations.

16.2.3.6 In case a nitrogen receiver or a buffer tank is installed, it may be installed in a dedicated compartment, in a separate compartment containing the air compressor and the generator, in the engine room, or in the cargo area. Where the nitrogen receiver or a buffer tank is installed in a dedicated or separate compartment, the access shall be arranged only from the open deck and the access door shall open outwards. Permanent ventilation and alarms shall be fitted as required in Sec 16.2.3.4.

16.2.3.7 Nitrogen separating systems that may be destroyed or damaged by high temperature in the supply air shall be arranged with an alarm and automatic shutdown of the system upon alarm conditions.

Table 16.2.1 Certification of Nitrogen Generator System Components

Equipment	**Cert. Type**	**Remarks**
Deck water seal	NV-P(…Pt)	
Sea water pump for deck water seal	NV-P(…Pt 1)	
Liquid P/V breaker	NV-P(…Pt 1)	
Absorption or refrigerant dryer	NV-P(…Pt 1)	If pressure vessel (eg. swing type)
Control and monitoring system	NV-P(…Pt 1)	
Electrical motors and starters	NV-P(…Pt 1)	Refer Pt.6 (..Electrical Installations)
Membrane separation vessels	NV-P(…Pt 1)	If pressure vessels as below: p x V > 1.5
Air compressor ≤ 100 kW	W-P (Pt 1)	

Air compressor ≥ 100 kW	NV-P(…Pt 1)	
Cooling water pumps (compressors)	NV-P(…Pt 1)	Normally air cooled
Pressure vessels containing N_2 (eg Buffer tanks)	NV-P(…Pt 1)	
NV-P: INTLREG Product Certificate (…include in Pt 1) W-P: Makers (Works) Product Certiicate (…include in Pt 1) NV-TA: INTLREG Type Approval (…Include in Pt 1) (*) Electric motors pertaining serving dryers need therefore not be delivered with INTLREG product certificate or Type Approval Certificate, but only required to have Manufacturer's (Works) certificate (…Include in Pt 1) regardless of size.		

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

1. Oxygen enriched air from nitrogen generator- safe location on the open deck are:

   - Outside of the hazardous area
   - Not within 3 m of areas traversed by personnel; and
   - Not within 6 m of air intakes for machinery (engines, boilers etc) and all ventilation inlets.

2. Nitrogen-product enriched gas from the protective devices of the nitrogen receiver - safe locations on the open deck are:

   - Not within 3 m of areas traversed by personnel; and
   - Not within 6 m of air intakes for machinery (engines and boilers) and all ventilation inlets/ outlets.

   Refer IACS UR F20 also for more details.

16.2.4 Nitrogen inert gas systems fitted for other purposes

16.2.4.1 If an inert gas system is fitted for other applications than stated in Sec 16.1.1.1, the requirements in Sec 16.2.3 apply. However, only one air compressor is required and a permanent recording of the parameters in Ch 3, Sec 11.5.2.2 is not mandatory.

16.2.4.2 Where the connections to the hold spaces or to the cargo piping are not permanent, two non-return valves may substitute the non-return devices required in Ch 3, Sec 11.3.6.2 and Ch 3, Sec 11.3.6.3 Refer IACS UR F20 for details.

Note:
Cargo tank connections for inert gas padding, as required for the carriage of certain products, are considered as permanent for the purpose of this requirement.

16.3 Instrumentation

16.3.1 General

16.3.1.1 The inert gas systems shall comply with the requirements of Ch 3, Sec 11.5 to the extent these requirements are applicable. In addition, for inert gas generator systems where nitrogen is produced by passing compressed air through hollow fibres, semi-permeable membranes or adsorber materials, the requirements in Table 16.3.1 shall be applicable.

Table 16.3.1 Control and Monitroing of Inert Gas Plant bsed on N_2 Separation

Failure/ Indication	Setting	Permanent recording	Continuous Indication	Alarm (1)	Remarks
Operational status of the inert gas system	-	-	CCR	-	Indicator showing that inert gas is being produced and delivered to cargo area 6)
Oxygen content(5)	-	CCR	ECR and CCR	-	-
Pressure in IG main(4)	-	CCR	ECR, CCR and Bridge	-	To be active also when plant not in use
IG supply temperature	-	-	ECR and CCR	-	-
High oxygen content (5)	> 5%	-	-	CCR and ECR	-
Low pressure IG main(4)	< 100 mm	-	-	CCR and ECR	-
Low-low pressure IG main	< 50 mm	-	-	CCR or automatic shut down of cargo pump with alarm	Shall be independent of the low pressure alarm. ie separate pressure transmitter.
High pressure IG main(4)	-	-	-	CCR	-
Low level in deck water seal	-	-	-	CCR	To be active also when IG plant is not in use
Failure of air compressors	-	-	-	CCR	-
Power failure of the control and monitoring system	-	-	-	CCR and ECR	-
Power failure to oxygen and pressure Indicators and recorders	-	-	-	CCR and ECR	To be active also when the plant is not in use
Oxygen level in inert gas room(s)	< 19% O_2	-	-	Outside space and ECR	Min 2 O_2 sensors to be provided in each space. Audio visual alarm at the entrance to the IG room(s)
Power failure of the N_2 generator	-	-	-	CCR	-
Loss of inert gas supply (flow or differential pressure)	-	-	-	CCR	-

Faulty operation of double-block and bleed valves	-	-	-	CCR	Note [3]
Double block and bleed valve position	-	-	CCR	-	-
Loss of power to double-block and bleed or Nitrogen generator	-	-	-	-	-
Air temperature at suction side of the N_2 generator (aftercompressors and coolers if fitted)	75^{O} C	-	CCR	CCR	Maker's alarm settings may apply, but must not exceed that specified in Sec. 7.1.1.11
Air pressure at suction side of the N_2 generator	-	-	CCR	-	-
Failure of electric heater (if fitted)	-	-	-	CCR	-
Low feed air pressure from compressor	-	-	-	CCR	-
High condensate level at automatic drain of water separator	-	-	-	CCR	-

[1] Alarms shall be audible and visible
[2] Applicable only for ships with doubl-block and bleed replacing deck water seals
[3] Faulty operation of duble-block and bleed valves:
-One block valve open and other block valve closed
-Bleed-valve open and block valves open
-Bleed valve closed and block valve closed
-Block valves open when there is no inert gas supply
[4] A common pressure transmitter is acceptable
[5] A common oxygen sensor is acceptable
[6] Indication of position of gas regulating valve is accepted as status of delivery to cargo area

Table 16.3.1 Control and Monitroing of Inert Gas Plant bsed on N_2 Separation (Continued.)

Failure/ Indication	Shut-down of Gas Regulating Valve	Automatic Shut-down of Compressors	Activation of double block and bleed[2]
Operational status of the inert gas system	-	-	-
Oxygen content[5]	-	-	-
Pressure in IG main[4]	-	-	-
IG supply temperature	-	-	-
High oxygen content [5]	X	-	-
Low pressure IG main[4]	-	-	-
Low-low pressure IG main	-	-	-
High pressure IG main[4]	-	-	-
Low level in deck water seal	-	-	-
Failure of air compressors	X	-	-
Power failure of the control and monitoring system	-	-	-

Power failure to oxygen and pressure indicators and recorders	-	-	-
Oxygen level in inert gas room(s)	-	-	-
Power failure of the N_2 generator	-	-	-
Loss of inert gas supply (flow or differential pressure)	X	-	X
Faulty operation of double-block and bleed valves	-	-	-
Double block and bleed valve position	-	-	-
Loss of power to double-block and bleed or Nitrogen generator	-	-	X
Air temperature at suction side of the N_2 generator (aftercompressors and coolers if fitted)	X	X	-
Air pressure at suction side of the N_2 generator	-	-	-
Failure of electric heater (if fitted)	-	-	-
Low feed air pressure from compressor	-	-	-
High condensate level at automatic drain of water separator	-	-	-

(1) Alarms shall be audible and visible
(2) Applicable only for ships with doubl-block and bleed replacing deck water seals
(3) Faulty operation of duble-block and bleed valves:
-One block valve open and other block valve closed
-Bleed-valve open and block valves open
-Bleed valve closed and block valve closed
-Block valves open when there is no inert gas supply
(4) A common pressure transmitter is acceptable
(5) A common oxygen sensor is acceptable
(6) Indication of position of gas regulating valve is accepted as status of delivery to cargo area

SECTION 17 PERSONNEL PROTECTION

Contents

17.1 General Requirements

17.1.1 Protective Equipments

17.1.1.1 The ship shall have on board suitable protective equipment consisting of large aprons, special gloves with long sleeves, suitable footwear, coveralls of chemical-resistant material, and tight-fitting goggles or face shields or both, for the protection of crew members who are engaged in loading and discharging operations. The protective clothing and equipment shall cover all skin so that no part of the body is unprotected.

Six (6) sets of protective clothing and equipment shall be carried onboard.

17.1.1.2 Protective equipment and working clothes shall be kept in easily accessible places and in special lockers. Such equipment shall not be kept within accommodation spaces, with the exception of new, unused equipment and equipment which has not been used since undergoing a thorough cleaning process. Storage rooms for such equipment may, however, upon special consideration be approved within accommodation spaces if adequately segregated from living spaces such as cabins, passageways, dining rooms, bathrooms, etc.

17.2 Safety Equipment

17.2.1 Safety Equipment

17.2.1.1 Ships intended for carriage of toxic products for which the IBC Code Ch.17 column o refers to 15.12, 15.12.1 or 15.12.3, shall have on board sufficient, but not less than three complete sets of safety equipment each permitting personnel to enter a gas filled compartment and perform work there for at least 20 minutes. Such equipment shall be in addition to that required by SOLAS regulation II-2/10.10.

17.2.1.2 Safety equipment, one complete set shall comprise of the following:

1. One set of self contained air breathing apparatus, not using stored oxygen
2. Protective clothing, gloves, boots and tight-fitting goggles
3. Lifeline (fire proof type) with belt resistant to the cargoes carried.
4. Explosion proof lamp

17.2.1.3 All ships shall carry the following for the safety equipment required in Sec 17.2.1.1:

1. One set of fully charged spared air bottles for each breathing apparatus;
2. For the supply of high-pressure air of required purity, a special air compressor;
3. Charging manifold capable of dealing with sufficient spare breathing apparatus air bottles for the breathing apparatus, or
4. Fully charged spare air bottles with a total free air capacity of at least 6000 liters for each breathing apparatus on board in excess of the requirements of SOLAS regulation II-2/10.10.

17.2.1.4 A cargo pump-room on ships carrying cargoes which are subject to the requirements of Sec 15.1.8 or cargoes for which in the IBC Code Ch.17 column k, toxic vapour detection equipment is required, but is not available shall have either:

1. A low-pressure line system with hose connections suitable for use with the breathing apparatus required by Sec 17.2.1.1. This system shall provide sufficient high-pressure air capacity to supply, through pressure reduction devices, enough low-pressure air to enable two men to work in a hazardous space for at least 1 h without using the air bottles and breathing apparatus air bottles from a special air compressor suitable for the supply of high-pressure air of the required purity;
   or
2. In lieu of the low-pressure air line, an equivalent quantity of spare bottled air.

17.2.1.5 One set of safety equipment, as a minimum and as required by Sec 17.2.1.2 shall be kept in a suitable clearly marked locker in a readily accessible place near the cargo pump-room. The other sets of safety equipment should also be kept in suitable, clearly marked, easily accessible, place.

17.2.1.6 A stretcher which is suitable for hoisting an injured person up from spaces such as the cargo pump-room shall be placed in a readily accessible location.

17.2.1.7 Ships intended for the carriage of products which in the IBC Code Ch.17 column n are assigned "Yes", shall be provided with suitable respiratory and eye protection sufficient for every person on board for emergency escape purposes, subject to the following:

1. Breathing apparatus (self contained type) shall normally have a duration of service of at least 15 min.
2. Emergency escape respiratory protection shall not be used for fire-fighting or cargo handling purposes and should be marked to that effect.

17.2.1.8 Those ships intended for the carriage of products which in the IBC Code Ch.17 column n are assigned “Yes”, lifeboats shall be provided with a self-contained air support system complying with the requirements of the International Life-Saving Appliance (LSA) Code.

17.3 Medical First-Aid Equipment

17.3.1 General

17.3.1.1 The ship shall have on board medical first-aid equipment including oxygen resuscitation equipment and antidotes for cargoes carried based on the guidelines developed by IMO.

Note:
See the Medical First Aid Guide for Use in Accidents Involving Dangerous Goods (MFAG) which provides advice on the treatment of casualties in accordance with the symptoms exhibited as well as equipment and antidotes that may be appropriate for treating the casualty.

17.4 Decontamination Showers and Eye Washes

17.4.1 General

17.4.1.1 Decontamination showers and eyewashes, properly identified and marked and shall be available on deck in convenient locations. The showers and eyewashes shall be operable in all ambient conditions.

Eye wash units and decontamination showes should be located on both sides of the ship in the cargo manifold area and at the aft end of the cargo area. A heating system with temperature control is considered required. Water supply capacity shall be sufficient for simultaneous use of at least two units.

Note:
Thermal insulation is not considered as an alternative to a system with temperature control.

CHAPTER 7 CARGO REFRIGERATION INSTALLATIONS

CONTENTS

SECTION 1 GENERAL REQUIREMENTS

Contents

1.1 Class notation

1.1.1. An appropriate notation shall assign to refrigerated cargo installations which conform to the requirements of this Chapter on an Owner’s request. The particulars of the installation and class notations assigned together shall be entered in the Register Book. The class shall be maintained as long as the installation observed in an efficient condition and comply Class Rules. Any damage or breakdown affecting the maintenance of class or temperature assigned shall be reported to INTLREG...

1.1.2. Ships built for carriage of refrigerated dry cargo shall assign the class notation **Reefer(...°C/...°C sea)** (lowest chamber temperature/maximum seawater temperature).

1.1.3. Dry cargo ships having a partial cargo carrying capacity for refrigerated cargo or fishing vessels with refrigerating plant for cooling or freezing catches of fish, shall assign the class notation **RM(...°C/...°C sea)** (lowest chamber temperature/maximum seawater temperature).

1.1.4. Ships built and fully equipped for carriage of bananas and fruit in general under a controlled cargo chamber atmosphere in at least 50% of the ship's total refrigerated cargo chamber volume shall assign the class notation **CA**. should be **RF** or **RF (port)**

1.1.5. Ships built and equipped for carriage of bananas and fruit in general under a controlled cargo chamber atmosphere in at least 50% of the ship's total refrigerated cargo chamber volume except that a nitrogen generating unit and possibly parts of the alarm and monitoring equipment have not been permanently installed shall assign the class notation **CA(port.).**

1.1.6. Ships built for bulk transport of fruit juices and similar cargoes in refrigerated tanks shall assign the class notation **Fruit Juice Tanker** provided they also comply with relevant parts of the rules in Ch.6 Chemical Carriers.

1.2 Vessels Built Under Survey

Vessels carrying refrigerated cargoes, complying the Class Rules, and constructed, at the Owners request, under survey by the Surveyors, shall be distinguished in the Record by the notations described in Part 1 Chapter 1 Section 4[4.8] , as appropriate, followed by the date of survey

1.3 Vessels Not Built Under Survey

Vessels not been constructed under survey by the Surveyors, but which have been subsequently surveyed by INTLREG on Owners request, satisfactorily reported upon by the Surveyor, and comply the requirements of this Chapter, shall be distinguished in the Record by one of the notations listed in Part 1,Chapter 1 Sect 4 as appropriate, but the mark signifying survey during construction will be omitted

1.4 Survey during construction

1.4.1. New installation proposed for classification is to be constructed and tested under Special Survey as per the terms and the requisites of this Chapter.

1.4.2. The materials used in the construction are to be manufactured and tested in terms with the requisites of Part 2. Materials for which provision is not made in Part 2 may be accepted, provided that they conform to an approved specification and such tests as may be considered necessary.

From the initiation of the construction and installation of the refrigerating plant and of the insulation and fitting out of the cargo chambers, to the testing of the completed installation, the Surveyors are to inspect the materials and workmanship and are to indicate at the earliest opportunity, and require the rectification of, any items not as per the Rules or the approved specifications and plans or any material, workmanship or arrangement found to be defective or unsatisfactory.

1.5 Application

This chapter Rules apply to ships with refrigerating plants for

a).carriage of refrigerated dry cargo

b) carriage of fruit or vegetables under a controlled atmosphere

c).cooling down or freezing catches of fish or

d).carriage in bulk of refrigerated fruit juices and similar liquid cargoes

SECTION 2 CARRIAGE OF REFRIGERATED CONTAINERS

Contents

2.1 Carriage of Refrigerated containers Refer this Part Chapter 2 Section 10

SECTION 3 CERTIFICATION AND PERFORMANCE

Contents

3.1 The control and monitoring

Systems for cargo hold temperature system shall be certified according to Pt.6 Ch.8

3.2 Performance

The ship shall be designed, and equipped to make suitable for cooling down and/or carrying cargoes, freezing catches of fish etc. as relevant according to the design operating conditions specified by the builders and stated in the classification certificate. The builders' of the ship's operational performances and abilities shall together with the specific requirements of this chapter be used as basis for assignment of class

SECTION 4 PLANS AND DATA TO BE SUBMITTED

Contents

4.1 Hull Construction Drawings

General Arrangement

Capacity Plan

Midship Section

Framing Plan

Scantling profile and decks

Bottom Construction, floors, girders, etc.

Inner bottom plating

Shell expansion

Deck plans

Pillars and girders

Watertight and deep tank bulkheads

Miscellaneous non-tight bulkheads used as structural supports

Shaft tunnel

Machinery casings, engine and main auxiliary foundations

Fore end construction

Aft end construction

Stern Frame and rudder

Shaft struts

Superstructures and deckhouses and their closing appliances

Hatches and hatch closing arrangements

Side Shell Door – Construction and locking and sealing arrangements

Ventilation systems on weather decks

Anchor handling arrangements

Foundation structure for cranes and other lifting devices

Plan of hull showing steel grades

Cargo securing manual

For stability review:

- Lines and body plan
- Hydrostatic curves

- Cross curves
- Stability information

Additional plans for container ships

- Stowage arrangement of containers including stacking loads
- Location of container supports and their connection to hull

4.2 Refrigerated cargo spaces

Details of insulation installation including density, *K* factor, etc.

Details of the fixing arrangements for the load bearing supports of the insulation and linings and of all other insulation support fittings embedded by the insulation.

Details of the weld designs for the attachment of the fittings to the vessel’s structure

Proposed arrangements for fixing insulation to the vessel’s structure

Details of the fasteners used for supporting pipework embedded in insulation.

Cargo space heating arrangements (where fitted)

Corrosion protection of the steel structure

Temperature gradient calculations

4.3 Refrigeration systems and refrigeration machinery spaces

Design pressure and temperature of the refrigeration system

Details of the refrigerant and secondary coolant

Heat-load calculations and refrigeration capacity, including rate of ventilation of the cargo spaces, where applicable.

Details of the compressors, prime-mover drive, condensers, receivers, pumps, thermostatic expansion valves, oil recovery equipment, filters and dryers, evaporators and other pressure vessels and heat exchangers

Piping diagrams of refrigerant, brine and condenser cooling system

Details of the air-coolers, including corrosion protection

General arrangement of refrigeration units, indicating location

Ventilation details of refrigeration machinery spaces, including ventilation rates

Capacity calculations for all of the pressure vessel safety relief valves

Details of the safety relief devices discharge piping, including design calculations

Corrosion protection of the refrigerant and brine pipes

Cargo hold defrosting arrangements

Drainage and bilge pumping arrangements

Location and types of portable fire extinguishers

Additional plans and data for the ammonia refrigeration system:

- Access arrangement to the refrigeration machinery spaces
- Details of the emergency ventilation system
- Details of the emergency drainage system
- Details of the sprinkler system and water screen devices
- Fixed ammonia detection system
- Details of the personnel safety equipment

4.4 Electrical ,Control and monitoring systems

Electrical one line wiring diagram for refrigeration machinery

Power supply and distribution

Arrangements of electrical equipment and cable way in refrigerating machinery spaces and refrigerated cargo holds including cable penetrations of insulated bulkheads and decks

Arrangements of thermometers in refrigerated cargo spaces

Heat tracing arrangements, where fitted

Control and monitoring panels for refrigerating machinery including schematic diagrams, function description, construction plans and outline view

Operational description of automatic or remote control and monitoring systems including a list of alarms and displays

Computer-based systems are to include a block diagram showing system configuration including interface, description of hardware specifications, fail safe features and power supply

Control and monitoring

Temperature measuring system

Refrigerant leakage detection and alarm system

O_2 and CO_2 content measuring system

Ammonia vapor detection and alarm system

4.5 Cargo handling equipment

4.5.1 Where cranes are fitted, the resulting loads on the structure are to be indicated in the plans. The total crane weight including hook load and the arrangement of wheels and rails etc are to be submitted for approval of the supporting structure. Certification of cranes would be specially considered.

4.5.2 **Derrick and Booms**

The drawing submittal is to be in accordance with Part-9, Chapter-2, Sec-2.

4.5.3 **Cargo Elevators**

Where elevators are fitted, the resulting loads on the structure are to be indicated in the plans. The total weight of elevators and the arrangement of same are to be submitted for approval of the supporting structure. Certification of elevators would be specially considered.

4.6 Automatic and semi-automatic side loading system

4.6.1 **Structural Plans**

Location of guide supports
Stowage arrangement for pallets including stacking loads
Guide arrangement, scantlings, material grades and details
Details of the structural connections to the hull (including insulation)
Track, conveyors, foundation and support structure for the lifting devices
Deck and Side shell openings, framing and reinforcement details, details of the closing appliances, locking and sealing arrangements.
Pallet securing arrangement and scantling plan.
Deck openings, framing and closing appliance.
Deckhouse
Operating manual

4.6.2 **Electrical, Automation and Control**

Rated load, rated speed and operating condition
Electric power installation including motor, control, wiring and protective devices

Details of controls, interlock, safety devices and brakes
Control and monitoring panels including schematic diagrams, function description, construction plans and outline view
Hydraulic and control piping system details

Arrangements for emergency operations

4.7 Refrigerated Porthole Cargo Container System

Number and overall heat transfer rates of insulated cargo containers to be individually cooled by shipboard refrigeration system
Space heating arrangements for cargo cells

Details of the air ducting
Air circulation rates
Details of the flexible coupling, together with means of actuation

4.8 Refrigerated Internal Cargo Container System

Cooling water arrangements

Air freshening (ventilation) arrangements for cargo cells

4.9 Controlled Atmosphere

Capacity calculation for the nitrogen plant

Arrangements for controlling the CO_2 in cargo hold

Details of CO_2 and ethylene scrubber

Details of compressors and prime-movers

Details of the pressure vessels and heat exchangers

General arrangement of nitrogen generation plant, indicating location and access

Ventilation details of nitrogen generator space

Piping system, arrangement and details

Arrangements to render cargo spaces gas tight; to include details of liquid sealed traps

Arrangements for pressure and vacuum relief in cargo spaces

Ventilation arrangements, for designated controlled atmosphere spaces, and adjacent spaces

Schematic diagram of control and monitoring systems

One line electrical wiring diagram and details of the power supply

Details of the gas analyzing system

A list of alarms and displays

Details of the humidification system

Details of personnel safety equipment

Operations, equipment and procedure manual

4.10 Refrigerated Edible Bulk Liquid Tankers

Design specific gravity of cargo

Cargo tanks arrangements and details

Cargo tank construction and material details

Cargo tank foundations/supports (non-integral tanks)

Details of cargo tank coatings

Cargo pumping arrangements

Cargo tank refrigeration system

Cargo tank washing system

Nitrogen injection system for cargo tanks (where fitted)

Details of inert gas system, if provided

4.11 Refrigerated Fish Carriers

Details of the hull reinforcement (where provided)

Details of the cargo spaces, as per 4.2

Details of the refrigeration system and refrigeration machinery spaces.

Details of the refrigerated sea water (RSW) tanks

Details of the arrangement for protection of the Ammonia piping in cargo hold (direct expansion syst

SECTION 5 MATERIALS

Contents

5.1 Hull Structures

5.1.1 Definitions

ts = steel temperature, defined as the temperature of the material when the refrigerated chamber is at its lowest service temperature and the ambient temperature is 0°C. Where structures protrude into refrigerated spaces (e.g. rounded deck plates at hatch corners, deep girders etc.) and are insulated on both sides, the temperature ts in such structures shall not be taken higher than 10°C above the refrigerated chamber temperature.
The temperature ts in web plates may be taken as the average of the two flanges.
σ_{tv} = tensile stress in transverse girder flanges.
= $\sigma_t + \sigma_b$
σ/t =total longitudinal tensile stress in plating or girders.
= $\sigma_l + \sigma_t + \sigma_b$
σ_l = longitudinal tensile stress in hull girder.
In the deck plate at a hatch corner the longitudinal stress □□$_l$ shall be multiplied by 2.

$$= \quad 135 f_2 \ \frac{Z_n + Z_a}{Z_n}$$

f_2 = stress factor.
z_n = vertical distance in m from the baseline or deckline to the neutral axis of the hull girder, whichever is relevant.
z_a = vertical distance in m from the baseline or deckline to the point in question below or above the neutral axis, respectively.
In the deck plate at a hatch corner the longitudinal stress □$_l$ shall be multiplied by 2.
σ_t = thermal stress.

$$= \quad 50 \frac{t_s}{(-30)} \ \mathrm{N/mm^2}$$

σ_b = local tensile bending stress in girders in N/mm2.

5.1.2 Properties

The properties of steel materials in hull structural members at temperatures ts betwee – 5°C and – 40°C shall be as given in Table 7.5.1. Structural elements below □40°C shall be specially considered.The requirements are based on the assumption that structural details are carefully designed. Also in
'tween decks the hatch openings and smaller openings shall have well rounded corners. For steel structures completely on the chamber side of the insulation ts may normally be taken as the
chamber temperature.

5.1.3 Allowable stresses

Local tensile stress, $(\sigma_t + \sigma_b) \leq 190\ f_1$ N/mm^2.
Total longitudinal stress, $\sigma/t f_1 \leq$ N/mm^2.

Equivalent stress, $\sigma_e = \sqrt{\sigma^2 + 3\tau^2} \ \leq 235\ f_1\ \mathrm{N/mm^2}$.

Table 7.5.1 Hull materials for refrigerated cargo vessels		
Structural members	σ/t *or* σ_{tv} *N/mm²*	*Required minimum grade of steel.*
Plating and longitudinal girders in strength deck (upper continuous deck).	> 160 f_1 ≤ 160 f_1	NVE for -30°C ≤ ts ≤ -10°C. NVD for ts > -10°C. [1]) NVE for ts ≤ -20°C. NVD for ts > -20°C. [1])
Plating and longitudinal girders in decks below strength deck. Flanges of stringers at ships sides. Flanges of transverse girders in strength and tween decks and at sides. Girder flanges in hatch covers.	> 160 f_1	
	100 - 160 f_1	NVE in plating and longitudinal girders along hatches (including deck plating at hatch corners and above pillars) for an area extending transversely not less than 1.5 m outside hatches, when t_S < -20°C. NVD when t_S ≥-20°C. NVD elsewhere.
	< 100 f_1	NVD in plating and longitudinal girders alonghatches (including deck plating at hatch corners and above pillars) for an area extending transversely not less than 1.5 m outside hatches, when t_S < -20°C. NVB when t_S ≥-20°C. NVB elsewhere.
Web plates in transverse girders in decks and at sides, stringers at sides and girders in hatch covers, where shear stress exceeds 60 f_1 N/mm².		NVD when t_S ≤-20°C. and thickness t ≥10mm NVB when t_S > -20°C.
		NVB when t_S ≤--20°C and thickness t < 10mm
1) For t_S < -30°C minimum impact energy 27J at a temperature 10°C below t_S.		

5.2 Refrigerated Chambers

5.2.1 Insulation

Qualities of insulation material :
— Insulation shall shall not affect the cargo
— At actual temperatures insulation shall have good mechanical resistance to vibrations and deformations.
Disintegration and structural changes shall not occur
— it shall be resistant to decay and be chemically neutral

When insulation materials with low resistance against moisture transmission and air movements are used, the integrity and completeness of the lining and vapour barrier shall be given special attention.

The insulation material shall be durable at working temperatures and temperature variations. Material placed on surfaces which may be exposed to direct sunshine, on tanks which are heated, etc. shall withstand at least 100°C without being destroyed. Use of wood will be specially considered.

Organic foams shall be of a flame-retarding quality, i.e. low ignitability and low flame-spread properties. Testing shall be carried out in accordance with a recognized standard, e.g. DIN 4102.IB2, or equivalent. The test method chosen shall be suitable for the type of foam in question.

A foam “in-situ” type of insulation may be used when full details of the process have been approved

SECTION 6 REEFER PLANT

Contents

6.1 Application and Referigerants

This section applicable to refrigerating plants using Group 2 refrigerants (R717) and R744(CO2). For other Group1 refrigerants the rules apply for plants with a total prime mover effect of 100 kW and above.

6.1.1. Materials- Generally comply Pt 5A,Chapter 10 Sect 2

Other suitable material specifications shall be considered for approval in each case. The materials
shall be tested in accordance with the regulations for material testing.. For a closed refrigerating circuit using refrigerants of Group 1, or R717 and with a lowest design evaporating temperature of -41°C or warmer:The materials shall be corrosion-resistant to the refrigerant and the compressor oil and to the combination of the two.
Piping located in areas where exposure to high humidity or water splashing is expected, e.g. fish processing spaces, shall be of corrosion resistant material, e.g. stainless steel.
The following materials and refrigerants shall not be combined:
1) Copper with ammonia.
2) Magnesium with fluorinated hydrocarbons.
3) Zinc with ammonia and fluorinated hydrocarbons.

6.1.2. Group 1 Refrigerants

Refrigerants in this group are normally nonpoisonous, but all of them, except R744,can be poisonous when decomposed by a flame or by a hot surface. These refrigerants are heavier than air, give no odour warning and will give a dangerous atmosphere by displacement of air. The lack of odour and the high density make these refrigerants particularly dangerous with regard to suffocation

Table 7.6.1 - Group 1 refrigerants	
R22	CHF_2Cl
R134a (1,1,1,2-tetrafluoroethan)	$CH_2F\text{-}CF_3$
R404A	Hydrofluorocarbon mix
R407A	Hydrofluorocarbon mix
R407B	Hydrofluorocarbon mix
R407C	Hydrofluorocarbon mix
R410	Hydrofluorocarbon mix
R507	Hydrofluorocarbon mix
R744 (Carbon Dioxide)	CO2

6.1.3. Group 2:Referigerants

Refrigerants in this group are particularly poisonous. R717 is lighter than air and is flammable in very high mixing ratios with air. A very high ignition energy is required to start a fire. Group 2 refrigerants shall not be used in air conditioning systems with direct expansion.

Table 7.6.2 - Group 2 refrigerants	
Refrigerant	*Description*
R717 (ammonia)	NH_3

The use of other refrigerants will be given special consideration.

6.1.4. Design pressures

The scantlings of the various parts of the refrigerating plant shall be based on the pressures specified in Table 7.6.3.

Table 7.6.3 Design pressures for refrigerating plant		
Refrigerant	Minimum design pressure bar	
	HP side of	LP side of
R22	22	15
R134a	14	11
R717	22	15
R404A	25	20
R407A	25	20
R407B	27	21
R407C	24	19
R410	34	27
R507	26	20
R744 (CO2)	1)	1)

6.2 Conditions The refrigerating plant to work well at the following conditions:

- permanent list: 15°
- rolling: ± 22,5°
- trim and pitch according to Table 7.6.4

Table 7.6.4 Trim and pitch					
Trim and pitch		*Length of ship (m)*			
		< 100	*< 200*	*≤ 300*	*> 300*
Trim 1)	Aft	5°	2.5°	1.5°	1°
	Forward	2°	1°	0.5°	0.3°
Pitch 1) 2)		±10 °	±7.5 °	±5 °	±3 °
1) Other values may be accepted if justified by calculations for the actual ship.					
2) From even keel or designed rake of keel.					

6.3 Design criteria :

- carriage of frozen cargo at -20°C or colder
- freezing down from ambient to -20°C or colder a specified quantity of fish per. 24 hours
- carriage of fruit in general at approximately +4°C to 0°C
- carriage of bananas at approximately +12°C
- other specified operating conditions.

6.4 Redundancy

a) Minimum two refrigeration units shall be installed for ships with class notation **Reefer**. Units shall work independently of each other.The arrangement shall be such that each unit may be connected to any one chamber.

b) Minimum two refrigeration compressors with drive motors shall be fitted for ships with class notation **RM**

c) **If** separate refrigeration plants installed for individual chambers or groups of chambers, the standby units shall be subject to special consideration.

d) System using indirect cooling and circulation of the refrigerant by pumps, a standby pump shall be installed. The capacity of the standby pump shall not less than that of the largest of the other pumps, and it shall not be for other purposes on board.
e) If two or more refrigeration units, refrigeration compressors, cooling water pumps, brine pumps, etc. are required for redundancy purposes these shall have separate electrical supply.

6.5 Capacity

6.5.1. With any one of the units or compressors required by [6.4 (a)], alternatively [6.4(b)] being out of operation, the available capacity shall be sufficient to maintain the chamber temperature at all design operating conditions. If forced air circulation, the chamber temperature defined as:

- delivery air temperature in the case of temperatures above 0°C
- return air temperature in the case of temperatures below 0°C

6.5.2. Plant design with the maximum seawater temperature mentioned for the plant is as specified in the class notation.

The average outside air temperature for a 24-hour period shall be taken as 3°C above the specified seawater temperature. The air humidity assumed to be 70%.

Guidance note:

Typical values for maximum seawater temperatures

Tropical waters, open sea	30°C
Tropical coastal waters	32°C
The Persian Gulf	35°C
The Mediterranean	27°C
The North Sea	20°C

6.5.3. For fruit in general and bananas the total capacity of the refrigeration plants shall be sufficient to lower the temperature of the entire cargo from the average day temperature of the loading port to the specified transporting temperature within a reasonable period of time.

Guidance note:
The capacity requirement of [6.5.3] is considered to be complied with if an excess capacity of minimum 33% relative to that required to maintain the cargo at specified chamber temperatures during the carriage is available, i.e. with 4 equal units fitted, 3 must fulfil the capacity requirement in [6.5.1].

6.6 Plant

6.6.1. Plant and machinery shall be accessible for inspection and overhauling.

6.6.2. Effective ventilation shall be provided for cooling the refrigerating machinery. The mechanical ventilation shall have two main controls, one of which shall be from outside the room.

6.6.3. The normal and the catastrophe ventilation shall be arranged such that a single failure cannot cause a complete ventilation failure for the refrigerating machinery room.

6.7 Chambers and cooling/freezing tunnels machinery.

6.7.1. In direct expansion plants the total air cooler area/cooling grid area in each chamber is normally to be sufficient to ensure that the evaporating temperature is maximum 10°C colder than the chamber temperature as defined in [6.5..1] in any of the design operating conditions.

6.7.2. In indirect systems the mean value between the inlet and outlet brine temperatures shall be used in lieu of the evaporating temperature.

Guidance note:
The water velocity should not exceed:
2.5 m/s for aluminium brass pipes
2.5 m/s for 90/10 copper/nickel pipes
1.5 m/s for steel pipes.

The air cooler overall heat transfer coefficient measured during the heat balance test shall be assumed constant when the verification calculations (based on the balance test results) of the cooling capacity at all design operating conditions are carried out.

6.7.3. Air coolers In each chamber shall be divided minimum into two independent units with separate electrical supply for their air circulation fan(s), so that any one of them shall be shut off without essentially influencing the others. For small spaces up to 300 m3 one unit shall be considered.

6.7.4. In chambers fitted with cooling grids minimum two independent circuits must be installed, so that any one of them may be closed without essentially influencing the others. For small spaces up to 200 m3 one unit may be considered.

6.7.5. A defrosting system shall be installed if air cooler temperature below sub zero

6.7.6. Drip trays with water drainage shall be located under air coolers with forced air circulation and under cooling grids fitted vertically on bulkheads or ship sides. Drain pipes shall have an internal diameter of not less than 50 mm. While carry frozen cargo the drip trays and drain pipes shall be fitted with tracing heat system.

6.7.7. Fans and air coolers shall be easily accessible. Equipments shall be able to change with the chambers fully loaded also .

6.7.8. If forced air circulation is installed, the fans failure alarm shall be provided.

6.7.9. All air cooler and freezing tunnel fans shall be fitted with effective protection grids or equivalent.

6.7.10. Fan emergency shut down shall be fitted in all air cooler rooms or similarly.

6.7.11. Motors and other electrical equipment shall have safe enclosures.

6.7.12. If chambers installed , coolers with forced air circulation, the number of air circulations shall be atleast:

- 90 pr. hour for bananas
- 60 pr. hour for fruit in general
- 30 pr. hour for frozen cargo.

Even distribution of the circulated air without «blind» zones shall be arranged.
Guidance note:

To obtain even distribution of the air, it is essential that the pressure losses in the distribution ducting/grating are small both longitudinally and athwartship compared to the losses at the inlet "nozzles" to the chamber. This will ensure that the various "nozzles" are supplied with the same air overpressure. Uncontrolled air supply to the chamber e.g. in connection with 'tween deck hatches or "leakages" between the grating and bulkheads/ shipsides should be kept as low as possible.
For an air circulation system with the air supply through a homogeneously perforated grating, the highest mean air velocity through the perforations in any section of the grating shall, when measured in an empty chamber, not exceed the lowest mean velocity in any other section by more than 75%.

6.7.13. While ship carry cargo and if the temperature in the chambers fall below that specified for the cargo, it shall be arranged to heat the refrigerated chambers.

6.7.14. Chambers provided for bananas or fruit shall be equipped with an effective ventilation system having at least 2 air renewals per hour. Each chamber shall have closeable separate feed and discharge ducts. The air intake shall be so placed that the possibility of foul air (from ventilation outlets from the same or other cargo chambers or from other ventilation outlets) coming into the chamber is reduced to a minimum. The air intake is normally to be located away from any ventilation outlet.

6.7.15. The required air circulation rates in [6.7.12] and air renewal rates in [6.7.14] shall be based upon the bale chamber volumes.

6.7.16. Other air circulation and air renewal rates than mentioned in [6.7.12] and [6.7.14] shall be accepted upon request and will then be specified in the the classification certificate.

6.8 Refrigeration system

6.8.1. A direct expansion system shall be fitted with shut off valves to divide the system into a suitable number of sections. A section may include e.g. all chambers below the same hatch. The shut off valves shall be outside the refrigerated chambers and shall be installed so that the section shall be isolated for maintenance without affecting the operation of the other sections.

6.8.2. Shut off valves shall be fitted upstream and downstream of all filters, strainers and automatic expansion valves to facilitate cleaning, replacements and -Repairs.

6.8.3. Systems using R744 as refrigerant, arranged such that loss of refrigerant during a standstill period of 24 hours does not prevent re-starting of the system

6.9 Capacity of Cooling water, Condenser and brine cooler

6.9.1. Cooling water shall be supplied from a minimum of two sea connections to the water-cooled components of the refrigerating plant.

6.9.2. A standby cooling-water pump, shall be installed. The capacity of the standby pump shall not be less than that of the largest of the other pumps. Automatic start of the standby pump not be required.

6.9.3. The standby pump may also be used for other purposes on board, provided it has sufficient capacity to serve the refrigerating machinery at the same time.

6.9.4. With clean sea water side and water velocity as given by the normal sea water pump, however not exceeding the values mentioned below.

The water velocity
2.5 m/s for aluminium brass pipes
2.5 m/s for 90/10 copper/nickel pipes
1.5 m/s for steel pipes

The condenser heat transfer capacity is sufficient to ensure that the condensing temperature is maximum 6°C warmer than the inlet sea water temperature in any of the design operating condition. When considering the overall refrigerating capacity, the condensing temperature shall be increased from the value available by the heat balance test by 2°C to take into account the fouling of the sea water side of the condenser

6.9.5. The brine coolers shall be designed such that the evaporating temperature is not more than 6°C colder than the mean between the inlet and outlet brine temperatures. An increased design temperature difference across the brine coolers, however not grater than 8°C, shall be accepted provided the sum of the design temperature differences across the brine coolers and the air coolers (Refer 6.7.1) does not exceed 16°C.

6.10 Refrigerated seawater tanks

6.10.1. Refrigerated seawater (RSW) tanks for storage of catches of fish shall be kept at a temperature of -1°C, or at a temperature specified by the designer, at design ambient condition. The maximum allowable variation of the RSW temperature is 2°C. The arrangements of water inlets and outlets shall be to ensure even temperature distribution throughout the tank.

6.10.2. The RSW cooler shall be protected against freezing, e.g. by automatic shut-off of refrigerant suction line or automatic stop of the compressor(s) at loss of circulation.

6.10.3. A standby circulation pump shall be fitted. The standby pump may also serve other seawater services on board.

6.11 Compressors

6.11.1. Compressors shall comply the following,

a) The rules applicable to all types of compressors for the following systems:

- those with pressure above 40 bars
- starting air
- instrument air including working compressors applied as back-up
- breathing gas (monobaric and hyperbaric systems)
- refrigerating (for ships having additional class notations Reefer, RM or RM CONTAINER)
- evaporated cargo compression.
- inert gas production (when such a system is required by SOLAS).

b) Design approval required for all compressors listed in [6.11.1 a)]for shaft power exceeding 200 kW.

c) Documentation
Plans and particulars shall be submitted according to Table 7.6.5.
Documentation for special type compressors shall be considered specifically.

Table 7.6.5 Documentation				
Component	*Drawing*	*Material*	*Calculations*	*Miscellaneous*
Compressor cross section	I			
Crankshaft	A	A	Shaft strength: UR	NDT: I
Connecting rod	I	I		
Cylinder and -head with bolts	I	I		
Rotors (w/ blades)	A 1)/I	A1)/I	Burst speed: UR1)	NDT: I
Rotor casing	A1)/I	A1)/I	Strength: UR Containment: UR1)	
Internal piping	I			
Particulars: 3) medium 4) design pressure for all stages 5) working temperature 6) working capacity 7) maximum shaft power and	I			
Alarm set points and delay times	A			
A = For approval I = For information UR = Upon request NDT = Non-destructive testing 1) = If > 1 000 kW and rotor with blades.				

d) The compressor piping shall be designed to prevent condensation from entering the cylinders.
Starting air compressors shall comply the requirements Pt 5A of the Rules for Classification of Ships. Compressors for breathing gas systems shall be provided to avoid oil or poisonous gases from
entering the breathing air system.
Gas compressors will be especially considered and shall normally comply with a recognised national or international standard.
Compressors for instrument and control air receivers shall deliver sufficient air for the intended
instruments. The compressors shall be provided with proper filtering equipment in order to deliver air free from oil, moisture and other contamination.

e) Crankshafts
Crankshafts shall include a satisfactory safety factor against fatigue failures. Various calculation
methods shall be used. The Guidance note gives one method for evaluation of safety against fatigue in the web fillets. The method applies for crankshafts made of forged and cast steel and nodular cast iron intended for one or multistage compressors with the cylinders arranged in line, V or W. More detailed methods shall be especially considered.
Guidance note.

$$\sigma_b \leq \frac{\sigma_f}{S}$$

σb = the bending stress amplitude in the fillet (N/mm□)
σf = the fatigue strength (N/mm□)
S = the minimum safety factor
For the fatigue criteria mentioned below, the following minimum safety factor applies:
S = 1.4

This safety factor includes the influence of torsional stresses in the fillets, which for the sake of simplicity are
neglected in this method.
The fatigue strength shall be calculated as follows:
$\sigma_f = (0.33\ \sigma_B + 40)\ k_m$
σ_B = ultimate tensile strength of the material (N/mm□)
k_m = material factor, see Table 7.6.6
The bending stress amplitude shall be evaluated as follows:

Table 7.6.6 Material factor	
Material	k_m
Forged steel Cast steel Nodular cast iron	1.0 0.8 0.9

The bending stress amplitude shall be evaluated as follows:

$\sigma_b = 0.7\ \sigma_{nom}\ \alpha$

0.7 = factor to correlate the pulsating bending stress range into an equivalent single amplitude reversed stress
α = fatigue notch factor for bending
$\sigma_{nom} = M_B / W_B$ (N/mm^2)

M_B = bending moment in the middle of the web nearest the centre of the bearing span

$$M_B = \frac{k_d \pi D^2 p\, a\, b}{40L}$$

D [1] = cylinder bore (mm)
p [1] = design pressure (bar)
L = distance between the centres of two adjacent bearings (mm), Refer Fig. 7.6.1
a = distance from the centre of a bearing to the center of the web nearest the center of the bearing span (mm), see Fig. 1
b = L ≥ a, (b ≥ a) (mm)
k_d = design factor, see Table 7.6.7

1) For multicylinder arrangements on one bearing span, use the maximum of the individual pD^2.

$W_B = B\ W^2 / 6$

W_B = sectional modulus of the web
B = width of the web (mm), Refer Fig. 7.6.1
W = thickness of the web (mm).

Table 7.6.7 Design factor	
Design	k_d
In line V-90, W-90 V-60, W-60 V-45, W-45	1.0 1.1 1.5 1.7

The fatigue notch factor for bending may be calculated as follows:

$\alpha = 1 + \eta\,(\alpha_{th} - 1)$

η = notch sensitivity factor

α_{th} = theoretical stress concentration factor (referred to web bending stress)

$\eta = 0.62 + 0.2 \log R + \sigma_y 10^{-4} \log (400 / R)$

(if calculated > 1, η = 1 applies)

σ_y = the yield strength of the material (N/mm^2)
R = the actual fillet radius (mm)

$\alpha_{th} = 3.0\, f(A/d)\, f(W/d)\, f(B/d)\, f(R/d)$

$f(A/d) = 1 - 0.8\ A/d$
$f(W/d) = 1 + 2.2\ (W/d - 0.35)$
$f(B/d) = 1 + 0.4\ (B/d - 1.45)$

$$f(R/d) = \frac{0.22}{\sqrt{R/d}}$$

A = pin overlap (mm), Refer Fig. 7.6.1
d = diameter of the crankpin (mm).

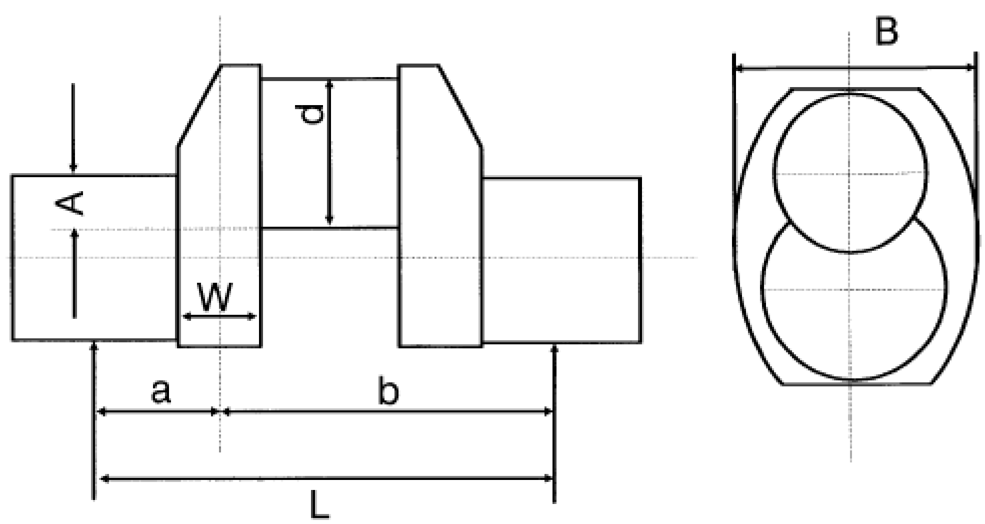


Fig. 7.6.1
Crank throw for compressor

f) Rotors

Calculation of the rotor strength shall be carried out in accordance with recognised standards.

g) Rotor casing

The strength of the casing shall be documented by calculations in accordance with recognised standards.
Proof tests shallbe used to establish the allowable design pressure of the rotor casing. The proof test shall be carried out in accordance with the ASME Boiler and Pressure Vessel Code, Section VIII, Division I, or other recognised standards.
Containment shall be fulfilled for blade and or disc failure respectively, at 110% of rated speed.

h) Inspection

It is advised to establish an MSA {manufacturing survey Arrangement) with sub-suppliers delivering materials or parts mentioned in [6.11.1 f)]. This applies also to those documented by work certificate (W) and test report (TR), and should at least verify that the premises for using W and TR are fulfilled.

i) Testing, inspection and certification of parts

Certificates for product and material according to Table 7.6.8
All parts subject to pressure of the compressors shall be hydraulically pressure tested (W) to 1.5 times the design pressure for the respective parts. The test pressure need not exceed the design pressure by more than 70 bars.

Table 7.6.8 Requirement for testing, inspection and certification

Component	*Materi al*	*Ultraso nic*	*Crack detecti*	*Hydraul ic*	*Dimensi on*	*Other*
Crankshaft	W	W	W		W	
Connecting rod	TR					
Cylinder with head	TR			W		
Rotors	W	W	W		W	
Rotor casing	W			W		

j) Workshop Testing

Function testing and setting of the safety valves shall be carried out on each compressor in the presence
of a surveyor.
102 A capacity test shall be carried out with the compressor running at design condition (rated speed,
pressure, temperature, type of gas, etc.). The capacity test shall be waived for compressors produced in seriesand when previous tests have been carried out on similar compressors with satisfactory result. The capacity test shall be witnessed by a INTLREG surveyor.

k) Control and Monitoring

Control and monitoring shall be in accordance with Table 7.6.9.

Table 7.6.9 Control and monitoring of compressors				
System/Item	*Gr 1 Indication alarm load reduction*	*Gr 2 Automatic start of stand-by pump with*	*Gr 3 Shut down with*	*Comment*
1.0 Bearings				
Temperature	HA			For shaft power > 1
2.0 Lubricating oil				
Pressure	IL, LA			Applicable for forced lubrication
Sump Level 1)	IL or IR			Applicable for splash lubrication

Gr 1 Sensor(s) for indication, alarm, load reduction (common sensor permitted but with different set points and alarm shall be activated before any load reduction)
Gr 2 Sensor for automatic start of standby pump
Gr 3 Sensor for shutdown

IL = Local indication (presentation of values), in vicinity of the monitored component
IR = Remote indication (presentation of values), in engine control room or another centralized control station such as the local platform/manoeuvring console
A = Alarm activated for logical value
LA = Alarm for low value
HA = Alarm for high value
AS = Automatic start of standby pump with corresponding alarm
LR = Load reduction, either manual or automatic, with corresponding alarm, either slow down (r.p.m. reduction) or alternative means of load reduction (e. g. pitch reduction), whichever is relevant
SH = Shut down with corresponding alarm. May be manually (request for shut down) or automatically executed if not explicitly stated above.

1) For compressors with shaft power less than 500 kW dipstick is considered adequate indicator.

l) Vibration

Reciprocating compressors with shaft power exceeding 500 kW, torsional vibration analysis shall be
determined.
For resilient mounted reciprocating compressors, the vibration shall be observed by the surveyor and
considered with regards to hooked-up connections
The permissible limits of any component in the system shall not be exceeded.

m) Installation Inspection

After installation onboard, the compressor and the system to which it is connected, shall be function tested under working conditions. .The function test shall include testing of any control and safety functions.

6.11.2. Oil coolers shall be installed, unless the service area of the cargo refrigerating plant is restricted to nontropical waters.

6.11.3. The low-pressure side of the compressor or the plant shall be that liquid refrigerant or oil cannot be sucked into the compressor ..

6.11.4. Safety valves fitted on the high-pressure side of the compressor ahead of the shut off valve. The Safety valve outlet , lead back to the suction side of the compressor.

6.11.5. A refrigeration plant of suction pressure below atmospheric shall be fitted with air separating equipment.

6.12 Piping corrosion protection and insulation

6.12.1. Piping corrsion protection shall be provided against moisture.

Guidance note:
For mild steel pipes hot dip galvanizing (minimum 70 microns) or shot blasting to SA 2.5 followed by a minimum 2coat paint system with a minimum total dry film thickness of 250 microns are considered a suitable protections.

6.12.2. Cold refrigerant liquid and gas pipes and cold brine pipes shall be insulated to prevent the harmful effect on equipment, cargo chambers or cargo from condensation or frosting (with subsequent defrosting).

Guidance note**:**
Insulation and water vapour barriers should preferably be led continuously through the fastening arrangements

6.13 Pressure vessels and heat exchangers

6.13.1. Pressure vessels shall be constructed in accordance with Pt.5A Ch.10.

6.13.2. Receivers with shut off valves for full capacity of refrigerant shall be installed.

Guidance note:
A corrosion-reducing agent consisting of 2.0 kg sodium dichromate + 0.54 kg caustic soda for each $m^3$of the solution should be added to calcium chloride. The pH value should be about 8. It is advised that a closed brine system be installed.

6.14 Oil separators, filters and driers

6.14.1. The plant shall be arranged and equipped so that any lubricating oil bypassing the oil separator is returned to the oil system. The lub oil system shall be fitted with heating arrangements to boil out any accumulating refrigerant as applicable.

6.14.2. Filters or strainers shall be located in the liquid lines upstream of the expansion valves and in the suction lines upstream of the compressors.

6.14.3. Driers necessitated by the refrigerant shall be located in the liquid lines downstream of the condensers.The drying agent shall be replaceable during operation.

6.15 Indication meters/level gauges.

6.15.1. The temperatures of the refrigerant on the suction and discharge sides of compressors, of the cooling water inlet and outlet of the condensers, of the brine and the refrigerated sea water (RSW) feed and return as well as of the refrigerant from all coolers and freezers with direct expansion, shall be indicated.

6.15.2. Compressor suction and discharge pressure of the refrigerant in the suction lines, i, in the refrigerant circulation pumps' delivery lines, in the return lines from all direct expansion air coolers and freezers and on the brine pumps' pressure side shall be indicated.

6.15.3. Level indication shall be provided on liquid receivers. Liquid level indicators constructed of glass tubes are not permitted. Liquid level indicators with long glass plates shall be fitted with self closing valves in lower and upper connections (EN 378-2).

6.16 Automatic control

6.16.1. If automatically operated expansion valves are fitted , manually operated bypass valves shall be provided. Alternatively, duplicated automatic valves can be accepted.

6.16.2. The automatic control systems shall keep the cooling capacities within acceptable limits at all design operating conditions.

6.17 Monitoring

6.17.1. Machinery and equipment necessary for the safety of the cargo cooling machinery shall be provided with an efficient monitoring system. Monitoring parameters depend upon output and type of machinery as well as arrangement of the plant. Other combinations of measuring points than those listed below may be accepted when an equivalent degree of safety is achieved.

6.17.2. A refrigerant leakage detection system with alarm, in case of direct expansion, in all refrigerated chambers shall be installed. For plants of group 1 refrigerants except R744, monitoring for oxygen deficiency is an acceptable alternative to refrigerant gas detection. A sampling system with sequential analyzing is used, each sampling point shall be analyzed at intervals not exceeding 1 hour. Sampling lines shall be monitored with regard to flow failure. The sensors / sampling suction points shall be located with due regard to the relative density of the refrigerant in gas form as well as to the ventilation flow

Refrigeraent R717 or R744 systems, are used for cargo space/air cooler rooms room these spaces shall be covered by a refrigerant leakage detection system with alarm levels not higher than 150 PPM for R717and 2000 PPM for R744.

6.17.3. Alarm required for the following :

- fresh air fans, failure
- circulating fans, failure
- brine/RSW temperature, high and low
- low level in the brine header tank
- Cooling sea water temperature outlet condensers, high.

6.17.4. Temperature alarm: All chambers shall be fitted with chamber temperature alarm as defined in [6.5.1] deviates from from high/low values set

6.17.5. Compressor auot shut down alarm shall be provided for the following:

- suction pressure, low
- discharge pressure, high
- discharge temperature, high
- lubrication oil pressure, low
- low superheat temperature in the suction line or low compressor discharge temperature
- liquid return from evaporators, (e.g. high level in suction line liquid separator).

6.17.6. If no continuous watch attending to the refrigeration plant the above listed alarm and stop functions are, except as mentioned in [6.5.2] , to be connected to the engine room alarm system.

6.17.7. Referigerent using R744, a low pressure alarm with set point above the triple point pressure (abt. 5.2 bar) shall be fitted in the low pressure liquid part of the system.

SECTION 7 REFRIGERATED CHAMBERS

Contents

7.1 General

Steel or equivalent material gas tight bulkheads shall be fitted between the refrigerated chambers and the other rooms of the ship, as well as between the individual chambers, if these are intended to contain cargo which interacts with gas produced by the cargo in an adjacent chamber.

Guidance note:
With all openings closed with their normal closing appliances, an air supply through the ventilation inlet giving an internal overpressure in the chamber(s) of 40 mm water column should normally not cause an air flow in excess of 0.25 air changes per hour.

7.1.1. Oil tanks adjacent to vertical boundaries of refrigerated chambers, manholes in these boundaries not permitted.

7.1.2. Bilge wells shall be separated from the insulated cargo chambers by a gas tight construction.

7.1.3. Tank top insulation in way of manholes shall be provided with a liquid tight coaming to prevent seepage into the insulation.

7.1.4. All chambers and air cooler rooms shall have access doors, hatches and ladders arranged for easy access and escape. If any injured personnel, shall be possible the use of stretchers as well as no obstructions by the cargo when the chambers are loaded.

7.1.5. Access doors and -hatches shall either be used from both sides or be fitted with catches to prevent inadvertent closing.

7.1.6. All chambers and air cooler rooms are each to be fitted minimum one alarm call button.

7.1.7. **Refrigerated seawater tanks**

Refrigerated sea water (RSW) tanks for transportation of fish are to be designed for relevant pressure
heads in accordance with the rules.Where an internal skin is fitted and welded continuously to every other frame/stiffener and slot-welded to the rest, and the gap between skin and hull structure is filled with insulation of an approved type an effective flange, b = 40 t (where t = skin thickness, minimum 5 mm) may be included, when calculating the section modulus of strength members. The skin plate is to be made continuous with good end connections and should not be terminated abruptly
The insulation material is to have good adhesion to steel and suitable strength characteristics (e.g.polyurethane foam, density of 45 kg/m3). The steel surface is to be corrosion protected before it is insulated.
Corrugated bulkheads are to be supported along both bulkhead flanges in the bottom structure with sufficient connections to crossing members. Carlings are to be fitted in way of corners in corrugations and ends of unstiffened plate panels .Refer also Ch 7 ,Sect 6[6.10]

7.2 Insulation

Steel covered with insulation, shall be cleaned thoroughly and shall be painted with a rust-proofing coating.
note:
Shot blasting to SA 2.5 followed by a minimum 2 coat paint system with a minimum total dry film thickness of 250 microns is considered a suitable protection.

7.2.1. Bolts, nails and steel fittings shall be galvanized.

7.2.2. Concealed woodwork shall be pressure/vacuum impregnated with a recognized odourless preservative. All wooden materials shall be well dried before use.

7.2.3. Metallic fittings or other items passing through the insulation shall be avoided as far as practicable.

7.2.4. On the 'tween decks and bulkheads which are not fully insulated, strip insulation shall be used.

note:

If the insulation is made from slabs, several layers laid with staggered ends, should preferably be used. The seams between the slabs shall be filled with a recognized, odourless material. The thickness of the insulation should preferably be adjusted so that the heat transmission per unit area is of the same magnitude for all surfaces. Heat gain through the deck plates, bulkhead plates and stiffeners should preferably not exceed 20 W per metre of edge length.

7.2.5. Insulation adjacent to engine and boiler room shall be made of non-combustible material.

7.2.6. The lining and insulation shall be inspected inspected and hull members behind it.

7.2.7. Insulation on sides, bulkheads and below deck. The insulation shall be securely fastened or thoroughly packed, so that settling caused by vibrations and deformations avoided.

note:

At frames and deck beams, any form of heat-conducting bridge should preferably be avoided.Where plane bulkheads are insulated, attempts should be made to reduce or eliminate through connections by using insulation materials with sufficient strength to resist load from the cargo.

7.2.8. **Insulation on tank top and 'tween decks**

Guidance note:
The insulation used material with sufficient strength to withstand the weight from the cargo, so that through connections are avoided. The insulation on the tank top, should preferably be of a material with particularly high resistance to penetration of moisture.

7.2.9. **Insulated hatches and doors**

Guidance note:
Insulation materials with great strength, little weight and a low coefficient of thermal conductivity should preferably be chosen. Attempts should be made to avoid heat-conducting bridges.

7.2.10. Ships carrying fruits in general or bananas, with class notation **Reefer** hatch covers and doors between insulated chambers must be provided with double seal packings. Hatch covers and doors exposed to weather, must in addition to double seal packing have packing for weather tightness withcompression bar of corrosion resistant material. For smaller covers or doors exposed to weather, two packings may be accepted. Fittings, hinges and handles shall be corrosion resistant.

7.2.11. **Cooling grids and refrigerant pipes protection:** Cooling grids located on sides and bulkheads shall be protected with dunnage ribs.

Note:
Wooden ribs should preferably be about 50 x 150 mm with a spacing of approximately 300 mm.

7.2.12. The refrigerant pipes shall be securely fastened and protected.: Refrigerant pipes, electrical cables etc. pass through gastight bulkheads or decks,shall be gastight and fireproof.Refrigerant pipes shall not be in metallic contact with the steel parts of the ship. Stuffing boxes shall be able to take thermal movements of the pipes

7.2.13. The lining in refrigerated chambers shall be fitted to prevent circulating air from entering the insulation, causing forced convection in the insulation. The lining on decks, sides, bulkheads and below decks shall be of a material and of a workmanship which will not be damaged or allow water to penetrate into the insulation during hosing down of the chambers.The lining of all surfaces shall have sufficient strength to withstand load from the cargo.

7.2.14. The lining shall be:

- impervious to water, and it shall not crack at the service temperatures and stresses
- resistant to corrosion by oil, organic matter or other material.
- Bitumen solution shall not be used unless all the solution agent is evaporated before the room is used.

7.2.15. Under the hatches and approximately 0.6 m outside their edges, the insulation on the tank top and shaft tunnel shall be protected with an extra covering of hardwood about 50 mm thick, or another efficient covering, for instance fixed or removable gratings, which is not damaged by impacts during loading and unloading.

7.2.16. Where the insulation shall support fork lift trucks, the strength of the lining and its support shall be demonstrated. A sample of the insulation, approximately 4 x 4 m, shall be prepared and tested by a fully loaded fork lift truck being driven and manoeuvred over the sample.

7.3 Moisture Protection:

7.3.1. Air pipes, hatchways, etc. shall be constructed and located such that the chambers are not fed with moisture from spray and shipped water.

7.3.2. Before the insulation work ,bulkheads tightness shall be verified by hose or pressure testing

7.3.3. Efficient drainage of the chambers essential , especially if the ship shall carry cargo giving off water.

7.3.4. The inside lining shall be constructed of a material with high resistance to moisture and moisture diffusion.

note:
Measures against condensation on the warm side of the bulkheads and decks should preferably be taken by using heating cables or similar devices

7.4 Drainage, air circultion, sounding and water pipes

7.4.1. The chambers shall be provided adequate air circulation around/through the cargo even if the chambers are partially loaded. The air circulation arrangements may be based on permanent installations, on portable equipment and/ or on operational procedures for stowage and packing of the cargo. Local high-velocity air streams shall be avoided. A permanently installed forced air circulation system shall be arranged with well-rounded corners and other detail designs to reduce the air flow resistance.

7.4.2. ships with class notation **Reefer** carrying fruit in general or bananas, the chambers shall be fitted with an arrangement for distributing the cooling air at the bottom, e.g. by means of ducts and grating.

7.4.3. In ships not fitted with an air distribution grating the cargo shall be stowed on pallets or otherwise be lifted clear of the deck or bottom insulation to ensure air circulation below the cargo.

7.4.4. Air circulation through the stowed cargoshall br provided otherwise the bulkheads and ship sides shall be fitted with battens

7.4.5. Ships with class notation **Reefer** provision shall be made for adequate air circulation in the chambers inside hatch coamings foreseen for stowage of cargo, for instance by return air channels from top of hatch coamings.

7.4.6. Air ducts and air cooler rooms walls shall have good strength to resist pressure from the cargo, and shall be as airtight , paricularly against insulated surfaces.

7.4.7. **Drainage**
liquid-sealed traps shall be fitted below drain pipes from the chambers and from the cooler drip trays sto prevent air communication between chambers and from the bilge wells to the chambers.

7.4.8. check valves shall be provided for drain pipes from chambers and from cooler drip trays to prevent water communication between chambers.

7.4.9. Liquid-sealed traps shall be arranged on the warm side of the insulation and minimum pressure heads: 100 mm when connected to air ducts, 50 mm otherwise.

7.4.10. If liquid-sealed traps are located inside the refrigerated spaces, they shall be easily accessible for checking and refilling with brine.

7.4.11. Other rooms drain pipes shall not pass down to bilge wells of refrigerated chambers.

Note:

Overboard drain pipes should meet the requirements given in Pt.5A Ch.9 Sec.2[2.2.3]

7.4.12. **Air, sounding and water pipes**

7.4.12.1. Air and sounding pipes through the cold chambers shall be effectively insulated. Pipes shall be well insulated from cold decks.

7.4.12.2. If chamber temperature below 0°C,then inside diameter of sounding pipes shall not be less than 65 mm, Sounding pipes for oil tanks shall not terminate in refrigerated chambers or rooms for fans or air coolers.

Note:
Water pipes and air and sounding pipes through freezing chambers should preferably be avoided.

7.4.12.3. Tanks or sea chests air pipes and water pipes are passing through freezing chambers or its insulation, they shall be arranged to prevent freezing.

7.4.12.4. Pipes penetrating the tank top shall have substantial wall thickness in way of the insulation on the tank top.

7.4.12.5. Refrigerated chambers bilge wells shall be accepted with a level alarm in lieu of a sounding pipe. Ships with class notation **Reefer** designed for carriage of fruit in general or bananas, 2 independent level alarms shall be fitted in each bilge well without sounding pipe.

7.5 Temperature, Gas indication equipment

7.5.1. Temperature measurements

7.5.1.1. The rules in Pt.6 Ch.8 regarding documentation to be submitted for approval, system design, component design, and installation shall be complied with.

7.5.1.2. 7.5.1.2 Chambers with forced air circulation coolers, a minimum of one thermometer is required in the circulated air inlet of each air cooler, and one at outlet of each air cooler. Additional thermometers shall be required dependent upon the air circulation system.

7.5.1.3. 7.5.1.3 Chambers without forced circulation air coolers the number of thermometers shall not be less than:

Up to approximately 200 m^3 net volume	3
Up to approximately 400 m^3 net volume	4
Up to approximately 600 m^3 net volume	5 thermometer

and then one thermometer in addition for each approximately 300 m^3 net volume. ships carrying
exclusively frozen cargo a smaller number of thermometers shall be accepted based on the arrangement of the air coolers

7.5.1.4. 7.5.1.4 More thermometers shall be required as per design depending of the chambers.

7.5.1.5. The thermometers shall be readable without entering the chamber.

7.5.1.6. RSW installations thermometers are required on inlet pipes as well as outlet of RSW tanks.

7.5.1.7. If only electronic thermometers are fitted,then minimum two mutually independent systems with separate power supply shall be installed. The sensing elements in each chamber shall be divided between the two systems in an appropriate manner. One of the indicating instruments shall be a data logger. The data logger shall comply with [7.5.1.8].

7.5.1.8. The thermometers shall range from 10°C above the highest expected cargo temperature at loading to 5°C below the lowest design operating chamber temperature.

The thermometers accuracy shall be ± 0.5°C for frozen cargo and ± 0.25°C for fruit in general and bananas. The combined errors of instrument reading and hysteresis shall be less than 0.1°C. The scale deflection of analog instruments is for bananas and fruit in general not to be less than approximately 5 mm/°C and for frozen cargo not to be less than 2.5 mm/°C.
The temperature reading shall be possible within 0.1°C on both analog instruments and digital displays.

7.5.1.9. The sensing elements shall be well protected against damage from mechanical abuse and moisture. They shall be permanently connected to their instruments, i.e. no plug-in connections are allowed.

7.5.1.10. Instruments for remote thermometers shall comply with the requirements of Pt.6 Ch.8. The installation is in general to comply with the requirements of Pt.6.

7.5.2. **CO2 indication equipment**

201 All chambers carrying fruit in general or bananas shall be fitted with permanently installed equipment for indication of CO_2 content.

7.5.3. Oxygene indication equipment: Cargo chambers shall be fitted with measurement of the O2 content without entering the chamber. Any portable O2 analyzer necessary for this purpose shall be kept onboard**.**

SECTION 8 CONTROLLED ATMOSPHERE

Contents

8.1 General

8.1.1. This Section applicable to ships for controlled atmosphere (CA) with low oxygen content in the refrigerated cargo chambers for the purpose of slowing down the ripening process and quality reduction of bananas and fruit in general.These requirements are supplementary to those applicable for class notations **Reefer** or **RM**.

8.1.2. **Class notations :** Ships complying this Section shall assign one of the following class notations:

CA RF- assigned to ships fully and permanently equipped for operation with controlled atmosphere.
CA(port.)- RF(port) assigned to ships using a portable nitrogen generating and possibly instrumentation unit has been foreseen for operation with controlled atmosphere.

8.1.2.1 The following apply in case of class notation **CA(port.)**: **RF (port)**

- the portable unit shall be common to several ships
- the complete installation including the portable unit comply with all relevant items of this Section
- Portable unit the location onboard is subject to approval
- the portable unit with its equipment shall be subject to approval by the Society and shall be covered by a certification procedure accepting its use in connection with one or more identified ships
- each time a portable unit is placed onboard a ship, a preloading functional test in accordance with an approved procedure is required. Such tests need not be carried out in the presence of a surveyor
- annual and complete periodical surveys applicable for the portable unit .

8.1.3. **Assumptions** It has been assumed that in no cases, except for the rescue of personnel in danger, will spaces with a low O_2 content be entered and onboard procedures will be established to such that all CA compartments are free from personnel and adequately locked before injection of low O_2 gas is commenced.

8.1.3.1 Unless a thorough tightness test has been carried out after the closing of the 'tween deck hatches, it has been assumed that a cargo chamber will not be put under controlled atmosphere until loading of all chambers under the same main weather deck hatch is completed. Correspondingly it has been assumed that unloading of a chamber will not be commenced until all chambers under the same main hatch have been completely ventilated to a normal atmosphere unless the above prescribed tightness test was carried out prior to the loading of the upper chambers.

8.1.3.2 It has been assumed that when one or more chambers are under controlled atmosphere then the gas monitoring and alarm system of any adjacent chamber with a normal atmosphere shall be kept in operation with relevant alarm set point.

8.1.3.3 It has been assumed that the controlled atmosphere chambers are maintained at a pressure as close as possible to the atmospheric pressure.

8.1.3.4 It has been assumed that certified test gases will be available onboard and used for regular calibration of all gas analyzing equipment.

8.2 Documentation:

8.2.1. In addition to the documentation required for the class notations **Reefer** or **RM** the following documentation shall be submitted: For approval:

- an arrangement plan including:
- — location of CA chambers and gas tight subdivisions

- design overpressure
- equipment location for CA
- arrangement and use of spaces adjacent to CA chambers
- supply and vent gas piping diagram for CA
- plan showing pipes led through CA chambers
- drawings of cleating, hinging and sealing arrangement for gastight weather- and 'tween deck main hatches, access hatches and loading- and access doors
- cable penetrations and gas tight glands for pipe
- ventilation arrangement including:
- gasfreeing of CA chambers
- ventilation of spaces adjacent to CA chambers or containing CA equipment
- plan showing the location of outlets from relief valves, ventilation systems etc. of gases which may have abnormal low or high oxygen content
- capacity calculations for CA chamber pressure relief valves
- diagram of N2 release prealarm system
- plan of water seal arrangement for drains from CA chambers
- plans of nitrogen generating equipment
- plans of carbon dioxide scrubber equipment if installed
- electrical drawings
- instruction manual
- documentation relating to a possible portable equipment unit including its installation onboard.

For information:

- description of the CA installation.

8.2.2. For requirements for documentation of instrumentation and automation, including computer based control and monitoring, Refer Pt 6 Ch 8.

8.3 System Arrangement

8.3.1. General

8.3.1.1 For assignment of the class notations **CA** or **CA (port.)** at least 50% of the ship's total refrigerated cargo chamber volume shall comply the operation with controlled atmosphere.

8.3.1.2 Chambers desined for CA shall be gastight. Alternatively a group of two or more chambers shall be provided as a common gastight unit intended to be operated with the same atmosphere.

8.3.1.3 A design overpressure with respect to gas tightness shall be defined for the chambers. The design overpressure shall be between 0.002 bar (20 mm water column) and 0.01 bar (100 mm water column).

8.3.1.4 During a tightness test chambers are individually to be pressurized to their design overpressure. With all openings closed and without air supply the pressure loss during 15 minutes shall not exceed 30% of the design overpressure.

8.3.1.5 Each chamber or gastight group of chambers shall be fitted with at least one pressure relief valve. The pressure set point and the pressure relieving shall be such that with the maximum capacity of the gas generating unit being delivered to any one chamber, the pressure in that chamber shall not exceed its design overpressure.

8.3.1.6 The liquid sealed traps on drains from chambers, air cooler drip trays etc. shall have a liquid head at least 50 mm greater than the chamber design overpressure. When the drains are connected to the pressure side of the chamber air circulation fans, the excess liquid head of the traps shall be at least 100 mm or otherwise as necessary due to the maximum pressure head of the circulation fans.

8.3.1.7 Bilge wells for CA chambers shall be fitted with air pipes to a safe location on open deck. Spaces and chambers not intended for CA shall not have bilge wells common with CA chambers.

8.3.1.8 N2 generating equipment shall not be located within the accommodation. It shall be located within a well ventilated part of the engine room. In case N2 generating equipment is located within a separate space, shall be provided with a permanent ventilation system of the extraction type giving at least 6 air changes per hour.

8.3.1.9 An hazardous area arrangement plan including general information about the hazards caused by a low oxygen level shall be posted within the crews living quarters. The information shall be in a language/ languages understood by the crew.

note:
When in this Section a reference is made to "spaces adjacent to CA chambers" this does not include other cargo chambers whether or not used or arranged for CA. Requirements for such cargo chambers are given directly in the text.

8.3.1.10 **Access:** All access doors and -hatches to CA chambers and air cooler rooms shall be fitted with locks/pad lock arrangements. Key for emergency opening shall be available in a nearby glass locker.

Signboards warning against the possibility of a low oxygen atmosphere shall be fitted.

8.4 Piping systems

8.4.1. Pipes for other media are not to pass through chambers with controlled atmosphere.

8.4.2. All pipes (e.g. air , sounding , drain and ventilation pipes for underlaying chambers, etc.) pass through chambers with controlled atmosphere and if a leakage may cause unintended low oxygen atmosphere in other spaces, shall be of a material and of a design that will ensure permanent tightness.

note:
When acceptable with regard to watertight and fire protecting subdivision it is adviced to utilize plastic pipes as far as possible. Spiro type ventilation ducts will be accepted only within the chamber where they have their open ends.

8.4.3. N_2 supply pipes shall not pass through the accommodation . If N_2 supply externally ,then an automatic shut off valve shall be fitted at the connection for the external supply. This valve shall close in case of excessive pressure in any of the CA chambers. Alternative means to protect the chambers against an excessive supply of N_2 will be specially considered.

8.4.4. The N_2 inlet valve arrangement to each chamber or gastight group of chambers shall include a set of valves in an interlocked fail to safe double-block-and-bleed arrangement.

To avoid an overpressure in the CA chambers, it is recommended that each chamber or gastight group of chambers is fitted with a vent valve connected to the inlet valve arrangement so that supply of N_2 is normally carried out with the chamber vent valve in open position. An override arrangement with automatic reset to the normal condition shall be arranged.

Serial supply of N2 between chambers will be specially considered.When a portable gas generating unit with separate hose connections to each CA chamber or gastight group of chambers is used, the double-block-and-bleed arrangement may be ommitted provided operational procedures are established to ensure that the hoses are not connected until the chamber is ready to be put under controlled atmosphere and to ensure that hoses are not connected for other CA chambers. Similarly the procedures shall ensure that hoses are disconnected prior to unloading the chamber.

8.4.5. All outlets from CA chambers and from pressure relief valves on the N_2 distribution pipes shall be located at least 2 m above the main deck or any gangway, platform, trunk, etc., if situated within 4 m of the gangway, platform, trunk, etc. ensure the distance between such outlets and ventilation intakes or openings to spaces.

8.4.6. **Ventilation** Outlets of the CA chambers shall be directed vertically upwards. .

8.4.7. Pipes connected to CA chambers are normally not to have open ends or connection possibilities within enclosed spaces. Equipment connected to such pipes may normally be located within enclosed spaces only if the equipment is substantially gastight.

8.4.8. **Ventilation of adjacent spaces**

8.4.8.1 All normally accessible spaces adjacent to cargo chambers with controlled atmosphere or where a pipe leakage, equipment leakage etc. may cause an oxygen deficient atmosphere, shall have a permanent ventilation system operable from outside the space and giving at least 6 air changes pr. hour.

Note:
Spaces without permanent electrical lighting will normally not be required to have a fixed ventilation system.

8.4.8.2 All other spaces or tanks adjacent to cargo chambers with controlled atmosphere shall be arranged for efficient ventilation, e.g. by use of portable ventilators. Suitable air inlet and exhaust openings shall be arranged. Permanent ducting within the space or tank may be required if considered necessary. For ballast tanks, ballasting with subsequent deballasting shall be considered as efficient ventilation.

8.4.8.3 Minimum two portable ventilators suitable for use on the above mentioned inlet or exhaust openings and with a nominal capacity equivalent to at least 2 air changes pr. hour in the largest of the relevant spaces/tanks shall be available onboard.

8.4.8.4 N_2 release prealarm**:** Means shall be provided for automatic audible warning of injection of N_2 into any chamber or gastight group of chambers. The alarm shall be continuous for at least 60 seconds before injection can take place. The operating medium for the alarm shall be taken from the supply of operating medium for the double-block-and-bleed inlet valve arrangement in such a way that the inlet valve cannot be opened unless the alarm signal has been activated. The alarm may be interlocked with the O_2 analyzer in such a way that alarm is not given when the O_2 content in the chamber is below 14% by volume.

8.5 Performance

8.5.1. **Atmosphere quality:** Equipment shall be installed to maintain in any chamber or gastight group of chambers any O_2 level between 10.0% and 2.0% by volume with an accuracy of ± 0.2% by volume .

8.5.2. The ship shall be fitted with equipment to reduce excessive concentrations of CO_2 in any chamber or gastight group of chambers. Between 0.2% and 10.0% CO_2 by volume the equipment shall maintain any desired CO_2 concentration with an accuracy of ± 0.2% by volume or better.

8.5.3. **Required capacities:** The N_2 generating equipment at normal operating temperature and at 4.0% O2 shall have a capacity in Nm_3/h not less than 0.05 times the total bale volume of all CA chambers. At 2.0% O_2 the capacity shall be minimum 50% of the above. The capacities stated shall be available at the inlet openings to the chambers at a backpressure equal to the pressure setting of the pressure relief valves.

8.5.4. Each chamber or gastight group of chambers shall be fitted with a ventilation system minimum 2 air changes per. hour based on the bale volumes..

8.6 Nitrogen generator. Carbon dioxide scrubbers

8.6.1. **Nitrogen generator**

8.6.1.1 The piping system, the pressure vessels including separation or apsorbtion units and the compressors shall comply Pt.5A

8.6.1.2 Active components including compressors shall be arranged with redundancy. Two compressors with approximately 50% of the required capacity shall be accepted. The main and additional units need not be exclusive for the nitrogen generator provided they may always available for this purpose. Passive components such as gas separators or apsorbtion units need not be duplicated.

8.6.1.3 **To provide clean gas** in cargo chambers system a suitable separator or filter shall be used , and also to prevent damages to any gas separating or apsorbtion equipment, shall be installed.

8.6.1.4 Exhaust of O_2 enriched gases shall be to safe locations on open deck.

8.6.1.5 Exhaust of N_2 enriched gases shall be to safe locations on open deck. .

8.6.1.6 Any N_2 storage vessel shall be fitted with non-return valves on the inlet connections.The N_2 delivery line shall be fitted with a safety relief valve sized for the maximum delivery of the nitrogen generating equipment.

8.6.1.7 **Carbon dioxide scrubbers:** CO_2 scrubbers for atmosphere control, if fittedshall be considered.

8.7 Electrical installations

8.7.1. All electrical installations shall comply with Pt.6.

8.7.2. **Cable penetrations**
Cable penetrations between cargo chambers and surrounding spaces, and between individual cargo chambers shall be gas tight. The penetrations shall be with separate

glands for each cable, or with boxes or glands filled with a suitable packing or moulded material.

8.8 Instrumentation

8.8.1. General

8.8.1.1 For instrumentation and automation, including computer based control and monitoring, this chapter is additional to those given in Pt.6 Ch.8.

8.8.1.2 Indication, monitoring, logging and/or control of atmosphere quality in cargo area as well as of other functions described in this Section shall be provided at a centralized control stand.

8.8.1.3 Cable penetrations, Refer [8.7.2].

8.8.2. O_2 and CO_2 contents**:** For CA chambers O_2 and CO_2 contents in cargo chamber atmosphere measuring equipment shall be installed. Minimum of one measuring point each for O_2 and CO_2 shall be provided in any chamber which may be isolated from other chambers.

8.8.2.1 A logging system of above parameters automatically during the entire length of the loaded voyage shall be installed. Gas monitors shall be common with monitors for indication and alarm.

8.8.2.2 All spaces, cargo chambers not in CA,if leakage of bulkheads, doors, hatches, pipes, etc. shall be filled with an atmosphere with reduced O_2 concentration,and fitted with equipment for measurement of O_2 content in the atmosphere. Minimum of one measuring point shall be installed in each space. The sampling point shall be located with due regard to the ventilation arrangement for the space.

8.8.2.3 Discrete gas sensors shall be installed locally at the respective points of measurement , or a sampling system shall be arranged, with sampling pipes led from points of measurement to a centralized gas monitor. One gas monitor each for O_2 and CO_2 is required.

8.8.2.4 Sampling point shall be analyzed at intervals not exceeding 1 hour. Sampling time at each point shall be at least equal to 3 times pipe length divided by mean gas velocity in the connected sampling line, to ensure a fresh gas sample is analyzed.Sampling of gas shall be continuous process Flow failure in the sampling lines shall be monitored. The sampling system shall be designed to function at any chamber pressure within set pressure of relief valves. The sampling lines shall be arranged for easy testing of tightness.

8.8.2.5 Common sampling lines for the measurement of O_2, CO_2 and refrigerant gas shall be arranged.

8.8.2.6 The analyzers shall have an accuracy of at least ±0.1% by volume or better. The oxygen analyzer(s) shall have a range of 0 to 21% O_2.
The CO_2 analyzer(s) shall have a range of at least 0 to 15% CO_2.

8.8.2.7 If the fixed equipment/ordinary sampling lines fail then two portable gas analyzers for O_2 and at least one portable gas analyzer for CO_2 shall be kept onboard.

8.8.3. **Control of cargo chamber atmosphere** :Manual or automatic system **to** Inject tnitrogen and removal of CO_2 shall be arranged to control chamber atmosphere. If automatic control is used , separate gas analyzing equipment shall be installed for this purpose.

8.9 Alarm and monitoring

8.9.1. An alarm system for monitoring of atmosphere in cargo area and other functions shall be installed according to Table 8.8.1. Proper grouping of alarm reqired to differentiate machinery alarms

Table 8.8.1 Alarm points

Item	*Al*	*Comments*
O_2 content, high	X	Each CA chamber/group
O_2 content, low	X	Each CA chamber/group
O_2 content less than	X	Each space
CO_2 content, high	X	Each CA chamber/group
Atm. pressure, high	X	Each chamber/group if external supply of N_2. Automatic closing of supply valve
Liquid seal, low level	X	Each liquid seal trap
Ventilation failure	X	Electric failure.
Compressor failure	X	Electric failure, all compressors for N_2 generating equipment
Sampling lines, flow	X	All sampling lines
Gas sensors, failure	X	Out of normal range
Logger out of order	X	

8.10 Personnel protection and Instruction manual.

8.10.1. **Personnel protection equipment**

Minimum 10 off portable O_2 analyzers with alarm and of a type designed to be continuously worn for personal protection and mimnimum one set of oxygen resuscitation equipment shall be available onboard.

8.10.2. **Instruction manual**

An instruction manual containing following shall be available onboard:
use of CA and installation details

- complete description of the ship's CA installation,lowoxygen hazard,and effects to personal
- Treatment in case of exposure to low oxygen atmosphere
- functional testing procedure portable gas unit
- operation, maintenance and calibration instructions for all types of gas detectors.
- instructions regarding use of portable O_2 analyzers with alarm for personal protection
- prohibition of entry of spaces under CA even with use of breathing apparatus
- instructions with regard to loading of all chambers under the same main hatch being completed prior to injection of nitrogen
- procedures for checking chambers and locking door/hatches prior to injection of nitrogen. Procedures for safe keeping of key by responsible officer
- a list of signboards
- procedures relating to connection and disconnection of hoses .
- procedures for checking that all gas detectors are in operation and with correct alarm set points prior to injection of nitrogen
- gas freeing procedures for CA chambers
- procedures for checking completed gas freeing prior to entry of CA chambers
- instructions with regard to gasfreeing and atmosphere testing of spaces without fixed ventilation and fixed gas detection equipment.

SECTION 9 TESTS

Contents

9.1 Pressure Tightness Testing

9.1.1. **General**

A hydraulic strength test and a pneumatic tightness test shall be carried out in the presence of the surveyor.

Guidance note:
After tightness testing and before charging with refrigerant it has been assumed that an extensive drying out (vacuumation) of the complete plant is carried out by the contractor. It is adviced that pressure rise curves are recorded and analyzed to to verify tightness and that the plant is dry. A satisfactory drying cannot be carried out at very low temperatures.

9.1.2. Hydraulic pressure tests shall be carried out with any liquid, including water.. Pneumatic tightness tests may be carried out with nitrogen, CO_2 or air.

9.1.3. Combined single strength and tightness tests shall be carried out with special consieration The strength test pressure for piping systems shall normally be 1.5 × design pressure.

9.2 Installation function and capacity test.

9.2.1. All systems, components and equipment shall be included in operational and capacity testing including all design functions and all design operating conditions.

9.2.2. Testing under low ambient temperatures special considerations shall be given. In that cases, heating of the chambers shall be demanded.

9.2.3. Test report shall be submitted to the surveyor.

9.3 Refrigeration machinery test

9.3.1. All components of the refrigerating machinery shall be tested in operation. If required capacity tests of the components shall be demanded.

9.3.2. The testing shall be carried out in accordance with an approved test program. The test to carry out afeter plant commission only. The plant in its entirety shall perform satisfactorily Normal maintenance work including filter replacements or filter cleaning shall be carried out during convenient periods of the testing. Test periods minimum 2 hours

9.3.3. Plan test program to include minimum of following components :

- compressor capacity control system
- refrigerant distribution between units
- oil return
- oil transfer between units
- defrosting
- operation with 2 or more different chamber temperatures simultaneously.

9.3.4. During the cooling down- and stable periods relevant data shall be recorded at sufficiently short intervalsto give relevant information of the ongoing process. The intervals is normally not to exceed 30 minutes during transient processes and 60 minutes during stable (stabilizing) periodes.

9.3.5. RSW tanks shall be cooled down to the tank design temperature.

9.3.6. Tunnel freezers and plate freezers shall be tested by simulated operation.

9.3.7. All alarm and automatic stop functions shall be tested. The accuracy and set point of all indicating instruments and all sensors for alarm and automatic stop functions shall be tested.

9.4 Thermometers. Gas indicating equipment

9.4.1. All chamber, cooling air, freezing tunnel and RSW thermometers shall be tested for accuracy.

9.4.2. CO2 concentration measuring equipment for the chambers shall be tested.

9.5 Air circulation and air renewal systems

9.5.1. All fans for air coolers shall be tested. Dual or multi speed fans shall be operationally tested at all speeds and with applicable chamber temperature. Capacity testing is required only at full speed. Variable speed fans need only be tested at maximum speed and at the warmest chamber design temperature. The testing shall include measurements of the air flow, pressure difference across the fans, electrical frequency or rotational speed and power consumption. The resulting air circulation rates shall be calculated and recorded..

9.5.2. All air renewal fans, dual or multi speed fans shall be tested operationally at all speeds. Capacity testing is required only at full speed. The testing shall include measurements of air flow, electrical frequency or rotational speed and power consumption. The resulting air renewal rates shall be calculated and recorded.

9.5.3. Ships carrying bananas or fruit in general the tightness of the chambers (group of chambers) shall be verified and the leakage rate shall be measured and recorded.

9.6 Insulation and heat balance test

9.6.1. Using infrared detecting equipment thermographic investigation shall be carried out to verify the completeness of the insulation of the cargo chambers. For a series of two or more identical sisterships the thermographic investigation may on the 2nd and the following ships be replaced by an external cold spot inspection with regard to excessive condensation or frost deposits while the chambers are at their lowest design temperature.

9.6.2. With heat balance test report the overall heat transfer coefficient of the insulation and overall refrigerating capacity shall be verified. All chambers shall be cooled down to lowest design operating temperature and normally at least 20°C below the mean ambient temperature. If the lowest design operating temperature is different between the chambers, this difference to be maintained during the heat balance test. The chambers may be cooled down to the expected balance temperature . When the expected balance temperature has been reached, the plant shall be run manually and as far as possible in accordance with the following:

- the inlet sea cooling water temperature shall be automatically controlled to a chosen set point within the design range
- the compressor(s) shall be run with constant and well defined capacity. Only one of several identical compressors need be in operation
- each compressor shall be in operation together with the other components of the same unit.
- automatic brine temperature controllers and chamber temperature controllers shall not be in operation.

The situation shall be accepted as in balance when:

- the mean chamber temperature (measured by use of all installed chamber temperature sensors) for each individual chamber and for all chambers together for each hour of a 4 hour period have been changing less than 0.05°C/h
- the ambient weather conditions have remained stable for 6 hours
- there are no indications of an unstable or off-balance situation.

Chambers with the same design operating temperature shall have chamber balance temperatures preferably within a range of 1.5°C.All data necessary for the verification calculations,(refer [9.7]) shall be recorded hourly for a period of at least 6 hours prior to the balance. All heat input to the chambers (fan motors, lighting fixtures, heat tracing on drainpipes, etc.) shall be measured by a calibrated kW-meter. Use of A-meter with estimate of cosΦ will not be accepted. A heat balance test shall be carried out for RSW tanks.

9.7 Refrigerating capacity

The refrigerating capacity shall be noted from the compressor curves or data corrected . The heat transfer losses shall be based on the heat transfer coefficient calculated after the balance test. In case of different heat transfer coefficients for various areas, the overall coefficient shall be the same as the overall coefficient calculated after the balance test. Evaporating and condensing temperatures shall be estimated based on observations during the balance test and to be corrected in accordance with Sect 6[6.7.1] and Sect 6[6.9.4]

9.8 Controlled atmosphere installations testing

9.8.1. **General**
Each chamber or gastight group of chambers shall be individually pressure tested with air to the design overpressure to verify that the leakage rate does not exceed that specified in Sec.8 [8.3.1.4]

9.8.2. The nitrogen distribution system shall be hydraulically pressure tested to at least 1.5 times the relief valve setting but not less than 5 bar.

9.8.3. All other pipes or piping systems shall be tightness tested to at least 2 bar or by equivalent means confirmed to be tight.

9.8.4. N_2 release prealarm and inlet valve interlock shall be tested.

9.8.5. Nitrogen generating equipment shall be tested for capacity and quality of the delivered gas.

9.8.6. **CO_2 s**crubbers, if installed, shall be tested.

9.9 Instrumentation

9.9.1. When installations completed, all functions shall be tested according to an approved test program,related to the testing and safety requirements applicable to all ships with CA installation.

9.9.2. Gas detectors shall be tested for zero, span and linearity by means of certified test gas. This is done by three points test, preferably 0%, 50% and 100% of range.

9.9.3. Flow failure alarms for gas sampling lines shall be tested by blocking the relevant pipe manually. Gas sampling pipes shall be tested for tightness.

9.9.4. Alarm setpoints are preferably to be tested by letting the measured parameter pass the setpoint value (may be done by process parameter calibrators).If not possible, change of setpoint may be accepted for analog channels.

9.9.5. Automatic control functions shall be tested by setpoint changes and observing stable adaption to new value.

9.9.6. Operator interface (display/indicating) panels shall be checked for acceptable functionality and compliance with Pt.6 Ch 8

CHAPTER 8 SHIPS FOR CARRIAGE OF POTABLE WATER

CONTENTS

SECTION 1

Contents

1.1 Objective

Ensure transport potable water in bulk quantity in standard quality with minimal risk of contaminating the cargo.

1.2 Application

201 This chapter rules applicable to vessels exclusive to carriage of potable water. The requirements are considered as supplementary to those for the assignment of main class.

1.3 Class notation

Vessels comply with this Chapter shall assign the class notation: **Potable Water Tanker**

1.4 Tanker for Potable Water

Cargo tanks are intended only for carriage of potable water, except emergency conditions.

1.5 Documents and plans to be submitted:

a) General Arrangements
b) Cargo tank arrangements
c) Cargo piping
d) Cargo tank air vents
e) Cargo tank sounding
f) Specification of tank coating with certificate of acceptance for toxicity and tainting testing by recognized laboratory or health authority
g) Specifications of metallic and non-metallic materials in contact with the cargo.
h) Documentation of instrumentation and automation, including computer based control and monitoring, Refer Pt.6 Ch 8 Sec.1.Control and monitoring system shall be approved by the Society:
i) Water quality instrument.

1.6 Surveys: All systems and installations of this chapter shall be surveyed and tested to the satisfaction of the surveyor

SECTION 2 MINIMUM REQUIREMENTS

Contents

2.1 Materials

Potwater piping and tank materials in contact with water and coatings are not to react and produce harmful substances .
Non-metallic materials and coatings documentation of water intended for human consumption shall be submitted, e.g. test as per BS 6920 or equivalent.

2.2 Potwater tank

Cofferdams shall be arranged to separate Potwater tanks from fuel oil, lubricating oil tanks or any other liquid, except ballast water tank

2.3 Ballast tanks

The vessel shall have sufficient segregated ballast water capacity under all conditions in normal operation and safety of the vessel.

2.4 Piping and tank vent

Cargo piping shall be separated from all other piping systems, i.e. no physical connection is allowed.
Tank vents shall be designed to avoid ingress of sea water. Hydraulic valves are not to be fitted inside cargo tanks .Submersible cargo pumps not allowed if leakage of hydraulic fluid or lubricants may contaminate the cargo.

2.5 Quality of water

The quality of the water loaded shall comply the Directive 98/83/EC of the European Union or with a quality standard specified by the receiving country or port. To prove the quality of water loaded, laboratory test results from quality control system implemented by the water supplier is required. On board instruments shall be provided for measuring pH-value and conductivity.

CHAPTER 9 PIPE LAYING VESSELS

CONTENTS

SECTION 1

Contents

1.1 Application and Classification

This Chapter rules applicable to vessels for laying pipelines on the sea bottom.
Vessels comply this chapter rules shall assign the class notation **Pipe Laying Vessel**.
Vessels comply Pt 7B,Chapter 5 Sect 10 shall assign the class notation **Pipe Laying Barge**.

1.2 Scope

The Classification includes the following:

a) hull structural details related to the pipe laying operations
b) supporting structures for equipment applied in the pipe laying operations
c) equipment for anchoring and mooring
d) equipment and installations for pipe laying
e) equipment for positioning during pipe laying

1.3 Documents

1.3.1. The following Documents shall be submitted.

a) Documents for Approval

i. Pipe laying supporting structural drawing showing geometric dimensions,scantlings and arrangement of structural object including details of parts and openings,material specification,standard details,details of joints,welding procedures ,filler metal pariculars, heat treatment specification after welding.
ii. Pipe reel supporting structural drawing
iii. Stowed pipe supporting structure

b) Documents for information

i. Pipe laying equipment with details of applied loads static and dynamic, rating and environmental conditions.
ii. Pipe laying equipment arrangement plan
iii. Stowed pipe supporting structure design criteria including maximum weight of stowed pipes.

1.3.2. In case of an anchoring system for position-keeping installation , additional documents shall be submitted as following.

a) Documents for approval.

i. Anchoring system supporting structural drawing including supporting structure.

b) Documents for information.

i. Anchoring system Design with anchor line forces and arrangement plan including limiting anchor line angles.

1.3.3. In case of barges towed by tugs during pipe laying, additional documents shall be submitted as follows.

a) Documents for approval

i. Towing system supporting structural drawing including supporting structure

b) Documents for information.

i. Towing system design including towing line forces and limitsing towing line angles

SECTION 2

Contents

1.1 Hull Structural Strength

It shall be same as main class considering strength of support structures equipment for pipe laying. Catamarans, semi-submersibles and special hull configurations, the hull structural strength shall be specially considered.

1.2 Equipment for mooring and anchoring

1.2.1. It shall be same as main class, i.e. anchors, chain cables, windlass, mooring ropes etc., are Catamarans, semi-submersibles and special hull configurations, the equipment shall be specially considered.

1.2.2. Equipment for positioning during pipe laying shall be specially considered.

1.3 Certification

Pipe Laying Equipment certification subjected to pipe loads when the vessel is in operation shall be certified by the INTLREG product certification. Pipe handling equipment which is idle while the vessel is in operation, e.g. spooling towers, not to be certified.

CHAPTER 10 SHIPS FOR CARRIAGE OF DANGEROUS GOODS

CONTENTS

SECTION 1

Contents

1.1 Class notations

Ships complying this chapter shall be assigned the class notation **DG**, appended by one of the letter **Bulk** or **Pack** as detailed below.

a) **Bulk**- Ships designed for carriage of dangerous solid bulk cargoes
b) **Pack**- Shps designed for carriage of dangerous goods in packaged form

1.2 Requirements

1.2.1. Refer to the requirements carriage of dangerous goods in packaged form of SOLAS Reg. II-2/19

1.2.2. Regarding potentially hazardous bulk cargoes not subject to the SOLAS requirements in [1.2.1]the rules to satisfy the recommendations in IMO's "International Maritime Solid Bulk Cargoes Code - IMSBC Code" in ships construction and equipments.

Note:
When authorised by the government of the flag state, the Society shall issue a Document of Compliance, certifying that the construction and equipment comply SOLAS Reg. II-2/19 and or the IMSBC Code, asamended. For such certification applicable parts of this chapter are used, also when class notations are not assigned.

1.2.3. It is considered that the operational requirements of SOLAS Chapter VII, Part A and the International Maritime Dangerous Goods Code, IMDG Code (IMO Resolution A.81(IV)) or the "International Maritime Solid Bulk Cargoes Code", as applicable, are complied.

1.2.4. In case of dangerous goods in packaged form, i.e. substances for well stimulation, carried on board i.e. a supply vessel, are discharged, then other codes, resolutions, etc., shall be considered, i.e. "Guidelines for the transport and handling of limited amounts of hazardous and noxious liquid substances in bulk on offshore support vessels (Resolution A673(16) as amended)".

1.3 Plans and Datas

1.3.1. Following documents shall be submitted for approval depending upon type of cargo to carry for class notaion DG

i. Hazardous area classification drawing.Each deck arrangement plan with location and zone area including locations of Air intakes,exhausts,Ventilation system,doors and cpenings

ii. Structural fire protection drawing consisting of construction method,Space category,Horizontal and vertical fire zones and divisions, Bridge insulation, method of construction of continuous "B" class ceiling or linings contributing to insulation and fire integrity of fire divisions and type of doors in class divisions, including information if self-closing is arranged

iii.

a) Fire water supply and distribution system drawing consisting of pipe ,valves anfittings materials,material,Pipe outside diameters and thickness of pipes,expansion elements, design pressure if exceeding 7 bar, and design temperature if exceeding 60^{o}C, hydrostatic test pressure after installation on board

b) In case of plastic pipes fire endurance class ,conductive or non-conductive grade ,maximum working pressure and temperature

c) Fire water calaculation of capacity of the system

d) Fire water supply arrangement plan.

iv. Fixed fire extinguishing system in cargo holds,
The documentation shall be based on a relevant selection from the following documentation types:Control and monitoring system documentation.Piping diagram, Capacity analysis, including pressure drop calculations and application rates,Arrangement plan,Operation manual, including release instructions as applicable for the system

v. Ventilation system ducting diagram with arrangement of ventilation ducts and associated components,penetrations through class divisions etc., arrangement of air condition units showing which ventilation ducts that are served by each air conditioning unit, size and material description of ventilation ducts including fire insulation

vi. Electrical schematic drawing. schematic drawing showing the configuration of the electrical circuits. Information on protection,synchronisation, interlocks, undervoltage trips, remote control circuits etc. shall be included if relevant, Single line diagrams for all intrinsically safe circuits, for each circuit .

1.3.2. Following documents shall be submitted for information

i. Cargo handling arrangements with cargo list .Specification of the cargoes to be carried in each cargo compartment.

For dangerous solid bulk cargoes: A specification of cargoes to carry in each cargo hold.

For dangerous goods in packaged form: A specification of goods to be carried in each cargo space or hold.

ii. Electrical installations in hazardous areas. Arrangement plan of Electrical equipment in hazardous areas. Where relevant, based on an approved 'Hazardous area classification drawing'

1.3.3. Additional documents for carriage of dangerous solid bulk cargoes B to be submitted for Apprval

i. Inert gas system Piping diagram applicable for cargoes requiring inerting of cargo holds , Refer [1.3.1] iii).

ii. Fixed hydrocarbon gas detection and alarm system Control and monitoring system and arrangement plan

iii. Cargo temperature monitoring system

1.3.4. Additional documents for Packaged form P shall be submitted for approval

i. Fire detection and alarm system .Arrangement plan

ii. Fixed fire extinguishing system in vehicle, special category and ro/ ro spaces. Refer [1.3.1]iv)

1.4 Classes of Dangerous Goods

Classes of dangerous goods as per SOLAS, Chapter VII, Part A, the IMSBC-Code and the IMDGCode, as follows:

Division 1.1: Substances and articles of a mass explosion hazard

Division 1.2: Substances and articles of a projection hazard but not a mass explosion hazard

Division 1.3: Substances and articles of a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard

Division 1.4: Substances and articles which present no significant hazard

Division 1.5: Very insensitive substances of a mass explosion hazard

Division 1.6: Extremely insensitive articles which do not have a mass explosion hazard

Class 2: Gases

Class 2.1: Flammable gases

Class 2.2: Non-flammable, non-toxic gases

Class 2.3: Toxic gases

Class 3: Flammable liquids

Class 4: Flammable solids; substances liable to spontaneous combustion; substances which, in contact with water, emit flammable gases

Class 4.1: Flammable solids, self-reactive substances and desensitized explosives

Class 4.2: Substances liable to spontaneous combustion

Class 4.3: Substances in contact with water, emit flammable gases

Class 5: Oxidizing substances and organic peroxides

Class 5.1: Oxidizing substances

Class 5.2: Organic peroxides

Class 6: Toxic and infectious substances

Class 6.1: Toxic substances

Class 6.2: Infectious substances

Class 7: Radioactive material

Class 8: Corrosive substances

Class 9: Miscellaneous dangerous substances and articles

Class MHB: Materials hazardous only in bulk.

Note:

Class 6.2 and Class 7 are neither covered by SOLAS Reg. II-2/19 nor this Chapter 10 of the Rules for Classification of Ships.

SECTION 2

Contents

2.1 Fire water supplies:

2.1.1. Arrangements shall be made to ensure immediate availability of a supply of water from the fire main at the required pressure. (SOLAS Reg. II-2/19 3.1)

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2.1.2. The capacity of the fire pumps shall be sufficient for supplying four (4) jets of water, and the number and position of hydrants shall be at least two (2) of the required four (4) jets of water, when supplied by single lengths of hose, shall reach any part of the cargo space when empty; and all four (4) jets of water, each supplied by single lengths of hose shall reach any part of ro-ro cargo spaces. (SOLAS Reg. II-2/19 3.1.2 and IACS UI SC 168).

2.1.3. Drainage and pumping arrangement shall be able to prevent the build-up 0f free surfaces.Stability information shall consider adverse effect upon stability of the added weight and free surface of water.

2.1.4. **Fixed fire extinguishing**

A ship carrying dangerous goods in any cargo spaces shall be provided with a fixed carbon dioxide or inert gas fire-extinguishing system complying with the provisions of the Fire Safety Systems Code or with a fire-extinguishing system.
(SOLAS Reg. II-2/10.7.2)

2.1.5. Each open ro-ro cargo space having a deck above it and each space deemed to be a closed ro-ro cargo space not capable of being sealed, shall be fitted with an approved fixed pressure water-spray system for manual operation. The capacity of the system shall be sufficient at least 5 litres/m^2/min. of the horizontal area of decks and platforms. The use of any other fixed fire-extinguishing system that has been shown by full-scale test to be no less effective, shall be permitted. (SOLAS Reg. II-2/19.3.9)

2.2 Electrical Equipments and cables

2.2.1. Electrical equipment and wiring shall not be fitted in hazardous areas and in areas where explosives are stored unless it is essential for the safety and operation of the ship. (IEC 60092-506, 5.1)

2.2.2. Electrical equipment shall be certified safe type for use in dangerous environments.

2.2.3. The hazardous area shall be categorised in accordance with IEC 60092-506 Annex B

2.2.3.1 If a space open to an adjacent hazardous space or area, it shall be made into a nonhazardous space in accordance with the following requirements:

- A minimum overpressure of 25 Pa (0.25 mbar) with respect to the adjacent hazardous space or area is provided at all points inside the space and its associated ducts at which leaks are liable to occur, all doors and windows being closed.
- Visual and acoustic alarm is provided at a manned position in case of loss of pressure.

2.2.3.2 The requirements for electrical equipment in hazardous areas Refer IMDG code

2.2.3.3 If electrical equipment, not approved for the use in hazardous areas as specified in [2.2.3.1] is installed, it shall be arranged to isolate the equipment completely, and to protect it against unauthorized reconnection. Disconnection shall be made outside the hazardous areas and shall be effected with isolating links or lockable switches. Equipment essential either for the safety of the ship or crew shall be approved for the installation in hazardous area and shall not be disconnected

2.2.4. Portable electrical equipment shall have its own self-contained electrical source of energy, except for intrinsically safe circuits

2.2.5. Cables-Bulkhead and deck cable penetrations shall be sealed against passage of gas or vapour.Cable runs within the cargo spaces shall be protected against damage from impact.

2.2.6. Cables shall be either

a) protected by electrically continuous metal sheathing or metallic wire armour braid or tape, or

b) Enclosed in screwed heavy gauge steel drawn or seam-welded and galvanized conduit.

2.2.7. All metallic protective coverings of power and lighting cables passing through a hazardous area or connected to equipment in such an area, shall be earthed at least at each end. The metallic covering of all other cables shall be earthed at least at one end.

2.2.8. Cable joints in cargo spaces shall be avoided where possible. Where joints are unavoidable, they shall be enclosed in metal-clad or impact strength plastic junction boxes of certified safe type, or heat shrink or encapsulated crimp sleeve cable joints

2.3 Fire detection system

2.3.1. RO-RO spaces shall be fitted with a fixed fire detection and fire alarm system complying SOLAS Ch II-2 Reg 20.

2.3.2. All other types of cargo spaces except spaces shall be fitted with either a fixed fire detection and fire alarm system(Regulation II/7) or a sample extraction smoke detection system (SOLAS Ch II-2 Reg 7-2). If a sample extraction smoke detection system is fitted, provision shall be made to discharge contaminated atmosphere to open air at safe location.Appropriate notice shall be exhibited.

2.4 Ventilation

2.4.1. Adequate power ventilation shall be provided in enclosed cargo spaces. Cargo holds shall be provided with a minimum of two ventilation fans, at least 6 air changes per hour in the cargo spaces based on the empty cargo space.

2.4.2. 2.4.2- Holds intended for the carriage of cargoes for which continuous ventilation is required, shall be provided with ventilation openings which may be kept opened when required. Such openings shall comply with the requirements of the Load Line Convention as amended for openings not fitted with means of closure

2.4.3. Electric motors and associated electrical installations shall be certified type.

2.4.4. Wire mesh guards (protection screens of not more than 13 mm square mesh) fitted over inlet and outlet ventilation openings.

2.4.5. If no provision for mechanical ventilation for enclosed cargo spaces for carriage of solid dangerous goods in bulk, then natural ventilation shall be provided. (SOLAS Reg. II-2/19 3.4.3)

2.4.6. The fan(s) shall be permanently fitted or of a portable type adapted for being permanently fitted prior to loading and during voyage.

2.4.7. The height of ventilation inlets and outlets must satisfy the requirements of the Load Line Convention for openings fitted with closing appliances.

2.4.8. If no provision for mechanical ventilation, thenNatural ventilation with closing appliances shall be provided in enclosed cargo spaces. (SOLAS Reg. II-2/19 3.4.3)

2.4.9. The exhaust fans shall be fitted with suitable wire mesh guards (maximum 13´×13 mm mesh). (SOLAS Reg. II-2/19 3.4.2 and IACS UI SC 52.)

2.4.10. The inlet and outlet ventilation openings shall be fitted with spark-arresting screens.

2.5 Bilge system

2.5.1. Bilge pumping and drainage system for cargo spaces shall be arranged outside machinery spaces. If bilge ejectors are used driving water may be taken from a pump in the engine room provided a non-return valve isfitted in the supply line.(SOLAS Reg. II-2/19.3.5.1)

2.5.2. If the bilge drainage system for cargo space is additional to the system served by pumps in the machinery space, the capacity of the system shall be not less than 10 m3/h per cargo space served. If the additional system is a common system, the capacity need not exceed 25 m3/h.

2.5.3. 2.5.3 Whenever flammable or toxic liquids are carried, the bilge line into the machinery space shall be isolated either by fitting a blank flange or by a closed lockable valve to be located in a readily accessible space outside cargo holds, e.g. in the engine room.
(SOLAS Reg. II-2/19.3.5.3)

2.5.4. Enclosed spaces outside machinery spaces containing bilge pumps serving cargo spaces intended forcarriage of flammable or toxic liquids shall be fitted with separate mechanical ventilation of at least 6 air changes per hour. If the space has access from another enclosed space, the door shall be self-closing. (SOLAS Reg. II-2/19 3.5.4)

2.5.5. If gravity drainage is applied the discharges to be lead directly overboard, alternatively to a closed collecting tank, located outside the machinery spaces, having a minimum volume sufficient to accumulate 1/3 of the drainage capacity per hour of the largest cargo space. The tank shall be provided with vent pipe to a safe location on the open deck.

Drainage from a cargo space to wells in a lower cargo space is only permitted if the lower cargo space satisfies the same requirements as the cargo space above.
(SOLAS Reg. II-2/19.3.5.5)

2.6 Portable Fire extinguishers

Portable fire extinguishers provided for the cargo spaces, with a total capacity of at least 12 Kg of dry powder or equivalent, in addition to any portable fire extinguishers required elsewhere under SOLAS Ch II-2
These extinguishers are in addition to any poratable fire extinguishers required elsewhere in the rules.

2.7 Insulation of machinery space boundries

2.7.1. Bulkheads forming boundaries between cargo spaces and machinery spaces of category A shall be insulated to “A-60” standard, unless the dangerous goods are stowed at least 3 m horizontally away from such bulkheads. (SOLAS Reg II-2/19 3.8)

2.7.2. Decks forming boundries between cargo spaces and machinery spaces of category 'A' insulated to 'A60' standard.

2.7.3. The ship with ro-ro cargo spaces, a separation shall be provided between a closed ro-ro cargo space and an adjacent open ro-ro cargo space. The separation is to minimize the passage of dangerous vapours and liquids between such spaces. Alternatively, such separation need not be provided if the ro-ro cargo space is considered to be a closed cargo space over its entire length and shall fully comply with the relevant special (SOLAS Reg. II-2/19.3.10.1)

2.8 Personnel protection

2.8.1. Four sets of full protective clothing resistant to chemical attack provided,covering all skin so that part of the body isunprotected,in addition to the fireman's outfits required by SOLAS Ch II-2 Reg 10.10

2.8.2. At least two self-contained breathing apparatus shall be provided in addition to those required by SOLAS Ch II-2 Reg 10.10.

2.8.3. Medical oxygen

Provided that the Administration requires that the guidelines in the MFAG in the IMDG Code supplement with respect to medical oxygen shall be complied by the following :
A 40 litre/200 bar medical oxygen cylinder shall be mounted in the ship's hospital, equipped with one flow-meter unit for supplying oxygen for two persons simultaneously. A complete portable set, ready for use, with a 2 litre/200 bar medical oxygen cylinder and a spare cylinder (also 2 litre/200 bar) shall also be available on board.
The 40 litre/200 bar cylinders shall be stored in fixed supports connected directly to vessels steel structure within the ship's hospital. The cylinders shall be stored within a steel cabinet with natural ventilation to free air. Signboard warning of possible ignition by static electricity from clothing or open flame when medical oxygen is used (released) shall be posted on the cabinet.
Alternative arrangements, according to the Administration are equivalent, shall be accepted.

2.9 Water sparay system

2.9.1. Each open ro-ro cargo space deck above shall be fitted with an approved fixed pressure water spraying system.It shall protect all parts of any deck and vehicle platform in such case.

2.10 Special requirements for Carriage of Dangerous Goods, Refer SOLAS Ch II-2, Regulation 19 Table 19.1, Table 19.2 and Table 19.3

2.11 Details of carriage of Dangerous Goods in packaged form, Refer SOLAS Ch VII Part A and Carriage of dangerous goods in solid form in bulk Refer SOLAS Ch VII Part A-1

2.12 Special Arrangements:

2.12.1. Gas measuring instruments
While transporting a bulk cargo, the ship shall be provided with gas measuring instruments as follows:
a) Instruments for measuring hydrogen gas or methane gas (0-100% LEL).
b) Instruments for measuring toxic gases.
c) Instruments for measuring oxygen concentration (0-21% by volume).

(SOLAS Reg. VI/3.1)

The instruments shall be portable or fixed.

When portable gas measuring instruments are used, suitable sampling connections to check atmosphere in holds and cargo handling spaces without entry, shall be arranged.

Note:

Sampling points for cargo holds should be located as high as possible, e.g. upper part of hatch coaming. In order to ensure safe access in adverse weather conditions, two sampling points per hold should be provided, preferably one on each side. Fore and aft location may also be accepted if this is deemed more advantageous.

2.12.2. Temperature detection in cargo holds

Cargo holds shall be fitted with temperatures sensors in the cargo.The temperature sensors shall be either permanently fitted or of portable type.By using portable sensors the measurement of the temperature of the cargo without entry of the hold shall be possiblel.

2.12.3. Inerting of cargo holds

Cargo holds shall be provided with arrangements for maintaining an inert atmosphere in the loaded hold.

Oxygen content is not to exceed 5% by volume. The arrangement enables purging of the space above the cargo with inert gas.

2.12.4. Separation of cargo holds from oil tanks

Fuel oil,lubricating oil tanks not to locate adjacent to cargo holds unless [2.12.5] is complied with.

2.12.5. Separation of cargo from heated surfaces

Heated oil tanks; double bottom tanks, top wing tanks, deep tanks, hopper tanks, side tanks, etc., adjacent to cargo holds, shall be fitted with permanent temperature indicators or provided with a suitable arrangement for using portable indicators. Temperature limits as specified in the IMSBC Code shall not be exceeded.

2.12.6. Tightness testing of oil tanks prior to loading

Before loading oil tanks adjacent to the cargo hold shall be hydrostatically tested for tightness.

2.12.7. Acidity of bilge water

Means for testing acidity of water in bilge wells of cargo holds shall be provided.

2.12.8. Gas monitoring of coal cargoes

Sampling points for gas monitoring of coal cargoes shall be arranged in the hatch comings. Refer the IMSBC Code, BROWN COAL and COAL, Procedures for gas sampling for brown coal briquette cargoes and coal cargoes respectively

2.13 Self unloading systems for solid bulk cargoes

2.13.1. Types of self unloading systems:

Closed: The part of the system located outside the cargo hold is fully enclosed, e.g. pneumatic systems or fully enclosed chain conveyors.

Open: Open type systems, e.g. belt conveyors and bucket conveyors.

2.13.2. For some cargoes the use of self unloading systems are not permitted due to hazards involved. For other cargoes only closed systems are permitted.

2.13.3. Enclosed spaces containing self unloading systems shall be provided with a water flushing system for easy cleaning/removal of dust deposits.

2.13.4. Self unloading systems of the open type shall be arranged for emergency stop from convenient locations within the cargo handling spaces and on open deck.

2.13.5. Spaces outside cargo holds containing self unloading systems shall be fitted with mechanical ventilation giving at least 6 air changes per hour.

2.13.6. Conveyor belts shall be made from materials not liable to accumulate static electricity.

2.14 Minimum requirements for cargo spaces intended for packaged goods

2.14.1. In the case of ships dedicated to transport of goods in special packaging, e.g. ship borne barges, carriage requirements shall be specified upon special considerations in particular cases.

2.14.2. Packaged goods in Class 6.2 and Class 7 there are no specific requirements to ships' design or equipment in SOLAS Reg. II-2/19.
Refer to SOLAS Ch. VII, the IMDG Code and the INF Code as applicable

CHAPTER 11 SHIPS FOR CARRIAGE OF COMPRESSED NATURAL GAS

CONTENTS

SECTION 1

Contents

1.1 Application

This chapter rules applicable to ships for carriage of compressed natural gases (CNG).

1.2 Safety basics

Generally safety related to life, property and environment shall be similar or better than liquefied natural gas (LNG) vessels built and operated according to traditional ship rules and industry practices.

1.2.1. Documentation submission shall include a quantitative risk assessment (QRA). The QRA shall comply with the principles for safety assessment outlined in e.g. IMO Report MSC 72/16. For information.during modifications a hazard identification (HAZID)/hazard operability study (HAZOP) of the cargo tank, cargo piping, process system, operational procedures etc. shall be submitted.

1.2.2. Basically consider safety targets for following :

- Life (crew and third party personnel)
- Property (damage to ship, off-hire)
- Environment (oil pollution, gas release to the atmosphere).

1.2.3. The safety on a LNG carrier represents the minimum acceptable safety level for a CNG vessel. The targets values are as per the table 11.1.1.

Table 11.1.1 Safety target values for CNG carriers (annual risk)

	data LNG	*Target Safety Values for*	*Comment*
Individual risk for crew members (due to major accidents)	1.2×10^{-4}	1×10^{-4}	Does not include occupational risks and work place accidents
Total loss due to collision	1.2×10^{-4}	1×10^{-4}	Total loss frequency – generic LNG vessel
Total loss due to cargo hazards (fires and explosions)	2.4×10^{-4}	1×10^{-4}	Total loss frequency – generic LNG vessel
Individual risk from cargo cylinder failure		1×10^{-5}	Safety Class High.
Individual risks for public ashore		1×10^{-5}	IMO MSC 72/16 Annex 1

The **as low as reasonably practicable** (ALARP) principle shall be adopted as a safety to ensure:

- focused and continuous safety efforts
- That the overall targets are not misused that sound safety measures are not implemented.

Note:
ALARP is applied on a project specific basis and applies the principles that:

- Intolerable risk cannot be justified and the vessel cannot be built or continue to operate.
- Where the risk is below this level but higher than the broadly acceptable risk, then the risk is tolerable provided that the risk is ALARP, i.e. further risk reduction is impracticable or its cost is grossly disproportional to the risk improvement gained. This means that the owner or operator shall take all reasonably practicable precautions to reduce the risk, either by ensuring the faults do not occur, or that if they do then their consequences are not serious.

- In the broadly acceptable region, the risk is so low that further risk assessment or consideration of additional precautions is unnecessary

1.3 Class notation

1.3.1. The requirements for assigning shall be main class and this chapter supplementary. Ships built according to these rules shall be assigned the class notation **CNG Tanker.**
The following special features notations shall be stated in the register of vessels classed with INTLREG: (... bar,..temp), which refers to the design pressure and minimum operating temperature. If carriage of the gas in the chilled condition the carriage temperature shall be stated. If no chilling arrangement then ambient temperature shall be stated.

1.3.2. Ships having offshore loading arrangements shall comply with the requirements in Ch.3 Sec.14.

1.3.3. The process plant, relief and flare system shall be designed according to a standard recognised by the Society.

1.4 Definitions

1.4.1. Blow down is depressurising or disposal of an inventory of pressurised gas.

1.4.2. Cargo area means the cargo tanks, hold spaces, process area, turret space and cofferdams and deck areas over the full length and breadth of the ship over the above mentioned spaces.

1.4.3. Cargo hold vent pipes are low pressure pipes for venting of cargo hold spaces to vent mast.

1.4.4. Cargo load/unload valve is the valve isolating the cargo piping from external piping.

1.4.5. Cargo piping is the piping between the cargo tank valve and the cargo load and or unload valve.

1.4.6. Cargo tank is the storage system for the compressed gas, i.e. all pressurised equipment up to the cargo tank valve.

1.4.7. Cargo tank valve isolates the cargo tank from the cargo piping.

1.4.8. Cargo vent piping is the piping from the cargo relief valve to the vent mast.

1.4.9. “Class H fire division”: divisions formed by bulkheads and decks.

1.4.10. *Coiled type cargo tank* is a cargo tank consisting of long lengths of small diameter coiled piping.

1.4.11. Cylinder type cargo tank is a cargo tank consisting of an array of cylinder type pressure vessels connected by cargo tank piping. The following definitions are relevant for the cylinder type tank:

a) Cargo tank cylinder is a large diameter standard offshore pipe with end-caps constituting the main tank volume.
b) Cargo tank piping is the piping connecting the cargo tank cylinders up to the cargo tank valve.

1.4.12. Pressure

a) Design pressure is the maximum gauge gas pressure at the top of the cargo tank .
b) *Maximum allowable operating pressure* is 95% of the design pressure.
c) *Set pressure of pressure relief system*, the design pressure less the tolerance of the pressure relief system.

1.4.13. Design temperature for the selection of materials in cargo tanks, piping, supporting structure and inner hull structure is the lowest or highest temperature.

1.4.14. Hold space is the space enclosed by the ship's structure in which a cargo tank is situated.

1.4.15. Hold space cover is the enclosure of hold space above main deck .

1.5 Datas and plans

1.5.1. For inforamtion a general safety factors shall be submitted.

a) A Quantitative Risk Assessment (QRA) shall be submitted . The QRA shall comply with the principles for Formal Safety Assessment outlined in IMOReport MSC 72/16 and 74/19

b) For information a Hazard Identification (HAZID)/Hazard and Operability Study (HAZOP) of the cargo system, process system (if applicable), operational procedures etc. shall be submitted.

1.5.2. Following general arrangement plans shall be submitted for approval :

a) machinery spaces, accommodation, service and control station spaces, chain lockers, cofferdams, fuel oil tanks, drinking and domestic water tanks and stores
b) cargo tanks and cargo piping systems
c) cargo control rooms
d) cargo piping with shore or offshore connections including loading and discharge arrangements and emergency cargo dumping arrangement, if provided.
e) ventilating pipes, doors and openings to gas-dangerous spaces
f) doors, air locks, hatches, ventilating pipes and openings, hinged scuttles which can be opened, and other openings to gas-safe spaces within and adjacent to the cargo area
g) entrances, air inlets and openings to accommodation, service and control station spaces
h) gas-safe spaces and zones and gas-dangerous spaces and zones to be clearly identified. If cold venting a gas dispersion analysis shall be conducted in order to evaluate the extent of the gas dangerous area
i) information on gas specification to be carried on the ship
j) drawings showing ventilation systems in cargo area with capacities.

1.5.3. Cargo tank. The following plans and particulars shall be submitted for approval:

a) drawing of tanks with information on non-destructive testing of welds and strength and tightness testing of tanks
b) specification of materials and welding in cargo tanks
c) specification of design loads and structural analysis of cargo tanks
d) detailed arrangement of cargo tank system with description on operation modes
e) calculation of maximum and minimum design temperature for materials in the cargo tank, supporting structure and inner hull due to loading/unloading/depressurising
f) the cooling effect from gas released as a result of a leakage or rupture of piping
g) proposal for prototype testing with full scale fatigue and burst test for cargo tank
h) drawings and calculation of stresses in the cargo tank piping as per Ch.5 Sec.6 including vibrations and fatigue analysis
i) fatigue crack propagation calculations for the cargo tank piping using leak-before-failure principle
j) detailed drawings of all pressurised parts of the cargo tank system
k) documentation and calculations for hull and cargo tank using model tests, refined analytical tools and analysis methods to determine stress levels, fatigue life , crack propagation characteristics and Vibration analysis.
l) stresses in the cargo tank cylinders
m) fatigue analysis for cylinders
n) relevant fatigue crack propagation calculations for cargo tank cylinders .
o) drawings of supports for cargo tank cylinders with calculations including collision loads .

1.5.4. Piping systems in cargo area. The following plans and particulars shall be submitted for approval:

a) schematic drawings of fittings and thickness with specification of materials for the following piping systems
b) bilge and ballast systems and air pipes
c) cargo deck piping
d) emergency shut down
e) inert gas
f) heating, if any
g) systems for refrigeration, if any
h) a complete stress analysis for each branch of the cargo deck piping system shall be conducted according to ANSI/ASME B31.3
i) operational and emergency procedures for possible incidents in the cargo tank
j) drawings showing overpressure protection for cargo tank, including details of pressure relief devices

k) arrangements and procedure for gas freeing
l) arrangements for mechanical ventilation in cargo area
m) specification of pressure tests.

1.5.5. Ship arrangements. The following plans and particulars shall be submitted for approval:

a) drawing showing protection of cargo tank system with double hull and minimum distance to ship bottom
b) raking damage calculations, showing that the maximum ship speed, at which the extent of raking damage will not penetrate into the forward cargo hold space, is sufficient for safe manoeuvring of the ship at not less than 5 knots
c) collision damage analysis which demonstrates that the energy absorption capability of the ship side is sufficient to prevent the bow of the striking vessel(s) from penetrating the inner hull as defined in Sec.3

1.5.6. Environmental control in hold spaces. The following plans and particulars shall be submitted for approval:

a) an inspection plan shall be submitted for approval. The plan shall include a detailed description on how safe access for inspection is provided
b) inerting of cargo hold space drawing
c) instrumentation in hold spaces drawing
d) drainage in hold spaces drawing
e) overpressure protection drawing

1.5.7. Fire protection and extinction. The following plans and particulars shall be submitted for approval:

a) fire loads based on risk analysis and fire and explosion analysis
b) means of escape
c) fire fighting systems drawings related to cargo area including fire mains, sprinkler and water spray and water and or powder systems
d) heat radiation from the flare towards cargo holds and other important areas and equipment.

1.5.8. Electrical Installations

- Refer Sect 11

1.5.9. Control and Monitoring

- Refer Sect 12

1.5.10. In- service inspection

- Inspection and monitoring

SECTION 2 MATERIALS

Contents

2.1 Materials

The materials used in the hull structure shall comply with Pt 2 Ch 1 and Pt 3 Ch 2

2.1.1. For the cylinder type cargo tank the materials used in the cylinder and end-caps shall comply with the requirements for manufacture, survey and certification. Special consideration shall be given to corrosion protection.

2.1.2. For the coiled type cargo tank the materials used shall comply with the requirements for manufacture, survey and certification or a recognised standard acceptable to INTLREG.

2.1.3. The materials used in the cargo tank piping, cargo piping and all valves and fittings shall be of quality NV 316L or equivalent (equivalent with respect to ductility, fatigue and corrosion resistance) and shall comply with the requirements for manufacture survey and certification given in Pt.2 and Ch.5.

2.1.4. Cargo hold vent pipes shall be of a fire resistant material capable of withstanding the calculated pressure.

2.1.5. All material used in the cargo tank and cargo piping shall be provided with INTLREG material certificate.

2.2 Design Temperature

2.2.1. The maximum design temperature for selection of materials is the highest temperature which can occur in the cargo tanks or cargo piping due to:

a) Loading/transport/unloading.

2.2.2. The minimum design temperature for the selection of materials is the lowest temperature which can occur in the cargo tanks, cargo piping, supporting structure or inner hull due to:

a) Loading/transport/unloading.

b) The cooling effect from accidental release of cargo gas.

2.2.3. When determining the minimum design temperature the cooling effects from an accidental release inside the cargo holds shall be documented. The documentation shall address:

2.2.3.1 A leakage or complete rupture of the cargo tank piping at one location for the cylinder type system

2.2.3.2 The cooling effect from the complete rupture of one pipe in the coil for the coiled system.

Partial protective boundaries shall be provided to prevent direct cooling down of tank units or of ship's structure. Ambient temperatures for calculating the above steel temperatures shall be 5°C for air and 0°C for sea water unless other values are specified for special areas.

SECTION 3 CARGO TANKS

Contents

3.1 General

3.1.1 The ship shall comply Liquified Gas Carriers Ch 18. Additional requirements are as below applies.

3.1.2 A tanker for CNG ship shall be of a double hull construction with double sides and double bottom.
Equivalent bottom solutions shall be used if by calculations or tests to offer the same protection to the cargo tank against indentations and the same energy absorption capabilities as conventional double bottom design. (Refer raking damage calculations in 3.1.4.)

3.1.3 Cofferdams
Cofferdams are arranged to segregate cargo holds from engine rooms and accommodation spaces and similar spaces.

3.1.4 Collision and grounding
Conventional double bottom height shall at least be B/15 or 3 m whichever is less, but not less than 1.0 m. A safe maximum navigating speed where by the cargo tank or its supports are not damaged by grounding on a rocky seabed, shall be determined by grounding raking damage calculations. The maximum navigating speed shall be equal to or larger than the minimum safe manoeuvring speed of the vessel. For the purpose of these calculations this speed shall not be taken to be less than 5 knots.

3.1.5 For new building a collision frequency analysis shall be conducted for a characteristic vessel trade. The analysis shall determine the annual collision frequency and associated collision energies of striking vessels, based on vessel sizes, types and speeds determined from traffic data for the selected trade. If applicable traffic data for the actual trade is not available, or no specific trade rather than world-wide trading is planned, relevant traffic data for North Sea trading acceptable to the Society shall be adopted .

3.1.6 Collision damage analysis shall be carried out to show :

- For the ship sizes and energies determined in Sect [3.1.5] the energy absorption capability of the ship side shall be sufficient to prevent the bow of the striking vessel(s) from penetrating the inner hull, thus not damaging the cargo tanks.
  Alternatively:
  For the purpose of the calculations it may conservatively be assumed that all the collision energy will be absorbed by the struck ship side. Hence, the following simplifications will be accepted:

  a) the use of an infinitely stiff striking bow
  b) hit perpendicular to the ship side and no rotation of struck ship
  c) no common velocity of the two ships after collision

  In lieu of more specific information a 5000 tonnes standard supply vessel with a raking bow and a stem angle of 65 degrees may be used. It shall be demonstrated by calculations that the side of the CNG carrier has an energy absorption capability according to Sect [3.1.5], but not less than given by the formula in [**3.1.7]** without the bow penetrating the inner hull.

3.1.7 The minimum collision energy to be absorbed in the collision shall be :

max. [13 (Lpp / 100)2 / (1 + 0.8 Δ1 / ΔCNG); 10] [MJ]
Lpp = length between perpendiculars of the CNG vessel in (m)

$\Delta 1$ = the displacement of the average size of the population of striking vessels which shall be taken as 10000 tons

ΔCNG = the displacement of the struck CNG vessel.

3.1.8 For conventional double side designs the width of the double side shall at least be minimum B/15 or 2 m whichever is the greater.
Equivalent side solutions shall be used if they can be shown by tests or calculations to offer the same protection to the cargo tank against indentations, the same energy absorption capabilities as conventional double side designs and complies with the energy absorption requirements in 302, 303 and 304 whichever is the more conservative. The minimum horizontal distance from the outer hull to the cargo containment system shall not be less than as stated in the beginning of this paragraph.

3.1.9 Due to changing ship lines at the ends of the cargo area it shall be acceptable to apply the minimum double bottom height in Sect [3.1.4] and the minimum double side width in Sect [3.1.8] at the forward cross-section and aft crosssection of the of the cargo area.
When the side width (w) and the double bottom height (h) are different, the distance w shall have preference at levels exceeding 1.5 h above the base line as shown in Fig.11.3.1.

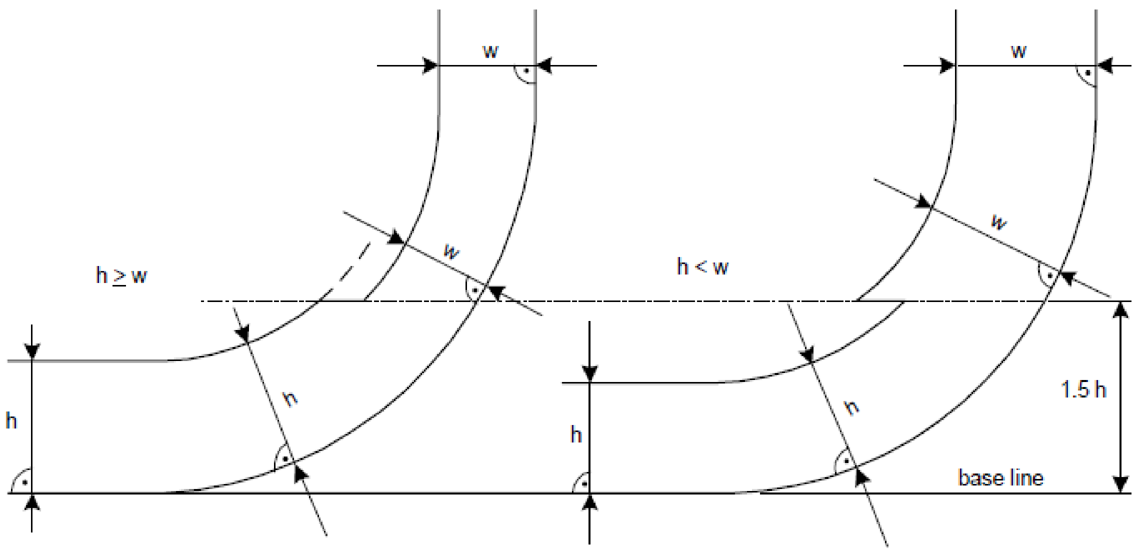


Figure 11.3.1

SECTION 4 CARGO HOLDS

Contents

4.1 Inspection

4.1.1 Inspection of cargo tank cylinders, supports, foundations and cargo tank piping of cylinder type cargo tank, access shall be provided from outside the cylinders where as for the coiled type cargo tank a method for inspection from inside by use of special inspection tools shall be predetermined.

4.1.2 An inspection plan shall be submitted for approval. The plan shall emphasize safe access for inspection .

4.1.3 The cargo tank valve shall be fitted outside the hold space. Corrosion and fire protection of the cargo tanks in open hold spaces and leakage shall be considered.

4.2 Cargo hold inerting

4.2.1 The hold space shall be inerted by nitrogen or inerted with other suitable non corrosive medium. The nitrogen supply system shall be arranged to prevent back flow in the case of overpressure in hold space. The nitrogen system shall be arranged redundancy for maintaining the safe operation of the vessel.

4.2.2 Composite cargo tanks the hold space shall be enclosed and inerted.
The atmosphere in the hold space shall be purged with nitrogen or other suitable inert gas and the concentration shall be kept under 0.3LEL (Lower Explosion Limit).

4.2.3 **Protection of hold spaces**
Hold space shall be fitted with a overpressure protection system. The following functional requirements apply:

a) Pressure control of inerted atmosphere with positive pressure automatically adjusted between 0.05 and 0.15 bar above atmospheric pressure shall be provided.
b) Pressure relief device, normally set to open at 0.25 bar, shall be provided. The relief device shall have sufficient capacity to handle a rupture of the largest cargo tank piping in the hold space for the cylinder type cargo tank and a rupture of one pipe in the coil for the coiled type cargo tank. This applies to the largest cargo tank in the relevant hold space.
c) The discharge from the hold spaces shall lead to a safe location.
d) In addition to the relief system required by b) relief hatches, normally set to open at 0.4 bar shall be provided in each hold space cover.
e) Ensure pressure protection devices and their surrounding structures are capable of handling the lowest temperature during pressure relieving at maximum capacity.

4.2.4 **Drainage**
Hold spaces shall be provided with a suitable drainage arrangement not connected with machinery spaces. Means for detecting leakage of water into the hold space shall be provided

4.2.5 In case of cold venting for the gas relief system a gas dispersion analysis shall be conducted to evaluate the extent of the gas dangerous zone. The analyses shall be carried out according to a recognized standard/software and the boundaries of the gas dangerous zone , based on 50% LEL (Lower Explosion Limit) concentration.

SECTION 5 STRUCTURE AND TESTING CARGO TANKS

Contents

5.1 General

5.1.1 The cargo tank shall be designed using model tests, refined analytical tools and analysis methods to determine stress levels, fatigue life and crack propagation characteristics. Changes to material properties with time due to long term static loads and the environment shall also be considered for composites.

5.1.2 The dynamic loads due to ship motions shall be considered as the largest loads the ship shall expect during its operating life. Loading rates shall be considered for composites.The dynamic effect of pressure variations ship operations shall represent the extreme service conditions the containment system will be exposed to during the lifetime. As a minimum the design number of pressure cycles from maximum to minimum pressure shall not be less than 50 per year.

5.1.3 The effects of all dynamic and static loads shall determine the strength of the structure with respect to:

a) maximum allowable stresses

b) buckling

c) cyclic and static fatigue failure

d) crack propagation.

5.1.4 For cargo tank types other than coiled type and cylinder type, the requirements for cylinder type tanks mentioned in Sect [5.3] applies.
Process prototype testing shall be carried out to document that the system functions as specified with respect to accumulation and disposal of liquids. It shall be verified that liquid hammering does not occur in the piping system during any operation.
If full scale testing not feasible , then successful operation shall be simulated computationally and in small scale testing to provide adequate assurance of functionality.Commissioning and start-up testing shall be witnessed by a surveyor and is considered complete when all systems, equipment and instrumentation are operating satisfactorily.

5.2 Cargo Tank Coiled Type

5.2.1 General

Requirements for the coiled type cargo tank shall be particularly considered. The requirements applicable for the cylinder type cargo tank shall be complied with, as found relevant.

5.3 Cargo Tank Cylinder Type

5.3.1 The stresses in the cargo cylinder and the hemispherical end caps shall fulfil the burst requirements for safety class high. Recognised standards such as the ASME BPV VIII Div. 3 may also be used. The pressure used for calculating the wall thicknesses is the design pressure defined in Sec.1 [1.3.12]. The maximum operating pressure shall not be higher than 95% of the design pressure. Hemispherical ends shall have a cylindrical extension (skirt) so that the distance to the circumferential weld to the cylinder is not less than:

$$l_{cyl} = \sqrt{Rt}$$

where

R = radius of hemispherical end
t = thickness of hemispherical end.
For elliptical or toro-spherical end-caps additional requirements shall apply .
The local equivalent surface stress (primary bending + membrane stress) in the cargo tank cylinders according to von Mises shall not exceed 0.8 **×** yield stress of the material.
The cargo tank cylinder shall be subject to fatigue analysis by both S-N curves and fracture mechanics crack propagation analysis as described in [5.3.2] and [5.3.3]..
The number of load cycles to be used for design is the number of cycles expected during design life multiplied by a Design Fatigue Factor (DFF) in order to achieve an appropriate safety level.
The minimum calculated fatigue life for all analysis options is not to be less than 20 **×** DFF years.

5.3.2 S-N curves shall be applicable for the material, the construction detail and the state of stress .
Model testing of cargo tank details required to establish the curve. Testing shall be carried out for longitudinal welds and circumferential girth welds of the cargo cylinders. Testing shall also be required for special details as deemed necessary by INTLREG.

Two alternative formulations are given based on the following definitions of characteristic value for $\log_{10}N$ for the system of n_s cylinders:
1) Mean value minus 3 standard deviations (μ-3σ) and no further adjustment
2) Mean value minus 2 standard deviations (μ -2σ), supplemented with a system effect term.

The two formulations for the estimate of the characteristic value of $\log_{10}N$ for the system of n_S cylinders are correspondingly denoted as Alternative 1 and Alternative *2*:
Alternative 1:
The characteristic S-N curve for use in design is defined as the “mean-minus-three-standard-deviations” curve as obtained from a $\log_{10}\Delta\sigma$-$\log_{10}N$ plot of experimental data. With a Gaussian assumption for the residuals in $\log_{10}N$ with respect to the mean curve through the data, this corresponds to a curve with 99.865% survival probability. The uncertainty in this curve when its derivation is based on a limited number of test data shall be accounted for. It is required that the characteristic curve be estimated with at least 95% confidence. When a total of n observations of the number of cycles to failure N are available from n fatigue tests carried out at the same representative stress range $\Delta\sigma$, then the characteristic value of $\log_{10}N$ at this stress level is to be taken as:

$$\log_{10} N_c = \overline{\log_{10} N} - c_3(n) \cdot \hat{\sigma}_{\log N}$$

in which

$\log_{10} N$ is the mean value of the n observed values of log10N,

$\hat{\sigma}_{\log N}$ is the standard deviation of the n observed values of $\log_{10}$ N, and
$c_3(n)$ is a factor whose value depends on number of tests n and is tabulated in Table 11.5.1
The combined Miner sum for fatigue loads due to loading/unloading and dynamic ship loads is not to be higher than
1) 0.1 (DFF=10) for cylinders with design S-N curve established as mean minus 3 standard deviations and with enhanced control in fabrication with respect to production tolerances. Out-of-roundness has not been specifically considered for the longitudinal welds, and the

weld length is not explicitly accounted for in the design analyses. The safety level is calibrated for a long weld.

Alternative 2*:*

Here the system information is taken into account providing an estimate of the characteristic value of $\log_{10}N$ for the system based on “mean value minus two standard deviations” of the test data.

$$\log_{10} N_c = \overline{\log_{10} N} - \left(c_2(n) + \frac{1}{2}\log_{10}\left(\frac{l_{weld}}{l_{ref}} n_s\right) \right) \cdot \hat{\sigma}_{\log N}$$

where

$c_2(n)$ = is a factor whose value depends on number of tests n and is tabulated in Table 11.5.1 corresponding to a 97.725% probability of survival. It is noted that for σ_{logN} = 0.20, the expression for the characteristic value of $\log_{10}N$ for the system is identical to the expression for the S-N curve with system effects.

l_{weld} = is length of weld subjected to the same stress range (typical length of one cylinder).

l_{ref} = is reference weld length with similar weld quality and fatigue strength as the tested specimen. l_{ref} = 120 mm may be used if not otherwise documented by fatigue testing.

n_S = is number of similar connections subjected to the same stress range (typical number of cylinders).

The combined Miner sum for fatigue loads due to loading/unloading and dynamic ship loads is not to be higher than

1) 0.2 (DFF=5) with length effect and design S-N curve established as mean minus 2 standard deviations. The cylinders are assumed to be fabricated with enhanced control with respect to production tolerances. Outof- roundness has not been specifically considered for the longitudinal welds.
2) 0.33 (DFF=3) with length effect and standard design S-N curves. Out-of-roundness and local stress concentrations are specifically considered in design (all local stresses included in the fatigue stress range). This does not necessarily require enhanced control in fabrication of the cylinders.The fatigue damage effects from filling and emptying of the containment cylinders and the damage contribution from support stresses originating from the accelerations of the ship in the seaway can be combined.

Table 11.5.1 Coefficient c(n) for estimation of characteristic values with confidence 95%

Number of tests, n	*$c_2(n)$ survival prob. 97.725%*	*$c_3(n)$ survival prob.*
2	32.2	46.0
3	9.24	13.7
5	5.01	7.29
7	4.09	5.96
10	3.45	5.05
12	3.26	4.72
15	3.07	4.45
20	2.88	4.19
25	2.75	4.00
30	2.65	3.91
50	2.48	3.66
100	2.32	3.44
□	2.00	3.00

5.3.3 Additional fatigue analyses using fracture mechanics crack growth calculations shall be carried out for the cargo tank cylinders using mean plus 2 standard deviation values for the crack growth data ($\mu + 2\sigma$),. The analysis shall be carried out for planar defects assumed located in both the longitudinal and circumferential welds of the cylinders. The calculated fatigue life for a crack to grow through the cylinder wall thickness shall be 3 times the design life, but not less than 60 years (i.e. using DFF=3 and no system length effect). A realistic stress concentration factor relevant for the weld toe shall be applied. The assumed initial planar defect shall reflect the largest non detected defect during the non destructive inspection carried out. The applied crack growth parameters shall be documented for the cylinder base material and its welds.
The fracture mechanics assessments may be carried out according to e.g. BS 7910:2005 "*Guide to methods for assessing the acceptability of flaws in metallic structures*".

5.3.4 If the necessary number of load cycles for the crack to propagate through the wall thickness required in 103 cannot be shown, or if Leak-Before-Failure is to be used, it shall be documented that unstable fracture will not occur in the cylinder from a fatigue crack before a possible leak from the calculated through thickness crack can be detected and the tank pressure relieved (blown-down). Applied fracture toughness values shall be documented for the base material, heat affected zone and weld metal for relevant operation temperature.

5.3.5 The supported areas of the cargo containment cylinders shall be included in the fatigue calculation required by Sections [5.3.2], [5.3.3] and [5.3.4].

5.4 Piping

5.4.1 Pipes made of steel including stainless steel, the permissible stress to be considered in the formula is the lower of the following values

$$\frac{\sigma_B}{2.7} \text{ or } \frac{\sigma_F}{1.8}$$

σ_B = specified minimum tensile strength at room temperature (N/mm2)
σ_F = specified lower minimum yield stress or 0.2% proof stress at room temperature (N/mm2).
Pipe materials other than steel, the permissible stress shall be considered by the Society

The calculation of maximum stresses and stress range shall be carried out according to ASME B31.3. The design principles in Sec.6 [6.4] applies also for the cargo tank piping.

5.4.2 The cargo tank piping shall be subject to a fatigue analysis. The S-N curve shall be applicable for the material, construction detail and state of stress considered. Model testing of details of piping as fabricated may be required. The S-N curve shall be based on the mean curve of $\log_{10}N$ with the subtraction of 2 standard deviations $\log_{10}N$. The Miner sum (from combined dynamic loads and fatigue loads due to loading and unloading) shall not be higher than 0.1.

5.4.3 Fatigue crack propagation calculations shall be carried out for the cargo tank piping. The analysis shall be carried out for defects assumed located in circumferential welds only as the piping shall be of a seamless type or equivalent. The leak-before-failure principle shall be used, i.e. a crack shall propagate through the thickness allowing gas detection and safe blow-down or venting of the affected cargo tank before a complete rupture takes place.

5.4.4 The cargo tank piping shall be supported so that brekdown of a top pipe will not lead to the rupture of other pipes by the damaged pipe hitting other pipes. At the same time sufficient flexibility shall be provided to allow the cylinders to expand without causing excessive stresses in the piping system which might lead to yielding or fatigue problems. Cargo tank piping up to the cargo tank valve shall be welded construction.

5.4.5 All fittings in the cargo tank piping shall be of forged type.

5.5 Welding

5.5.1 *Qualification.*

Pre-production weldability testing shall be carried out for qualification of the tank material and welding
consumable. Metallographic examination shall be conducted to establish the presence of local brittle zones. The maximum and minimum heat inputs giving acceptable properties in the weld zones with corresponding preheat and working temperatures and post weld heat treatment temperatures shall be determined for both fabrication and installation welding.
101. Relevant documentation may be agreed in lieu of weldability testing. Fracture mechanics testing at the minimum design temperature shall, however, be performed for the base material, heat affected zone and weld metal after being subjected to any post weld heat treatment..

5.6 Pressure testing and tolerances

Fabrication tolerances and hydraulic testing of the complete cargo tank shall be in accordance with Ch.5 as applicable.
A test pressure equal to 1.2 times the design pressure is considered appropriate.

5.7 Non-destructive testing (NDT)

All welds in cylinders and cargo tank piping shall be 100% NDT tested in accordance with an approved NDT program. Reference Section [5.3.3] regarding required detectable crack size.

5.8 Post weld heat treatment

All longitudinal welds in the cylinders shall be post weld heat treated or stress relieved by an equivalent procedure acceptable to INTLREG.

5.9 Prototype testing

A set of full scale (with respect to diameter, thickness, number of circumferential welds, including endcaps but not necessarily full length) fatigue and burst tests shall be performed. It must be documented that the cylinder wall, end-caps and welding has sufficient reliability against fatigue and that the cylinder possesses sufficient burst resistance after twice the number of anticipated pressure induced stress cycles. A minimum of 3 tests shall be carried out..
One burst test , subjected to twice the anticipated number of stress cycles and 2 fatigue tests to document that the fatigue capacity carried out during the design lifetime is

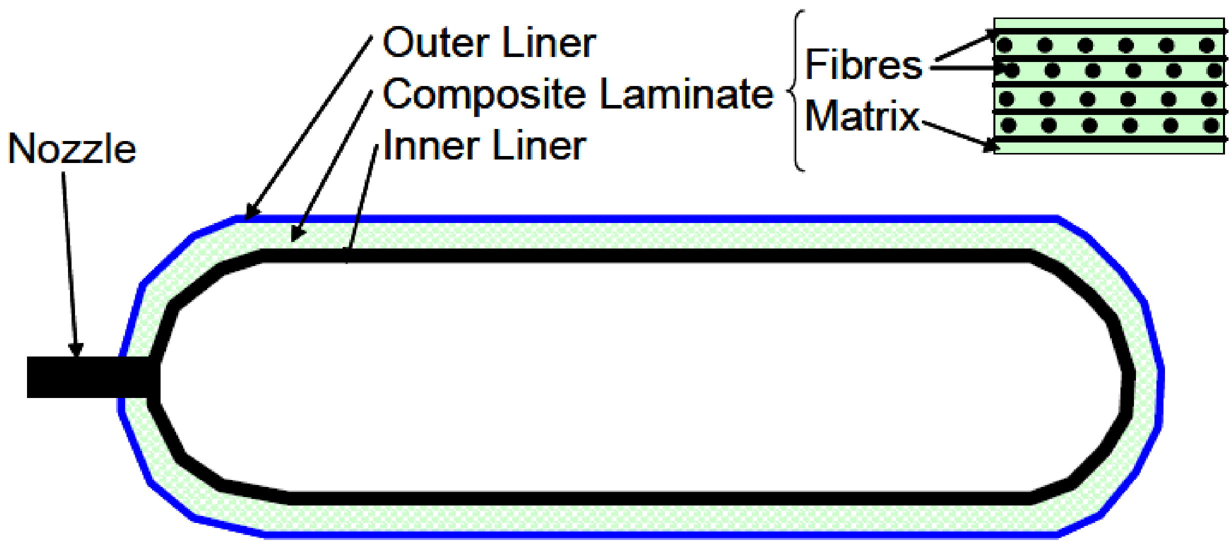
- 15 × the number of stress cycles for fatigue design analysis without length effect, and
- 10 ×the number of stress cycles for the cylinders when length effect has been explicitly included in the design analyses

5.10 Cargo tank –composite type

5.10.1 All general requirements from Sec.5 [5.1] apply also to composite tanks.

5.10.2 The composite cargo tanks addressed here are made of fibre reinforced plastic. A typical simplified pressure vessel with a laminate and inner and outer liner is shown in Figure 1. The inner liner is the fluid barrier. It may also be designed to carry part of the loads. The composite laminate carries the pressure loads alone or in combination with the inner liner. The fibres are typically carbon, glass or aramid. The plastic matrix is typically an epoxy or polyester. Other fibres and matrices may be used. Whatever material system is chosen the short term and long term material properties must be sufficiently characterized. . The outer liner is a protective layer against external loads environments. It does typically not carry any loads

Figure 11.5.1 Typical composite pressure vessel



5.10.3 All metal parts shall be designed according to the requirements of Sect [5.1] to [5.9]. If the liner is made of polymeric materials can be used.

5.10.4 The dynamic short term loads *due to ship motions* shall be taken as the most probable largest loads the ship will encounter during its operating life (normally the characteristic load effect is defined as the 99% quantile in the distribution of the annual extreme value of the local response of the structure, or of the applied global load when relevant). Dynamic long term loads may be taken as realistic load sequences.

5.10.5 The requirements given here are mainly related to cylindrical cargo tanks. Requirements for the coiled type cargo tank shall be specially considered. The requirements applicable for the cylinder type cargo tank shall be complied with as found relevant.

5.10.6 **Cargo tank cylinder – calculations**

As a minimum requirement, the composite tanks shall be designed for the potential modes of failures as listed in Table 11.5.2 for all relevant conditions expected during the various phases of its life.
All failure mechanisms that can be related to the limit states shall be identified and evaluated.

Table 11.5.2 Typical limit states for the tank system		
Limit state category	**Limit state or failure mode**	**Failure definition or comments**
Ultimate Limit State (ULS)	Bursting	Membrane rupture of the tank wall caused by internal overpressure, possibly in combination with axial tension or
	Liquid tightness	Leakage in the tank system including pipe and components, caused by internal overpressure, possibly in combination with axial tension or bending moments.
	Buckling	Buckling of the tank cross section and/or local buckling of the pipe wall due to the combined effect of bending, axial loads and possible external overpressure (when flooding).
	Damage due to wear and tear	Damage to the inside or possibly to the outside of the tank during operation or installation, resulting into burst or leakage.
	Explosive decompression	Rapid expansion of fluid inside a material or interface leading to damage that may cause leakage or burst.
	Chemical decomposition Corrosion	Chemical decomposition or corrosion of materials with time that leads to a reduction in strength, resulting into burst or leakage.
Accidental Limit State (ALS)	Same as ULS	Failure caused by accidental loads directly, or by normal loads after accidental events (damage conditions).
	Impact	Damage introduced by dropped objects.
	Fire	Resistance to fire.
	Cooling down	Accidental quick release of the gas can cause cooling down of the damaged and possibly neighbouring tanks. Materials and structures should be able to operate under these conditions.
Fatigue Limit State (FLS)	Fatigue failure	Excessive Miner fatigue damage or fatigue crack growth mainly due to cyclic loading, directly or indirectly.
	Resonance	The effect of vibrations and resonance frequencies may cause fatigue and shall be considered.

5.10.7 The maximum operating pressure should be 5% or more below the design pressure. The ends and cylindrical part of the composite laminate shall be made in one piece. Special attention shall be given to all metal composite connections.

5.10.8 The cargo tank cylinder and all composite metal joints shall be subject to fatigue analysis. The *S-N* curve shall be established as described in Sect [5.3.2]. . The Miner sum (for both dynamic loads and fatigue loads due to loading and unloading) shall not be higher than 0.02.

5.10.9 The resonance frequencies shall be checked, . Vibrations from machinery and wave loading should not coincide with the resonance frequencies of the pressure vessel (filled or unfilled).

211 The safety factors for all load bearing metal parts shall be the same as given in C**.** The safety factors for the composite laminate and safety class high shall be chosen. The partial safety factors are given for the entire system. The effect of combining various components in a system is described by the system effect factor □S. If the components do not interact the system effect is not relevant and γ_S = 1.0.Otherwise a system factor shall be documented. A value of γ_S = 1.10 can be used as a first approach. In some cases a system may consist of parallel components that support each other and provide redundancy, even if one component fails. In that case a system factor smaller than 1 may be used if it can be based on a thorough structural reliability analysis

5.10.10 **Cargo tank piping**

Refer Sect [5.4] apply.Composite piping may be considered on an individual basis.

5.10.10.1 Production and test after installation
Fabrication tolerances and hydraulic testing of the complete cargo tank shall be in accordance with as applicable rules.

5.10.10.2 The cargo tanks shall be tested on the ship after installation as a final acceptance test. The test pressure shall be 1.25 times the design pressure.

5.11 Prototype pressure test

5.11.1 A set of full scale fatigue and burst tests shall be carried out and documented that the cylinder wall, end-caps and welding have sufficient reliability against fatigue and that the cylinder possesses sufficient burst resistance. Possible damage during installation or operation shall be included in the design tests.. The sequence of the failure modes in the test shall be the same as predicted in the design. If the sequence is different or if other failure modes are observed, the design shall be carefully reevaluated.
For minimum test requirements Table 11.5.3.

5.11.2 Testing shall be at room temperature and with water as a pressure medium if the effect of temperature changes and fluid changes shall be well described. If the effect of changing the environmental conditions is uncertain, testing should be carried out in the worst conditions and possibly with gas.

5.11.3 The tank shall be exposed to typical impact damage, like damage from a dropped hammer etc. Subsequently a pressure test and a fatigue test shall be carried out. The testing may be combined with the tests specified in Table 11.5.3

5.11.4 The specimen geometry for testing shall be chosen to be different from the actual under certain conditions. Specimens shall be shorter than in reality. If shorter specimens are chosen, the free length of the tank pipe between end-fittings should be at least 6 ×□diameter. Scaled specimens may be used if analytical calculations can demonstrate that:

a) all critical stress states and local stress concentrations in the joint of the scaled specimen and the actual tank are similar, i.e., all stresses are scaled by the same factor between actual tank and test specimen

b) the behaviour and failure of the specimen and the actual tank can be calculated based on independently obtained material parameters. This means no parameters in the analysis should be based on adjustments to make large scale data fit

c) the sequence of predicted failure modes is the same for the scaled specimen and the actual tank over the entire lifetime of the tank

d) an analysis method that predicts the test results properly but not entirely based on independently obtained materials data, may be used for other joint geometry. In that case it should be demonstrated that the material values that were not obtained by independent measurements can also be applied for the new conditions.

Tests on previous tanks may be used as testing evidence if the scaling requirement given above are fulfilled.Materials and production process should also be identical or similar.

Table 11.5.3 Summary of test requirements		
Name of test	**Description**	**Reference**
Design phase		
Pressure test	1 test to failure	[5.11.5]
Pressure fatigue of tank	2 tests to 5 × actual number of cycles or survival test to about 100 000 cycles, followed by burst test.	[5.11.6]and [5.11.7]
Stress rupture test of tank if matrix properties are critical or fibres can creep	2 tests to 50 × actual lifetime or survival test to about 1 000 hours	[5.11.8]
If the inner liner is bonded to the laminate	Test bond between liner and laminate	[5.11.9]
If impact requirement	Impact tests	[5.11.10
Process Prototype Testing	System test	[5.11.11]
After fabrication		
Pressure test	Test to 1.3 times design pressure for each tank component	[5.10.10.1]
System acceptance test	Test to 1.3 times design pressure for each tank component	[5.10.10.2]

5.11.5 **Burst pressure test:** A burst test shall be done and the burst pressure shall be at least the predicted **μ- σ ,** where **μ** is the mean prediction and $\sigma$is standard deviation of the predicted burst pressure.

5.11.6 **Pressure fatigue testing**: Fatigue tests shall be carried out with a typical pressure load sequence. Axial tension or bending should be added if relevant. The most relevant test should be found by evaluating the design analysis. At least two survival tests shall be carried out. The specimen shall not fail during the survival test and it shall not show unexpected damage. The requirements to the testing are:

a) Tests shall be carried out up to five times the maximum number of design cycles with realistic amplitudes and mean loads that the component will experience.
b) If realistic pressure sequences cannot be tested or if the anticipated lifetime exceeds 105 cycles, the test procedure may be changed.
c) All tests shall be completed with a pressure test. The failure load or pressure shall be at least the predicted **μ- σ** , where **μ** is the mean prediction and $\sigma$is one standard deviation of the predicted load.

5.11.7 In some cases high amplitude fatigue testing may introduce unrealistic failure modes in the structure. In other cases, the required number of test cycles may lead to unreasonable long test times. In these cases an individual evaluation of the test conditions should be made that fulfils the requirements of Sect [5.11.6] as closely as possible.

5.11.8 **Stress rupture testing:** Only if the performance of the metal composite interface depends on matrix properties or adhesives, or if the fibres in the laminate can creep, long term static testing should be performed.Two survival tests should be carried out.Stress rupture tests should be carried out with a typical load sequence or with a constant load. If a clearly defined load sequence exists, load sequence testing should be preferred. The specimen should not fail during the survival test and it should not show unexpected damage. The requirements to the test results are:

a) Tests should be carried out up to five times the maximum design life with realistic mean pressure loads that the component will experience. If constant load testing is carried out tests should be carried out up to 50 times the design life to compensate for uncertainty in sequence effects.
b) If the anticipated lifetime exceeds 1000 hours testing up to 1000 hours may be sufficient. The load levels should be chosen such that testing is completed after 103 hours. The logarithms of the two test results shall fall within **μ- σ** of the logarithm of the anticipated lifetime, where **μ** is the mean of the logarithm of the predicted lifetime and **σ** is one standard deviation of the logarithm of the predicted lifetime, both interpreted from a log(stress) - log(lifetime) diagram for the anticipated lifetime. .
c) All tests should be completed with a pressure test. The failure load or pressure should be at least the predicted μ- σ , where μ is the mean prediction and σ is one standard deviation of the predicted load.

5.11.9 **Liner bond testing:** If the design relies on a bond between liner and composite laminate, the quality of **Table 11.5.3** the bond shall be tested. Tests can be done on the pipe or representative smaller specimens. If the laminate may have cracks, it shall be insured that the cracks do not propagate into the liner or reduce the bond quality between liner and laminate.

5.11.10 **Impact testing:** The tank should be exposed to typical impact damage, like damage from a dropped hammer etc. Subsequently a pressure test and a fatigue test should be carried out. The testing may be combined with the tests specified above.

5.11.11 **Process prototype testing** shall be carried out to document that the system functions as specified with respect to accumulation and disposal of liquids. It shall be verified that liquid hammer does not occur in the piping system during any operation. Where it is impractical to perform full scale testing, successful operation can be simulated computationally and in small scale testing to provide adequate assurance of functionality.

5.12 Composite Non-destructive testing (NDT)

Composites laminates shall be inspected .

5.13 Composite - metal connector interface

5.13.1 The interface between the metal connector and the composite pipe is a critical part of the tank design.The interface is basically a joint . Section for “Joints” should be considered.

5.13.2 The composite metal connector interface shall be strong enough to transfer all loads considered for the connector and the pipe section.

5.13.3 Internal or external pressure on the tank system may be beneficial or detrimental to the performance of the joint. This effect shall be considered in the analysis.

5.13.4 Creep of any of the materials used in the joint may reduce friction, open up potential paths for leakage or lead to cracks. Effects of creep shall be carefully considered.

5.13.5 Metal parts should be designed in a way that they do not yield to ensure no changes in the geometric arrangement of the joint. If any yielding can occur a non-linear analysis shall be done taking all relevant load histories and accumulated plastic deformations into account. Local yielding in thin sections or near welds shall be evaluated.

5.13.6 Possible effects of corrosion on metals and interfaces shall be evaluated.

5.13.7 Possible galvanic corrosion between different materials shall be considered. An insulating layer between the different materials can often provide good protection against galvanic corrosion.

5.13.8 Leak tightness of the joint shall be carefully evaluated. In particular possible flow along interfaces should be analysed.

5.14 Inner liner

5.14.1 Most composite tanks have an inner liner as a fluid barrier. The liner may also carry parts of the pressure load. This inner liner is typically made of metal or polymeric materials.

5.14.2 It shall be shown that the inner liner remains fluid tight throughout the design life, if it is used as a fluid barrier.

5.14.3 The inner liner may contribute to the overall stiffness and strength of the tank system depending on its stiffness and thickness.

5.14.4 If the inner liner is only a fluid barrier it usually follows the deformations of the main load bearing laminate. It shall be shown that the inner liner has sufficiently high strains to failure and yield strains to follow all movements of the tank system.

5.14.5 If the inner liner is designed to carry also part of the pressure loads all requirements from 804 shall be fulfilled. In addition, the load bearing capability of the liner shall be checked according to C. The inner liner needs to deform somewhat and press against the composite laminate before the laminate can support the liner and reduce the loads in the liner. This effect shall be considered. Its magnitude depends on how tightly the laminate is wound around the liner and on how stiff the laminate is in relation to the liner.

5.14.6 The inner liner should be operated in its elastic range. Neither operational conditions nor test conditions should bring it to yield. An exception is the first pressure loading called autofretage. Autofretage is common practice to pressurize a vessel initially at the factory to such high pressures that the inner liner yields. This creates a tight fit between the liner and laminate. The liner will subsequently be compressed by the outer laminate when the high pressure is removed.

5.14.7 Autofretage of the inner liner is common practice. The tank is pressurized initially at the factory to such a high pressure that the inner liner yields. After removing the pressure the inner liner will be compressed by the outer laminate. This procedure ensures a tight fit between inner liner and laminate. It shall be shown that the inner liner does not buckle due to the compressive loads. The yielding of the inner liner during autofretage also causes the liner's welds to yield. This may reduce stress concentrations, but it can also cause local thinning around the weld. Any thickness variations in the inner liner may cause localised yielding. The weld zone may have lower yield strength than the main part of the inner liner. Due to this the inner liner may yield locally close to the welds. The strain in the localised yield region can be very high, possibly leading to instant rupture, lower fatigue performance, enhanced creep. The inner liner and its welds shall be analysed taking all these effects into account.

5.14.8 If the inner liner material can creep, then creep will happen especially in the thin highly strained regions. The effect of creep with respect to fatigue, stress rupture and buckling shall be evaluated.

5.14.9 If the inner liner is under compression, local yielding may create deformations resulting in local or global buckling.

5.14.10 Buckling of the liner due to hoop compression shall be considered as a potential failure mechanism. The following two phenomena should be considered as a minimum:

a) Rapid decompression causes a pressure to build up suddenly between the liner and the composite tank tube, at the same time as the pressure inside the liner suddenly drops. This effect can happen if gas or liquid can diffuse through the inner liner and accumulate in the interface between liner and laminate or inside the laminate. This effect can be ignored for metal liners, since they are diffusion tight, provided no other diffusion path through seals etc. exists in the system.

b) As a result of the sustained internal pressure, the liner yields plastically (or undergoes creep deformation) in tension in the hoop direction. Decompression causes the composite tank cylinder to contract, compressing the liner and causing it to buckle. This effect can be prevented by using initially the autofretage process [5.14.7] and by keeping the liner below yield during operation.

5.14.11 Inner liner specifications with respect to acceptable thickness variations, weld quality, and maximum misalignments should be consistent with the worst cases evaluated in the analysis.

5.14.12 Polymeric inner liners, like thermoplastic inner liners may be evaluated against the yield criterion .

5.14.13 The liner may be bonded to the composite laminate or it may be un-bonded.

5.14.14 A different layer of material may also be placed between the laminate and the liner.

5.14.15 All possible failure modes of the interface and their consequence to the performance of the system shall be evaluated.

5.14.16 If a bond is required between laminate and liner, for example to obtain good buckling resistance of the liner, the performance of the bond shall be tested D510

5.14.17 If interfaces only touch each other friction and wear should be considered ..

5.14.18 If the liner is not totally fluid tight, fluids may accumulate between interfaces. They may accumulate in voids or de-bonded areas and or break the bond of the interface. They may also accumulate in the laminate. The effect of such fluids should be analysed.
The fluid should diffuse more rapidly through the laminate than through the inner liner, and more rapidly through the outer liner then through the laminate. Possible effects of rapid decompression of gases should be considered.The effect of the slight gas leaks due to diffusion shall be considered in the system analysis.

5.14.19 If the laminate may have matrix cracks, but the liner shall not crack (or vice versa), it shall be shown that cracks cannot propagate from one substrate across the interface into the other substrate. Possible de-bondingone of the interface due to the high stresses at the crack tip should also be considered It should be shown that by stretching or bending both substrates and their interface that no cracks form in the one substrate even if the other substrate has the maximum expected crack density.

5.14.20 It is recommended to demonstrate by experiments that cracks cannot propagate across the interface from one substrate to the other. It should be shown that by stretching or bending both substrates and their interface that no cracks form in the one substrate even if the other substrate has the maximum expected crack density.

5.14.21 The inner liner should be strong enough to withstand possible shear, scraping and torsional loads from equipment running inside tank.

5.14.22 The inner liner shall be resistant to the internal environment. Possible accumulation of water or other liquids on the bottom of the tank shall be considered. A possible combination of water and H_2S from the gas shall also be considered.

5.15 Outer liner

5.15.1 An outer liner is usually applied for keeping out external fluids, for protection from rough handling and the outer environment and for impact protection.

5.15.2 If no outer liner is applied the outer layers of the laminate have to take the functions of the outer liner.

5.15.3 The outer liner material shall be chosen so that it is resistant to the external environment, e.g., seawater, temperature, UV etc.

5.15.4 If the outer liner is exposed to UV radiation in service or during storage, it should be UV resistant.

5.15.5 Outer liners are not exposed to autofretage. They should be kept below yielding.

5.15.6 Resistance of the outer liner to handling and the external environment shall be considered. The outer liner may get some damage from handling, but the structural layer underneath should not be affected.

5.15.7 The performance requirements to the outer liner should not be affected by a possible impact scenario.

5.15.8 If fluids can diffuse through the inner liner into the load bearing laminate the outer liner may suffer from blow out if the external pressure is lower than the pressure inside the laminate. Blow out can be prevented by a venting mechanism.

5.15.9 Blow out will also not happen if it can be shown that the fluids will diffuse from the laminate through the outer liner into the external environment more rapidly than from the inside of the tube through the inner liner into the laminate. In addition, the remaining fluid concentration should be low enough that even under low external pressure the outer liner cannot blow out.

5.16 Installation

5.16.1 A procedure for handling of the composite cargo tanks shall be submitted for information. The procedure shall describe how the tanks will be handled to avoid external impacts and point loads.

5.16.2 The installation procedure shall as a minimum address the following issues:

a) How can impact loads be avoided?
b) How can impact loads be detected, if they should happen?
c) What are the loads during installation and handling, point loads should be avoided?
d) What shall be done in case of fire during installation?
e) What is the effect of weld spatter, sparks, naked flames, how can it be avoided?

Possible excessive moments and forces from the manifold system during installation should be addressed.

SECTION 6 PIPE INSTALLAIONS IN IN CARGO SPACES

Contents

6.1 Bilge, ballast fuel oil piping

For piping systems in cargo area not forming a part of the cargo piping the requirements given in Pt.5A Ch.8, Ch.9 apply. Piping systems common to multiple holds shall be arranged so that release of gas from one hold space shall not leak into other hold spaces.

6.2 Cargo piping, General

6.2.1 Structure and supports shall be suitably shielded from leak from flanges and valves and other possible leak sources if the cool down effect cannot be shown to be negligible.

6.2.2 If cargo piping enters enclosed spaces above main deck in process area, these spaces shall be provided with overpressure protection in case of high pressure leak or explosion.

6.3 Cargo valves

6.3.1 All remotely operated valves shall be capable of local manual operation.

6.3.2 The cargo tanks shall be connected to the cargo piping in accordance with the following principles:

a) Each cargo tank shall be segregated from the cargo piping by a manually operated stop valve and a remotely operated valve in series. A combined manually and remotely operated stop valve is acceptable provided means are available to check the integrity of the valve.

b) The loading/unloading connection point shall be equipped with a manually operated stop valve and a remotely operated valve in series.

c) The remotely operated cargo tank valves and load/unload valves required above shall have emergency shut down (ESD) functions. The valves shall close smoothly so that excessive pressure surges do not occur.

d) The ESD valves shall be arranged so that they close automatically in case of high pressure, sudden pressure drop during loading/unloading operations and in the event of fire. The ESD valves shall be arranged to be operated manually from cargo control room and other suitable locations.

e) The cargo compressors shall shutdown automatically if the ESD system is activated.

6.4 Cargo piping design

6.4.1 The cargo piping system shall as a minimum meet the requirements given in Pt.5A Ch.8 and Ch.9 or a standard acceptable to INTLREG with the following additional requirements:

a) The design temperature shall be the minimum temperature achieved during all normal and emergency procedures e.g. loading/unloading and pressure relieving shall be considered.

b) The design pressure is the maximum pressure to which the system may be subjected to in service e.g. the set point of the safety relief valve Refer Sec.7 [7.1].

c) The pipes shall be seamless or equivalent.

d) Only butt welded and flanged connections of the welding neck type are allowed. Flange connections shall be limited as far as possible.

e) All butt welds shall be subject to 100% radiographic testing.

f) Welding procedure tests and production weld test are required for cargo piping as specified in Liqified Gas Carriers welding procedures and production tests.

g) After assembly the piping system shall be hydrostatic pressure tested to at least 1.5 times design pressure prior to installation.

h) After assembly on board the complete cargo piping shall be subjected to a leak test using air, halides or other suitable medium according to an approved procedure.

i) The effects of vibrations imposed on the piping system shall be evaluated.

j) A complete stress analysis for each branch of the piping system shall be conducted according to ANSI/ ASME B31.3.

6.4.2 Procedures for cargo transfer including emergency procedures shall be submitted for approval. The procedures shall address potential accidents related cargo transfer, and information regarding emergency disconnection, emergency shutdown, communication with offshore/onshore terminals etc. shall be included.

SECTION 7 PIPING AND CARGO TANK PROTECTION

Contents

7.1 Cargo piping

A pressure relief valve shall be fitted to prevent excess pressure in the cargo piping. The set point of the relief valve shall not be greater than the design pressure of the cargo piping, less the tolerance of the relief valve.

7.2 Cargo tanks

7.2.1 The cargo tanks shall be provided with a blow down and an automatic pressure relief system. The system shall perform collection and disposal of pressurised gas during normal and emergency conditions. The vent gas may be cold vented or ignited. If there are provisions for cold venting a gas dispersion analysis shall be conducted to evaluate the spread of the gas dangerous area.

7.2.2 The blow down system shall comply the following :

a) means for pressure relieving of individual cargo tanks due to leakage.

b) remote control to blow down individual cargo tanks.

c) Identify which of the cargo tanks is leaking based on input from e.g. gas detection system, pressure sensors in cargo tank sections, temperature in hold space, and pressure in hold space.

d) Cold venting shall be acceptable provided it does not impose an unacceptable risk. There shall be two blow down valves fitted in series with a common control signal. One of the valves shall be common for all cargo tanks. There shall be a provision to check the function of valve .

e) The capacity of the blowdown system shall be sufficient to ensure that rupture of cargo tank or cargo tank piping will not occur in case of heat input from a fire or cool down from a gas leak.

7.2.3 where the cargo valve may also serve as blow down valve and a safety relief valve In lieu of blow down valves required in Sect [7.2.2]above and the relief valve , then alternatively high integrity pressure protection systems (HIPPS)) where the cargo valve also serve as blow down valve and as safety relief valve shall be considered.) where the cargo valve may also serve as blow down valve and a safety relief valve The acceptability of such systems shall be considered on a case by case basis and shall) where the cargo valve may also serve as blow down valve and a safety relief valve be dependent upon demonstration of adequate reliability and response of the complete system from detector to actuated device(s). The reliability target shall be an order of magnitude higher than critical failure of a typical relief device.

SECTION 8 CARGO CONTAINMENT AND PIPING SYSTEM GAS-FREEING

Contents

8.1 General

Arrangements for gas freeing shall be provided for all parts of the cargo system. A detailed procedure describing this routine shall be included in the cargo handling manual and submitted to INTLREG for review.

SECTION 9 CARGO SPACE MECHANICAL VENTILATION

Contents

9.1 General

9.1.1 Hazardous spaces Ventilation ducting and cargo area ventilation shall be exclusive. Air inlets for hazardous enclosed spaces shall be from non-hazardous spaces. Air inlets for non-hazardous enclosed spaces shall be taken from non-hazardous areas at least 1.5 m away from the boundaries of any hazardous area.

9.1.2 Air outlets from non-hazardous spaces shall be located outside hazardous areas. Air outlets from hazardous enclosed spaces shall be located in an open area lesser hazard than the ventilated space.Mechanical ventilation in non-hazardous enclosed spaces shall be arranged with ventilation of the overpressure type and hazardous spaces shall have ventilation with underpressure relative to the adjacent less hazardous spaces.

9.1.3 Ventilation ducts outside openings shall have wire mesh screens of not more than 13 mm square mesh shall be fitted . Protection screens are also to be fitted inside of the fan to prevent the entrance of objects into the fan housing.

9.1.4 Spare parts shall be carried for each type of fan referred to in this section. Normally one motor and one impeller is required carried on board for each type of fan , unless there is a standby fan. For spaces served by more than one fan, wear parts for motor and impeller is considered sufficient.

9.2 Fans for hazardous spaces

9.2.1 Electric fan motors shall not be installed in ventilation ducts for hazardous spaces unless the motor is certified for the same hazard zone.

9.2.2 Starters for fans for ventilation of non-hazardous spaces, shall be located outside the cargo area or on open deck. If electric motors are installed in such rooms, the ventilation capacity shall be great enough to prevent the temperature limits , from being exceeded, taking into account the heat generated by the electric motors.

9.2.3 Fans shall be with the least possible risk for spark generation..In no case is the radial air gap between the impeller and the casing to be less than 0.1 times the diameter of the impeller shaft in way of the bearing but not less than 2 mm. It need not be more than 13 mm.
The parts of the rotating body and of the casing shall be made of materials which are recognised as being spark proof, and they shall have antistatic properties. The installation shall be safe bonding to the hull of the units themselves. Resistance between any point on the surface of the unit and the hull, shall not be greater than 10^6 ohm.

The following combinations of materials and clearances used in way of the impeller and duct are considered to be non-sparking:

a) impellers and or housings of non-metallic material, due regard being paid to the elimination of static electricity
b) impellers and housings of non-ferrous metals
c) impellers of aluminium alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non-ferrous materials is fitted in way of the impeller, due regard being paid to static electricity and corrosion between ring and housing,

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

9.3 Ventilation and Capacity Requirements

9.3.1 **General**

Total room volume considered as basis for capacity of the ventilation plant.

9.4 Non-hazardous spaces

9.4.1 Hazardous area, shall be arranged with an air-lock, and be maintained at overpressure, relative to the external hazardous area.

The overpressure ventilation shall be arranged according to the following requirements:

a) During initial start-up or after loss of overpressure ventilation, it is required before energising any electrical installations not certified safe for the space in the absence of pressurisation, to:

- proceed with purging (at least 5 air changes) or confirm by measurements that the space is nonhazardous, and
- Pressurise the space.

b) Operation of the overpressure ventilation shall be monitored.

c) In the event of failure of the overpressure ventilation:

- an audible and visual alarm shall be provided at a manned location
- if overpressure cannot be immediately restored, automatic or programmed disconnection of electrical
  Installations is required according to IEC 60092-502, Table 5.

9.5 Cargo handling spaces

9.5.1 Cargo handling *spaces* means pump rooms, compressor rooms, and other enclosed or similar spaces of cargo working.

9.5.2 A permanent mechanical ventilation system shall be installed capable of circulating sufficient air of at least 30 air changes per hour. Ventilation inlets and outlets shall be sufficient air movement through the space to avoid the accumulation of vapours and for a safe working environment.

9.5.3 The ventilation systems shall permit extraction from either the upper and lower parts of the spaces, or from both the upper and lower parts, depending on the density of the vapours of the products carried.

9.5.4 The exhaust outlets discharge upwards, shall be at least 4 m above deck and at least 10 m in the horizontal direction from ventilation inlets and other openings to accommodation, service and control station spaces and other non-hazardous spaces.

9.5.5 Ventilation systems for equipment rooms shall be in operation whenever those are working .Before starting Machineries the ventilation system in the electric motor room has been in operation for 15 minutes. Warning notices shall be placed in an easily visible and copious position near the control stand.

9.5.6 When the space is dependent on ventilation for its area classification, the following requirements apply:

a) During initial start-up, and after loss of ventilation, the space shall be purged (at least 5 air changes), before connecting electrical installations which are not certified for the area classification in absence of ventilation.

b) Operation of the ventilation shall be monitored.

c) In the event of failure of ventilation, the following requirements apply;

- an audible and visual alarm shall be given at a manned location
- immediate action shall be taken to restore ventilation
- Electrical installations shall be disconnected if ventilation cannot be restored for an extended period.

The disconnection shall be made outside the hazardous areas, and be protected against unauthorised reconnection. Intrinsically safe equipment suitable for Zone 0, is not required to be switched off. Certified flameproof lighting, may have a separate switch-off circuit.

9.6 Other hazardous spaces

9.6.1 Air lock spaces shall be mechanically ventilated at an overpressure relative to the adjacent open deck hazardous area.

9.6.2 Other spaces on or above cargo deck level (e.g. Cargo Handling Gear lockers) shall be accepted with natural ventilation only.

9.6.3 Spaces such as cofferdams, double bottoms, duct keels, pipe tunnels, spaces containing cargo tanks and other spaces where cargo may accumulate , a mechanical ventilation system (permanent or portable) shall be provided capable of circulating sufficient air to the compartments . The capacity of the ventilation system is normally at least 8 air changes per hour.For hold spaces containing independent tanks a lower capacity shall be accepted, provided it shall be satisfactorily gas-freed in less than 5 hours. For inerted spaces an increase of the oxygen content from 0% to 20% in all locations of the space within 5 hours would be acceptable.

9.6.4 Ducting shall be fitted, if necessary, to ensure efficient gas-freeing.

9.6.5 Fans shall be installed clear of access openings.

9.7 Fans Certification.

Fans and portable ventilators shall be delivered with a INTLREG product certificate.Manufacturer's certificate shall be accepted for type approved fans.

SECTION 10 FIRE PROTECTION AND EXTINCTION

Contents

10.1 General

10.1.1 The fire safety measures in SOLAS related to tankers in general, will apply depending on flag state authorisation, as specified in Pt 7B,Ch 3 Ch.3 Sec.7.

10.1.2 Fire safety measures applicable to gas tankers are specified in Sect [10.2] below .

10.1.3 **Firefighter's outfit**

All ships shall be provided with at least two firefighter's outfits complying with Ch.3 of Fire Safety Systems Code .

10.1.4 Ships carrying flammable products of a cargo capacity of less than 5000 m^3 two additional firefighter's outfits shall be provided and on ships of a cargo capacity of 5000 m3 and over three additional firefighter's outfits shall be provided.

10.2 Fire Extinction

10.2.1 **Fire water main equipment**

All ships, irrespective of size, carrying products which are subject to this chapter must comply with requirements to fire pumps, fire main, hydrants and hoses in SOLAS Reg. II-2/10.2 for ships above 2000 gross tonnage, except that the required fire pumps capacity and fire main and water service pipe diameter shall not be limited when the fire pump and fire main are used as part of the water spray system.
Additional, minimum pressure at hydrants shall be 5.0 bar.

10.2.2 The arrangement shall be such that at least 2 jets of water not emanating from the same hydrant, one of which shall be from a single length of hose can reach any part of the deck in the cargo area and those portions of the cargo containment systems and tank covers above the deck. Hose lengths shall not exceed 33 m.

10.2.3 Stop valves shall be fitted in any crossover provided and in the fire main or mains at the poop front and at intervals of not more than 40 m between hydrants on the deck in the cargo area for the purpose of isolating damaged sections of the main.

10.2.4 All water nozzles provided for fire-fighting use shall 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 shall be resistant to the effect of fire and corrosion by seawater, for example by use of galvanised pipe.

10.2.5 Where the ship's engine room is unattended, arrangements shall 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.

10.3 Water spray system

10.3.1 Ships carrying flammable or toxic products, a water spray system for cooling, fire prevention and crew protection shall be installed to cover:

a) Exposed cargo tank domes and 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 shall be at least equal to the area of the drip trays provided.
d) Boundaries of superstructures, deckhouses normally manned, cargo compressor

rooms, cargo pump rooms, store rooms containing high fire risk items and cargo control rooms facing the cargo area. Boundaries of unmanned forecastle structures not containing high fire risk items or equipment, do not require water spray protection.

10.3.2 The system shall be capable of covering all areas mentioned in Sect [10.3.1] with a uniformly distributed water spray of at least 10 l/m^2 per minute for horizontal projected surfaces and 4 l/m^2 per minute for vertical surfaces.
For structures having no clearly defined horizontal or vertical surfaces, the capacity of the water spray system shall 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 shall 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 201, items 1 and 2, shall cover the whole of the athwartship tank grouping which includes that area.

10.3.3 The capacity of the water spray pump shall 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 shall be such as to simultaneously supply water to any one section and to the surfaces specified in Sect [10.3.1], items (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 shall be made between the fire main and water spray main outside the cargo area.

10.3.4 Water pumps normally used for other services, shall be arranged to supply the water spray main.

10.3.5 The pipes, valves, nozzles and other fittings in the water spray system shall be resistant to corrosion by seawater, for example by galvanised pipe, and to the effect of fire.

10.3.6 Remote starting of pumps supplying the water spray system and remote operation of any normally closed valves in the system should be arranged in suitable locations outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the areas protected.
Note: Water spray pipes shall be provided with drain holes at the lowest points.

10.4 Dry powder fire extinguishing system

10.4.1 Ships carrying flammable products shall be fitted with a fixed dry chemical powder type extinguishing system for the purpose of fighting fire on the deck in the complete cargo area and bow or stern cargo handling areas, if applicable.
The system shall be of approved type and tested for its purpose.

10.4.2 The system shall be capable of delivering powder from at least two hand hose lines or a combination monitor and hand hose line(s) to any part of the above-deck exposed cargo area including above-deck product piping.
The system shall be activated by an inert gas, such as nitrogen, used exclusively for this purpose and stored in pressure vessels adjacent to the powder containers.

10.4.3 The system shall consist of at least two independent, self-contained dry chemical powder units with associated controls, pressurising medium, fixed piping, monitors or hand hose lines. For ships with a cargo capacity of less than 1000 m^3, consideration may be given to permit only one such unit to be fitted. A monitor shall be provided and so arranged as to protect the cargo loading and discharge manifold areas and be capable of actuation and discharge locally and remotely. The monitor is not required to be remotely aimed if it can deliver the necessary powder to all required areas of coverage from a single position. All hand hose lines and monitors shall be capable of actuation at the hose storage reel or monitor. At least one hand hose line or monitor shall be situated at the after end of the cargo-area.

10.4.4 A fire-extinguishing unit having two or more monitors, hand hose lines, or combinations thereof, shall have independent pipes with a manifold at the powder container. Where two or more pipes are attached to a unit the arrangement shall be such that any or all of the monitors and hand hose lines shall be capable of simultaneous or sequential operation at their rated capacities.

10.4.5 The capacity of a monitor shall not be less than 10 kg/s. Hand hose lines shall be non-kinkable and be fitted with a nozzle capable of on/off operation and discharge at a rate not less than 3.5 kg/s. The maximumdischarge rate shall be such as to allow operation by one man. The length of a hand hose line shall not exceed 33 m. Where fixed piping is provided between the powder container and a hand hose line or monitor, the length of piping shall not exceed that length which is capable of maintaining the powder in a fluidised state during sustained or intermittent use, and which can be purged of powder when the system is shut down. Hand hose lines and nozzles shall be of weather-resistant construction or stored in weather-resistant housing or covers and be readily accessible.

10.4.6 A sufficient quantity of dry chemical powder shall be stored in each container to provide a minimum 45 s discharge time for all monitors and hand hose lines attached to each powder unit. Coverage from fixed monitors shall be in accordance with the following requirements:

Capacity of fixed monitors (kg/s) each		2	4
Maximum distance of coverage (m)	10	3	4

Hand hose lines shall be considered to have a maximum effective distance of coverage equal to the length of hose. Special consideration shall be given where areas to be protected are substantially higher than the monitor or hand hose reel locations.

10.4.7 Ships fitted with bow or stern loading and discharge arrangements, shall be provided with an additional dry chemical powder unit complete with at least one monitor and one hand hose line. This additional unit shall 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 shall be protected by hand hose lines.

10.5 Cargo compressor and pump-rooms

10.5.1 The cargo compressor and pump-rooms of any ship shall be provided with carbon dioxide system as specified in Ch.5 of Fire Safety Systems Code . A notice shall be exhibited at the controls stating that the system is only to be used for fire extinguishing and not for inerting purposes, due to the electrostatic ignition hazard. The alarms referred to in Ch.5 of Fire Safety Systems Code shall be safe for use in a flammable cargo vapour-air mixture. For the purpose of this requirement, an extinguishing system shall be provided which is suitable for machinery spaces. However, the amount of carbon dioxide gas carried shall be sufficient to provide a quantity of free gas equal to 45% of the gross volume of thecargo compressor and pump-rooms in all cases.

10.5.2 Cargo compressor and pump-rooms of ships carry restricted number of cargoes shall be protected by an appropriate fire extinguishing system approved by the Society

10.5.3 The fire loads shall be determined as a part of the Quantitative Risk Assessment referred to in Sec.1 [1.2].

10.6 Structural fire prevention

10.6.1 Exterior boundaries of superstructures and deckhouses, including any overhanging decks, shall be A-60 fire-protected for the portions facing the cargo area, the fuel oil storage wing tanks area and the process plant area, and for 3 metres away of any such boundary line.

10.6.2 If a process plant or any other potential release sources with gas under high pressure is located in the vicinity of accommodation, additional means of fire protection shall be considered.

10.6.3 Hold space covers facing the process area shall be protected from the process area by a transverse firewall of not less than H-0. Hold space covers facing the engine room area and flare mast aft shall be constructed with a transverse fire class division of not less than A-0.
Hold space covers shall have:

a) fire integrity to withstand exposure of a standard fire test used for A-class divisions with exposure from outside

b) surface flammability characteristics according to resolution A.653(16) (towards weather deck)

c) sufficient strength and tightness to ensure effective inert atmosphere within hold space for one hour.

10.6.4 Hold spaces below the weather deck shall be protected from the turret area or process area by A-0 class division.
For cargo tanks made of materials with fire resistance properties not equivalent to steel, the hold space cover shall be insulated to “A-60” class standard. In addition, hold space covers which are facing a process area or equipment with pressurised hydrocarbons shall be insulated to "H-60" class standard.

10.6.5 Accommodation, service spaces and engine room below the weather deck shall be separated from the process area, turret and cargo holds by means of cofferdams. The minimum distance between the bulkheads shall be 600 mm.

10.6.6 Any external boundaries of the engine room or service spaces, casings and the vent mast shall be made of steel.

10.6.7 Hold space covers or other essential areas or equipment which may be exposed to heat loads from and ignited leak from the cargo tanks/piping shall be adequately protected for the time it takes to depressurise the cargo tanks.

10.6.8 Divisions formed by bulkheads and decks which comply with the following are regarded as Class H fire division:

a) It shall be constructed of steel or other equivalent material and stiffened

b) It shall be constructed for preventing the passage of gas, smoke and flames up to the end of the two-hour standard test for hydrocarbon fires. The relevant exposure model is implemented in the revised edition of ISO 834 (HC curve).

c) It shall be insulated with approved non-combustible materials or equivalent passive fire protection such that the average and maximum temperature of the unexposed side will not rise to more than 140°C and 180°C respectively above the original temperature, within the time listed below:
class H-120 120 minutes
class H-60 60 minutes
class H-0 0 minutes.

10.7 Means of escape

10.7.1 Means of escape shall be provided from the engine room or service spaces to accommodation by means of enclosed shelter, preferably without having to be exposed to the weather deck.

10.7.2 Escape routes shall be arranged from the process area and other working zones in the cargo area to the muster area in the accommodation.

10.7.3 The transverse firewalls required in Sect 10 [10.6.1] shall provide protection against heat radiation for lifeboats.

10.8 Firefighter’s outfit

10.8.1 Four sets of firefighter’s outfits shall be placed in two separate fire stations, within the accommodation.

10.8.2 For concepts where the cargo area is dividing the accommodation and engine room or service spaces, two sets of firefighter’s outfits are required in the engine room or service spaces in addition to the sets required in [10.8.1].

10.9 Fire main

10.9.1 The basic requirements for fire pumps, hydrants and hoses, as given in SOLAS Ch. II-2/10.2, apply with the additional requirements given in [10.9.2] to [10.9.8].

10.9.2 The arrangement shall be such that at least two jets of water, not emanating from the same hydrant, are available, one of which shall be from a single length of hose that can reach any part of the deck and external surfaces of the hold space covers. The minimum pressure at the hydrants with 2 hoses engaged shall be 5.0 bar. Hose lengths shall not exceed 33 m.

10.9.3 The fire main shall be arranged either as:

a) a ring main port and starboard or
b) as a single line along the centre line through the cargo area provided the fire main is shielded from possible jet fire occurring from within the cargo piping.

10.9.4 Two main fire pumps shall be installed, each with 100% capacity. One pump shall be located forward of the cargo area and one pump aft of the cargo area and both pumps shall be arranged with remote control from both the bridge and the engine room.

10.9.5 Both main fire pumps shall at any time during operation, when the ship is not gas-free, be available for start and delivery of water. The fire main shall be pressurised for immediate delivery of water at hydrants for engaging at least two effective jets of water onto the weather deck. The fire pumps shall start automatically upon low pressure detection in the fire main.

10.9.6 Remote controlled isolation valves shall be arranged on the weather deck at each end of the fire main leading into the cargo or process area. The isolation valves shall be on the protected side of the fire wall or boundary. Manual operated stop valves shall be provided between each cargo hold space, and the distance between the valves shall not exceed 40 m.

10.9.7 Fire fighting system all components shall be resistant to corrosion by seawater.

10.9.8 Mooring equipment positioned within gas dangerous zone shall be protected by a water sprinkler system with a capacity of not less than 5 l/m2/minute. The sprinkler system shall be activated prior to any simultaneously use of the mooring equipment and cargo handling. If only one side of the mooring equipment is used at a time, the capacity for the water supply may be based on one side in operation only. The water sprinkler system may be served from the fire main.

10.9.9 The cargo operating area on the open deck shall be covered by water monitors and shall be remotely controlled from a safe location.

10.10 Dual agent (water and powder) for process and load/unload area

10.10.1 Stiffened The system shall be capable of delivering water and powder from at least two widely separated connections to the process area, cargo load and unload area and any other high fire risk areas located on the open deck. The length of the hoses shall be 25 m to 30 m.

10.10.2 Water supply shall be from the main fire pumps and fire main if the added capacity of the system is included in capacity calculation for the main fire pumps. Powder shall be arranged in two separate units, each with discharge capacities: 3.5 kg/s powder for not less than 60 seconds for one hand held hose.

10.11 Water spray

10.11.1 Water spray is not an acceptable means for complying with the minimum structural fire integrity mentioned in [10.6].

10.11.2 The following shall be protected by water spray:

a) Process area

b) turret

c) unprotected and pressurised cargo tank/deck piping

d) Emergency Shut Down (ESD) valves

e) Other important equipment for controlling the pressure in the cargo tanks due to fire

f) the part of accommodation facing the cargo area

g) external bulkheads of hold space covers facing the engine room and the flare mast.

10.11.3 The system shall be capable of covering all areas mentioned in [10.11.2] with a uniformly distributed water spray of at least 10 l/m2 per minute for horizontal projected surfaces and 4 l/m2 per minute for vertical surfaces.

10.11.4 The outlets of gas disposal systems, e.g. flare, cold vent or pressure relief valves shall be led to an area where radiation, heat or gases will not cause any hazard to the vessel, personnel or equipment. The heat radiation from the flare towards the cargo holds or other important equipment or areas shall be calculated to verify that the heat load does not lead to high temperatures in the cargo holds or equipment failure. The flare shall comply with API RP521 or equivalent.

10.11.5 The water spray main shall be arranged as similar as [10.9.3]
Both water spray pumps shall be available for immediate start up and delivery of water. Two water spray pumps shall be installed, each with 100% capacity. One pump shall be located forward of the cargo area and one pump aft of the cargo area and both pumps shall be arranged with remote control from both the bridge and the engine room. Each water spray pump capacity shall be based on simultaneous demand for water spray to all areas.

10.12 Spark arrestors

Spark arrestors shall be installed on exhaust outlet from internal combustion engines and boilers

SECTION 11 ELECTRICAL INSTALLATIONS

Contents

11.1 The ship shall comply Pt 7B,Chapter 6 Section 12 as applicable

SECTION 12 CONTROL SYSTEMS AND TESTS

Contents

12.1 General

12.1.1 For instrumentation and automation, including computer based control and monitoring, the requirements in this Section are additional to those given in Pt.6 Ch 8.
The control and monitoring systems shall be certified according to Pt 6 Ch 8 for the following:

a) cargo tank level measurement system
b) cargo tank overflow protection system
c) cargo valves and pumps control and monitoring system
d) flammable gas detection system (permanent system only)
e) inert gas control and monitoring system
f) cargo and vapour pressure control and monitoring system
g) oxygen indication equipment (permanent system only).

12.1.2 Remote reading systems for cargo temperature and pressure shall not allow the cargo or vapour to reach gas-safe spaces. Direct pipe connections will not be accepted.

12.1.3 If cargo operation of the ship are carried out by means of remotely controlled valves and pumps, all controls and indicators associated with a given cargo tank shall be concentrated in one control position.

12.1.4 Where a secondary barrier is required, permanently installed instrumentation shall be provided to detect when the primary barrier fails to be liquid-tight at any location or when liquid cargo is in contact with the secondary barrier at any location. This instrumentation shall be appropriate gas detecting devices . However, the instrumentation need not be capable of locating the area where liquid cargo leaks throughthe primary barrier or where liquid cargo is in contact with the secondary barrier.

12.1.5 Instruments are calibrated at regular intervals and same shall be approved by the class Society.

12.1.6 Where components in remote control systems are required to be designed with redundancy, or to be independent of each other, e.g. gas compressors and cargo pumps, redundancy or independence has also to be provided for in the control system.

12.2 Alarm and monitoring

12.2.1 Cargo tank level gauging a provision to determine the quantity of cargo in tanks. Consideration of the hazard and physical properties of each cargo shall be the base for selecting one of the types defined in [12.2.2] to [12.2.8]:

12.2.2 Indirect devices, to determine the quantity of cargo by means of weighing or pipe flow meters.

12.2.3 Closed devices, which do not penetrate the cargo tank, such as devices using radio isotopes or ultrasonic devices.

12.2.4 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 shall be provided with a shut-off valve located as close as possible to the tank.

12.2.5 Restricted devices, which penetrate the tank, and when in use permit a small quantity of cargo vapour or liquid to escape to the atmosphere, such as fixed tube and slip tube gauges. When not in use, the devices shall be kept completely closed. The design and installation shall ensure that no dangerous escape of cargo can take place when opening the device. Such gauging devices shall be so designed that the maximum opening does not exceed 1.5 mm or equivalent area, unless the device is provided with an excess flow valve.

12.2.6 Types of gauging for individual cargoes shall be in accordance with the requirement in CH 18 "Liquified Gas Carriers " *List of Cargoes* , also Pt 7B ,Ch 3,Sect 9.3

12.2.7 Each cargo tank shall be fitted with at least one liquid level gauging device, designed to operate within the allowable tank pressure and temperature range. If only one liquid level gauge is fitted, it shall be arranged such that any maintenance shall be carried out even at the cargo tank is in service.

12.2.8 Tubular gauge glasses shall not be fitted. Gauge glasses of the robust type as fitted on high pressure boilers and fitted with excess flow valves, may be allowed for deck tanks.

12.2.9 Sighting ports with a suitable protective cover and situated above the liquid level with an internal scale, shall be accepted as a secondary means of gauging for cargo tanks which are designed for a pressure not higher than 0.7 bar.

12.3 Overflow control

12.3.1 Cargo tanks shall be fiited a high-level alarm, energized at about 95% of the tank volume. The alarm shall be activated by a level sensing device independent of the level gauging device required in Sect [12.2.7].

12.3.2 A level sensing device shall be provided which automatically actuates the shut-off of the flow of cargo to the tank in a manner which will both avoid excessive liquid pressure in the loading line and prevent the tank from becoming liquid full. This level sensing device shall be independent of the one which activates the high level alarm required by 12.3.1
The emergency shutdown valve referred to in Ch 18 "LIQUIFIED GAS CARRIERS'' may be used for this purpose. If another valve is used for this purpose..

12.3.3 A high liquid level alarm and automatic shut-off of cargo tank filling need not be installed when the cargo tank is either:

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 set pressure of the cargo tank relief valve.

12.3.4 When pumps situated in different tanks discharge into a common header, stop of the pumps shall be alarmed at the centralized cargo control position.

12.3.5 Level alarms shall be tested prior to loading.

12.4 Vapour contents indication and alarm

12.4.1 Gas detection equipment for the gases to be carried, shall be provided in accordance with column (d) of the *List of Cargoes*.(Ch 18 "Liquified Gas Carriers")

12.4.2 A permanently installed system of gas detection equipped with audible and visual alarms shall 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 cargo vapour may accumulate including hold spaces and interbarrier spaces
f) ventilation hoods and gas ducts :

   The air space between the gas fuel piping and the inner wall of this pipe or duct shall be equipped with mechanical exhaust ventilation having a capacity of at least 30 air changes per hour. The ventilation system shall be arranged to maintain a pressure less than the atmospheric pressure. The fan motors shall be placed outside the ventilated pipe orduct. The ventilation outlet shall be covered by a protection *screen* and placed in a position where no flammable gas-air mixture may be ignited. The ventilation is always to be in operation when there is gas fuel in the piping. The ventilation hood or casing shall be installed or mounted to permit the ventilating air to sweep across the gas utilization unit and be exhausted at the top of the ventilation hood or casing. Spaces in which gas fuel is utilized shall be fitted with a mechanical ventilation system and be arranged in such a way as to prevent the formation of dead spaces. Such ventilation to be particularly effective in the vicinity of electrical equipment and machinery or of other equipment and machinery which may generate sparks.

g) air locks
h) degassing tank for cargo heating medium if fitted.

12.4.3 If products are toxic or toxic and flammable, the use of portable equipment shall be accepted, except when column (f) in the *List of Cargoes* refers ch 18, for toxic detection as an alternative to a permanently installed system. In such cases, a permanently installed piping system for obtaining gas samples from the spaces shall be fitted.

12.4.4 For the spaces dscribed in[12.4.2] , alarms shall be activated for flammable products before the vapour concentration reaches 30% of the lower flammable limit. Except for spaces as specified in 305, gas detection instruments for flammable products capable of measuring gas concentrations below the lower flammable limit shall be accepted.

12.4.5 In the case of flammable products, where cargo containment systems other than independent tanks are used, hold spaces and/or interbarrier spaces shall be provided with a permanently installed system of gas detection capable of measuring gas concentrations of 0 to 100% by volume. Alarms shall be activated before the vapour concentration reaches the equivalent of 30% of the lower flammable limit in air, or such other limits as may be approved in the light of particular cargo containment arrangements.

12.4.6 Audible and visual alarms from the gas detection equipment, if required by this section, shall be located on the bridge, in the cargo control position required by [12.1.2] and at the gas detector readout location.

12.4.7 The gas detection and analyzing from each sampling head at intervals not exceeding 30 minutes, sampling shall be continuous. Separate sampling lines to the detection equipment shall be provided.

12.4.8 The suction capacity for every suction period and every suction point shall be sufficient to secure effectively that the gas is analyzed in the same period as it is drawn into the system.

12.4.9 Gas detection apparatus shall be tested and calibrated at regular intervals.. .

12.4.10 In every installation the positions of fixed sampling points shall 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.

12.4.11 Pipe runs from sampling heads shall not be led through gas-safe spaces except as permitted by [12.4.12] below

12.4.12 Gas detection equipment shall be located in the cargo control position required by [12.7.1], on the bridge or at other suitable location. When located in a gas-safe space, the following conditions shall be complied :

a) Sampling lines shall not run through gas safe spaces, except where permitted under sub item (e) .
b) The gas sampling pipes shall be provided by flame arresters of an approved type. The flame arresters shall be located in safe area, either inside or outside the gas detection unit. Sample gas shall be led to the atmosphere with outlets to a safe position.
c) Bulkhead penetrations of sample pipes between safe and dangerous areas shall be of approved type and have the same fire integrity as the division penetrated. A manual isolating valve shall be fitted in each of the sampling lines at the bulkhead on the gas safe side.
d) The gas detection equipment including sample piping, sample pumps, solenoids, gas detection sensors etc. shall be located in a reasonably gas tight enclosure and shall be monitored by its own sampling point. Gas concentrations above 30% of lower flammable limit inside the enclosure an alarm shall be issued, and the electrical equipment not being of certified safe type shall be automatically de-energised.
e) Where the enclosure cannot be arranged directly on the bulkhead facing the gas dangerous space or zone, sample pipes in safe areas outside the cabinet shall be of steel or other equivalent material and without detachable connections, except for the connection points for isolating valves at the bulkhead and gas detection units, and be routed in the shortest way possible.

12.4.13 Two sets of portable gas detection equipment suitable for the products carried shall be provided.

12.4.14 An instrument to the measure oxygen content in inert atmospheres shall be provided.

12.5 Temperature monitor and alarm

12.5.1 Each cargo tank shall be provided with a minimum of 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 shall be marked to show the lowest temperature for which the cargo tank has been approved.

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

12.5.3 In case of cargo shall be carried at temperatures less than -55°C, the cargo tank boundaries, if appropriate for the design of the cargo containment system, shall be fitted with temperature indicating devices as follows:

a) number of sensors ggod enough to confirm that an unsatisfactory temperature gradient does not occur
b) on one tank a number of devices in excess of those required above in order to verify that the initial cool down procedure is satisfactory. The devices shall be either temporary or permanent. When a series of similar ships are built, the second and successive ships need not comply with these requirements.

12.6 Pressure monitor and alarm

12.6.1 Each tank shall be provided with at least one local indication for pressure on each tank and remote pressure indication in the cargo control position required by [12.7.1]. The manometers and indicators shall be clearly marked with maximum and minimum pressure permissible in the tank. In addition a high pressure alarm and, if vacuum protection is required, a low pressure alarm shall be provided on the bridge.

The alarms shall be activated before the set pressures. For cargo tanks fitted with pressure relief valves, high pressure alarms shall be provided for each set pressure.

12.6.2 Manometers shall be fitted to cargo pump discharge lines and to the main loading and discharge vapour and liquid lines.

12.6.3 Local reading manifold pressure gauges shall be provided to indicate the pressure between stop valves and connections to the shore.

12.6.4 Hold spaces and interbarrier spaces without open connection to the atmosphere shall be provided with pressure gauges.

12.6.5 **Hold leakage alarm**
A device shall be provided in each hold space surrounding independent cargo tanks for an alarm if leakage of water, oil or cargo into the holds.

12.7 Locations

12.7.1 Alarms shall be located on the navigating bridge and in the cargo control room.

12.7.2 Means for detection of moisture and H2S at the load/unload or shore connection shall be provided.

12.7.3 As a minimum the following locations shall be monitored for gas:

a) suitable positions in each hold space
b) deck piping (line sensors)

c) ventilation inlets for gas safe spaces

d) ventilation outlets for gas dangerous spaces

e) air inlets to machinery spaces

f) manifold area.

12.7.4 The following locations shall be fitted with pressure monitors and alarm:

a) each hold space

b) each cargo tank

c) cargo piping at load/unload connection.

12.8 Tests

12.8.1 All systems shall be tested after installations

SECTION 13 CARGO LIMITATIONS

Contents

13.1 Pressure Limit

13.1.1 The pressure in the cargo tanks, after filling, shall be limited so that the pressure does not increase above 95% of the design pressure at any time during transport or unloading taking into account:

a) for a system without cooling.

b) for a system provided with a cooling system, the capacity of the cooling system and the ambient temperature conditions .

SECTION 14 GAS SPECIFICATION

Contents

14.1 General

14.1.1 The gas shall have a water dew point that during all operation modes does not lead to formation of hydrates or corrosion due to free water in the system.

SECTION 15 MONITORING AND INSPECTION

Contents

15.1 General

15.1.1 An inspection and monitoring schedule shall be made and follow the program accordingly.

15.1.2 For the cylinder type cargo tank the program shall as a minimum address:

a) number of cargo tank cylinders to monitor
b) inspection tools and accuracy
c) periodical surveys
d) NDT requirements
e) destructive testing of cargo tank cylinders if found necessary
f) cargo tank piping, fittings and supports
g) cargo piping, fittings and supports.

The inspection plan shall ensure that cracks and corrosion are detected with high reliability.

CHAPTER 12 SPECIAL PURPOSE SHIPS

CONTENTS

SECTION 1 GENERAL

Contents

1.1 General

1.1.1. Application- This Chapter relates to a special purpose ship .It is a ship of not less than 500 gross tonnage which carries more than 12 special personnel, i.e. persons who are specially needed for the particular operational duties of the ship and are carried in addition to those persons required for the normal navigation, engineering and maintenance of the ship or engaged to provide services for the persons carried on board.

1.1.2. The requirements of this section comply to the Code of Safety for Special Purpose Ships (SPS Code), as defined in [1.2].

1.1.3. A ship that in compliance with the requirements of this section shall be assigned the class notations **SPS**, denoting Special Purpose Ship.

1.1.4. A passenger or cargo ship, whenever built, which is converted to a special purpose ship shall be treated as a special purpose ship constructed on the date on which the contract for conversion is signed.

1.1.5. For flags that have not accepted the use of the SPS Code, flag requirements will prevail whilst under that flag, i.e. SOLAS Ch.III for cargo ships to be applied

1.2 Definitions

1.2.1 For the purpose of this Chapter, the definitions hereunder shall apply. For terms used, but not defined in this Code, the definitions as in SOLAS apply.

1.2.2 “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.

1.2.3 “Crew” means all persons carried on board the ship to provide navigation and maintenance of the ship, its machinery, systems and arrangements essential for propulsion and safe navigation or to provide services for other persons on board.

1.2.4 “IMDG Code” means the International Maritime Dangerous Goods Code, adopted by the Maritime Safety Committee by resolution MSC.122(75), as amended

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

1.2.6 “LSA Code” means the International Life-Saving Appliance Code, adopted by the Maritime Safety Committee by resolution MSC.48(66), as amended.

1.2.7 “Organization” means the International Maritime Organization.

1.2.8 “Passenger” means every person other than:

- the master and the members of the crew or other persons employed or engaged iany capacity on board a ship on the business of that ship; and
- a child under one year of age.

1.2.9 "Permeability" in relation to a space is the ratio of the volume within that space which is assumed to be occupied by water to the total volume of that space.

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

1.2.11 Special personnel" means all persons who are not passengers or members of the crew or children of under one year of age and who are carried on board in connection with the special purpose of that ship or because of special work being carried out aboard that ship. Wherever in this Code the number of special personnel appears as a parameter, it should include the number of passengers carried on board which may not exceed 12.
Special personnel are expected to be able bodied with a fair knowledge of the layout of the ship and to have received some training in safety procedures and the handling of the ship's safety equipment before leaving port and include the following:

a. scientists, technicians and expeditionaries on ships engaged in research,non-commercial expeditions and survey;
b. personnel engaging in training and practical marine experience to develop seafaring skills suitable for a professional career at sea. Such training should be in accordance with a training programme approved by the Administration;
c. personnel who process the catch of fish, whales or other living resources of th sea on factory ships not engaged in catching;
d. salvage personnel on salvage ships, cable-laying personnel on cable-laying ships seismic personnel on seismic survey ships, diving personnel on diving support ships, pipe-laying personnel on pipe layers and crane operating personnel on floating cranes; and
e. other personnel similar to those referred to in a) to d) who, in the opinion of the Administration, may be referred to this group.

1.2.12 "Special purpose ship"1 means a mechanically self-propelled ship which by reason of its function carries on board more than 12 special personnel2.

1.2.13 "Training programme" means a defined course of instruction and practical experience in all aspects of ship operations, similar to the basic safety training as offered by the maritime institutions in the country of the Administration.

1.3 Plans and datas

1.3.1 The intact stability of special purpose ships should comply with the provisions of section 2.5 of Part B of the 2007 Intact Stability Code.
Following Stability and subdivision documents shall be submitted.

A. For Approval

i. Stability analysis
ii. Preliminary stability manual
iii. subdivision index calculation
iv. Inclining test

v. Final stability manual

vi. damage control plan and booklet

vii. Life saving appliances-Ships carrying more than 60 persons muste list and emergency instructions shall be submitted.

viii. Fire protection

a. Ships carrying more than 240 persons on board, the requirements of chapter II-2 of SOLAS for passenger ships carrying more than 36 passengers shall be applied.

b. Ships carrying more than 60, but not more than 240 persons on board, the requirements of chapter II-of SOLAS for passenger ships carrying not more than 36 passengers shall be applied.

c. ships carrying not more than 60 persons on board, the requirements of chapter II-2 of SOLAS for cargo ships shall be applied.

B. For Information

i. Lines plan offset tables

ii. External and internal water tight integrity plan

External watertight integrity plan consists of air pipes, ventilators, hatches, doors, etc. of volumes affecting stability calculations.
Internal watertight integrity plan information on items affecting damage stability calculations, such as internal subdivision, possibility of progressive flooding from one compartment to another through internal openings, pipes, tunnels or ventilation ducts and pipes, ducts, tunnels in the damage penetration zone specified in the damage assumptions.

SECTION 2 REQUIREMENTS

Contents

2.1 Compliance . SPS Code shall comply this chapter Special Purposes Ship.

General cargo ships Pt 7B,Ch.2 Sec.4 and which are not covered by the requirements of this section shall also be complied with.

2.2 Stability and subdivision

2.2.1. The intact stability requirements of Pt.8 Ch.1 Sec.4 shall be complied with. The stability documentation shall include calculations of the most unfavourable loading conditions anticipated for each intended service mode.

2.2.2. For ships carrying 240 persons or more, the supplementary intact stability requirements of Pt 7B,Ch.2 Sec.2 [2.6] shall be complied with as though the ship is a passenger ship and the special personnel are considered passengers.

Note:
Unless required by the Flag State a SPS ship need not be considered a passenger ship for application of SOLAS
regulation II-1/5.5 on periodical lightweight surveys.

2.2.3. The subdivision and damage stability shall in general be in accordance with SOLAS II-1 as amended where the ship is considered a passenger ship and special personnel are considered passengers, with an R-value calculated in accordance with SOLAS regulation II-1/6.2.3 as follows:

a) for ships carrying 240 persons or more, the R-value is assigned as 1.0 R

b) for ships carrying not more than 60 persons, the R-value is assigned as 0.8 R; and

c) for ships carrying more than 60 persons, but less than 240 persons, the R-value

shall be determined by linear interpolation between the R-values given above.

2.2.4. For ships carrying 240 persons or more, the requirements of SOLAS regulations II-1/8 and II-1/8-1 and of SOLAS chapter II-1, parts B-2, B-3 and B-4 shall be applied as though the ship is a passenger ship and the special personnel are passengers. However, SOLAS regulations II-1/14 and II-1/18 are not applicable.

2.2.5. Except as provided in [2.2.6] for ships carrying less than 240 persons the provisions of SOLAS chapter II-1, parts B-2, B-3 and B-4 shall be applied as though the ship is a cargo ship and the special personnel are crew. SOLAS regulations II-1/8, II-1/8-1, II-1/14 and II-1/18 are not applicable.

2.2.6. All ships shall comply with SOLAS regulations II-1/9, II-1/13, II-1/19, II-1/20 and II-1/21 as though the ship is a passenger ship.

Note:
The interpretations in the Notes to SOLAS chapter II-1 subdivision and damage stability regulations, adopted by IMO as Resolution MSC.281(85) shall be used for the application of SOLAS chapter II-1. The recommendations in resolution MSC.245(83) should be applied if cross-flooding systems are utilised.

SECTION 3 INSTALLATIONS

Contents

3.1 Machinery installations

3.1.1 All ships shall comply with Pt 7B,Ch 2, Sect 2 as though the ship is a passenger ship Requirements of bilge pumping in passenger ships refer Solas Reg II-1/21.2

3.2 Steering gear installation

3.2.1 All steering gear installations in special purpose ships carrying more than 240 persons shall comply following as though the ship is a passenger ship.Where the main steering gear comprises two or more identical power units, an auxiliary steering gear need not be fitted provided that requirements below are complied with:

a) Isolation:

1) a single failure in the main steering gear piping system or one of the power units can be isolated and steering capability can be maintained or speedily regained.

b) Capacity:

i. in a passenger ship, the main steering gear is capable of operating the rudder while any one of the power units is out of operation be capable of operating the rudder for the purpose of steering the ship at maximum ahead service speed which shall be demonstrated

ii. Main steering have capacity to turn the rudder from side to side according to requirements given below at maximum ahead service speed

1) For vessels complying with rules for ships the main steering gear shall comply with the following:

- turning the rudder over from 35° on one side to 35° on the other and visa versa
- turning rudder from 35° on either side to 30° on the other sides respectively within 28 seconds
- turning rudder back to neutral position from any possible steering angle that intentionally or unintentionally may be initiated.

Refer also below for over-balanced rudders and rudders of unconventional design.

3.2.2 **Over balanced rudders**

Section [3.2.2] relevant for steering gear for over-balanced rudders and rudders of unconventional design.

i. Documentation required.

Table 12.3.1

Object	Additional description	For approval (AP) or For information (FI)
Rudder arrangement	Covering rudders, propeller outlines, actuators, stocks, horns, stoppers and bearing lubrication system. Specify maximum speed ahead and aft, and Ice Class when applicable.	FI
	Mounting and dismounting or rudder (including flaps as a detached component), rudder stock and pintles.	FI
	Measurement of bearing clearances.	FI
	Flap rudders: Hinges, link systems and criteria for allowable bearing clearances.	FI
	Non-conventional rudder designs: Torque characteristics (torque versus rudder angle in homogeneous water stream).	FI
	Expected life time of bearings subjected to extraordinary wear rate due to dynamic positioning.	AP
Stern frame, sole pieces and rudder horns		AP
Rudder blades	Including details of bearings, shafts and pintles.	AP
Rudder stocks	Including details of connections, bolts and keys.	AP
Propeller nozzles		AP
Propeller shaft brackets		AP
Rudder and steering gear supporting structures	Including fastening arrangements (bolts, cocking and side stoppers).	AP

3.2.3 The influence of increased friction due to age and wear of bearings on steering gear torque capacity shall be duly considered. Unless such friction losses are accounted for and specified in submitted approval documentation, the friction coefficient for the bearing in worn condition shall be taken at least twice as when new.

3.2.4 Loss of steering torque due to a single failure in the steering gear power or control systems (inclusivefailure in power supply) shall not cause a sudden turn of rudder.

3.2.5 Steering gear shall be capable of bringing the rudder from any rudder angle back to neutral position. This is to be verified by testing on sea trial.

3.2.6 Capacity in a cargo ship, the main steering gear is capable of operating the rudder as required [3.2.1 (b).(ii)] in while operating with all power units

3.3 Electrical installations

3.3.1 Electrical distribution systems in ships carrying more than 60 persons shall be so arranged that fire in any main vertical zone, as defined in Pt.5A Ch.13,also refer Pt 7B,Ch 2 Sect 2[2.5], will not interfere with services essential for safety in any other such zone. This requirement will be met if main and emergency feeders passing through any such zone are separated both vertically and horizontally as widely as is practicable

3.3.2 **Emergency source of power**
The emergency source of electrical power in special purpose ships carrying not more than 60 persons and which are more than 50 m in length shall be capable, having regard to starting currents and the transitory nature of certain loads, of supplying simultaneously at least the following services for a period of half an hour if they depend upon an electrical source for their operation:

1) any watertight doors required by SOLAS Reg. II-1/13 to be power operated together with their indicators and warning signals.

2) the emergency arrangements to bring the lift cars to deck level for the escape of persons.

3.3.3 Installations in special purpose ships carrying more than 60 persons shall comply with Pt 7B Ch.2 Sec.2[2.4] as though the ship is a passenger ship.

3.4 Periodically unattended machinery spaces

3.4.1 All ships shall comply with the requirements in Pt.6 Ch.8 for additional class notation **UM**

3.5 Fire protection

3.5.1 For ships carrying more than 240 persons on board, the requirements of chapter II-2 of SOLAS for passenger ships carrying more than 36 passengers shall be applied.

3.5.2 For ships carrying more than 60, but not more than 240 persons on board, the requirements of chapter II-2 of SOLAS for passenger ships carrying not more than 36 passengers shall be applied.

3.5.3 For ships carrying not more than 60 persons on board, the requirements of chapter II-2 of SOLAS for cargo ships shall be applied.

3.6 Dangerous goods

3.6.1 Dangerous goods that are carried on board for shipment as cargo and are not used on board are subject to the provisions of the IMDG Code.

3.6.2 Spaces used for the carriage of any significant amount of dangerous goods as ships' stores and intended for use on board shall comply with the provisions of the IMDG Code as far as reasonable and practicable.

3.7 Life-saving appliances

3.7.1 The requirements of chapter III of SOLAS shall be applied with the specifications given[3.7.2] in through [3.7.6].

3.7.2 Ships carrying more than 60 persons shall comply with the requirements contained in chapter III of SOLAS for passenger ships engaged in international voyages that are not short international voyages.

3.7.3 Notwithstanding the provisions of [3.7.2] , a ship carrying more than 60 persons but not more than 200 persons may in lieu of meeting the requirements of regulations 21.1.1 of chapter III of SOLAS comply with the requirements of regulation 21.1.5 of chapter III of SOLAS, including the provision of at least two rescue boat(s) in accordance with regulation 21.2.1 of chapter III.

Note:
item [3.7.3] to apply only for ships with a gross tonnage of less than 500 and with a total number of persons on board less than 200.

3.7.4 Ships carrying not more than 60 persons shall comply with the requirements contained in Chapter III of SOLAS for cargo ships other than tankers. Such ships may, however, carry life-saving appliances in accordance with the passenger ship requirements in [3.7.2] if they comply with the subdivision requirements in [2.2.3] as though the ship is carrying 60 persons.

3.7.5 Regulations 2, 19.2.3, 21.1.2, 21.1.3, 31.1.6 and 31.1.7 of Chapter III of SOLAS and the requirements of paragraphs 4.8 and 4.9 of the LSA Code are not applicable to special purpose ships.

3.7.6 Where in Chapter III of SOLAS the term “passenger” is used; it should be read to mean “special personnel”.

3.8 Radio communications

3.8.1 All special purpose ships shall carry a valid Cargo Ship Safety Radio Certificate in compliance with Chapter IV of SOLAS

3.9 Safety of navigation

3.9.1 All special purpose ships shall comply with the requirements of Chapter V of SOLAS.

CHAPTER 13 ESCORT VESSELS

CONTENTS

SECTION 1 GENERAL

Contents

1.1 Class notation and escort rating

1.1.1. The requirements of this chapter apply to vessels specially provided for escort service. Vessels built in compliance with the requirements in this chapter shall assign the class notation **Escort Vessel.** The escort rating number (**FS,t,v**) shall be determined by approved trials, performed within acceptable limits set by stability and winch criteria specified in these Rules. A test certificate indicating the escort rating number shall be issued on completion of successful trials. If trials carried out at both 8 and 10 knots, the escort rating number will consist of 6 parts.

1.1.2. The requirements for **Tug** notation given in Pt 7B,Ch 5 Sec.9 shall be complied with. The winch, crucifix etc. and their supporting structures shall comply with the requirements for Tug notation based on towline force FW (Refer Fig.13.1.1) instead of BP.

1.2 General Terms

1.2.1. The term Escort service includes steering, braking and otherwise controlling the assisted vessel. The steering force is provided by the hydrodynamic forces acting on the tug's hull.

1.2.2. The term Escort test speed is the speed at which the full scale measurements are to be carried out, normally 8 knots and/or 10 knots.

1.2.3. The term Escort tug is the tug performing the escort service, while Assisted vessel is the vessel being escorted.

1.2.4. FS indicates maximum transverse steering pull in metric tonnes exerted by the escort tug on the stern of the assisted vessel with the intention of controlling it, t is the time required for the change of the tug's position from one side to the corresponding opposite side, and v is the speed at which this pull may be attained (Refer Fig.13.1.1).

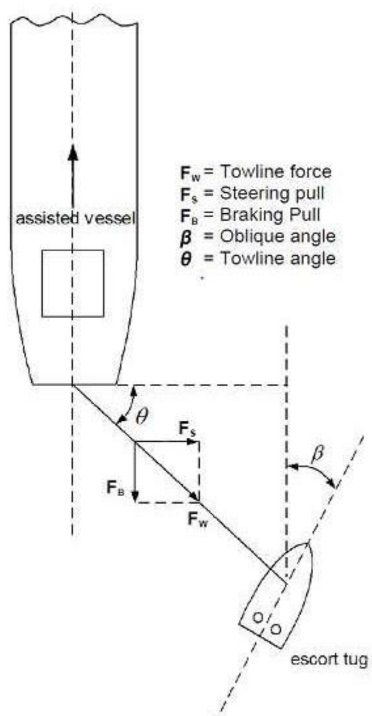


Fig. 13.1.1 Typical Escort configuration

1.3 Plans and datas

1.3.1. Documentation shall be submitted as required by Table 13.1.1.

Table 13.1.1 - Documentation requirements for Escort (FS, T, V)			
Object	Documentation type	Additional description	Info
Vessel	Test procedure for quay and sea trial		FI
	Report from quay and sea trial		FI
Stability	Preliminary stability manual, A document of stability information, including documentation necessary to demonstrate compliance with the applicable rules and regulations or Final stability manual, providing the same content as the preliminary stability manual , however updated with respect to the approved lightweight data and any comments in connection with the preliminary approval	Including stability escort calculations as described in Sect [2.3]	AP
Towing arrangement	A drawing showing the arrangement of a specified area or system. All major equipment shown on the drawing shall be identified by tag number and name. In case of an area, e.g. the engine room, the drawing shall include the main dimensions and layout of the area.All rooms shall be identified by room number and name. Side views and the global location of the area shall be indicated on a miniature general arrangement plan.	Including layout of vessels and towline path with theta-beta angles.	FI
	Calculation reportA document describing assumptions, inputs, boundary conditions, results and conclusions for a calculation that has been carried out	Towing forces, including FW, FS and FB as described in Fig.13.1.1.	FI
Tow line	Specification .A document describing the design basis and technical specification for a product.	Minimum breaking strength / safe working load for tow line and associated components, fixations and supporting structures.	FI

SECTION 2 DESIGN AND STABILITY,TESTS

Contents

2.1 Design

2.1.1. The hull of the tug shall be designed to provide adequate hydrodynamic lift and drag forces when in indirect towing mode. Due attention shall be paid to the balance between hydrodynamic forces, towline pull and propulsion forces, as well as sudden loss of thrust.

2.1.2. The vessel shall be designed so that forces are in equilibrium with a minimum use of propulsive force except for providing forward thrust and balancing transverse forces during escorting service.

2.1.3. The propulsion system shall be able to provide ample thrust for manoeuvring at higher speeds for the tug being in any oblique angular position.

2.1.4. In case of loss of propulsion, the remaining forces shall be so balanced that the resulting turning moment will turn the escort tug to a safer position with reduced heel.

2.2 Freeboard and towing winch

2.2.1. Freeboard shall be arranged so as to avoid excessive trim at higher heeling angles. Bulwark shall be fitted all around exposed weather deck.

2.2.2. The towing winch shall have a hydraulic load reducing system in order to prevent overload caused by dynamic oscillation in the towing line. Normal escort operation shall not be based on use of brakes on the towing winch, but the hold function shall be provided by the gearbox and the hydraulic system instead. The towing winch shall pay out towing line before the pull reaches 110% of the rated towline force F_W.

2.3 Stability

2.3.1. The general stability Pt 7B,Ch 5,Sect 9 [9.5] are to be complied with, in addition to stability criteria given below.

2.3.2. Stability criteria

The area under the righting arm curve and heeling arm curve shall satisfy the following ratio:
$R_{ABS} \geq 1.25$
R_{ABS} = Ratio between righting and heeling areas between equilibrium and 20° heeling angle. Equilibrium is obtained when maximum steering force is applied from tug.

2.3.3. Heeling arm shall be derived from the test. The heeling arm shall be kept constant from equilibrium to 20°, Refer Fig. 13.2.1

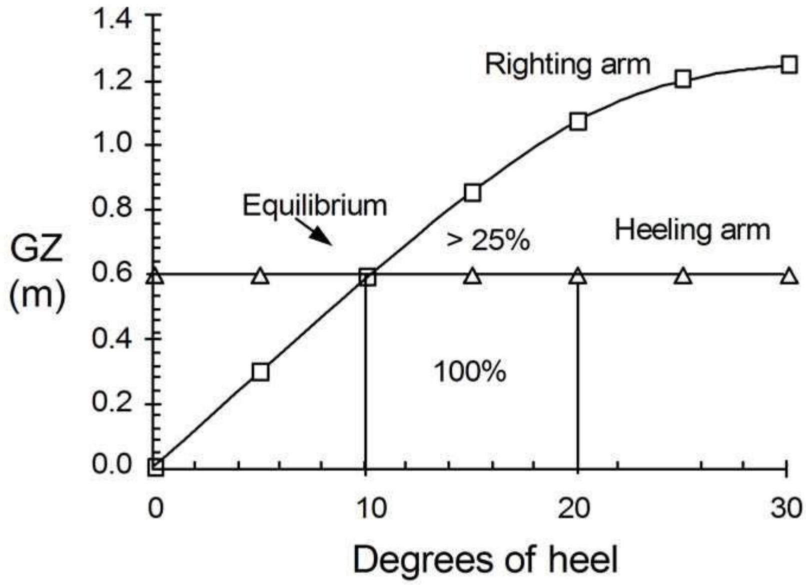


Fig. 13.2.1

Equilibrium to 20°

Note:
The heeling arm shall be taken as escort heeling moment divided by the displacement. For preliminary calculations the heeling arm shall be taken as the maximum value that ensures compliance with the criteria in [2.3.2] and [2.3.4]

2.3.4. The following shall be satisfied:

$A + B \geq 1.4\ (B + C)$
A + B = area under the GZ curve
B + C = area under the heeling moment curve.
The areas are taken from 0° heel to the angle of down flooding or 40°, whichever is less.
Refer Fig.13.2.2.

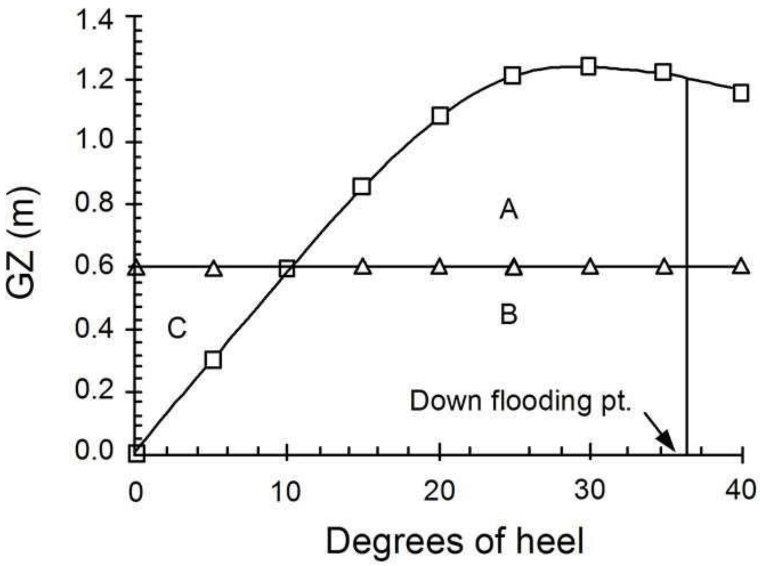


Fig. 13.2.2
Total area requirements

2.4 Tests and trials

2.4.1. The following tests shall be carried out:

a) Measurement of F_S: The escort tug shall connect its towing line wire to the assisted vessel's stern and follow it with the wire slack, both ships travelling at the same speed. The tug will then position itself at an agreed angle of attack relative to the flow of water and the resulting towline tension F_W shall be recorded. These readings combined with the respective θ-β angles combinations shall be then used to establish F_S.

b) Manoeuvre test: The escort tug will shift its position from a steering position minimum 30° from one side of the assisted vessel (i.e. θ is 60°) to the mirror position in the opposite side and *t* will be the time required.

c).The escort test speed is 8 knots and/or 10 knots. An INTLREG surveyor will attend the test for the purpose of witnessing compliance with the agreed test program.

2.4.2. Approved escort departure and escort arrival loading conditions from the stability booklet shall define the way the tug shall be loaded for the trial.

2.4.3. Data Recordings during trials

At least the following data shall be recorded continuously in real time mode during trials for later analysis:

a) towline tension
b) towline length
c) towline angle θ
d) oblique angle β
e) heeling angle on tug
f) speed of assisted vessel, relative to the sea

g) time for the manoeuvre test
h) weather condition and sea state.

2.4.4. Sea trials exceeding critical heeling angle from approved stability calculations shall not be accepted.

CHAPTER 14 DREDGERS

CONTENTS

SECTION 1

Contents

1.1 Application and notation

This chapter applicable to vessels designed for dredging.
Vessels built in compliance with the requirements in this chapter shall be assigned the class notation **"Dredger"**.

1.2 Scope

1.2.1. The following matters are covered by the classification:

a) hull structural details related to the dredging operations

b) supporting structures for the dredging equipment.

1.2.2. The Society shall on request supervise the construction and testing of the following items not covered by the classification:

a) equipment for anchoring and mooring during dredging.

b) equipment and installations for dredging.

1.3 Plans and datas

The following plans and particulars shall be submitted for approval or information:

1.3.1. Plans to be submitted for approval

Foundation and support for dredging equipment –Structural drawing consisting of the geometric dimensions, scantlings and arrangement of a structural object, including:

a) details of parts and openings

b) material specifications.

i. metals describing:

- scope, references and definitions
- production process, delivery condition and chemical requirements
- mechanical testing and requirements
- inspection and non-destructive testing
- repair
- dimensions and tolerances
- surface protection
- certification and marking.

ii. material specifications , non-metallic describing:

- scope, references and definitions
- chemical composition
- delivery conditions
- production process
- testing and requirements
- inspection and non-destructive testing
- repair
- dimensions and tolerances
- surface protection
- certification and marking.

iii. reinforced materials, e.g. glass fibre reinforced plastics, in addition:
- type of reinforcement and production process for reinforcing material
- production process of finished, composite material
- inspection and non-destructive testing of finished, composite material
- repair
- dimensions and tolerances of finished material
- surface protection
- certification and marking.

c) standard details - Shipyard booklet providing drawings of standard details used in the structure. The corresponding details should be identified on the structural drawings

d) details of joints, welding procedures, filler metal particulars and specification of heat treatment after welding

e) inspection category, if not default category

f) procedure for stress relieving of cast steel parts.

1.3.2 Plans to be submitted for information

Dreadging arrangement drawing- the arrangement of a specified area or system. All major equipment shown on the drawing shall be identified by tag number and name.
In case of an area, e.g. the engine room, the drawing shall include the main dimensions and layout of the area. All rooms shall be identified by room number and name. Side views and the global location of the area shall be indicated on a miniature general arrangement plan

1.4 General

The hull structural strength shall be as required for the main class considering necessary strengthening of supporting structures for equipment applied in the dredging operations

CHAPTER 15 CABLE LAYING VESSELS

CONTENTS

SECTION 1

Contents

1.1 Application and Class notation

This chapter applicable to vessels designed for laying cables on the sea bottom.
Vessels built in compliance with the requirements in this chapter shall be assigned the class notation **Cable Laying Vessel**.
Vessels complying with the requirements for the class notation **Barge** (Refer Ch 5 Sect 10) and which comply with the requirements of this section, shall be assigned the class notation **Cable Laying Barge**.

1.2 Scope

1.2.1. The following are included in the classification:

a) hull structural details related to the cable laying operation
b) equipment and installations for cable laying
c) supporting structures for equipment applied in the cable laying operations
d) equipment for anchoring and mooring related to the cable laying operations
e) equipment for positioning during cable laying.

1.3 Plans and datas

1.3.1. Following documents shall be submitted for approval or for information.

a) Documents to be submitted for approval.

i. Cable laying equipment supporting structural drawing Including footprint loads from pipe laying equipment.
The drawing shall have the geometric dimensions, scantlings and arrangement of a structural object, including:

- details of parts and openings
- material specifications , Refer Pt7B Chapter 14 Sect [1.3.1] (b)
- standard details, Refer Pt 7B,Chapter 14 Sect [1.3.1] (c)
- details of joints, welding procedures, filler metal particulars and specification of heat treatment after welding
- inspection category, if not default category
- procedure for stress relieving of cast steel parts

ii. Stowed cable supporting structural drawing as above [1.3.1] (a) (i) excluding footprint loads from pipe equipments

b) Documents to be submitted for information

i. Cable laying equipment with following design criterias,

- applied loads, static and dynamic
- rating with respect to power, temperature, pressure, etc.
- environmental conditions

The description shall include ,
- safe working loads/brake rendering loads
- load directions and points of exertion
- dynamic amplification factors
- description of operational features

ii. Cable laying equipment /arrangement plan of the arrangement of a specified area or system. All major equipment shown on the drawing shall be identified by tag number and name.
In case of an area, e.g. the engine room, the drawing shall include the main dimensions and layout of the area.All rooms shall be identified by room number and name. Side views and the global location of the area shall be indicated on a miniature general arrangement plan.

iii. Stowed cable supporting structure with following design criterias,

- applied loads, static and dynamic
- rating with respect to power, temperature, pressure, etc.
- environmental conditions including maximum weight of stowed cable

1.3.2. Documents for ships with anchoring system for position keeping.

a) Documents to be submitted for approval

i. Anchoring system supporting structural drawing , Including supporting structure for winches and force transmitting structures at points where the anchor lines change direction
The drawing shall have the geometric dimensions, scantlings and arrangement of a structural object, including:
- details of parts and openings
- material specifications , Refer Pt7B Chapter 14 Sect [1.3.1] (b)
- standard details, Refer Pt 7B,Chapter 14 Sect [1.3.1] (c)
- details of joints, welding procedures, filler metal particulars and specification of heat treatment after
- welding
- inspection category, if not default category
- procedure for stress relieving of cast steel parts

b) Documents to be submitted for information

i. Anchoring system /following design criterias

- applied loads, static and dynamic
- rating with respect to power, temperature, pressure, etc.
- environmental conditions Including anchor line forces

ii. Anchoring system arrangement plan , refer Sect [1.3.1](b)(ii) and including limiting anchor line angles.

1.4 Structural strength

1.4.1. The hull structural strength shall be as for the main class taking into account necessary strengthening of supporting structures for equipment applied in the cable laying operations.

1.4.2. For catamarans, semisubmersibles and other special hull configurations, the hull structural strength shall be specially considered

1.5 Equipments

1.5.1. The equipment for mooring and anchoring, i.e. anchors, chain cables windlass, mooring ropes, etc., are shall be as required for the main class.

1.5.2. For catamarans, semisubmersibles and other special hull configurations, the equipment shall be specially considered.

1.5.3. Equipment for positioning during cable laying will be specially considered.

1.6 Certification

1.6.1. Cable laying Equipment subjected to cable loads when the vessel is in operation shall be certified by INTLREG product certificate

1.6.2. Cable handling equipment which is not used while the vessel is in operation, e.g. spooling towers, need not be certified.

CHAPTER 16 SLOP RECEPTION AND PROCESSING FACILITIES

CONTENTS

SECTION 1 GENERAL

Contents

1.1 Application and class notation

1.1.1. Application .This chapter rules applicable to new buildings and conversions of existing vessels to use as floating facilities for reception and processing of oily water and oil residues.These are considered as supplementary to the main class and relevant requirements as in Pt.7B Ch.3 for ships intended for carriage of oil with flashpoint below 60°C.

1.1.2. Class notation

Additional class notation assigned as :**SRP Vessel** considering vessel built with facilities provided,surveyed ,tested and comply the rules of this chapter
Safety against hazards to the personnel, the facility and the environment shall be the major outlook of the class society

1.1.3. Assigning of class shall be subjected to:

- approval of documents, i.e. datas, plans, calculations, etc.,
- approval of the instruction manuals for the facility,
- inspection during manufacturing of materials and equipment,
- inspection during construction, installation and testing of the facility,
- inspection after completion, testing of the separating system for the relevant function.

In addition to the rules of the Society, relevant requirements in the Regulations of National Authorities shall also be complied with the registration and or location of the facility.

1.2 Plans and datas

1.2.1. Refer Certification required oil tankers in Pt 7B Ch.3 Sec.1[1.3] , also the following shall be submitted for approval:

- Drawings and specification for the separating system.
- Drawings of the fendering arrangement.
- Specification of transfer hoses.
- Drawings of deck lighting arrangement.
- Instruction manuals for the facility.

1.2.2. The following control and monitoring datas shall be approved by the Society:

- oil separating system
- fire extinguishing system
- fire detection system
- inert gas system

1.3 Documentation

1.3.1. General

Documents as per Table 16.1.1 shall be submitted before approval work, applicable for ships with integrated systems installed.Typically submitted by yard based upon their detailed specification.

1.3.2. For document assessment, documents in Table 16.1.2 shall be submitted for control and monitoring systems.

1.3.3. For a system subject to certification, documents in Table 16.1.3 shall be available for the surveyor at testing at the manufacturer.

1.3.4. For on-board inspection, documents in Table 16.1.4 shall be submitted to survey station.

1.3.5. Approved control and monitoring systems Operation and Maintenance manual shall be available on board.

1.3.6. The document type number with identification of the control and monitoring system shall be used as a unique identifier for the document. The "T" indicates that the document type is required also for control and monitoring systems where type approved components or software modules are used.

Table 16.1.1 Documents to be submitted before approval work
(typically submitted by yard based upon their detailed specification, applicable for ships with integrated systems installed)

Documentation	Information element	Purpos	Where to
Control System consists of distribution /allocation/segregation of sub systems, description of local/remote controls, specification of failure handling and safe states,description of power distribution principles. (T)	a) .the tasks allocated to each sub-system, divided between system tasks and manual tasks, including emergency recovery tasks b).principles that will be used in the technical implementation of each system	Information	Approval centre
General arrangement	General ship information	Information	Approval centre
General arrangement for the main engine	Equipments layout	Information	Approval centre
Specification of main electro/mechanical equipment	Electric power generation. Main propulsion line(s) with machinery and essential auxiliaries. Miscellaneous machinery or equipment (where control and monitoring systems are specified by other sections of the rules). The following shall be specified: — manufacturer and type — rating — number of — purpose	Information	Approval centre

Table 16.1.2 Documents for assessment (project specific documentation typically submitted by manufacturers)		
Documentation type	Information element	Purpos
Control system Functional description of system configuration,scope of supply, safe states for ach function implemented .(T)	a).clear text description of the system configuration b).clear text description of scope of supply and what is controlled and monitored and how c).clear text description of safe state(s) for each function implemented d).clear text description of switching mechanisms for systems designed with redundancy R0 e).P&I/hydraulic/pneumatic diagrams if relevant.	Approva l
System block diagrams including loactions,and	a). a diagram of connections between all main components (units, modules) of the system and interfaces with other systems.	Approva l
User interface documentation	a). a description of the functions allocated to each work and operator station b). a description of transfer of responsibility between work and operator stations.	Approva l
Power supply ,electric pneumatic ,hydraulic	a).electrical supply: diagram showing connection to distribution board(s), batteries, converters	Approva l
Functional failure mode analysis (T)	The purpose of this functional failure analysis is to document that for single failures, essential systems will fail to safety and that systems in operation will not be lost or degraded beyond acceptable performance criteria when specified by the rules. The following aspects shall be covered: a).a description of the boundaries of the system including power supply preferably by a block diagram b).a list of items which are subject to assessment with a specification of probable failure modes for each item, with references to the system documentation c).a description of the system response to each of the above failure modes identified d).a comment to the consequence of each of these failures.	Approva l

Table 16.1.2 Documents for assessment (Continued) (project specific documentation typically submitted by manufacturers)		
Documentation type	Information element	Purpos
Failure mode and effect analysis (FMEA) (T)	A failure modes and effect analysis (FMEA) shall be carried out for the entire system. The FMEA shall be sufficiently detailed to cover all the systems' major components and shall include but not be limited to the following information: a).a description of all the systems' major components and a functional block diagram showing their interaction with each other b).all significant failure modes c).the most predictable cause associated with each failure mode d).the transient effect of each failure on the vessels position e).the method of detecting that the failure has occurred f).the effect of the failure upon the rest of the system's ability to maintain station g).an analysis of possible common failure mode. h).Where parts of the system are identified as non-redundant and where redundancy is not possible, these parts shall be further studied with consideration given to their reliability and	Approva l

List of control & monitored points (T)	A list and or index identifying all input and output signals to the system as required in the rules, containing at least the following information: a).service description b).instrument tag-number c).system (control, safety, alarm, indication)	Approva l
Circuit diagrams	a).for essential hardwired circuits (for emergency stop, shutdown, interlocking, etc.) details of input and output devices and power source for each circuit.	Approva l
Test procedure at the manufacturer (T)	Description of test configuration and test simulation methods. Based upon the functional description, each test shall be described specifying: a).initial condition b).how to perform the test c).what to observe during the test and acceptance criteria for each test. The tests shall cover all normal modes as well as failure modes identified in the functional failure analysis, including power and	Approva l
Data sheets with environmental specifications	a)data sheet of environmental conditions for temperature, vibration, humidity, enclosure .	Informati on

Table 16.1.3 Documents for the testing at the manufacturer		
Documentation	Information element	Purpose
Software quality plan, based upon life cycle activities	The software life cycle activities shall minimum contain procedures for: a).software requirements specification b).software and hardware design and development plans c).software function test: d).software module test e).software integration testing f).siftware validation ,both functionally and failure modes	Available for information at testing at the manufacturer.
Operation manual	A document intended for regular use on board, providing information as applicable about: a).operational mode for normal system performance, related to normal and abnormal performance of the EUC b).operating instructions for normal and degraded operating modes c).details of the user interface d).transfer of control e).redundancy f).test facilities g).failure detection and identification facilities (automatic and manual) h).data security i).access restrictions j).special areas requiring user attention k).procedures for start-up l).procedures for restoration of functions	Available for information at testing at the manufacturer.
Installation manual	A document providing information about the installation procedures.	Available for information at testing at the manufacturer.

Maintenance manual	A document intended for regular use on board providing information about: a).maintenance instructions b).fault identification and repair c).list of the suppliers' service net.	Available for information at testing at the manufacturer.

Table 16.1.4 Documentation required for on-board inspection, typically supplied by the yard		
Documentation	Information element	Purpose
Test procedure and sea trials	A description of all tests at the quay or at sea trial including: a).initial condition b).how to perform the test c). acceptance criteria for the test.	Approval at local station

1.3.7. Control and monitoring system
The following control and monitoring system shall be certified.

- oil separating system
- fire detection system
- inert gas system.

1.3.8. Conditions

Following conditions of the facility shall consider:

1.3.8.1. The oily water and oil residues originating from oil with flash point below 60°C are considered to maintain a flash point below 60°C and that such liquids are not transferred to the facility's engine room,

1.3.8.2. The transfer of oily water and oil residues between discharged to the facility carried out done under favourable weather conditions,

i. the facility is operated by qualified personnel,
ii. a two-way communication system is essential between the delivery vessel and the facility during the transfer operation.

1.3.8.3. The above stated conditions shall be mentioned in the Appendix to the Classification Certificate for the Facility

SECTION 2 HULL ,PIPING ,FIRE PROTECTION

Contents

2.1 General

Main class rules are applicable for hull strength, also the following shall be considered.:

2.1.1. Additional openings in strength members. The local strength shall be considered in connection with openings and cut-outs in deck, bulkheads, etc.

2.1.2. Loading conditions. The longitudinal strength shall be satisfactory for all relevant loading conditions and conditions during transfer to new location. The facility shall have a loading manual and also a loading instrument.

2.1.3. Tank pressure. The local strength shall be considered for increased internal pressure in the tanks caused by the separating process.

2.2 Fenders

Fenders are provided , supported by hull strength members. Fenders arranged a safe distance of hull , minimum of 3 metres beteween the delivery vessel and the reception facility so as to prevent steel to steel contact and to avoid risk for sparks.

2.3 Transfer of Oily mixtures

2.3.1. The hose minimum bursting pressure shall be 20 bar and maximum allowable working pressure shall be 8 bar.

2.3.2. Hose diameters shall be sufficient for the maximum transfer rate for the facility . Hoses shall be secured well with minimum of bends .At any case hose vibrations not permitted .

2.3.3. A pressure gauge shall be fitted in the transfer line, before the reception tanks.

2.3.4. Before hose disconnection ensure complete draining of the hose . Coamings of suitable height shall be arranged below manifolds and hose connections to avoid spillage

2.4 Deck illumination

2.4.1. Adequate deck lighting shall be provided :

- at the transfer area for safe working and equipments
- for the fire extinguishing equipment, and
- for observation of possible oil in the processed water discharging to the sea [Refer 2.5.4]

2.5 Oil separation

2.5.1. The separating system restrict the oil content in the water being discharged into the sea to a concentration not exceeding 15 parts per million . The actual design performance shall be stated in the Appendix to the Classification Certificate for the facility.

2.5.2. Overpressuring of the process tanks shall be avoided. Sytem design shall be such that for separation process ,ensure an overflow pipe with sectional area at least 25% greater than the area of the filling pipe shall be arranged from the first tank to another tank with surplus capacity.

2.5.3. Detection of the oil/water interface in the tanks shall be arranged .

2.5.4. Monitor also visually oil content in the processed water discharging into the sea by observing the sea surface at the outlet. Visual inspection of the surface in the last separating tank shall alternatively be accepted.

2.5.5. Discharges of separated water from the process shall be above waterline.

2.5.6. The maximum flow rate through the separating tanks shall be specified in the instruction manuals for all grades of oil .

2.5.7. Storage of sediments and separated oil residues shall comply cargo systems on oil tankers as mentioned in Pt.7B Ch.3.

2.6 Oil Content Monitoring

2.6.1. Automatic monitoring of oil content in the processed water shall be arranged. At the set limit exceeded, an automatic stop of the discharge and an alarm shall be activated.

2.6.2. The oil content meter shall be type tested in accordance with relevant IMO specifications and guidelines (Res. A 393 (X) or revised version of same).

2.6.3. The oil content monitor shall be located outside gas dangerous spaces or zones unless the monitor is “certified safe”.

2.7 Fire Protection

2.7.1. Hydrocarbon gas shall not discharge from the vessel to enter gas-safe spaces or zones on the facility and vice versa. The location and the periodical closing of doors and air intakes for ventilating systems, etc., shall be considered as well as the provision of “air locks”.

2.7.2. Spark arresters shall be provided to prevent sparks from the funnel of the facility to enter gas dangerous spaces or zones .

2.7.3. Fire protection, extinguishing and detection
The fire protection, extinguishing and detection arrangements shall comply SOLAS 74 for oil tankers.

2.7.4. A fixed deck foam system as per Reg. 61 of Ch. II-2 of the 1981 Amendments to SOLAS 1974 shall be installed.

2.7.5. An inert gas system complying with the rules for the class notation INERT shall be arranged for supplying inert gas to all tanks.

2.7.6. The capacity of the inert gas plant shall be at least 25% greater than the maximum discharge rate for processed water.

2.8 Electrical installations in gas dangerous spaces and zones

2.8.1. Electrical installations shall comply with applicable requirements in Pt.7B Ch.3.

2.9 Oil residues

2.9.1. Oil residues flash point greater than 60°C originating from engine rooms shall be transferred to tanks within the facility's engine room, and shall be incinerated within the engine room.

SECTION 3 INSTRUCTIONS AND LOG BOOK

Contents

3.1 Instruction Manuals

3.1.1 Class approved Instruction manuals for the facility shall be avaialble onboard. The manuals shall contain following details :

- operation,
- maintenance,
- testing,
- identification of faults and rectification for the following equipment and systems:
- fire detection and extinguishing ,
- inert gas system,
- O_2-content analyzer,
- oily water and oil residues transfer procedure,
- oil content monitoring system,
- other equipment onboard necessary for a safe and pollution-free operation,
- the complete separating system, including possible limitations (pumping rates, types of oil, etc.).

3.2 Operating procedures

3.2.1 The instruction manuals shall also contain relevant information about the operational procedures to be applied onboard, such as:

- mooring,
- safety actions (required closing of doors and ventilating intakes, etc.) to be carried out before the transfer between the delivery vessel and the facility,
- general procedures for operation of the separating system and the inert gas system.

3.2.2 The operational procedures shall include the following:

- The O_2-content of storage and separating tanks , shall be checked upon discharge, and at least twice a week.
- Two-way communication between the reception facility and the delivery vessel shall be established before the transfer commences.
- Before discharge into the sea , visual inspection of the surface (Refer Sec.2 [2.5.4]) shall be carried out and the automatic oil content monitor checked.

3.2.3 The maintenance procedures shall include:

- sheduled inspection and maintenance of the exhaust spark arresters.

3.3 Log Book

3.3.1 Entries in log book

For record keeping and documentation versus local/national authorities it is recommended that the following guidelines are complied

a) The officer in charge of the operations concerned shall be responsible for the entries in the log book.

The log book should be kept onboard available for inspection.
The log book entries should be kept onboard for a period of at least three years.

b) Entries before commencement of operation

- -Transferring material specification
- -Quantity to be transferred.
- -Safety actions carried out.
- -Rate of transfer.
- -Weather conditions during transfer.

c) Volume and the exact time when processed water is dis-charged into the sea.
Exact time when the oil content in the processed water being discharged into the sea exceeds the specified limit.

Internal transfer of oily water and oil residues.
Use of the inert gas plant.
Result and the exact time of checking O2-content in the tanks.
Inspection and testing of fire detection and extinguishing equipment.
Inspection and maintenance of the inert gas plant.
Inspection and maintenance of the exhaust spark arrester.
Inspection and maintenance of the transfer arrangement.
Inspection and maintenance of the oil content monitor.

CHAPTER 17 DIVING SUPPORT VESSELS

CONTENTS

SECTION 1 GENERAL

Contents

1.1 Scope and classification

1.1.1. The scope of this section :

a) Classification of diving systems,certification and related activities
b) Classification process in general.

1.1.2. Classification

For general regulations and classification rules Refer Pt.1 Ch.1

1.1.3. Diving support vessels arranged for support of diving operations applying rope and/or umbilical connection between the submerged bell and the diving support vessel shall assign the class notation:

a) DSV-SD or
b) DSV-DD

as applicable.
The above class notations require that the diving support vessel is equipped with a diving system classified by INTLREG in compliance with - Rules for Classification of Diving Systems

Table 17.1.1 Class Notations

Class	**DSV -SD** Diving system – Surface/Shallow	**DSV -DD** Diving system – Saturated/Deep Diving
Restrictions	d_{max} ≤ 60 msw *) T_{OP} ≤ 8 hours	None, except those imposed by the rule requirements
Provisions	Open or closed bell allowed No HES required (Hyperbaric Evacuation System).	Closed bell Dedicated HES required (Hyperbaric Evacuation System .
*) msw = metres sea water, d_{max} = maximum operating depth		

Note:
These requirements comply the IMO Code of Safety for diving systems adopted 23 November 1995 as res. A.831(19).

1.2 Diving systems survey

1.2.1. Below requirements applicable to ships with class notation:**DSV** or **Diving systems**.

1.2.1.1. The requirements also apply to transferable diving systems, where the regular periodical surveys are carried out when such systems are in service.
In case of transferable diving systems are out of commission, annual surveys as described in [1.2.5] are carried out.

1.2.1.2. Survey requirements by a recognised classification society apply to all diving systems on vessels classed by the Society.

1.2.1.3. A Survey Planning Document shall be part of the documentation on board for the lifetime of the diving system.

1.2.1.4. For transferable diving systems, the Survey Planning Document shall specify scope for surveys when the system is installed and for surveys when the system is in storage (laid-up).

1.2.1.5. The Survey Planning Document shall be written in English (or translated into English), and approved by the Society prior to the survey . Checklists shall be included, as attachments.

It shall have the following information printed on the front page:

- “DSV Survey Planning Document” (title)
- name of support vessel or installation given in the Classification Register
- the Society’s identity number given in the Classification Register
- IMO number (for statutory surveys)
- name of company
- revision number and date.

Note:
A Survey Planning Document gives owners and surveyors a chance to tailor the instructions to fit each individual system or component and thereby avoid misunderstandings often encountered with respect to the application of generic requirements. This may also streamline the surveys in consideration of the operational situations in each case.

Checklists shall be made available for the surveyor to fill out and endorse at each survey. The checklists shall include the following information at the top of each page:

- name of support vessel or installation given in the Classification Register
- the Society’s identity number given in the Classification Register
- IMO number (for statutory surveys)
- page number
- name of company
- scope of survey (Annual, Intermediate, Renewal or otherwise) in columns:

Survey item, Condition, Action, Comment.

1.2.2. Annual survey

The survey is normally to include:

- calibration of essential instrumentation (depth gauges, gas analysers etc.)
- Switching from main to emergency electrical power supply
- emergency systems including bell emergencies (buoyancy if applicable)
- functional and power testing of normal and emergency systems of the bell handling system shall be carried out with a load of at least 1.25 times the working weight in the most unfavourable position
- partly dismounting of heat protection and penetrators on the bell may be required.

Detailed specification of test requirements are given in the relevant sections of Rules.

1.2.3. Intermediate survey

The following tests shall be carried out:

- gas leak tests
- testing of safety valves

- functional test of fire detection-, alarm- and extinction systems
- functional tests of life support systems
  functional tests of alarm systems
- functional tests of mechanical and electrical systems.

1.2.4. **Complete survey (5 years)**

1.2.4.1. Bell buoyancy materials, heat protection, penetrators, windows and attached members shall be dismounted for inspection for possible corrosion and deterioration.

1.2.4.2. Pressure tests and inspections shall be carried out according to an approved procedure given as part of the Survey Planning Document, and following the principles given in items [1.2..4.6] and [1.2.4.7].

Test pressure shall be stamped on the pressure vessels according to the design code or, in the case of welded pressure vessels, engraved on an attached tag.
Applicable codes, standards and regional requirements shall be specified in the procedure.
Pressure testing shall be carried out according to the design code of the pressure vessel and to international standards for such testing.
The test pressure shall be as stamped on the pressure vessel and given in the accompanying certificate.

Note:
International testing standards include EN 1968 *Transportable gas cylinders - Periodic inspection and testing of seamless steel gas cylinders*.
The applicable working pressure and corresponding filling ratios should meet the requirements in BS EN 13099:2003

Transportable gas cylinders. Conditions for filling gas mixtures into receptacles or equivalent standard.

Regional requirements may also apply, such as the HSE Approved

Specification Number CP1-3T Specification for Large seamless steel (897 to 1069 N/mm^2) Transportable Gas Containers or Code of Federal Regulations Title 49 Ch.I Part 178 Subpart C Sec.178.45 Specification 3T seamless steel cylinder. (CITE: 49CFR178.45 US DOT).

1.2.4.3. Proof test or volumetric expansion test shall be carried out according to that which is required by the design code or regional requirements.

1.2.4.4. Downgrading of chambers may be requested either:

- to carry out periodical pressure testing after ten years pneumatically at a reduced pressure, or
- after installation of view-ports with a lower design pressure than the chamber, or
- after any other causes which do not imply a reduction of strength of the pressure vessel.

The procedure necessitates re-stamping of the pressure vessel, and issue of Memo to Owners (MO). The MO shall include the necessary information with respect to:

- the new maximum operating pressure of the diving system, and
- the reasons behind the downgrading.

1.2.4.5. Pneumatic testing shall not be carried out at pressures above the design working pressure.

1.2.4.6. At 1st Complete survey the interval for hydraulic pressure testing of gas containers may be extended to 10 years if the following principles are applied:

- External and internal survey by intrascope.
- If internal survey is not possible or if corrosion or other items of concern are found, hydraulic test shall be carried out to the test pressure determined by the design code.

At all subsequent Complete periodical surveys:

- External and internal survey by intrascope.
- Hydraulic test to the test pressure determined by the design code.

1.2.4.7. At 1st Complete survey the interval for hydraulic pressure testing of bell and chambers may be extended to 10 years if the following principles are applied:

- External and internal survey.
- If internal survey is not entirely possible or if corrosion or other items of concern are found, hydraulic test shall be carried out to the test pressure determined by the design code.
- Alternatively, pneumatic test to the working pressure may be carried out and the pressure vessel down graded, [Refer [1.2.4.4]

At all subsequent Complete periodical surveys:
Alternatively, pneumatic test to the working pressure shall be carried out and the pressure vessel down graded, [Refer 1.2.4.4]

1.2.4.8. The working weight of the bell shall be checked.

1.2.4.9. A test of the bell handling system with a static load equal to the design load shall be carried out.

1.2.4.10. If applicable the bell's releasable ballast system with attachments shall be structurally tested with a static load 1.5 times the weight of the ballast in air.

1.2.4.11. Viewports with an age of 10 years or more shall be changed unless a special survey warrants an extension.

The special survey shall be carried out to a procedure approved by the Society in accordance with ASME
PVHO-2 - 2012 *Safety Standard for Pressure Vessels for Human Occupancy: In-Service Guidelines*.

1.2.5. **Survey of diving systems 'out of commission'**

1.2.5.1. Diving systems which have been out of commission, i.e. laid up, for a period normally of at least 12 months, shall be surveyed and tested before re-entering service. The extent of the surveys and tests will be considered in each case depending upon:

- the time the diving system has been out of commission
- the maintenance and preservative measures taken during lay-up
- the extent of surveys carried out during this time.

As a minimum, a sea trial for function testing of the diving system shall be carried out.

1.2.5.2. During lay-up, diving system shall be subjected to a lay-up survey on an annual basis.

The extent of the lay-up survey is reduced compared to the regular annual survey, but shall cover system integrity, planned maintenance system, fire protection and equipment in use.

1.2.5.3. If the lay-up period is more than 12 months, other periodical surveys shall be postponed, depending on the maintenance and preservative measures taken during lay-up.

1.2.6. Requirements which do not specifically refer to **DSV-SD** or **DSV-DD** diving systems, or which are called minimum requirements in the rules, apply to all systems.

1.2.7. In case of a diving system classified by the Society has been installed on:

a) a ship or a mobile offshore platform mobile offshore unit not covered by the Society's classification, or
b) on a fixed offshore installation, or
c) on an onshore site,

an arrangement shall be agreed for periodical surveys in order to ensure proper maintenance of the diving system. Corresponding documents shall be issued. INTLREG will require that the ship or mobile offshore platform be classified in a recognized classification society.The main particulars of the diving system shall be entered in the register of vessels classed with INTLREG.

1.3 Class notation

1.3.1. A DSV Class notation will be issued in the Classification Certificate for the vessel as a formal statement confirming that the diving system installation has been completed in accordance with specified requirements.

1.3.2. Accompanying documents to the class notation shall contain:

a) diving system description and item number, the certificates and reports
b) operational limitations and conditions of use for which the diving system is intended
c) codes and standards , the diving system compliance.

1.4 Control station

1.4.1. Centralized station “Control stand” or “Control station” is a control station of following controls and indicator functions are provided :

1) Indication and operation of all vital life support conditions, including pressure control
2) Visual observation, communication systems including telephones, audio-recording and microphones to public address systems
3) Disconnection of all electrical installations and Insulation monitoring
4) Provisions for calibration of and comparison between gas analysing
5) Indication of temperature and humidity in the inner area

6) Alarms for abnormal conditions of environmental control systems
7) Fixed fire detection and fire alarm systems
8) Ventilation fans
9) Automatic sprinkler, fire detection and fire alarm systems
10) Launch and recovery systems, including interlock safety functions
11) Operation and control of the hyperbaric evacuation system

Plans and datas

Plans and datas shall be submitted for approval as specified in Pt.1 Chapter 1 Sect 5 and the respective sections of the rules.

1.5 Position Keeping, Stability and Floatation

1.6.1. The diving support vessel shall comply the requirements to Stability and Floatation ,Refer Rules for Building and Classing steel veseels Pt.7B Ch.5 Sec.5 for additional class notation **SF**.

1.6.2. The diving support vessel shall be able to keep its position safely during diving operations. This implies a system with built in redundancy for position keeping. The position keeping system may be a mooring system with anchors or a dynamic positioning system.

1.6.3. For diving support vessels, equipped with a dynamic positioning system, the class notation **DP** or higher is mandatory. Alarms shall be initiated and set accordingly.

1.6.4. For mooring systems with anchors, the notation **MOOR** or higher is mandatory.

1.6.5. Between the operation centre for the positioning system and the dive operation centre there shall be:

a) redundant communication systems
b) a manually operated alarm system.

1.6 Quality plan

1.7.1. For diving system installation a quality plan shall be submitted for approval . Reference shall be ISO 10005:2005 - “Guidelines for Quality Plans”.

1.7 Pre-Classification

1.8.1. Data and description of system development and general arrangement of the diving system installation shall be established and submitted to INTLREG for design approval preview.

1.8.2. The data and description shall include the following, as applicable:

a) safety objective
b) locations, supporting structures and interface conditions
c) diving system description with general arrangement and system limits
d) functional requirements including system development restrictions, e.g., significant wave height,
e) hazardous areas, fire protection
f) installation, repair and replacement of system elements and fittings
g) project plans and schedule, including planned period for installation
h) design life including specification for start of design life, e.g. final commissioning, installation
i) data of contained liquids and gases

j) capacity and sizing data
k) geometrical restrictions such as specifications of diameter, requirement for fittings, valves, flanges and the use of flexible hoses second and third party activities.

1.8 Installation Plan

1.9.1. The design and planning for a diving system installation shall include all development phases of manufacture, installation and operation.

1.9.2. Installation

Detailed plans, drawings and procedures shall be prepared for all installation activities. Minimum following shall be included:

a) diving system location overview (planned or existing)
b) other vessel (or fixed location) functions and operations
c) list of diving system installation activities
d) alignment rectification
e) installation of foundation structures
f) preparation of outer area to proceed with installation of interconnecting services (e.g. pipes, cables, etc) completing welding, painting, general cleaning, etc.
g) installation of interconnecting services
h) installation of protective devices
i) hook-up to support systems
j) as-built survey
k) final testing and preparation for operation.

1.9 Inspection and Testing

1.10.1. The general scope for survey of diving systems shall be documented in a system specific survey planning document.

1.10.2. When a diving system is built and installed according to these rules, surveyor shall verify that:

a) the design and scantlings comply with the approved plans and the requirements in these rules and other specified recognized standards, codes, and national regulations
b) that the materials and components are certified according to these rules and the terms of delivery
c) that the work is carried out in accordance with the specified fabrication tolerances and required quality of welds etc.
d) that piping systems conducting gas in life support systems are cleaned in accordance with an approved cleaning procedure
e) that gas cylinders are clean and sealed
f) that all required tests are carried out.

The inspection shall be carried out during the assembly and during installation. The extent and method of examination shall be agreed prior to the work being carried out.

1.10.3. Installation test after completion

A comprehensive test plan for the fully installed system shall be submitted for approval. This plan shall include testing details for, as a minimum:

a) Pressure tests
b) Purity tests Gas leakage tests

c) Handling systems
d) Life support systems
e) Safety systems
f) Electrical systems
g) Instrumentation
h) Environmental control systems after installation onboard
i) Sea trials

1.10 Name plates

1.11.1. **1.**11**.1** Diving system installation main components shall be stamped with an official number or other distinctive identification .The certificate shall contain the official number and distinctive identification.

1.11.2. Nameplates shall be of flame retardant material bearing clear and indelible markings shall be placed so that all equipment necessary shall be easily identified. The name plates shall be permanently fixed.

1.11.3. **Pressure vessels, piping systems**
Pressure vessels, gas containers and piping systems shall be consistently colour coded. There shall be a chart posted in the control room describing the colour code.

1.11.4. **Handling system**

The handling system shall be fitted a nameplate with following particulars:

a) identification number
b) static test load
c) functional test load
d) working weight
e) surveyor's mark and identification.

The above loads shall be specified for each transportation system involved.

SECTION 2 DIVING SYSTEMS

Contents

2.1 Location and arrangement of the diving system

2.1.1. Location of diving system shall be such that diving operations shall not be affected by propellers, thrusters or anchors.

2.1.2. Diving operations, systems are sited in hazardous areas, the electrical equipment should comply with the requirements for such equipment in hazardous areas. Diving systems should not be permitted in hazardous areas designated as zone O.

2.1.3. The location of a DSV-DD diving system on a ship, mobile unit or fixed offshore structure, or land site, shall be in a safe area with respect to explosive gas-air mix.
Safe areas are areas not defined as hazardous zones in International Electro technical Commission's Publication No.79-10, and IMO (MODU) code, chapter 6, as follows:

a) Zone 0: an explosive gas-air mixture is continuously present or present for long periods.
b) Zone I: an explosive gas-air mixture is likely to occur in normal operation.
c) Zone 2: an explosive gas-air mixture is not likely to occur, and if it occurs it will only exist for short time.

However, DSV-DD diving systems shall be located in spaces , defined as Zone 2.

2.1.4. When any part of the diving system is sited on deck,consideration shall be provided for reasonable protection from the sea, icing or any damage which may result from other activities on board the ship or floating structure. This includes the Hyperbaric Evacuation System (HES).

2.1.5. Diving systems located on open decks shall not be near the vicinity of ventilation openings from machinery spaces, exhausts or galley ventilation outlets .

2.1.6. The diving system shall avoid sources of noise that may expose divers to harmful noise. Personnel in the in the outer area shall have the possibility to communicate in an acceptable way where 75 dB(A) should be the noise limit.

If the diving support vessel does not carry the class notation **COMF-V**, the diver's accommodation area (inner area) shall be subject to the relevant vibration and noise measurements . The noise limit shall not exceed 60 dB(A). The noise limit 55 dB(A) shall be recommended.

2.1.7. The breathing gas storage and diving system shall be away from machinery spaces.

2.2 Environmental Conditions

2.2.1. Diving system components shall withstand the environmental conditions expected at their installed location (on the diving support vessel or otherwise) and their geographic area of operation.

2.2.2. Consideration shall be taken to external environment in terms of Toxic (H2S and Hydro Carbon) gas. If an environment of Toxic gas exist at operating in known geographical araeac, then contingencies shall environment in terms of Toxic be provided and operational response to mitigate exposed risk. The effects of environmental phenomena relevant for the particular location shall be considered .

2.2.3. External environmental conditions

2.2.3.1. Design inclinations shall be according to Table 17.2.1 .

Table 17.2.1 Design inclinations				
Location	R o	Per m	P i	T r
Chambers and other surface installations:				
On a ship	+ /	+/- 15	+ /	+ /
On a mobile offshore unit		+/- 15		+ /

2.2.3.2. Range of ambient temperature: -10°C to 55°C, unless otherwise specified. For greater temperature ranges, temperature protection shall be provided.

2.2.3.3. Humidity: 100%.

2.2.3.4. Atmosphere contaminated by salt (NaCl): Up to 1 mg salt per 1 m3 of air, at all relevant temperatures and humidity conditions.

2.3 Corrosion

2.3.1. Corrosion control, including corrosion allowance , inspection and monitoring, the following conditions shall be defined:

a) maximum and average operating temperature and pressure profiles of the components, and expected
b) variations during the design life
c) expected content of dissolved salts in fluids, residual oxygen and active chlorine in sea water
d) chemical additions and provisions for periodic cleaning
e) provision for inspection of corrosion damage and expected capabilities of inspection tools limits and sizing capabilities for relevant forms of corrosion damage) the possibility of wear and tear, galvanic effects and effects in still water pools shall be considered.

2.4 System integrity

2.4.1. Diving systems shall be operated to:

a) fulfil the specified operational requirements
b) fulfil the defined safety objective and have the required support capabilities during planned operational conditions
c) have sufficient safety margin against accidental loads or unplanned operational conditions
d) cater for the possibility of changes in the operating conditions and criteria during the lifetime of the system.

2.5 Monitoring

2.5.1. Parameters shall be monitored and evaluated with a frequency that enables remedial actions to be carried out before personal harm is done or the system is damaged.

2.5.2. Instrumentation shall be required when visual inspection or simple measurements are not considered practical or reliable, and available design methods and previous experience are not sufficient for a reliable prediction of the performance of the system.

2.5.3. The various pressures in a diving system shall not exceed the design pressures of the components during normal steady-state operation.

SECTION 3 SUPPORT STRUCTURES

Contents

3.1 Fastening arrangements

3.1.1 Arrangements shall be made for the diving system installations and auxiliary equipment securely fastened to the ship or floating structure and adjacent equipment is similarly secured.

The relative movement between the components of the system and the fastening arrangements shall be sufficient to meet any required survival conditions of the ship or floating structure.

The diving system onboard and the equipment related to the diving system shall be permanently attached to the hull structure (e.g. by welding, bolted connection or similar). Securing by lashing is not a permanent fitting.
All supporting structure(s) shall be according to Pt.3 with additional requirements as below.

Note:
Foundations are considered as a part of the diving system,and the supporting structures structural
supports are considered as a part of the ship's structure/hull.

3.1.2 In addition to [3.1.1] above, foundation supporting structures supporting diving system equipment shall have scantlings based on the supported mass. The design loads shall not be less than:

a) Pv = 16 M (kN), for L < 100 m
b) Pv = $(g_0 + a_v)$ M (kN), for L ≥100 m
c) P_L (forward dir.) = 0.5 g0 M (kN)
d) P_L (aft dir.) = 0.25 g_0 M (kN)
e) P_T (transverse dir.) = 0.5 g_0 M (ref.**3.2.2**).

Where:
M = mass of equipment, heavy components, etc. in tonnes
a_v = combined vertical acceleration as given in Pt.3 Ch.4 Sec.2[2.6] .
For deck cargo units , Refer Pt.3 Ch.4 Sec.3[3.5] .
Acceptable stress levels for the girders are:

- σ_b = 160 f_1 (N/mm2)
- τ = 90 f_1 (N/mm2)
- $\sigma e = (\sigma_b^2 + 3\tau^2)^{1/2} = 200 f_1$ (N/mm^2)
- f_1 = material factor as defined in Pt.3 Ch.3 Sec.[3.2].

3.1.3 The supporting structures and foundations shall be calculated for values of accelerations determined as in Pt.3 Ch.4 or other acceptable standards. Design loads for external sea pressure on deck mounted diving system modules essential to the diving operations, shall be calculated according to Pt.3 rules for deck housing sides and ends, including supporting structures.

3.1.4 The supporting structures of other equipment, not categorised under [3.2]or [3.3] , shall be considered.Drawings of the deck structure below the foundation shall be submitted for approval when the static forces exceed 50 kN or when the resulting bending moments at deck exceed 100 kNm. The drawings shall indicate the relevant forces and bending moments acting on the supporting structure.

3.2 Supporting structures and foundations for pressure vessels

3.2.1 Pressure vessel(s) exposed to static and dynamic loads while allowing contraction and expansion of the pressure vessel(s) under pressure variations and temperature variations, shall be supported. The stress level in the pressure vessel(s), connected pipes, the supporting structures and foundations shall be kept within acceptable level.Allowable deflections for the stiffness of supporting structure shall be a design input to the pressure vessel manufacturer(s).

Note:
Due to the pressure variations the chambers and large gas storage tubes shall expand and contract considerably in service All supporting structures and foundations for these pressure vessels shall allow for this movement.

3.2.2 The pressure vessels with supports shall be designed for a static inclination of 30° without exceeding the allowable stresses as specified in [3.1.3]

3.2.3 To withstand a collision force acting on the pressure vessels appropriate supporting structures and foundations shall be provided corresponding to one half the weights of the pressure vessels in the forward direction and one quarter the weight of the pressure vessels in the aft direction.

3.2.4 The loads mentioned in [3.2.3] need not to be combined with each other or with wave-induced loads.

3.2.5 Unless removal of the pressure vessel(s) is a simple operation, the supporting structure(s) shall be able to sustain the static load of the pressure vessel(s) during periodic hydro testing or it shall be possible to shore/ support the supporting structure(s) in order to avoid unacceptable deflections.

3.3 Supporting structures and foundations for handling systems.

3.3.1 Supporting structures and foundations for handling systems and lifting appliances shall be determined according to Pt.4 Ch.5 or according to other recognised standards.
Interfaces between the handling system structure and the vessel shall be especially considered. Drawings of scantlings and joint configuration including maximum design loads shall be approved including (but not limited to) supporting structures for winches, sheaves and dampers.

3.3.2 The dynamic coefficient shall as a minimum of 2.2 when the lifting appliance is used for handling manned objects such as surface bells, baskets or Hyperbaric Evacuation Systems. For other lifting appliances, not used for lifting people, the dynamic coefficient shall as a minimum of 1.5.

3.3.3 The side structure of the moon pool shall be strengthened with respect to possible impact loads from diving equipment guided through the moon pool.

Note:

All lifting appliances used in the operation of the diving system shall be considered offshore lifting appliances.

3.4 Documents

The following documents shall be submitted for approval and information:

a) General arrangement of hangar area of all lifting appliances and sheaves etc., including design loads
b) Design loads and allowable deflection at each foundation
c) Deflection calculation for the supporting deck structures under the diving chambers
d) Installation procedures.

SECTION 4 VENT PIPING,GAS STORAGE

Contents

4.1 Piping

4.1.1 Vent gases from the diving system shall be discharged to the open air away from sources of ignition, personnel or any area where the presence of those gases shall be hazardous.Arrangement shall be provided to prevent any dangerous accumulation of gases. The discharge from overpressure relief equipments and exhaust shall be led to a location where hazard is not created.

4.1.2 Piping systems carrying mixed gas or oxygen under high pressure shall not be permitted inside accommodation spaces, engine rooms or similar compartments.
Piping systems shall comply with the technical requirements for class I piping in these rules Pt.4 Ch.6.

4.1.3 All high-pressure piping shall be well protected from mechanical damage.

4.1.4 Piping for gas and electrical cables shall be separated.

4.1.5 All filters/strainers shall be arranged to isolate without interrupting the supply to essential systems.

4.1.6 Diving system sanitary and drainage systems connected to ship systems shall be designed to avoid an unintentional pressure rise in the ship system in case of malfunction or rupture of the diving systems.

4.1.7 Breathing gas and oxygen piping systems shall be cleaned and tested in accordance with an approved test method. The minimum acceptable cleanliness levels, as defined in ASTM G93-03 Standard Practice for Cleaning Methods and Cleanliness Levels for Materials and Equipment

Used in Oxygen-Enriched Environments, shall be:
1) ASTM Level B for non volatile residue in ‘Oxygen’ lines
2) ASTM Level D for non volatile residue in breathing gas lines
3) ASTM Level 175 for particulate contamination

4.1.8 Oxygen systems Relief devices high pressure discharge and exhaust from O2 systems shall be ducted to a safe place and not close to a source of ignition, engine room exhaust or ventilation from galley.

4.2 Gas Storage

4.2.1 If gas mixtures having oxygen content less than 20% are stored in enclosed spaces, there shall be two oxygen analysers with an audio-visual low level alarm in addition to the ventilation requirements in [4.2.2].These analysers shall be installed so as to one reading the upper levels and the other reading the lower levels of the enclosed space.

4.2.2 **Oxygen gas storage**
Oxygen bottles shall be stored in a well-ventilated space. The rooms shall be separated from adjacent spaces and ventilated according to Sec.[6 .2.5] and shall be fitted with an audio-visible oxygen alarm, at a manned control station.

4.2.3 Oxygen bottles are not to store near flammable substances.Oxygen shall not be stored or ducted in any form close to combustible substances or hydraulic equipment.

4.2.4 Diving support vessels with class notation FI-FI, the oxygen gas bottles shall be protected from heat that may radiate from a fire that is being extinguished.

SECTION 5 ELECTRICAL SYSTEMS

Contents

5.1 General

5.1.1 For general requirements for electrical systems refer Pt.6 . The purpose of this section describes additional requirements for electrical systems and equipment serving diving systems.

5.1.2 Documents

For electrical systems the following shall be documented:

i. A description of the overall electrical system shall be submitted. This document shall describe the operational modes of the system, failure scenarios , redundancy principles, automatic changeover systems, etc.
ii. General arrangement showing location of all important electrical equipment for diving system. E.g. main/emergency switchboards and distributions, UPSes, motor starters for bell winches, hot water heaters, lighting, control stations, etc.
iii. Single line distribution system diagrams for the whole installation. The diagrams shall provide information on full load, cable types and cross sections, and make, type and rating of fuse- and switchgear for all distribution circuits.
iv. Calculations on load balance analysis, including emergency power and battery system.
v. Complete multi-wire diagrams, preferably key diagrams, of control and alarm circuits for all motors or other consumers
vi. Plans showing arrangements of batteries with information about their make, type and capacity
vii. Plans showing arrangement and single line diagrams of the communication system.

5.2 Electrical systems serving diving systems

5.2.1 All electrical equipment and installation, including power supply arrangements, shall be designed for the environment in which they will operate to minimize the risk of fire, explosion, electrical shock and emission of toxic gases to personnel, and galvanic action of the surface compression chamber or diving bell. Electrical cables and piping for gas shall be separated.

5.2.2 In case of failure of the main source of electrical power supply to the diving system an independent source of electrical power shall be available for the safe termination of the diving operation.

5.2.3 Ship's emergency source of electrical power shall be also used for diving system provided it has sufficient electrical power capacity to supply the diving system and the emergency load for the vessel simultaneously.

5.2.4 The alternative source of electrical power shall be located outside the machinery casings to function in case of fire or other casualty causing failure to the main electrical installation.

5.2.5 Interface between diving system and the ship or floating structure shall be provided with suitable electric lighting.Primary and emergency lighting in all critical handling areas shall be provided.

5.3 Communication and testing

5.3.1 The communication system should be arranged for a fixed direct two-way communication between the control stands and:

a) diving system handling positions
b) dynamic position control centre
c) bridge, ship's command centre or drilling floor
d) crane
e) ROV control stand.

This fixed communication systems shall also be arranged for direct two-way voice communication between the Dive control room and the SAT control room (for DSV-DD). it has sufficient electrical power capacity to supply the diving system and the emergency load for the vessel at the same time

5.3.2 The communication system shall be functionally tested after installation

SECTION 6 FIRE PREVENTION,DETECTION AND EXTINCTION

Contents

6.1 General

6.1.1 For general requirements for fire protection refer Pt.5A Ch.13. Additional requirements are detailed in this section regarding fire protection of areas containing diving equipment with auxiliaries and systems to be connected to the diving compression chambers and diving bells.

6.1.2 This section applicable to all systems,but some systems shall be located on open deck. The requirements for insulation against adjacent spaces and sprinkler systems shall be evaluated as relevant.

6.2 Documents

6.2.1 Fire prevention, detection and extinction shall be documented as follows:

a) General arrangement defining all spaces serving as “outer area”, their fire integrity towards other spaces and type of fixed fire-extinguishing proposed for each area as part of “outer area”.
b) A list of insulation materials to be installed in the outer area, where possible with data on and or evaluation of flammability in conditions under which the materials can be used.
c) Plans of fire detection, fire alarm and fire extinction equipment for the outer area.

6.2.2 Materials and plan
Enclosed “outer area” shall have A-60 class towards other enclosed spaces. Outer area shall be subdivided into several spaces by A-0 class. There shall be no direct access between categories A machinery spaces outside of “outer area”. At least one of the required escape routes from spaces shall be independent of “outer area”. All doors between outer area and adjacent enclosed spaces shall be of self-closing type.

6.2.3 Piping and cables essential for the operation of the diving system shall install in separate structural ducts insulated to A-60 class standard where these transit from other spaces as main switch board room or engine room into “outer area”.

6.2.4 Ventilation shall provide for Outer area in the ship or floating structure should be arranged in spaces or locations which are adequately ventilated.If situated in enclosed spaces the outer area shall provide separate mechanical ventilation with minimum 8 air changes per hour.

6.2.5 To minimize the risk of fire and sources of ignition insulation materials used shall be of fire-retardant type.

6.3 Fire Detection and Alarm System outer area

6.3.1 The outer area if situated in enclosed spaces, shall be provided automatic fire detection and alarm systems complying with SOLAS Reg. II-2/7.1 and FSS Code Ch.9 . The section or loop of detectors covering the outer area shall not cover other spaces. Fire detection panel shall be placed on the bridge, with repeater panel at dive control room and in engine control room .A visual repeater, showing the alarm status, shall place at the saturation- and diving control stand.

6.3.2 Outer area: Those areas of the diving system that are exposed to atmospheric conditions during operation, i.e. outside the inner system and the room or area that surrounds or contains the diving system.

6.4 Fire Extinguishing Outer area

6.4.1 An appropriate fixed fire-extinguishing system shall be installed for Interior spaces containing diving equipment such as surface compression chambers, diving bells, gas storage, compressors and control stands .If situated in enclosed spaces, the outer area shall be provided with a fixed, manually actuated fire extinguishing system with such a layout as to cover the complete system. Release positions for these systems shall be at the dive control room, bridge and / or other positions.

6.4.2 It shall cover at least the largest area enclosed by A-0 class.

6.4.3 The extinguishing system shall be either:

a) a pressure water spraying system approved for use in machinery spaces of cat. A, or
b) an equivalent fixed gas fire-extinguishing system in accordance with the FSS Code and IMO MSC/circ. 848, amended by MSC/Circ. 1267.

6.4.4 If a gas system is planned, the agent shall be of a type not hazardous to humans in the concentration foreseeable in the protected space. The concentration shall be below the NOAEL as defined in IMO MSC/ Circ.848/1267.

6.4.5 If enclosed spaces have any pressure vessels,then a manually actuated water spray system at the rate of 10 l/m2/per minute of the horizontal projected area shall be provided to cool and protect such pressure vessels in the event of external fire. For equivalent water-mist fire-extinguishing systems with application rate less than 5 l/min/m2, an additional object protection of 5 l/min/m2 is accepted as equivalent to 10 l/min /m2.Release positions for these systems shall be at the dive control room, bridge and / or other positions as required. The capacity shall be sufficient to cover the most demanding space enclosed by A-class divisions.

6.4.6 If pressure vessels are situated on open decks, fire hoses shall provide for necessary protection.
If on open deck, the outer area shall be provided with fire extinguishing equipment.
In the case of a fire Hyperbaric evacuation systems shall be provided with fire extinguishing systems for launching of the hyperbaric evacuation unit. Object protection of area for hyperbaric evacuation systems shall be activated automatically upon any confirmed fire onboard.

6.4.7 Fire-fighter's outfit
A complete set of fire-fighter's outfit for each person required for operation of the diving system during a fire shall be located at the main control stands.

6.4.7.1. Ships above 150 gross tonnage shall be provided with at least two (2) complete sets of fire-fighter’s outfits stored in separate locations.

6.4.7.2. Ships of 150 gross tonnage and below shall be provided with at least one (1) complete set of fire-fighter’s outfit.

6.4.7.3. The fire-fighter’s outfits shall be as required for ships of 500 gross tonnage and above (ref. SOLAS Ch. II-2/10.10). The sets are additional to other sets on board. Breathing apparatus are required for control stations manned during recovery of bell or launching of hyperbaric evacuation unit.

Note: Fire-fighter's outfit recommended in consideration of the time it shall take for recovery of the divers from the water, into the bell and all the way up to the hyperbaric evacuation system. The operator(s) of the diving system shall be exposed to hot environments which render evacuation impossible unless they are protected whilst performing their work.

6.5 Portable fire extinguishers

6.5.1 The capacity of every portable fire extinguisher shall be at least equivalent to that of a 9 L liquid extinguisher.

6.5.2 Not less than three (3) portable fire extinguishers shall be provided in the accommodation and service spaces.

6.5.3 Not less than two (2) portable fire extinguishers, suitable for extinguishing oil fires, shall be provided in each boiler room, cargo pump room and spaces containing any part of any oil fuel installation.

6.5.4 In machinery spaces containing internal combustion machinery, one (1) portable fire extinguisher shall be provided for every 375 kW of engine power, however, the total number shall not be less than two (2) and need not exceed six (6).

6.5.5 For ships above 150 gross tonnage, at least one fire extinguisher equivalent to that of at least one (1) 45 L liquid extinguisher shall be provided in every machinery spaces of category A.

6.5.6 Portable fire extinguishers shall be distributed throughout the space containing the diving system so that no point in the space is more than 10 m walking distance from an extinguisher.

6.5.7 One of the portable fire extinguishers shall be fitted near each entrance.

6.5.8 A portable fire extinguisher shall be fitted at the control stand.

6.5.9 Spare charges or extinguishers shall be provided on board as follows:

- 100% for the first 10, and
- 50% for remaining extinguishers.

SECTION 7 HYPERBARIC EVACUATION

Contents

7.1 General

7.1.1 In case of the ship to be abandoned an evacuation system shall be provided with sufficient capacity to evacuate all divers under pressure, and shall be in accordance with the provisions of the“Guidelines and Specifications for Hyperbaric Evacuation Systems”, adopted by the IMO organization by resolution A.692(17).

Note:

As life saving appliances are governed by statutory regulations, there may be overriding requirements for hyperbaric evacuation systems (HES). Consequently, it is important to inform INTLREG at an early stage what Flag state is intended for the diving support vessel.
It is INTLREG intention to apply SOLAS requirements to hyperbaric evacuation systems “as far as is practicable”. This includes the launching arrangement.
In the cases where the system does not comply with the prescriptive requirements in SOLAS, INTLREG shall verify evaluations and tests that show substantially equivalent conformance with the recommendations. This is in accordance with recommendations given in SOLAS Ch. III Part A Regulation 4.

Guidelines and Specifications for Hyperbaric Evacuation Systems, adopted by the IMO organization by Resolution

A.692(17) on 6 November 1991, shall be included as normative references under SOLAS.
Yards, owners or designers will have to carry out engineering analyses according to the new SOLAS Ch. III, Reg. 3 as amended by IMO Res. 216(82).

SECTION 8 NON-INTLREG CERTIFIED DIVING SYSTEMS

Contents

8.1 General

8.1.1 Diving systems in class with other class societies onboard INTLREG classed diving support vessels Installed saturation diving systems and equipment carried onboard in excess of the minimum required for class shall either be maintained to applicable standards, or be removed or disconnected in such a way as to ensure that the installed system or equipment cannot be used.

Applicable standards may be those of a recognized classification society which has rules for diving systems acceptable to the Administration as stated in 2.1.4 of the IMO Code of Safety for Diving Systems, 1995 (Res.831(19))

8.1.2 The following minimum requirements are applicable to surface oriented diving systems :

a) a recognised authority shall certify all pressure components .
b) Test shall carry out for certified pressure components according to schedules defined in these rules.

8.1.3 For diving systems Classified by other classification Societies,compliance shall be verified by INTLREG. The following documents shall be submitted:

a) Diving system Class certificate from the recognised Classification society
b) IMO Diving System Safety Certificate (DSSC) (ref. IMO Code of Safety for diving systems adopted 23 November 1995 as res. A.831(19).), as required by the vessel's Maritime Administration.

8.1.4 If a diving system Classified by another classification Society, is installed onboard a ship or mobile offshore unit by INTLREG Classification, the diving system shall be designed, manufactured and maintained in Class in accordance with the rules and the requirements of the Class Society in which the diving system is Classed and periodical surveys shall be carried out by that Class Society. Statutory requirements- and periodical surveys shall be carried out by a recognised organisation or by the Flag Administration itself.

8.1.5 If diving systems, Classified by another recognised Classification society, are installed on INTLREG Classified diving support vessels, procedures for verification of compliance shall include the following scope involving each society according to their individual scope:

a) Classification of diving system:

   i. The Classification society classifying the diving system, shall bring the entire diving system into class in accordance with their procedures, and issue all applicable certificates and reports.
   ii. The classification certificate, and class status, issued by the diving system’s Class society shall be presented to the attending INTLREG surveyor.
   INTLREG shall consider conditions of class (CC) issued to the diving system by the diving system’s Class society, to determine if any of these affect the main Class for the diving support vessel.

b) Interoperability between diving system and diving support vessel:

   i. Prior to the installation the diving system onboard,the owners of the diving system shall inform INTLREG of the various system interfaces affecting the diving support vessel.

c) INTLREG shall verify supporting structure foundations related to the diving support vessel in support of the diving system. Drawings and load calculations shall be submitted to INTLREG according to requirements in INTLREG Rules for Ships Pt.4

Ch.5 Sec.1,Sect 2, Sect 3.

d) INTLREG shall verify that additional power supplied from the diving support vessel to the diving system do not adversely affect the main class on the diving support vessel.

e) Statutory Certification – when authorised by the Maritime Authorities:

   i. The diving system's Class society will issue the Diving System Safety Certificate (DSSC) in compliance with the IMO Code of Safety for diving systems on behalf of the maritime authorities where the diving support vessel is registered. Compliance includes verification of the hyperbaric evacuation system against the guidelines referred to in chapter 3 of the IMO Code.

f) The DSSC issued by the diving system's Class society shall be presented to the attending INTLREG surveyor.

g) INTLREG shall consider all conditions of authority (CA) issued to the diving system, to determine if any of these affect the statutory certification for the diving support vessel.

h) If authorised, INTLREG shall verify that the diving operations are included in the ship's management system in accordance with requirements in the ISM Code.

i) The following documents required for information:

   i. All class and statutory certificates
   ii. Current class status of the dive system
   iii. Evidence of a review by the diving systems class society for installation on the vessel. Normally this should include stamped drawings (for info or approved as relevant)
   iv. Vessel GA with dive system arrangement
   v. Block diagram of the dive system showing quantified vessel supplies and demarcation lines showing limit of dive system class
   vi. Drawings of system foundations showing accelerations as installed and allowable deflections
   vii. Details of intended area of operation including environmental conditions and contingency planning.

j) The following documentation is required for approval:

   i. Deck drawings showing supporting structure(s)
   ii. Interface drawings for fresh, gray and black water, electrical and fire extinguishing systems
   iii. Updated safety plan including escape routes for critical dive personnel involved in launching or manning the HES.

8.2 Class entry of diving systems and diving support vessels

If a diving system, or part of a diving system, Classified by another recognized classification society, evidence of previous design approval shall be required. Such evidence shall include drawings of the arrangement and details bearing the approval stamp, or specifically covered by an approval letter. In addition, for components requiring certification, the corresponding certificates shall be available along with maintenance records.

SECTION 9 CLASSIFICATION OF DIVING SYSTEMS

Contents

9.1 General

9.1.1 This section related to the classification process for diving systems.

9.1.2 For general regulations and classification principles,refer Pt.1 Ch.1.

9.1.3 Diving systems designed for diving operations applying rope and/or umbilical connection between the submerged bell and the diving system shall be assigned the class notation:

a) DSV - SD or
b) DSV - DD
as applicable.

9.1.4 The above class notations require that the diving system is certified by INTLREG in compliance with INTLREGDSS- 105 Rules for Classification of Diving System.

Table 17.9.1 Class Notations

Class	**DSV -SD** **Diving system – Surface/Shallow**	**DSV -DD** **Diving system – Saturated/Deep Diving**
Restrictions	d_{max} ≤ 60 msw *) T_{OP} ≤ 8 hours	None, except those imposed by the rule requirements
Provisions	Open or closed bell allowed No HES required	Closed bell Dedicated HES required

*) msw = metres sea water, d_{max} = maximum operating depth

Note:
These requirements confirm that those mentioned in the IMO Code of Safety for diving systems adopted 23 November 1995 as res. A.831(19), are complied.

9.2 Classification certificate

9.2.1 A Diving system Class notation shall be issued in the Classification Certificate for the diving system as a formal statement confirming that the diving system complied the specified requirements.

9.2.2 Documents required to the classification certificate as follows:

a) diving system description and item number, in a data sheet accompanying the certificates and reports
b) operational limitations and conditions of the diving system
c) codes and standards of the diving system.

9.3 Maintenance of Class Notation

Certificates with period of validity shall have a specific area to be signed by INTLREG annually showing satisfactory completion of the annual verification required to maintain the certificate's validity.
These certificates shall be invalid if the signatures are not present.

For diving systems this applies to the statutory certificate 'IMO Diving System Safety Certificate' and certificates of conformance issued to modules.

9.4 Compliance during operation

Verification of compliance during operation is carried out by periodical or occasional surveys, to confirm the specified requirements of the system continue to be achieved. (Refer Rules for Classification of Ships Pt.1 Ch.1)

9.5 Obligations of the parties

9.5.1 The companies responsible for the certification and Classification of the diving system and diving support vessel shall confirm compliance with the applicable rules, regulations and normative references.

Compliance shall be demonstrated through verifiable evidence.

9.5.2 Further compliances ,refer Pt.1 Ch.1.

9.6 Diving systems class entry

9.6.1 Class entry procedures are, in general terms, refer Pt.1 Ch.1 Sec.3.
For existing diving systems classified by another classification society, previous design approval shall be required. Such approval shall include drawings of the arrangement and details bearing the approval stamp, or specifically covered by an approval letter. For components requiring certification, the corresponding certificates shall be available along with maintenance records.

9.6.2 After review and testing in accordance with relevant parts of INTLREG-OSE402 Sec.2 J or INTLREG-DS-E403, the system may be registered under Class Notation with INTLREG.

CHAPTER 18 LIQUIFIED GAS CARRIERS

CONTENTS

SECTION 1 GENERAL

Contents

1.1. Classification

1.1.1 Application

1.1.1.1. In this chapter, application of the rules are done to ships which are intended for carrying the liquefied gases listed in Section 20 - *Tanker for Liquefied Gas*. The requirements are supplementary to those for assignment of main class. In this chapter, fire, toxicity, corrosivity, reactivity, low temperature and pressure that are considered are included in the additional hazards. Ships that comply with the applicable parts of this chapter are considered suitable for the carriage of the volatile chemicals that are included in Section 20.

1.1.1.2. In order to meet the requirements of the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk, IGC Code, Res. MSC.5 (48), the requirements of this chapter are required to be taken into account. This edition of the rules contain the following amendments to the IGC Code: Res. MSC.30 (61) (1992 amendments), Res. MSC.32 (63) (1994 amendments), Res. MSC.59 (67) (1996 amendments) and Res.MSC.103 (73) (2000 amendments).

1.1.1.3. Gas tankers also intended for carriage of oil shall comply with Ch.3. If only volatile products such as light naphtha shall be carried, equivalent solutions may be accepted on some requirements applying to oil carriers.

1.1.2 Documentation

1.1.2.1. Ships built according to these rules may be assigned one of the following additional class notations:

- **Tanker LG**
- **C Tanker** where C indicates the type of cargo for which the ship is classified.

1.1.2.2. Depending on the nature of the cargo to be carried, ships with the class notation Tanker for C will be considered in each case.

1.1.2.3. Ships fitted with system for onboard regasification of LNG may be given the class notation **REGAS**.

1.1.2.4. Vessels intended for regasification operation with arrangement for export of natural gas through a submerged turret system may be given the notation **STL** provided that the applicable requirements in Ch.3 Sec.14 are complied with.Following documents are required to be submitted in addition to those specified in Pt.3, Ch.1, Sec.3.

1.1.3 Special features notations

1.1.3.1 Special features notations provide information regarding special features of the ship.

1.1.3.2 The damage stability standard according to IMO's International Gas Carrier Code as identified by one of the following notations:

- Ship type 1G
- Ship type 2G
- Ship type 2PG

- Ship type 3G

Will be stated in the Register of vessels classed with INTLREG

1.1.3.3 The minimum and/or maximum acceptable temperature in the tank (°C), maximum acceptable cargo density (kg/m^3) and the maximum allowable relief valve setting, MARVS (bar), will be stated in the Register of vessels classed with INTLREG.

1.1.4 List of Cargoes

1.1.4.1 The List of Cargoes in Appendix A gives a summary of minimum requirements for each individual cargo. This list will be supplemented and adjusted by the Society as found necessary.

1.2. Definitions

1.2.1 Terms

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

1.2.1.2. *An air lock* is an enclosed space for entrance between a hazardous area on open deck and a nonhazardous space, arranged to prevent ingress of gas to the non-hazardous space.

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

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

1.2.1.5. *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. It may be a boundary of the hold space, if the secondary barrier is part of the hull structure.

1.2.1.6. *Cargo control room* is a space utilized in the control of cargo handling operations and complying with the requirements of Sec.3 B400.

1.2.1.7. *Cargo process pressure vessels* are process pressure vessels in the cargo handling plant, which during normal operations will contain cargo in the liquid and or gaseous phase.

- Cargo process pressure vessels shall meet the requirements for scantlings, manufacture, workmanship, inspection, non-destructive testing and pressure testing for class I pressure vessels as given in Part 6.

- Materials in cargo process pressure vessels, welding procedure tests and production weld tests shall be in accordance with Sec.2 and Sec.5 of this chapter.

1.2.1.8. *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 or secondary barriers or both.

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

1.2.1.10. *Control stations* are those spaces in which ships' radio or main navigating equipment or the emergency source of power is positioned, or where the fire recording or fire control equipment is centralized. This does not include special fire control equipment which can be most practically located in the cargo area.

1.2.1.11. *Ambient temperatures* are the ambient temperatures in air and sea-water utilized when calculating the steel significant temperature for selection of hull steel grades. See Sec.2, [2.3].

1.2.1.12. *Design temperature* for selection of materials in cargo tanks and cargo piping is the lowest temperature which will happen in the respective components during cargo handling. Provisions shall be made so that the temperature cannot be lowered below the design temperature. See Sec.2, [2.2].

1.2.1.13. *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. See Sec.5.

1.2.1.14. Flammable products are identified by an «F» in column «d» in the *List of Cargoes.*

1.2.1.15. *Hazardous area:* Area in which an explosive gas atmosphere or a flammable gas with a flash point below 60°C is or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of electrical apparatus. Hazardous areas are divided into Zone 0, 1 and 2 as defined below and in accordance with the area classification specified in Sec.12 ,[12.3].

Zone 0
Area in which an explosive gas atmosphere or a flammable gas with a flash point below 60°C is present continuously or is present for long periods.
Zone 1
Area in which an explosive gas atmosphere or a flammable gas with a flash point below 60°C is likely to occur in normal operation.
Zone 2
Area in which an explosive gas atmosphere or a flammable gas with a flash point below 60°C is not likely to occur in normal operation and, if it does occur, is likely to do so only infrequently and will exist for a short period only.

1.2.1.16. *Non-hazardous area* is an area not considered to be hazardous, i.e. gas safe, provided certain conditions are being matched.

1.2.1.17. *Spaces not normally entered* are cofferdams, double bottoms, duct keels, pipe tunnels, stool tanks, spaces containing cargo tanks and other spaces where cargo may accumulate.

1.2.1.18. *Hold space* is the space enclosed by the structure of the ship in which a cargo containment system is situated.

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

1.2.1.20. *Insulation space* is the space which may or may not be an inter barrier space, occupied wholly or in part by insulation.

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

1.2.1.22. *Liquefied gas* is a cargo with a vapour pressure equal to or above 2.75 bar absolute at 37.8°C.

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

- Internal combustion machinery used for main propulsion; or
- 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
- Any oil-fired boiler or oil fuel unit.

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

1.2.1.25. *MARVS* means the maximum allowable relief valve setting of a cargo tank.

1.2.1.26. *Non-cargo process pressure vessels* are process pressure vessels in the cargo handling plant which during normal operations will not contain cargo. Non-cargo process pressure vessels generally consist of refrigerants of the halogenated hydrocarbon type in the liquid and or gaseous phase.

- Non-cargo process pressure vessels shall meet the requirements to scantlings, manufacture, workmanship, inspection and testing, and material selection as for pressure vessels as given in Part 6.

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

1.2.1.28. *Primary barrier* is the inner element designed to contain the cargo when the cargo containment system is made of including two boundaries.

1.2.1.29. *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 avoid the lowering of the temperature of the structure of the ship to an unsafe level.

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

- Removing spool pieces or valves and blanking the pipe ends

1.2.1.31. Arrangement of two spectacle flanges in series with provisions to detect leakage into the pipe between the two spectacle flanges. *Service spaces* are spaces outside the cargo area used for galleys, pantries containing cooking appliances, lockers, mail and specie rooms, store rooms, workshops other than those forming part of the machinery spaces and similar spaces and trunks to such spaces.

1.2.1.32. *Steel significant temperature* is the calculated temperature in the hull structures, tank fundaments and tank stayings when the cargo containment systems and the cargo piping systems are at the design temperature and the ambient temperatures are the design ambient temperatures. See Sec.2,[2.4].

1.2.1.33. *Tank cover* is the protective structure meant to protect the cargo containment system against damage where it protrudes through the weather deck or to make sure the continuity and integrity of the deck structure.

1.2.1.34. *Tank dome* is the upward extension of a portion of the cargo tank. The tank dome protrudes through the weather deck or through a tank cover in the case of below deck cargo containment systems.

1.2.1.35. *Toxic products* are identified by a Tin column «d» of the List of Cargoes.

1.2.1.36. *Vapour pressure* is the equilibrium pressure of the saturated vapour above the liquid expressed in bar absolute at a specified temperature.

1.2.1.37. *Void space* is the enclosed space in the cargo area external to a cargo containment system, other than ahold space, ballast space, fuel oil tank, cargo pump or compressor room, or any space in normal use by personnel.

1.3. Documentation

1.3.1 General

1.3.1.1 In 1.3.2 are specified the plans and particulars whose submission shall be done normally. The drawings shall clearly show that the requirements of this chapter are fulfilled.

1.3.1.2 Other plans, specifications or information shall be needed depending on the arrangement and the equipment utilized in each separate case.

1.3.1.3 For general requirements for documentation of instrumentation and automation, that includes computer based control and monitoring.

1.3.2 Plans and Particulars

1.3.2.1. A general arrangement shall be submitted for approval giving location of:

- Machinery and boiler spaces, accommodation, service and control station spaces, chain lockers, cofferdams, fuel oil tanks, drinking and domestic water tanks and stores.
- Cargo tanks and cargo containment systems
- Cargo pump and compressor rooms
- Cargo control rooms
- Cargo piping with shore connections including stern loading and discharge arrangements and emergency cargo dumping arrangement, if fitted
- Cargo hatches, vent pipes and any other openings to the cargo tanks
- Ventilating pipes, doors and openings to cargo pump rooms, cargo compressor rooms and other hazardous areas

- Doors, air locks, hatches, ventilating pipes and openings, hinged scuttles which can be opened, and other openings to non-hazardous areas within and adjacent to the cargo area including spaces in and below the forecastle
- Entrances, air inlets and openings to accommodation, service and control station spaces
- Hazardous areas of zone 0, 1 and 2, and their extent.

1.3.2.2. Plans of the cargo containment system with the following particulars shall be submitted for approval:

- Drawing of cargo tanks including information on non-destructive testing of welds and strength and tightness testing of tanks
- Drawings of support and staying of independent tanks
- Drawing of anti-flotation arrangement for independent tanks
- Specification of materials in cargo tanks and cargo piping systems
- Specifications of welding procedures for cargo tanks
- Specification of stress relieving procedures for independent tanks type C (thermal or mechanical)
- Specification of design loads and structural analysis of cargo tanks
- A complete stress analysis shall be submitted for independent tanks, type B and type C
- Detailed analytical calculation of hull and tank system for independent tanks, type B
- Specification of cooling-down procedure for cargo tanks
- Arrangement and specifications of secondary barriers, including method for periodically checking of tightness
- Documentation of model tests of primary and secondary barriers of membrane tanks
- Drawings and specifications of tank insulation
- Drawing of marking plate for independent tanks.

1.3.2.3. Plans of the following piping systems shall be submitted for approval:

- Drawings and specifications of cargo and process piping including vapour piping and vent lines of safety relief valves or similar piping, and relief valves discharging liquid cargo from the cargo piping system
- Drawings and specifications of offsets, loops, bends and mechanical expansion joints, such as bellows, slip joints (only inside tank) or similar means in the cargo piping
- Drawings of flanges and other fittings in the cargo piping system unless in accordance with a recognized standard
- Drawings of valves in the cargo piping system, if of a new type or of an unconventional design. Specifications of valve shall be submitted for information. For valves intended for systems with a design
- Temperature of below -55°C, documentation for leak test and functional test at the design temperature (type test) is required
- Complete stress analysis of piping system when design temperature is below -110°C
- Documentation of type tests for expansion components in the cargo piping system
- Specification of materials, welding, post-weld heat treatment and non-destructive testing of cargo piping

- Specification of pressure tests (structural and tightness tests) of cargo and process piping
- Program for functional tests of all piping systems including valves, fittings and associated equipment for handling cargo (liquid or vapour)
- Drawings and specifications of insulation for low temperature piping where such insulation is installed
- Specification of electrical bonding of piping
- Specification of means for removal of liquid contents from cargo loading and discharging crossover headers and or cargo hoses prior to disconnecting the shore connection.

1.3.2.4. The following plans and particulars for the safety relief valves shall be submitted for approval:

- Drawings and specifications for safety relief valves and pressure/vacuum relief valves and associated vent piping
- Calculation of required cargo tank relief valve capacity
- Specification of procedures for changing of set pressures of cargo tank safety relief valves if such arrangements are contemplated.

1.3.2.5. Plans of the following equipment and systems with particulars shall be submitted:

- Construction and specifications of pressure relief systems for hold spaces, inter barrier spaces and cargo piping if such systems are required
- Calculation of hull steel significant temperature when cargo temperature is below -20°C
- Specification of tightness test of hold spaces for membrane tank system
- Arrangement and specifications of means for maintaining the cargo tank vapour pressure below MARVS (cooling plant, gas burning arrangement, etc.)
- Drawings showing location and construction of air locks with alarm equipment
- Drawings of gastight bulkhead stuffing boxes
- Arrangements and specifications of mechanical ventilation systems for spaces in the cargo area, giving capacity and location of fans and their motors. Drawings and material specifications of rotating parts and casings for fans and portable ventilators
- Drawings and specifications of protection of hull steel beneath liquid piping where liquid leakage may be anticipated, such as at shore connections and at pump seals
- Arrangement and specifications of piping systems for gas freeing and purging of cargo tanks
- Arrangement of piping for inerting of inter barrier and hold spaces (not required for independent tanks type C)
- Specifications of equipment for provision of dry inert gas (dry air in hold spaces containing independent tanks type C) for the maintenance of an inert atmosphere in inter barrier and hold spaces
- For fixed gas detection and alarm systems: Specification and location of detectors, alarm devices and call points, and cable routing layout drawing
- Location of gas sampling points within cargo tanks
- Bilge and drainage arrangements in cargo pump rooms, cargo compressor rooms, cofferdams, pipe tunnels, hold spaces and inter barrier spaces
- Drawings and specifications of inert gas plants if installed see Sec 18

1.3.2.6. Plans of electrical installations giving the following particulars shall be submitted for approval:

- Area classification drawing(s)
- Drawing(s) showing location of all electrical equipment in hazardous areas
- Single line diagram for intrinsically safe circuits and data for verification of the compatibility between the barrier and the field component
- List of explosion protected equipment with reference to drawings together with certificates
- Maintenance manual as specified in Sec.12, [12.1.1], for electrical installations in hazardous areas shall be submitted for approval.

1.3.2.7 The following plans and particulars regarding fire protection and extinction shall be submitted for approval:

- Arrangement for the remote starting of the fire pumps and connecting them to the fire main from the bridge or other control station outside the cargo area
- arrangement and specifications of water spray systems, including pipes, valves, nozzles and other fittings
- Arrangement and specifications of dry chemical powder fire extinguishing systems
- Arrangement and specifications of fixed fire smothering installations in closed hazardous areas.

1.3.2.7. The following control and monitoring systems shall be approved by the Society:

- Cargo and vapour temperature control and monitoring system
- Cargo tank level measurement system
- Cargo tank overflow protection system
- Cargo valves and pumps control and monitoring system
- Cargo and vapour pressure control and monitoring system
- Emergency shut-down system
- Flammable gas detection system (permanent system only)
- Inert gas control and monitoring system
- Oxygen indication equipment (permanent system only).

For requirements to documentation, see Part 6.

1.4. Tank types

1.4.1 Integral Tanks

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

1.4.1.2 The design vapour pressure p_0 as defined in 1.1.14 is normally not to exceed 0.25 bar. If, however, the hull scantlings are increased accordingly, p_0 may be increased to a higher value, but less than 0.7 bar.

1.4.1.3 Integral tanks may be used for cargoes with a boiling point not below -10°C. Acceptance of a lower temperature maybe given subject to special consideration.

1.4.2 Membrane tanks

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

1.4.2.2 The design vapour pressure p_0 is normally not to exceed 0.25 bar. If, however, the hull scantlings are increased accordingly, and consideration is given, where appropriate, to the strength of the supporting insulation, p_0 may be improved to a higher value but less than 0.7 bar.

1.4.2.3 The definition of membrane tanks does not eliminate designs such as those in which non-metallic membranes are utilized or in which membranes are included or incorporated in insulation. However, such designs require special consideration by the Society. In any case the thickness of the membranes shall normally not exceed 10 mm.

1.4.3 Semi-membrane tanks

1.4.3.1. Semi-membrane tanks are non-self-supporting tanks in the loaded condition and have a layer, parts of which are reinforced 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.

1.4.3.2. The design vapour pressure p_0 is normally not to surpass 0.25 bar. If, however, the hull scantlings are increased accordingly, and where appropriate, consideration is given, to the strength of the supporting insulation, p_0 may be increased to a higher value but less than 0.7 bar.

1.4.4 Independent tanks

1.4.4.1 Independent tanks do not form a part of the hull of the ship. An independent tank is built and installation is done in such a way that the influence on the tank of the hull's deformation and stresses is minimized. An independent tank is not essential to the hull strength. An independent tank is normally to have longitudinally rigid fixture to the ship in only one transverse plane.

1.4.5 Independent tanks type A

1.4.5.1 Independent tanks type A are designed primarily utilizing recognised standards of classical ship-structural analysis procedures. The design vapour pressure p_0 shall be less than 0.7 bar, where such tanks are primarily constructed of plane surfaces (gravity tanks).

1.4.6 Independent tanks type B

1.4.6.1 Independent tanks type B are designed utilizing model tests, refined analytical tools and analysis methods to determine stress levels, fatigue life and crack propagation characteristics. The design vapour pressure p0 shall be less than 0.7 bar, where such tanks are primarily constructed of plane surfaces (gravity tanks).

1.4.7 Independent tanks type C

1.4.7.1 Independent tanks type C (also referred to as pressure vessels) are tanks meeting pressure vessel criteria and having a design vapour pressure p_0 not less than:

$$p_0 = 2 + A\,C\,(\rho_{co})^{1.5}\;(bar)$$
$$A = 0.0185\left(\frac{\sigma_m}{\Delta\sigma_a}\right)^2$$

Where,
σ_m- Design primary membrane stress

$\Delta\sigma_A$ - Allowable dynamic membrane stress (double amplitude at probability level Q = 10^{-8})
= 55 N/mm^2 for ferritic-perlitic, martensitic and austenite steels
= 25 N/mm^2 for aluminum alloy (5083-0)

C = a characteristic tank dimension to be taken as the greatest of the following: h_{tkd}, 0.75 b_{tk}, or 0.45 l_{Tk}
h_{tkd}= height of tank exclusive dome (dimension in ship's vertical direction)
b_{tk} = width of tank (dimension in ship's transverse direction) (m)
l_{Tk} = length of tank (dimension in ship's longitudinal direction) (m)
ρ_{co}= the relative density of the cargo at the reference temperature (ρ_{co} = 1 for fresh water of 4°C).
However, the Society may allocate a tank that act in accordance with this criterion to type A or type B, dependent on the configuration of the tank and the arrangement of its supports and attachments.

1.4.7.2 If the carriage of products not covered by Section 20 is intended, the relative density of which exceeds1.0, verification for it shall be done, that the double amplitude of the primary membrane stress $\Delta\,\sigma_m$ created by the maximum dynamic pressure differential $\Delta\,p$ does not exceed the allowable double amplitude of the dynamic membrane stress $\Delta\,\sigma_A$ as specified in 1.4.7.1 i.e.:

$$\Delta\,\sigma_m \;\leq\; \Delta\,\sigma_A$$

The dynamic pressure differential Δ p shall be calculated as follows:

$$\Delta p = \frac{\rho}{1.02 * \;10^4}\left(a_{\beta 1}Z_{\beta 1} - a_{\beta 2}Z_{\beta 2}\right)\,(bar)$$

Where $\rho,\ a_\beta,\ Z_\beta$ are as defined in Sec.5, [1.7.6], see also the sketches below.$a_{\beta 1}\ and\ Z_{\beta 1}$ are $a_\beta - and\ Z_\beta$ –values giving the maximum liquid pressure (P_{gd}) max.

$a_{\beta 2v}\ and\ Z_{\beta 2}\ are\ the\ a_\beta -\ \ and\ Z_\beta$ –Values giving the minimum liquid pressure (P_{gd}) min.

In order to evaluate the maximum pressure differential Δp, evaluation of pressure differentials shall be done over the full range of the acceleration ellipse as shown in the sketches below.

1.4.8 Internal insulation tanks

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

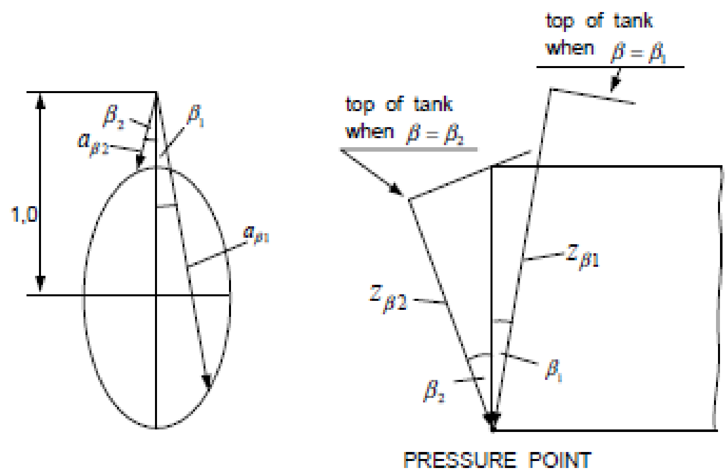


Figure 3.1.1: Acceleration ellipse used to evaluate pressure differential

1.4.8.2 The two categories of internal insulation tanks are:

- 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 shall function as the secondary barrier when needed.
- 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. 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.

1.4.8.3 Internal insulation tanks shall be of suitable materials enabling the cargo containment system to be designed using model tests and refined analytical methods as required in Sec.5, [5.10].

1.4.8.4 The design vapour pressure p_0 is not normally to exceed 0.25 bar. 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 bar if the internal insulation tanks are supported by the inner hull structure. However, acceptance of a design vapour pressure of more than 0.7 bar may be given by the Society provided the internal insulation tanks are supported by suitable independent tank structures.

1.5. Signboards

1.5.1. References

1.5.1.1. Signboards are required by the rules in:

- Sec.3, [3.1.9].Regarding plates bolted to boundaries facing the cargo area which can be opened for removal of machinery. These shall be fitted with signboards informing that plates shall be kept closed unless ship is gas-free.
- Sec.8. Regarding marking plates for independent tanks.
- Sec.10, [1.10.8]. Regarding pumps and compressors which shall not be started before the ventilation system in the electric motor room has been in operation for 15 minutes. Ventilation system for pump and compressor rooms shall be in operation when pumps and compressors are running.
- Sec.11, [2.4.1]. Regarding marking of controls for carbon dioxide system.
- Sec.12, [12.3.1]. Regarding opening of a lighting fitting. Before opening, its supply circuit shall be disconnected.
- Sec.12, [12.3.2]. Regarding spaces where the ventilation must be in operation before the light is turned on.
- Sec.12, [12.3.3] Regarding portable electrical equipment supplied by flexible cables. This equipment shall not be used in areas where there is gas danger.
- Sec.12, [12.3.4 Regarding welding apparatus. These shall not be used unless the working space and adjacent spaces are gas-free.
- Sec.16, [2.2.10], {2.2.11} & {2.2.12] and [3.1.6]. Regarding gas operation of propulsion machinery.

SECTION 2 MATERIALS AND HULL STRENGTH

Contents

2.1. General

2.1.1. Selection and Testing

2.1.1.1. Detailed necessities for chemical composition, mechanical properties, notch toughness etc. for plates, sections, pipes, forgings, castings and weldments utilized in the construction of cargo tanks, cargo process pressure vessels, cargo piping, secondary barriers and contiguous hull structures associated with the transportation of the products are found in Part.2.

2.1.1.2. The manufacture, testing, inspection and documentation shall be according to Part.2 and the specific requirements given in this section.

2.1.1.3. Materials not covered by Part 2 will be considered upon case by case basis.

2.1.1.4. For certain cargoes as specified in Sec.15 or in the *List of Cargoes*, special requirements for materials shall be applied.

2.1.1.5. The properties of the base material shall be determined in the heat-treated condition in accordance with the applicable Tables 3.2.2 to 3.2.4, where post weld heat treatment is specified or required, and the weld properties should be determined in the heat-treated condition in accordance with the requirements stated in Part 2. The test requirements may be modified at the discretion of the Society, in cases where a post weld heat treatment is applied.

2.1.1.6. Requirements for welding procedure and production tests are given in Sec.5 and Sec.6.The requirements for welding consumables are given in Part 2.

2.1.1.7. Thermal insulation materials shall be according to the requirements of Sec.7.

2.2. Temperatures for Selection of Materials

2.2.1 General

2.2.1.1 The necessities to material qualities are determined on the basis of the lowest temperatures in the material. These temperatures are determined as they are specified in 2.2. to 2.4

2.2.2 Design temperature

2.2.2.1. Design temperature for cargo tanks is the minimum temperature at which loading or transporting of cargo may be done in the cargo tanks. Provisions to the satisfaction of the Society shall be made so that the tank or cargo temperature cannot be lowered below the design temperature. The design temperature for the cargo tanks may be indicated in the Register of vessels classed with INTLREG. See Sec.1, [1.3].

2.2.2.2. Design temperature for cargo piping, cargo process pressure vessels and all associated equipment is the minimum temperature which can arise in the systems and components during cargo handling operations.

2.2.2.3. Design temperature for a complete or partial secondary barrier is equal to the boiling point of the most volatile cargo.

2.2.3 Ambient temperatures

2.2.3.1. The ambient temperatures are generally 5°C for air and 0°C for sea water for worldwide service, for the purpose of calculating the inner hull temperatures. However, higher values of the ambient temperatures may be accepted by the Society for ships operating in restricted areas.

Conversely, lesser values of the ambient temperatures may be fixed for ships trading occasionally or regularly to areas in latitudes where such lower temperatures are expected during the winter months.

2.2.3.2. The ambient temperatures are generally 5°C for air and 0°C for sea water for worldwide service, for the purpose of calculating the outer hull steel temperatures.

2.2.4 Steel significant temperature

2.2.4.1. Steel significant temperature is the minimum temperature of the hull structure, tank foundations and tank stayings determined by calculations as detailed in 2.2.5, taking into account the efficiency of any insulation and means of heating if accepted in accordance with 600. The calculations shall be made assuming that:

- The cargo tanks are at their design temperature according to 2.2.2.1
- If a complete or partial secondary barrier is required, the complete or partial secondary barrier is at the design temperature according to 2.2.2.3
- The ambient temperatures are those given in 2.2.3.1 and 2.2.3.2 for inner and outer hull respectively
- Piping systems are at their design temperatures.

2.2.5 Temperature calculations

2.2.5.1. Submission of calculations of the steel significant temperatures referred to in 2.2.4 shall be done, if the design temperature of the cargo tanks is lower than -10°C. The calculations shall be made assuming still air and still water. No credit will be given for means of heating, except as permitted by 2.2.6. The cooling effect of the rising boil-off vapour from the leaked cargo shall be considered in the heat transmission studies, if a complete or partial secondary barrier is required. The mean temperature may be taken for determining the steel grade, for structural members connecting inner and outer hulls.

2.2.5.2. The insulation shall comply with the requirements in Sec.7, when account is taken of insulation in the heat transmission studies.

2.2.6 Heating of hull structural material

2.2.6.1. 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 utilized to make sure that the temperatures of this material do not fall below the steel significant temperature. Approved means of heating may also be used for longitudinal hull structural material, if lower ambient temperatures are specified according to 2.2.3.1, 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 shall comply with the following requirements:

- Sufficient heat shall be available to maintain the hull structure above the steel significant temperature in the conditions referred to in 2.2.4 and 2.2.5.
- The heating system shall be arranged so that, in the event of a failure in any part of the system, stand-by heating can be maintained equal to not less than 100% of the theoretical heat load.
- The heating system shall be considered as an essential auxiliary.
- The design and construction of the heating system shall be approved.
- The heating system shall be tested for heat output and heat distribution.

2.3. Hull Materials

2.3.1 Inner hull structure

2.3.1.1 The inner hull structure includes longitudinal bulkhead plating, inner bottom plating, transverse bulkhead plating, floors, webs, stringers and all attached stiffening members.

2.3.1.2 If the steel significant temperature calculated according to 2.2.4 is below 0°C, materials in the inner hull structure which are subject to reduced temperature due to the cargo, and which do not form part of the secondary barrier, shall be according to Table 3.2.1.

2.3.2 Outer Hull Structure

2.3.2.1. The outer hull structure includes the shell and deck plating of the ship and all stiffeners attached thereto.

2.3.2.2. The materials in the outer hull structure shall be according to Part 3, unless then calculated temperature of the material in the design condition (see 2.2.4) is below -5°C due to the effect of the low temperature cargo, in which case the material shall be in accordance with Table 3.2.1 assuming the ambient air and sea temperatures of 5°C and 0°C respectively.

In the design condition the complete or partial secondary barrier is assumed to be at the cargo temperature at atmospheric pressure and for tanks without secondary barriers, the primary barrier is assumed to be at the cargo temperature.

2.3.3 Secondary barrier

2.3.3.1. Hull material forming the secondary barrier shall be according to Table 3.2.3. Metallic materials utilized in secondary barriers not forming part of the hull structure shall be according to Table 3.2.3 or 3.2.4 as applicable. Insulation materials forming a secondary barrier shall comply with the requirements of Sec.7, [3.3.2]. Where the secondary barrier is formed by the deck or side shell plating, the material grade required by Table 3.2.3 shall be carried into the adjacent deck or side shell plating, where applicable to a suitable extent.

Table 3.2.1: Plates and sections for hull structures required by 2.3.1 and 2.3.2

Steel significant Temperature (℃)	**Maximum thickness (mm) for steel grades in accordance with Part 2**						
	NV A	**NV B**	**NV D**	**NV E**	**NV AH[1)]**	**NV DH[1)]**	**NV EH[1)]**
0 and above [2)] - 5 and above[3)]	Normal Practice						
Down to -5	15	25	30	50	25	45	50
Down to -10	x	20	25	50	20	40	50
Down to -20	x	x	20	50	x	30	50
Down to -30	x	x	X	40	x	20	40
Below -30	In accordance with Table 3.2.3 except that the thickness limitation given in Table 3.2.3 and in footnote[2)] of that table does not apply.						

‘x’ means steel grade not to be used.
1) H means “High strength steel”.
2) For the purpose of 3.2.1
3) For the purpose of 3.2.2.

2.4. Materials for Cargo Piping, Cargo Tanks, Cargo Process Pressure Vessels and Secondary Barriers

2.4.1. Material requirements

2.4.1.1. Materials for cargo piping, cargo tanks, cargo process pressure vessels and secondary barriers shall comply with the minimum requirements given in the following tables:

- Table 3.2.2: Plates, pipes (seamless and welded), sections and forgings for cargo tanks and process pressure vessels for design temperatures not lower than 0°C.
- Table 3.2.3: 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 3.2.4: 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 3.2.4: Pipes (seamless and welded), forgings and castings for cargo and process piping for design temperatures below 0°C and down to -165°C.

2.4.1.2. The detailed requirements for materials as specified in Tables 3.2.2 to 3.2.4 are found as follows:

- Plates and sections:Pt.2 Ch.2
- Pipes: Pt.2 Ch.2
- Forgings: Pt.2 Ch.2
- Castings: Pt.2 Ch.2.

2.4.1.3. Aluminum alloy type 5083 (ISO Al Mg 4.5 Mn) and 36% nickel alloy steel, will be approved in each separate case.

Table 3.2.2 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 Society Composition limits to be approved by the Society Normalized, or quenched and tempered 2)		
TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS		
Plates	Each “piece” to be tested	
Sections and forgings	Batch test	
Tensile properties	Specified minimum yield stress not to exceed 410 N/mm^{2} 3)	
CHARPY V-NOTCH TEST		
Plate	Transverse test pieces. Minimum average energy value (E) 27 J	
Sections and forgings	Longitudinal test pieces. Minimum average energy value (E) 41 J	
Test temperature	Thickness t (mm)	Test temperature (°C)
	t≤20	0
	20 < t = 40	-20
1) For seamless pipes and fittings, normal practice applies. The use of longitudinally and spirally welded pipes and welded elbows, T-pieces, etc. shall be especially approved by the Society.		

2) A controlled rolling procedure may be used as an alternative to normalizing or quenching and tempering, subject to special approval by the Society.
3) Materials with specified minimum yield stress exceeding 410 N/mm^2, may be specially approved by the Society. For these materials, particular attention should be given to the hardness of the weld and heat affected zone.

Table 3.2.3 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)]

STEEL TYPE AND HEAT TREATMENT					
Carbon-manganese steel. Fully killed. Aluminium treated fine grain steel.					
CHEMICAL COMPOSITION (LADLE ANALYSIS)					
C (%)	Mn (%)	Si (%)	S (%)	P (%)	
0.16 maximum [3)]	0.70 to 1.60	0.10 to 0.50	0.035 maximum	0.035 maximum	
Optional additions: Alloys and grain refining elements may be generally in accordance with the following:					
Ni (%)	Cr (%)	Mo (%)	Cu (%)	Nb (%)	V (%)
0.80 maximum	0.25 maximum	0.08 maximum	0.35 maximum	0.05 maximum	0.10 maximum
Normalized or quenched and tempered [4)]					
TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS					
Plates	Each “piece” to be tested				
Sections	Batch test				
CHARPY V-NOTCH TEST Test temperatures 5°C below the design temperature or -20°C whichever is lower					
Plates	Transverse test pieces. Minimum average energy value (E) 27 J				
Sections and forgings [1)]	Longitudinal test pieces. Minimum average energy value (E) 41 J				

1) The Charpy V-notch and chemistry requirements for forgings may be specially considered.
2) For material thickness of more than 25 mm, Charpy V-notch tests shall be conducted as follows:

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

The impact energy value shall be in accordance with the table for the applicable type of test specimen. For material thickness of more than 40 mm, the Charpy V-notch values will 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 shall be the same as that required for the adjacent tank-shell thickness.
3) By special agreement with the Society, the carbon content may be increased to 0.18% maximum provided the design temperature is not lower than - 40°C.

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

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 according to Table 3.2.4 may be necessary.

Table 3.2.4 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
-65	2.25% nickel steel - normalized or normalized and tempered [5)]	-70
-90	3.5% nickel steel -normalized or normalized and tempered [5)]	- 95
-105	5% nickel steel -normalized or normalized and tempered [5)] [6)]	-110
-165	9% nickel steel -double normalized and tempered or quenched and tempered	-196
-165	Austenitic steels, such as types 304, 304L, 316, 316L, 321 and 347 solution heat treated [7)]	-196
-165	Aluminium alloys; such as type 5083 annealed	Not required
-165	Austenitic Fe-Ni alloy (36% nickel) Heat treatment as agreed	Not required
-165	Austenitic Fe-Ni alloy (36% nickel) Heat treatment as agreed	
TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS		
Plates		
Sections and forgings		
CHARPY V-NOTCH TEST		
Plates	Transverse test pieces. Minimum average energy value (E) 27 J	

Sections and forgings	Longitudinal test pieces. Minimum average energy value (E) 41J	

1) The impact test required for forgings used in critical applications will be subject to special consideration.
2) The requirements for design temperatures below -165°C shall be specially agreed.
3) For materials 1.5% Ni, 2.25% Ni, 3.5% Ni, and 5% Ni with thicknesses greater than 25 mm, the impact tests shall be conducted as follows:
Material thickness (mm) Test temperature (°C)
25 < t ≤ 30 10°C below design temperature
30 < t ≤ 35 15°C below design temperature
35 < t ≤ 40 20°C below design temperature
In no case shall the test temperature be above that indicated in the table. The energy value shall be in accordance with the table for the applicable type of test specimen. For material thickness of more than 40 mm, the Charpy V-notch values will 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 Society.
4) The chemical composition limits shall be approved by the Society.
5) A lower minimum design temperature for quenched and tempered steels may be specially agreed.
6) A specially heat treated 5% nickel steel, for example triple heat treated 5% nickel steel, may be used down to - 165°C upon special
agreement with the Society, provided that the impact tests are carried out at -196°C.
7) The impact test is required only for design temperature below -105°C.

Table 3.2.5 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) (J)
-55	Carbon-manganese steel. Fully killed fine grain. Normalized or as agreed 6)	4)	27
-65	2.25% nickel steel. Normalized or normalized and tempered 6)	-70	34
-90	3.5% nickel steel. Normalized or normalized and tempered 6)	-95	34
-165	9% nickel steel 7). Double normalized and tempered or quenched and tempered	-196	41

	Austenitic steels, such as types 304, 304L, 316, 316L, 321 and 347. Solution heat treated 8)	-196	41
	Aluminium alloys, such as type 5083 annealed		Not required
TENSILE AND TOUGHNESS (IMPACT) TEST REQUIREMENTS Each batch to be tested			
IMPACT TEST Longitudinal test pieces			
1) The use of longitudinally or spirally welded pipes and welded elbows, T-pieces, etc shall be especially approved by the Society. 2) The requirements for forgings and castings may be subject to special consideration. 3) The requirements for design temperatures below -165°C shall be specially agreed with the Society. 4) The test temperature shall be 5°C below the design temperature or -20°C whichever is lower. 5) The composition limits should be approved by the Society. 6) A lower design temperature may be specially agreed for quenched and tempered materials. 7) This chemical composition is not suitable for castings. 8) Impact tests are required only for design temperature below -105°C.			

2.5. Documentation of Material Quality and Testing of Pipe and Pipe Fittings

The materials used in cargo piping systems shall be furnished with documentation according to Table following. For definition of material documentation, see Pt.1 Ch.1 Sec.4.

Table 3.2.6 Documentation of material quality and testing

Type	Material	Piping system	Nominal diameter (mm)	Type of documentation			
				Design temperature (°C)	NV certificate	Works certificate	Test report
Pipes		Pressure	> 25		x		
		Pressure	≤ 25			x	
		Open ended				x	
Elbows, T-pieces etc., fabricated by welding	Steel	Pressure				x	
		Open ended					x
Flanges		Pressure				x	
		Open ended					x

Bodies of valves and fittings, pump housings, source materials of steel expansion bellows, other pressure containing components not considered as pressure vessels	Steel	Pressure	> 100	< -55	x		
		Pressure	> 100	≥ -55		x	
		Pressure	≤ 100			x	
		Open ended					x
	Copper alloys	Pressure	>50			x	
		Pressure	≤ 50				x
		Open ended					x
Nuts and bolts	Steel						x

SECTION 3 SHIP ARRANGEMENTS

Contents

3.1. Location of Cargo Tanks

3.1.1. General

3.1.1.1. If a ship is intended to carry more than one product listed in Section 20, *List of Cargoes*, in that case, requirements are to be related to the respective products intended to be carried as far as the location of individual cargo tanks for that ship is concerned.

3.1.1.2. Normally, solid ballast is not to be used in double bottom spaces in the cargo area. However, where because of stability considerations, the fitting of solid ballast in such spaces becomes obligatory, the quantity and its disposition shall be governed by the need to ascertain that resultant impact loads from bottom damage are not directly transmitted to the cargo tank structure.

3.1.2. Location of cargo tanks

3.1.2.1. Tanks intended to carry cargoes for which ship type 1G is required shall be located at a minimum distance from side shell plating of ship of B/5 or 11.5 m, whichever is less, measured inboard from side of the ship at right angle to the centre line at the level of the summer load line, and at a vertical distance from the moulded line of the bottom shell plating at centre line not less than:

- Lesser of B/15 and 2 m and nowhere less than 760 mm from the shell plating. See Fig.3.3.1
- Rule height for the centre girder in dry cargo ships, see Part 3

3.1.2.2. Tanks intended to carry cargoes for which Ship types 2G/2PG or 3G are required shall be positioned at a vertical distance from the moulded line of the bottom shell plating at centreline not less than:

- Lesser of B/15 and 2 m and nowhere less than 760 mm from the shell plating. See Fig.3.3.1.
- Rule height of centre girder in dry cargo ships, see Part 3

3.1.2.3. For semi-membrane and membrane tanks, distances given in 3.1.2.1 and 3.1.2.2 shall be measured to the longitudinal bulkheads and the inner bottom respectively and for independent tanks to the side and bottom of the cargo tanks. The extent of damage shall be measured to the supporting tank plating, in case of internal insulation tanks.

3.1.2.4. Excluding cargoes that require Ship type 1G cargo tank location, suction wells installed in cargo tanks may protrude below the distance from the outer bottom as specified in 3.1.2.2, provided that such wells are, as small as practicable, and the protrusion below the inner bottom plating does not exceed 25% of the depth of the double bottom or 350 mm, whichever is less.

Note:

The International Code for the Construction and Equipment of Ships carrying Liquefied Gases in Bulk gives in 1.1.4.1 to 1.1.4.4 additional requirements for the location of flammable liquid cargoes when simultaneously carrying cargoes requiring Ship type 1G or 2G/2PG cargo tank location.

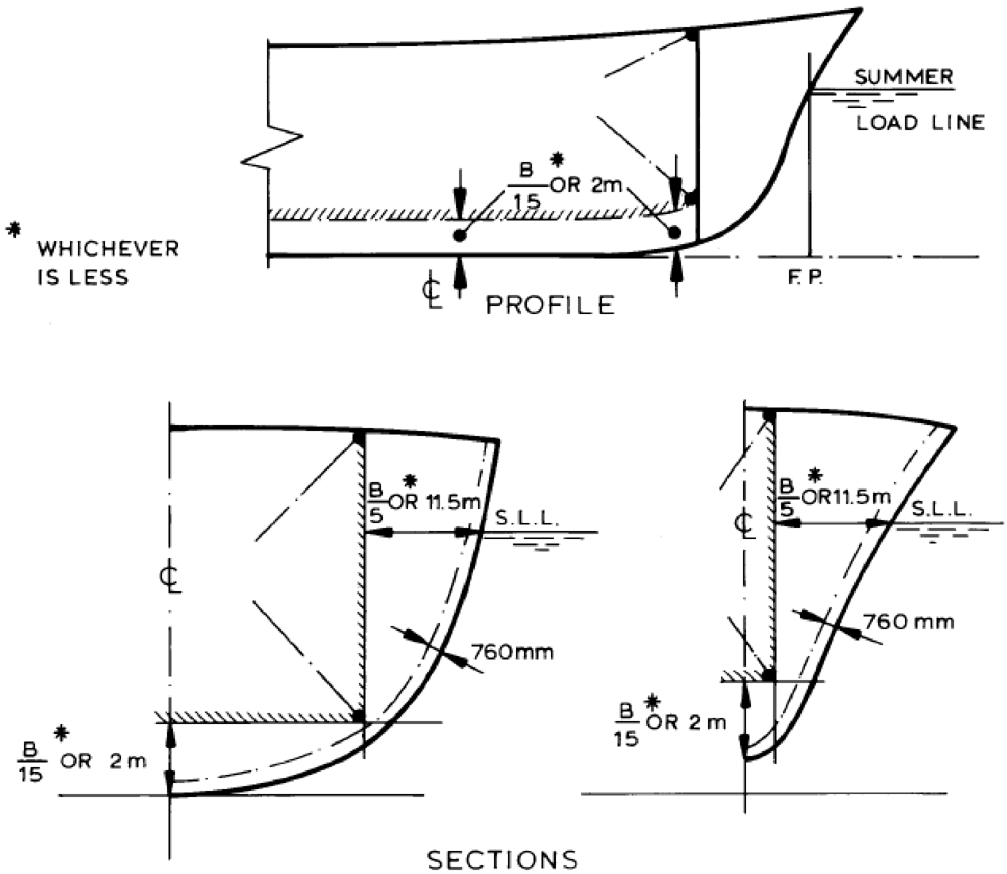


Figure 3.3.1: Tank location requirements as set out in 300

3.2. Location and Separation of Spaces

3.2.1. Segregation of the cargo area

3.2.1.1. The segregation of hold spaces from machinery and boiler spaces, accommodation & service spaces and control stations, chain lockers, drinking and domestic water tanks and from stores is required. These shall be located forward of machinery spaces of category A, except those deemed necessary by the Society for safety or navigation of the ship.ee

3.2.1.2. Where cargo is carried in such a cargo containment system that does not require a secondary barrier, segregation of hold spaces from spaces referred to in 3.2.1.1, or spaces either below or outboard of the hold spaces, may be effected by cofferdams, fuel oil tanks, or a single bulkhead of all welded construction forming an A-60 class division. A gastight A-0 class division is satisfactory, provided there is no ignition source or fire hazard in the adjoining spaces.

3.2.1.3. Where cargo is carried in a cargo pace, segregation may be by a single A-0 class division which is gastight. containment system that requires a secondary barrier, segregation's of hold spaces from spaces referred to in 3.2.1.1, or spaces either below or outboard of the hold spaces which contain an ignition source or fire hazard, shall be effected by cofferdams or fuel oil tanks. If there is no ignition source or fire hazard in the adjoining s

3.2.1.4. When cargo is carried in a cargo containment system that requires a secondary barrier at temperatures below -10°C, a double bottom shall segregate hold spaces from the sea, and when the cargo temperature is below -55°C, ship is also to have longitudinal bulkheads that form side tanks.

3.2.1.5. Any piping system which may contain cargo or cargo vapour, shall:

- Not pass through any accommodation & service space or control station or through a machinery space other than a cargo pump room or cargo compressor space, except as provided in Ch 3Sec.16
- Be located in the cargo area above the open deck, except for bow or stern loading provisions as per 3.3.1.3 and emergency cargo jettisoning systems as per 3.2.1.6, and except as per Ch 3,Sec.16
- Be located inboard of the transverse tank location requirements given in 3.1.3, except for thwartship shore connection piping not subjected to internal pressure at sea
- Be segregated from other piping systems, except where inter-connections are required for cargo related operations viz. purging, gas freeing or inerting. In such cases, precautions to ascertain that cargo or cargo vapour cannot enter such other piping systems through the inter-connections shall be taken
- be connected into the cargo containment system directly from the open deck, except that the pipes installed in a vertical trunkway or equivalent may be used to traverse void spaces above a cargo containment system, and except that pipes for drainage, venting or purging may traverse cofferdams

3.2.1.6. Any emergency cargo jettisoning piping system shall conform to 3.2.1.5, as appropriate and may be led aft externally to accommodation & service spaces or control stations or machinery spaces, but shall not pass through them. Suitable means of isolation from the cargo piping shall be provided within the cargo area, if an emergency cargo jettisoning piping system is permanently installed.

3.2.1.7. Arrangements for sealing the weather decks in way of openings for cargo containment systems shall be made.

3.2.2. Accommodation, service and control station spaces

3.2.2.1. No accommodation & service space or control station shall be positioned within the cargo area. The bulkhead of such spaces which face the cargo area is to be situated so as to avoid the entry of gas from the hold space to such spaces through a single failure of a deck or bulkhead on a ship having a containment system that needs a secondary barrier.

3.2.2.2. A cofferdam formed by a diagonal plate across the corner on the non-hazardous side may be accepted as separation, where a corner-to-corner situation occurs between a cargo tank and non-hazardous space. Such cofferdams shall be:

- filled with a suitable compound, if inaccessible
- ventilated, if accessible

3.2.3. Cargo pump rooms and cargo compressor rooms

3.2.3.1. Cargo pump and cargo compressor rooms shall be situated above the weather deck and within the cargo area unless specially approved by the Society. Cargo compressor rooms shall be treated as cargo pump rooms for the purpose of fire protection as per Ch.3 Sec.7.

3.2.3.2. When permission for cargo pump and cargo compressor rooms are given 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 forward most hold space, the limits of the cargo area as defined in Ch 3, Sec.1,[1.2.1] shall be extended to include the cargo pump rooms and cargo compressor rooms for full breadth and depth of the ship and deck areas above those spaces.

3.2.3.3. Bulkhead which separates the cargo pump rooms and cargo compressor rooms from accommodation and service spaces, control stations and machinery spaces of category A shall be so located that it avoids the entry of gas to these spaces upon a single failure of a deck or bulkhead, where limits of the cargo area are extended by 3.2.3.2. The same condition is to be fulfilled also when cargo pump-rooms and compressor rooms, fitted within the cargo area, have a common bulkhead with accommodation and service spaces, control stations and machinery spaces of category A.

3.2.3.4. Where pumps and compressors are driven by shafting that passes through a bulkhead or deck, gastight seals with efficient lubrication or other means of ascertaining the permanence of the gas seal shall be fitted in way of the bulkhead or deck.

3.2.4. Cargo control rooms

3.2.4.1. Any cargo control room is to be above the weather deck and may be positioned in the cargo area. It may be located within the accommodation spaces, service spaces or control stations, provided the following conditions are fulfilled:

- the cargo control room is a gas safe space
- if the entrance conforms to 3.3.1.2, the control room may have access to the spaces described above
- if the entrance does not conform to 3.3.1.2 the control room shall not have access to the spaces described above and the boundaries to such spaces shall be insulated to A-60 class integrity.

3.2.4.2. If cargo control room is designed as a gas-safe space, instrumentation, as much as feasible, is to be by indirect reading systems, and in any case, is to be designed to avoid 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 as per Ch 13, Sec.13, [13.2.3.12].

3.2.4.3. If the cargo control room for ships carrying flammable cargoes is a gas-dangerous space, ignition sources shall be excluded. The safety characteristics of any electrical installations shall be given special consideration.

3.3. Arrangement of Entrances and other Openings

3.3.1. Non-hazardous spaces and accommodation spaces

3.3.1.1. From a gas-safe space to a gas-dangerous space, access through doors, gastight or otherwise, is not permitted except for access to service spaces forward of the cargo area through air locks when accommodation spaces are aft.

3.3.1.2. Entrances, openings and air inlets to accommodation & service spaces, machinery spaces and control stations shall not face the cargo area. They shall be positioned on the end bulkhead not facing the cargo area or on the outboard side of the superstructure or deckhouse or on both at a distance of at least 4% of the length of the ship but not less than 3 m from the end of the superstructures or deckhouses facing the cargo area. However, this distance, need not exceed 5 m. Windows and side scuttles facing the cargo area and on the superstructure or deckhouse sides within the aforementioned distance shall be of the fixed (non-opening) type.

Wheelhouse windows may be non-fixed and wheelhouse doors may be situated within the above limits and so designed that a rapid and efficient gas and vapour tightening of the wheelhouse can be ascertained. Relaxations from the aforementioned requirements may be approved by Society for ships dedicated to the carriage of cargoes which have neither flammable nor toxic hazards.

Similar requirements are applicable to air outlets as applicable for air inlets and air intakes.

3.3.1.3. Entrances, openings and air-inlets to accommodation & service spaces, machinery spaces and control stations shall not face the cargo shore connection position of bow or stern loading and unloading arrangements. Location of them shall be on the outboard side of the superstructure or deckhouse at a distance of at least 4% of ship's length but not less than 3 m from the end of the superstructure or deckhouse facing the cargo shore connection location of the bow or stern loading and unloading arrangements. However, this distance, need not exceed 5 m. Sides cuttles facing the shore connection location and on the sides of the superstructure or deckhouse within the aforementioned distance shall be of the fixed (non-opening) type. Besides that, during the use of the bow or stern loading and unloading arrangements, all doors, ports and other openings on the corresponding superstructure or deckhouse side shall be kept closed. Relaxations from the above requirements may be approved by Society, where, in case of small ships, conformation to 3.1.1.2 and this paragraph is not possible.

Similar requirements are applicable to air outlets as those to air inlets and air intakes.

3.3.1.4. Side scuttles in the first tier of a superstructure or deckhouse and in the shell underneath the uppermost continuous deck is to be of the fixed (non-opening) type.

3.3.1.5. All air intakes and openings into the accommodation & service spaces and control stations is to be fitted with closing devices and shall be operated from inside the space for toxic gases. See also 3.3.1.10.

3.3.1.6. Access from open weather deck to non-hazardous spaces in the cargo area is to be positioned in a non-hazardous zone at least 2.4 m above the weather deck, unless access is through an air lock as per 3.3.3.

3.3.1.7. To guard against hazardous vapours, due consideration shall be given to the location of air intakes and openings into accommodation, machinery spaces, service and control station spaces with respect to cargo vent systems, cargo piping and machinery space exhausts from gas burning arrangements. Compliance with other relevant paragraphs of this chapter and in particular with 3.3.1.2 and 3.3.13, Sec.9,[3.9.2.8],[3.9.2.9], and Sec.10,[10.1 & 10.2], and Sec.12,[12.3], will ensure compliance with this requirement.

3.3.1.8. Permission of cargo control rooms, stores and other spaces not covered by 3.3.1.2 but located within accommodation, service and control station spaces may be given to have doors facing the cargo area. The spaces shall not have access to the spaces covered by 3.3.1.2, where such doors are fitted and the boundaries of the spaces shall be insulated to A-60 class (see Ch 3, Sec.11).

3.3.1.9. Bolted plates for removal of machinery may be fitted in boundaries facing the cargo area. Plates like this shall be insulated to A-60 class (see Sec.11). Near the plates, signboards giving instruction that the plates shall be kept closed unless the ship is gas-free, shall be posted.

3.3.1.10. The requirement for fitting air intakes and openings with closing devices operable from inside the space in ships intended to carry toxic products, see also 3.3.1.5, shall apply to spaces which are utilized for the radio of the ships and main navigating equipment, cabins, toilets, hospitals, mess rooms, galleys, etc. but application shall not be done to spaces not normally manned viz. deck stores, forecastle stores, engine room casings, steering gear compartments, workshops. The requirement does not apply to cargo control rooms located within the cargo area.

When internal closing is required, this shall include both ventilation intakes and outlets.

There shall be reasonable gas tightness in the closing devices as ordinary steel fire-flaps without gaskets or seals will normally not be considered satisfactory.

3.3.2. Hazardous spaces and cargo tanks

3.3.2.1. Arrangements for cargo tanks, hold spaces and other spaces containing gas sources shall provide:

- access through horizontal openings, hatches or manholes, whose dimensions shall be sufficient to allow a person wearing a breathing apparatus to ascend or descend any ladder without obstruction and also to provide a clear opening to facilitate the hoisting of an injured person from the bottom of the space; the minimum clear opening shall not be less than 600 mm by 600 mm
- access through vertical openings or manholes providing passage through the length and breadth of the space, the minimum clear opening of which shall not be 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.

The following applies for the purpose of this item:

1) The term minimum clear opening of not less than 600 × 600 mm means that such openings may have corner radii up to 100 mm maximum.

   Guidance note:

   Due regard should be given to avoid high stress concentrations. Thus for areas with high stresses the radius can be increased to

   $r = 0.2 \times b$ (min. 600 mm), i.e. 120 mm.

   For definition of: b = “breadth of opening”, see Part 3.

2) The term minimum clear opening of not less than 600 × 800 mm also includes an opening of the size shown in Fig.3.3.2.

3) Circular access openings in type C cargo tanks shall have diameters of not less than 600 mm.

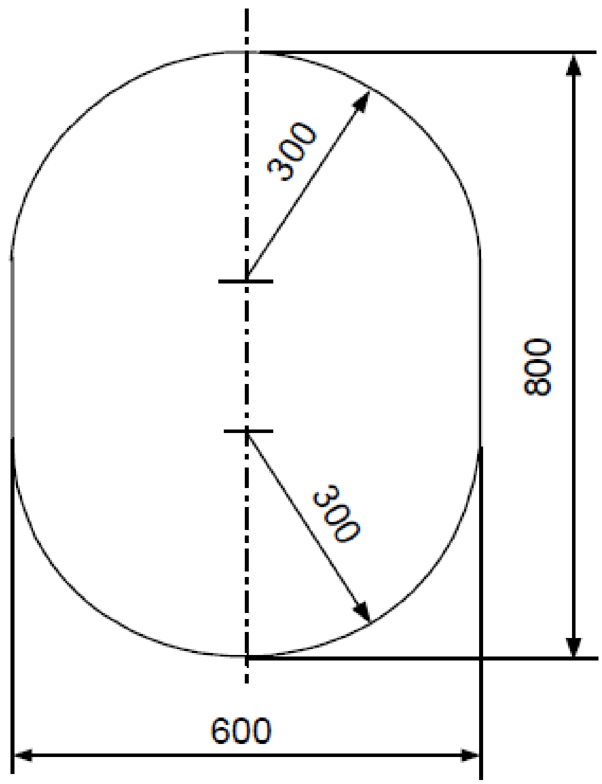


Figure 3.3.2: Minimum clear opening of not less than 600 x 800 mm

3.3.2.2. The dimensions referred to in 3.3.2.1, may be decreased in special circumstances upon consideration.

3.3.2.3. There shall be direct access to cargo tanks from the open deck.

3.3.2.4. Arrangement of cargo pump and cargo compressor rooms is to be such as to ascertain safe access for personnel wearing protective clothing and breathing apparatus, and in the event of injury to allow unconscious personnel to be removed. All valves those are necessary for cargo handling is to be accessible to personnel wearing protective clothing.

3.3.2.5. The application of the requirements of 3.3.2.1 shall not be done to spaces separated by a single gastight steel boundary from hold spaces containing a cargo tank requiring a secondary barrier. Provision of such spaces shall be done only with direct or indirect access from the open weather deck, not including an enclosed non-hazardous space.

3.3.3. Air locks

3.3.3.1. An air lock is an enclosed space that is enclosed by gastight steel bulkheads with two substantially gastight doors spaced at least 1.5 m and not more than 2.5 m apart. Subject to the requirements of the *International Convention on Load Line*, door sill shall not be less than 300 mm in height. The doors shall be self-closing and not have any holding back arrangements.

3.3.3.2. Air locks shall have efficient ventilation. For ventilation requirements, see Sec.10.

3.3.3.3. Air locks shall have a simple geometrical form, provide free and easy passage, and have a deck area not less than about 1.5 m^2. These shall not be used for other purposes, for instance as store rooms.

3.3.3.4. An airlock is permitted only between a gas-dangerous zone on the open weather deck and a gas-safe space.

3.3.3.5. On both sides of the air lock, an audible and visual alarm system to give a warning to indicate if more than one door is moved from the closed position shall be provided.

3.3.3.6. The monitoring of air lock space for cargo vapour shall be done.

3.3.3.7. The uncertified type of electrical equipment in spaces protected by air-locks shall be de-energized upon loss of overpressure in the space (see also Sec.12) in ships carrying flammable products. Electrical equipment which is not certified safe type for maneuvering, anchoring and mooring equipment and emergency fire pumps shall not be located in spaces to be protected by air-locks.

3.3.4. Cofferdams and pipe tunnels

3.3.4.1. Cofferdams shall be of adequate size for easy access to all parts. Minimum distance between bulkheads: 600 mm.

3.3.4.2. Ballast tanks will be accepted as cofferdams.

3.3.4.3. Pipe tunnels shall have plenty of for the inspection of pipes. The pipes shall be positioned as high as possible above the bottom of the ship.

3.3.4.4. In ships with integral tanks, connections between a pipe tunnel and the engine room either by pipes or manholes will not be accepted.

3.4. Guard Rails and Bulwarks

3.4.1. Arrangement

3.4.1.1. Normally, in the cargo area, open guard rails are to be fitted. Plate bulwarks with a 230 mm high continuous opening at lower edge may be accepted after considering the deck arrangement and probable gas accumulation.

3.5. Diesel Engines Driving Emergency Fire Pumps or Similar Equipment

3.5.1. General

3.5.1.1. Diesel engines which run emergency fire pumps or similar equipment shall be installed in a non-hazardous area.

3.5.1.2. The exhaust pipe of such diesel engines shall have an effective spark arrestor that is led out into the open atmosphere at a safe distance from hazardous areas.

3.6. Chain Locker and Windlass

3.6.1. General

3.6.1.1. The chain locker, windlass and chain pipes shall be arranged and located in a non-hazardous space.

3.7. Anodes, Washing Machines and other Fittings in Tanks and Cofferdams

3.7.1. General

3.7.1.1. Washing machines, anodes and other permanently installed equipment in tanks and cofferdams shall be securely fastened to the structure. These units and their supports shall be able to stand sloshing in the tanks and vibratory loads besides other loads which may be imposed in service.

While selecting construction materials for aforementioned permanently installed equipment in tanks and cofferdams, due consideration is to be given to contact spark-producing properties.

SECTION 4 ARRANGEMENTS AND ENVIRONMENTAL CONTROL IN HOLD SPACES

Contents

4.1. General Requirements

4.1.1. Access for inspection

4.1.1.1. Visual inspection shall be possible of at least one side of the inner hull structure without the removal of any fixed structure or fitting. The inner hull shall not be a fuel-oil tank boundary wall, if such a visual inspection whether combined with those inspections required in 4.1.1.2, 4.2.1.7 or Sec.14, [14.1.1.6] or not, is only possible at the outer surface of the inner hull.

4.1.1.2. Inspection of one side of any insulation in hold spaces shall be possible. Inspection of one side of the insulation in the hold space need not be required, 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.

4.1.1.3. Designated passage ways below and above cargo tanks shall have at least the cross sections as required by Ch 3 Sec.3, [3.3.2.1].

For the purpose of 4.1.1.1 or 4.1.1.2 the following applies:

1) Where the surveyor requires to pass between the surface to be inspected, flat or curved, and structural elements such as deck beams, stiffeners, frames, girders etc., the distance between that surface and the free edge of the structural elements should be at least 380 mm. The distance between the surface to be inspected and the surface to which the above structural elements are fitted, e.g. deck, bulkhead or shell, should be at least 450 mm in case of a curved tank surface (e.g. in case of type C-tank) or 600 mm in case of a flat tank surface (e.g. in case of type A-tank). See Fig.3.4.1.

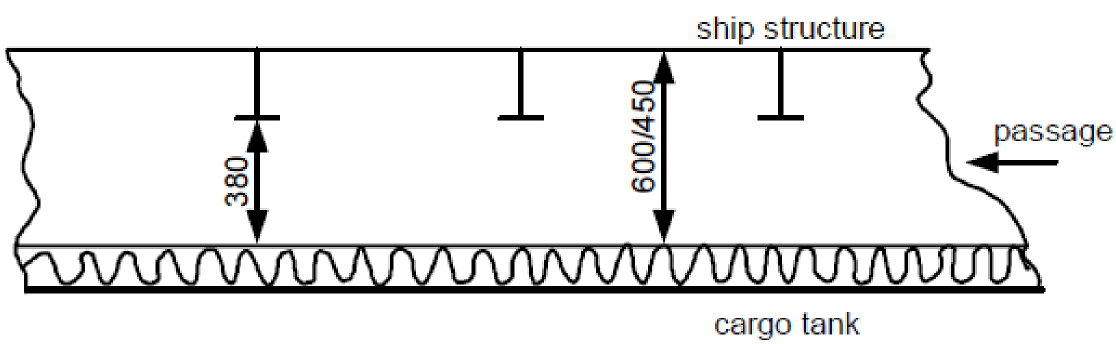


Figure 3.4.1: Minimum passage requirements involving structural elements

2) Where the surveyor does not require to pass between the surface to be inspected and any part of the structure, for visibility reasons the distance between the free edge of that structural element and the surface to be inspected shall be at least 50 mm or half the breadth of the structure's face plate, whichever is the larger. See Fig.3.4.2.

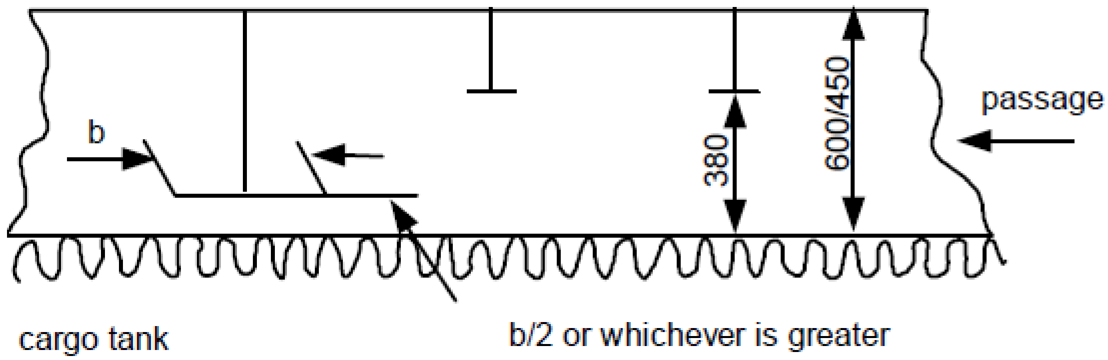


Figure 3.4.2: Minimum visibility requirements

3) If for inspection of a curved surface the surveyor requires passing between that surface and another surface, flat or curved, to which no structural elements are fitted, the distance between both surfaces shall be at least 380 mm, see Fig.3.4.3. A smaller distance than 380 mm may be accepted taking into account the shape of the curved surface, where the surveyor does not require passing between that curved surface and another surface.

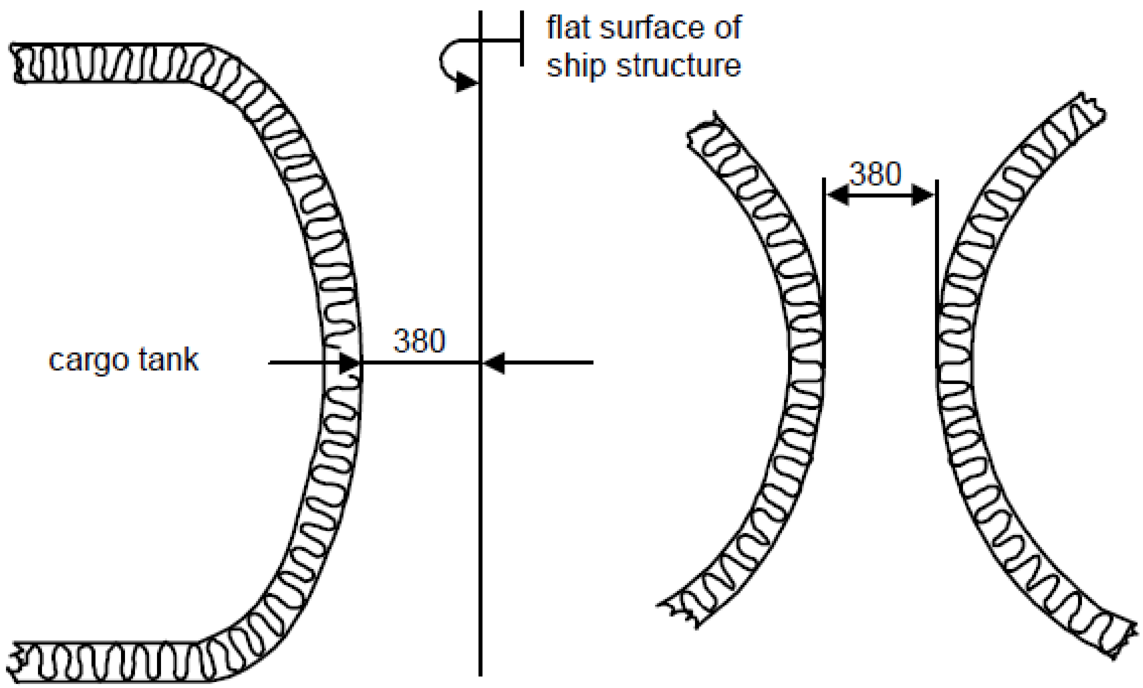


Figure 3.4.3: Minimum passage requirements between two curved surfaces

4) The distance between those surfaces shall be at least 600 mm, see Fig.3.4.4, if for inspection of an approximately flat surface the surveyor requires to pass between two approximately flat and approximately parallel surfaces, to which no structural elements are fitted.

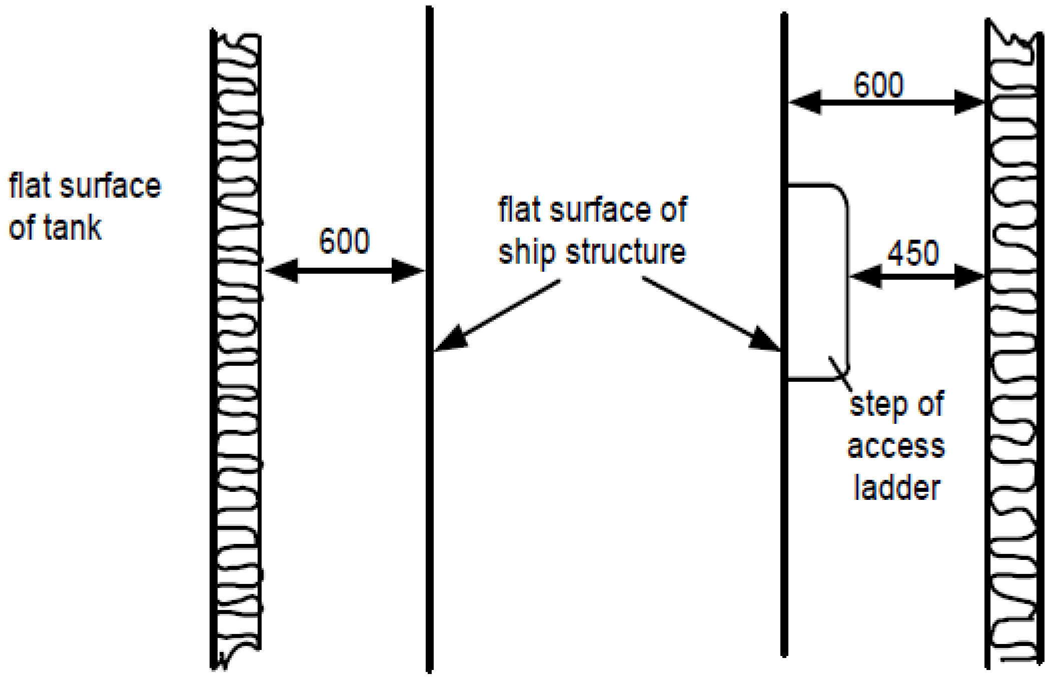


Figure 3.4.4: Minimum passage requirements between flat surfaces

5) The minimum distances between a cargo sump and adjacent double bottom structure in way of suction wells shall not be less than shown in Fig.3.4.5. The distance between the cargo tank sump and the inner bottom shall not be less than 50 mm, if there is no suction well.

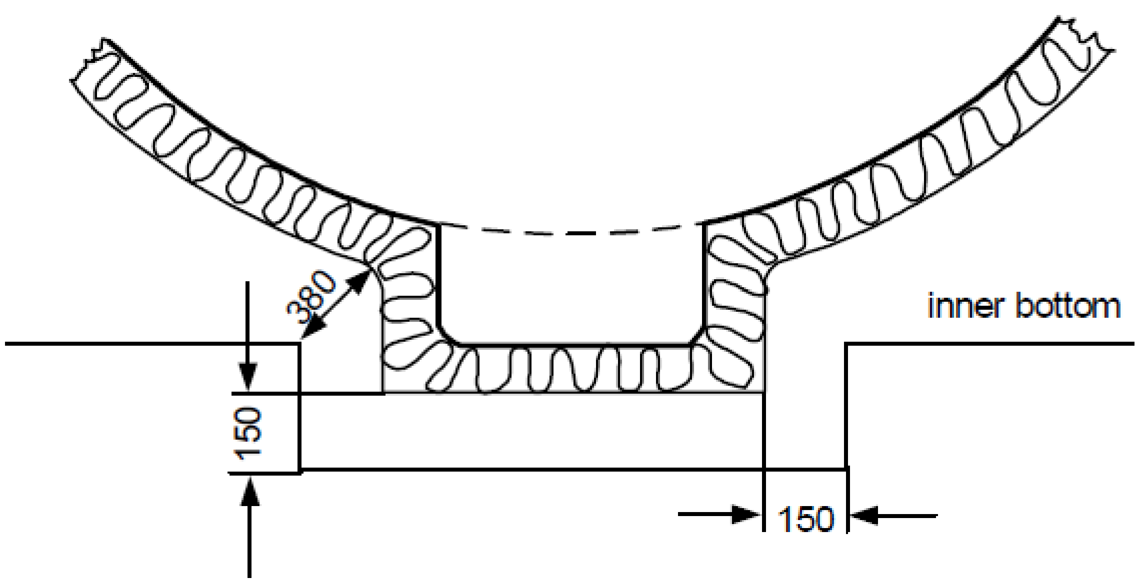


Figure 3.4.5: Minimum distance requirements involving a cargo sump

6) The distance between a cargo tank dome and deck structures is not to be less than 150 mm, see Fig.3.4.6.

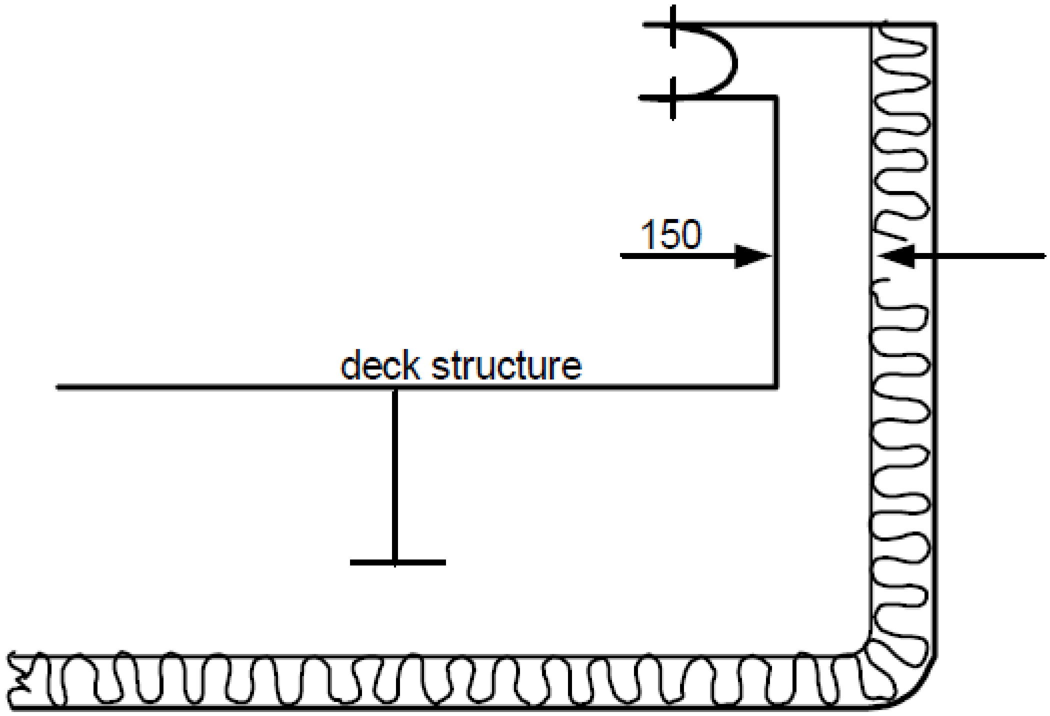


Figure 3.4.6: Minimum distance requirement between cargo tank dome and deck structures

7) If necessary for inspection fixed or portable staging should be installed. This staging should not impair the distances required under 1) to 4).
8) If fixed or portable ventilation ducting has to be fitted in compliance with Sec.10, [10.1.4] such ducting shall not impair the distances required under 1) to 4).

4.2. Secondary Barrier

4.2.1. General

4.2.1.1. Provision of a secondary barrier shall be done when required by 4.2.1.3 to act as a temporary containment for any envisaged leakage of liquid cargo through the primary barrier, where the cargo temperature at atmospheric pressure is below -10°C.

4.2.1.2. The hull structure may act as a secondary barrier, where the cargo temperature at atmospheric pressure is not below -55°C. In such a case the design is to be such that this temperature will not result in unacceptable hull stresses.

4.2.1.3. Secondary barriers in relation to tank types are normally to be provided according to Table 4.1.1.

Table 4.1.1 Secondary barriers in relation to tank types

Basic tank type	Cargo temperature at atmospheric pressure	
	Below -10⁰C down to -55⁰C	Below -55⁰C
	Hull may act as secondary barrier	Separate secondary barriers were required
Integral tank	Tank type not normally allowed 1)	
Membrane tank	Complete secondary barrier	
Semi-membrane tank	Complete secondary barrier 2) 3)	
Independent tank -type A -type B -type C	 Complete secondary barrier Partial secondary barrier 3) No secondary barrier required	
Internal insulation -type 2 -type 2	 Complete secondary barrier Complete secondary barrier is incorporated	

1) A complete secondary barrier is normally required if cargoes with a temperature at atmospheric pressure below 10⁰C are permitted as per Sec.1,[1.4.1.3].
2) In the case of semi-membrane tanks which conform to in all respects with the requirements applicable to independent tanks type B, except for the manner of support, the Society may, after special consideration, accept a partial secondary barrier.
3) The extent of secondary calculations and documentation will be decided in each separate case based on tank size and design.

Table 4.1.1 indicates the basic requirements with respect to secondary barrier. The secondary barrier requirements will be decided in each separate case for tanks which differ from the basic tank types as defined in Sec.1,[1.4].

4.2.1.4. The secondary barrier shall be designed so that:

- It is capable of containing any envisaged leakage of liquid cargo for a period of at least 15 days, unless different requirements apply for particular voyages. This condition shall be fulfilled taking into account the load spectrum defined in Sec.5,[5.1.7.10]
- It will prevent lowering of the temperature of the ship structure to an unsafe level in case of leakage of the primary barrier
- The mechanism of failure for the primary barrier does not also cause failure of the secondary barrier and vice-versa.

4.2.1.5. The functions of the secondary barrier shall be ensured assuming a static angle of heel equal to 30°.

4.2.1.6. Its extent shall be determined on the basis of cargo leakage corresponding to the extent of failure resulting from the load spectrum defined in Sec.5, [5.1.7.10] after the initial detection of a primary barrier leak, where a partial secondary barrier is required. Due account may be taken of liquid evaporation, rate of leakage, pumping capacity and other relevant factors. However, in all cases, protection for the inner bottom in way of cargo tanks shall be provided against liquid cargo. Provisions shall 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 at a safe level (spray-shield), clear of the partial secondary barrier.

4.2.1.7. The secondary barrier shall be capable of being periodically checked for its effectiveness. Checking may be a pressure/vacuum test, a visual inspection or another suitable method.

4.2.2. Insulation

4.2.2.1. The insulation shall be liquid-tight or protected by a liquid-tight coating, so that the cargo will not come in direct contact with any parts of the hull, if the secondary barrier is provided by insulation. The parts of the insulation located above the liquid level need not be liquid-tight or protected by a liquid-tight coating.

4.2.2.2. The insulation shall be able, under the above-mentioned conditions to withstand the loads it is exposed to, without the insulation itself or the liquid-tight coating being damaged.

4.2.2.3. Systems shall be tested for their purpose, for which sufficient service experience has not been gained. Experiments are normally to be carried out on an experimental tank, which is representative of conditions on board, both as regards size and construction.

4.3. Gas Pressure Relief Devices

4.3.1. Pressure/vacuum valves

4.3.1.1. If spaces for independent tanks may be completely closed, these spaces shall be equipped with pressure and vacuum valves. The number and size of these valves shall be decided depending on size and shape of the spaces.

4.3.1.2. The valves are normally to open at pressure of 0.15 bar above and below atmospheric pressure.

4.3.2. Pressure relief hatches

4.3.2.1. The spaces between the primary and secondary barriers shall be equipped with blow-out membranes or pressure relief hatches which shall open when the pressure exceeds 0.25 bar, if independent tanks are surrounded by a secondary barrier.

4.3.2.2. The combined relieving capacity of the pressure relief devices for inter barrier spaces surrounding type A independent cargo tanks where the insulation is fitted to the cargo tanks may be determined by the following formula:

$$Q_{sa} = 3.4\, A_c \frac{\rho_{lp}}{\rho_v} \sqrt{h} (m^3/s)$$

Q_{sa}= minimum required discharge rate of air at standard conditions of 273K and 1.013 bar

A_c= design crack opening area (m^2)

$$A_c = \frac{\pi}{4} d_{co} l \ (m^2)$$

d_{co}= maximum crack opening width (m)

$$d_{co} = 0.2 \ t_{tbpl} \ \ (m)$$

t_{tbpl}= thickness of tank bottom plating (m)

l= design crack length (m) equal to diagonal of the largest plate panel of the tank bottom, see Fig 3.4.7

h= maximum liquid height above tank bottom plus

10 X MARVS (m)

ρ_{lp} = Density of product liquid phase (kg/m^3) at the set pressure of the inter barrier space relief device

ρ_v = Density of product vapour phase (kg/m^3) at the set pressure of the inter barrier space relief device and a temperature of 273K

MARVS = maximum allowable relief valve setting of the cargo tank (bar)

Pressure relief devices for inter-barrier spaces need not be arranged to conform to the requirements of Ch 3, Sec.9,[9.2.2.8].

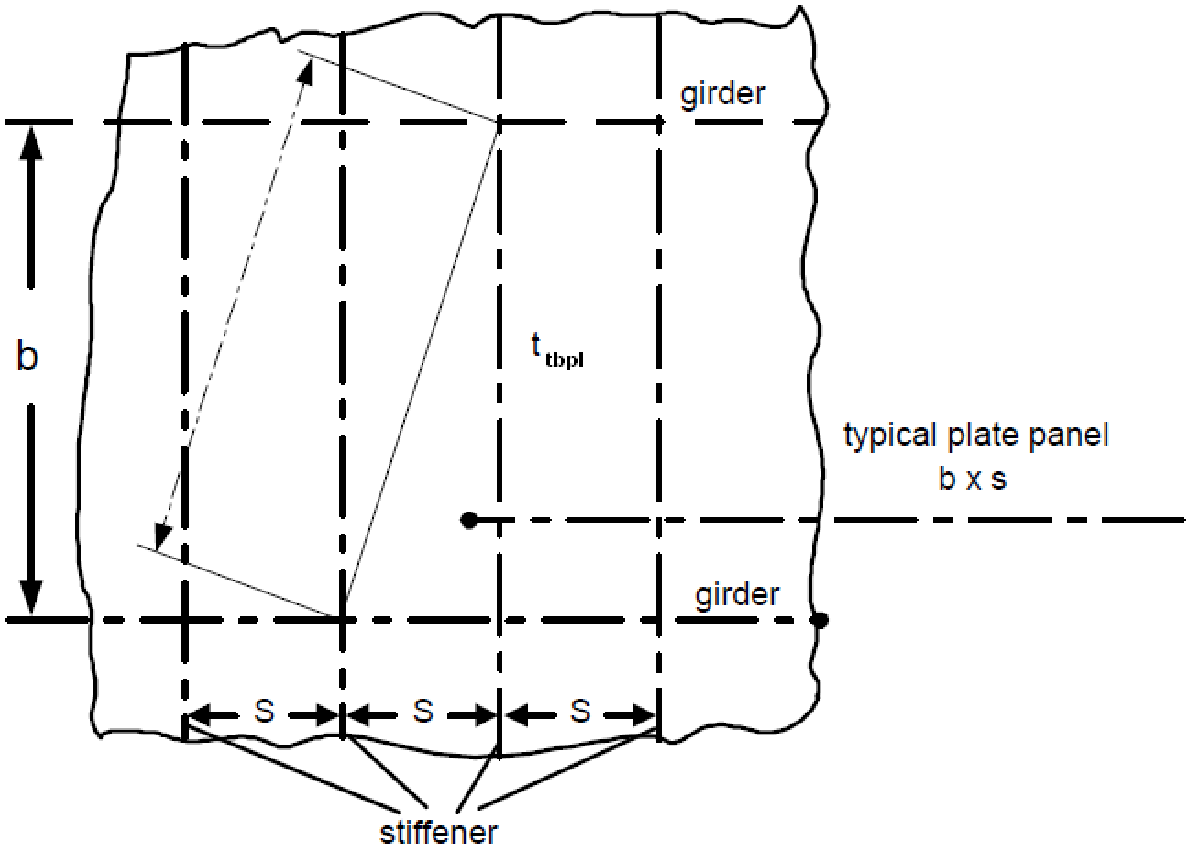


Figure 3.4.7: Design crack length, *l*

4.3.2.3. The relieving capacity of pressure relief devices of inter-barrier spaces surrounding independent type B cargo tanks shall be determined on the basis of the leakage rate determined according to 4.2.1.6.

4.3.2.4. Evaluation of the relieving capacity of pressure relief devices for inter-barrier spaces of membrane and semi-membrane tanks shall be done on the basis of the specific membrane or semi-membrane tank design.

4.3.2.5. Construction of the pressure relief hatches shall be done to avoid risk of damage by expected external forces.

4.4. Environmental Control within the Hold Space

4.4.1. Cargo containment systems requiring a secondary barrier

4.4.1.1. Inter barrier and hold spaces associated with cargo containment systems for flammable gases requiring full secondary barriers, shall 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 shall be adequate for normal consumption for at least thirty days.

4.4.1.2. Inter barrier and hold spaces associated with cargo containment systems for flammable gases requiring partial secondary barriers, is to 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 shall be sufficient for normal consumption for at least thirty days, alternatively, except as limited by Sec.15, the spaces referred to in this item may be permitted 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 tank will be rapidly detected and inerting effected before a dangerous condition can develop. Equipment for the provision of sufficient dry air of suitable quality to satisfy the expected demand shall be provided.

4.4.1.3. The spaces referred to in 4.4.4.1 and 4.4.4.2 may be maintained with a suitable dry air or dry inert atmosphere, for non-flammable gases.

4.4.1.4. Environmental control arrangements are not required for inter-barrier spaces and spaces between the secondary barrier and the inner hull or independent tank structures completely filled with insulation material conforming to Sec.7, [7.3.2.3], in case of internal insulation tanks.

4.4.2. Cargo containment systems not requiring a secondary barrier

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

4.5. Sealing around Tanks

4.5.1. General

4.5.1.1. Provision for efficient sealing shall be there where independent tanks extend above the upper deck. Its material shall be such that it will not deteriorate, even during considerable movements between the tanks and the deck and withstand all expected temperatures and environmental hazards.

4.6. Earth Connections

4.6.1. General

4.6.1.1. As a minimum, two effective earth connections shall be arranged between each tank and the hull.

SECTION 5 SCANTLINGS AND TESTING OF CARGO TANKS

Contents

5.1. General

5.1.1. Introduction

5.1.1.1. Requirements are given in this section, for scantlings and testing of cargo tanks of types as defined in Ch 3, Sec.1,[1.4], together with their supporting and keying structure.

5.1.2. Approval of works

5.1.2.1. Builders of cargo tanks intended for Tanker for Liquefied Gas is to be especially approved by the Society for manufacturing of the type of tank in question.

5.1.3. Definitions

5.1.3.1. The following definitions will normally not be repeated throughout this section:

p_0 = design vapour pressure as defined in Ch 3, Sec.1,[1.2.1.14] (bar)
MARVS = the maximum allowable relief valve setting of a cargo tank (bar)
L = ship length as given in Pt.3 Ch.1 Sec.1 (m)
L_1 = L, maximum 300 m
B_m = greatest moulded breadth (m)
C_B = block coefficient
V = service speed (knots)
GM = metacentric height (m)
g_0 = acceleration due to gravity (m/s^2)
E = modulus of elasticity (N/mm^2)
ρ_{co}= density of cargo (kg/m^3)
σ_B = the specified minimum tensile strength at room temperature (N/mm^2). For welded connections in aluminum alloys the tensile strength in annealed condition shall be used

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

$\sigma_{0.2}$ = the specified minimum 0.2% proof stress at room temperature (N/mm^2). For welded connections in aluminum alloys the 0.2% proof stress in annealed condition shall be used.

5.1.3.2. Cargo tank types are defined in Ch 3,Sec.1,[1.4].

5.1.3.3. Supporting structure transfers forces from the keys to the main elements of the hull of the ship (e.g. to the ship side and transverse bulkheads). The supporting structures may include parts of the hull structure (e.g. double bottom structures).

5.1.3.4. Keys form a boundary between the cargo tank and the supporting structure and prevent the cargo tank from bodily movement.

5.1.4. Design stress

5.1.4.1. The minimum specified mechanical properties of the material, including the weld metal in the fabricated condition shall be used, when determining the design stresses (as specified in this section for each type of tank). Subject to special consideration by the Society, for certain materials, advantage may be taken of enhanced yield strength and tensile strength at design temperatures below -105°C.

5.1.5. Loads to be considered

5.1.5.1. Tanks together with their supports and other fixtures is to be designed taking into account proper combinations of the various loads listed below:

- 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 mass
- loads in way of towers and other attachments
- vibrations

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

5.1.6. Static loads

The following static loads shall be taken into consideration:

5.1.6.1. The design vapour pressure p_0 shall not be taken less than:

1) p_0 shall not be less than the vapour pressure of the cargo at a temperature of45°C, for cargo tanks where there is no temperature control and where the pressure of the cargo is only dictated by the ambient temperature. However, acceptance of lesser values of this temperature may be given 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.

   Higher values of this temperature, on the other hand, may be required for ships permanently operating in areas of high ambient temperatures. Moreover, p_0 shall not be less than the maximum allowable relief valve setting (MARVS).

2) The pressure of the inert gas for tanks unloaded by means of inert gas.

   If this higher pressure is taken into account when determining the scantlings of the upper parts of the tank, subject to special consideration a vapour pressure higher than p_0 may be accepted in harbour condition where dynamic loads are reduced. However, this pressure shall not be higher than the limiting values given in Sec.1, [1.4] for the various types of tanks.

   For particular cargoes as indicated in the *List of Cargoes*, special requirements to p_0 may be given.

5.1.6.2. The static load due to 98% filling by volume of the tank with a cargo of design density.

5.1.6.3. The design external pressure, p_{ed}, is to be based on the difference between the minimum internal pressure (maximum vacuum) and the maximum external pressure to which the tank may be subjected simultaneously. The design external pressure shall be based on the following formula:

$$p_{ed} = p_1 + p_2 + p_3 + p_4$$

p_1 = opening pressure of the vacuum relief valves. For tanks not fitted with vacuum relief valves, p_1 shall be specially considered, but is in general not to be taken less than 0.25 bar

p_2 = for tanks or part of tanks in completely closed spaces: the set pressure of the pressure relief valves for these spaces

Elsewhere $p_2 = 0$

p_3 = external head of water for tanks or part of tanks on exposed decks

Elsewhere $p_3 = 0$

p_3 may be calculated using the formulae given in Ch 3,Sec.5,[3.5.3.3] multiplied by the factor c given in Part 3.

p_4 = compressive actions in the shell due to the weight and contraction of insulation, weight of shell, including corrosion allowance, and other miscellaneous external pressure loads to which the pressure vessel may be subjected. These include, but are not limited to, weight of domes, weight of towers and piping, effect of product in the partially filled condition, accelerations and hull deflection. In addition the local effect of external or internal pressure or both should be taken into account

5.1.6.4. Static forces imposed on the tank from deflection of the hull.

5.1.6.5. Account shall be taken of the loads corresponding to the pressure test mentioned in N.

5.1.7. Dynamic loads

5.1.7.1. The determination of dynamic loads shall take account of the long term distribution of ship motions that the ship will experience during her operating life. The operating life is normally taken to correspond to 10^8 wave encounters on the North Atlantic. Consideration for any pertinent effects on surge, sway, heave, roll, pitch and yaw in irregular seas shall be given.

Consideration of the probability of occurrence of different ship-to-wave heading angles shall be done, normally a uniform probability may be assumed.

The effects of speed reduction in heavy weather may be allowed for.

The wave-induced loads shall be determined according to accepted theories, model tests or full scale measurements.

5.1.7.2. Ships for restricted service will be given special consideration.

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

- Vertical acceleration:
- Motion acceleration of heave, pitch and, possible, roll (normal to the ship base).
- Transverse acceleration:
- Motion acceleration of sway, yaw and roll
- Gravity component of roll.
- Longitudinal acceleration:

- Motion acceleration of surge and pitch
- Gravity component of pitch.

5.1.7.4. For independent tanks type A and C, the following design accelerations shall be used unless other values are justified by independent calculations.

- vertical acceleration:

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

- transverse acceleration:

$$a_y = \pm a_0 \sqrt{0.6 + 2.5 \left(\frac{X_{tk}}{L} + 0.05\right)^2 + \kappa \left(1 + 0.6 \frac{\kappa_Z}{B}\right)^2}$$

- longitudinal acceleration:

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

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

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

Z_{tk} = vertical distance from the ship's actual waterline to the centre of gravity of tank with content (m). Z_{tk} is positive above and negative below the waterline

$$a_0 = \frac{0.2V}{\sqrt{L}} + \frac{34 - \frac{600}{L}}{L}$$

V = service speed (knots)

Generally, κ = 1.0. For particular loading conditions and hull forms, determination of κ according to the formula below may be necessary.

$$\kappa = \frac{13GM}{B_m} \;(\kappa \geq 1.0, GM = metacentric\ height\ (m))$$

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 may be assumed to act independently.

a_z does not include the component of the static mass.

a_y includes the component of the static mass in the transverse direction due to rolling.

a_x includes the component of the static mass in the longitudinal direction due to pitching.

Speed reduction in heavy weather has been taken into account in these formulae.

The most probable acceleration aβ in a given direction β may be found as shown in Fig.3.4.1. Where acceleration in three directions needs to be considered, an ellipsoid shall be used instead of the ellipse.

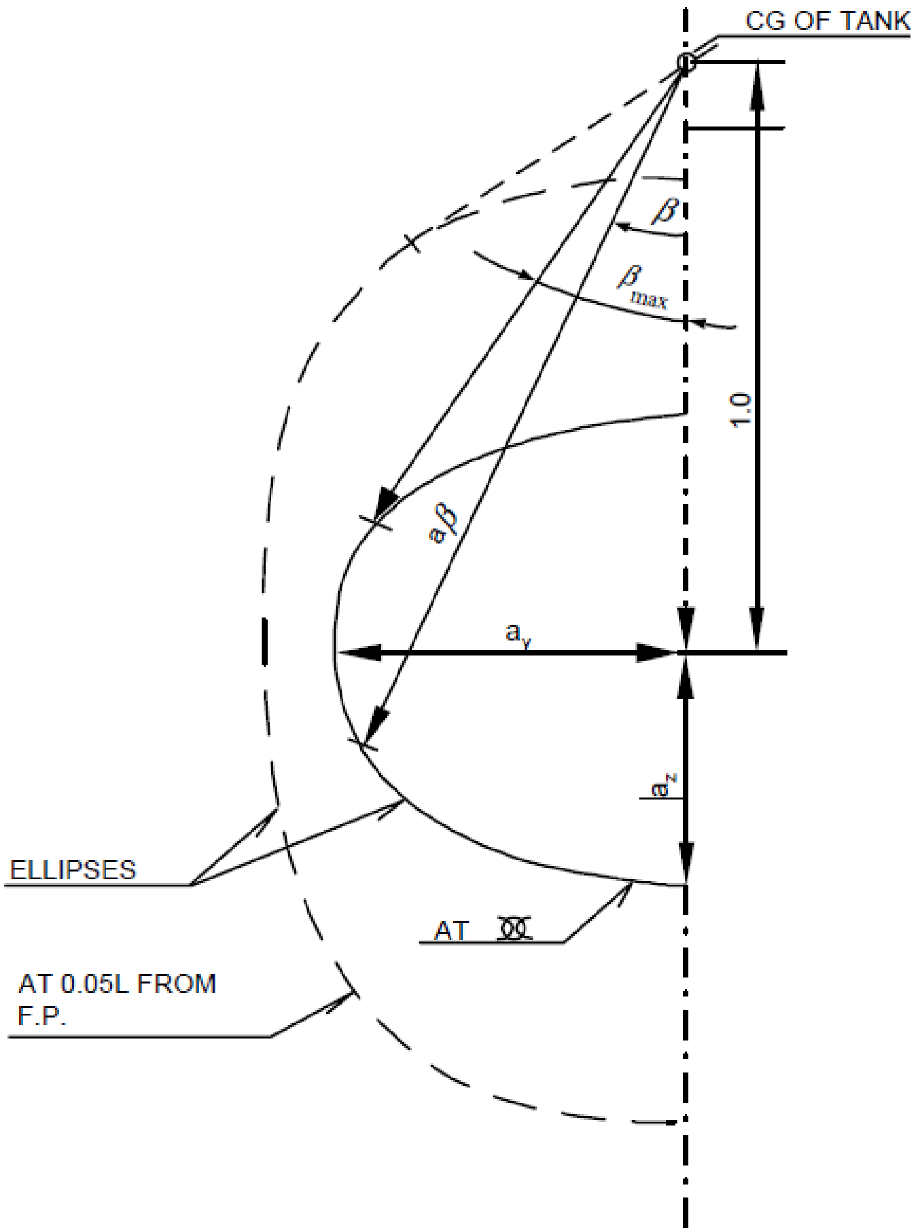


Figure 3.5.1: Resulting acceleration (static + dynamic) aβ in arbitrary direction β.

5.1.7.5. The following formula gives the value of internal pressure (or design liquid pressure) in a full tank, that results from the design vapour pressure p_0 and the liquid pressure defined in 5.1.7.6, but not including effects of liquid sloshing.

$$p_{eq} = p_0 + \left(p_{gd}\right)_{max} (bar)$$

Equivalent procedures may be applied.

5.1.7.6. The internal liquid pressures are created by the result of acceleration of the centre of gravity of the cargo due to the motions of the ship. The following formula provides the value of internal liquid pressure, resulting from combined effects of gravity and dynamic acceleration:

$$p_{gd} = \frac{a_\beta Z_\beta \rho_{com}}{1.02.10^4}(bar)$$

a_β = the dimensionless acceleration (i.e. relative to the acceleration of gravity) resulting from gravitational and dynamic loads, in an arbitrary direction β (see Fig.3.5.1)

ρ_{com} = the maximum density of the cargo in kg/m^3 at the design temperature

Z_β = largest liquid height (m) above the point where the pressure shall be determined measured from the tank shell in the β direction (see Fig.3.5.2)

Tank domes considered to be part of the accepted total volume should be taken into account when determining Z_β unless the total volume of tank domes V_D does not exceed the following value:

$$V_D = V_T\left(\frac{100-FL}{FL}\right)(m^3)$$

V_T = tank volume without any domes (m^3)

FL = Filling limit in accordance with Ch 3, Sec.17,[3.17.1.1] or [3.17.1.3] in %.

The direction β which gives the maximum value $(p_{gd})_{max}$ of p_{gd}, shall be considered. An ellipsoid shall be used instead of the ellipse in Fig.3.5.1, where accelerations in three directions need to be considered.

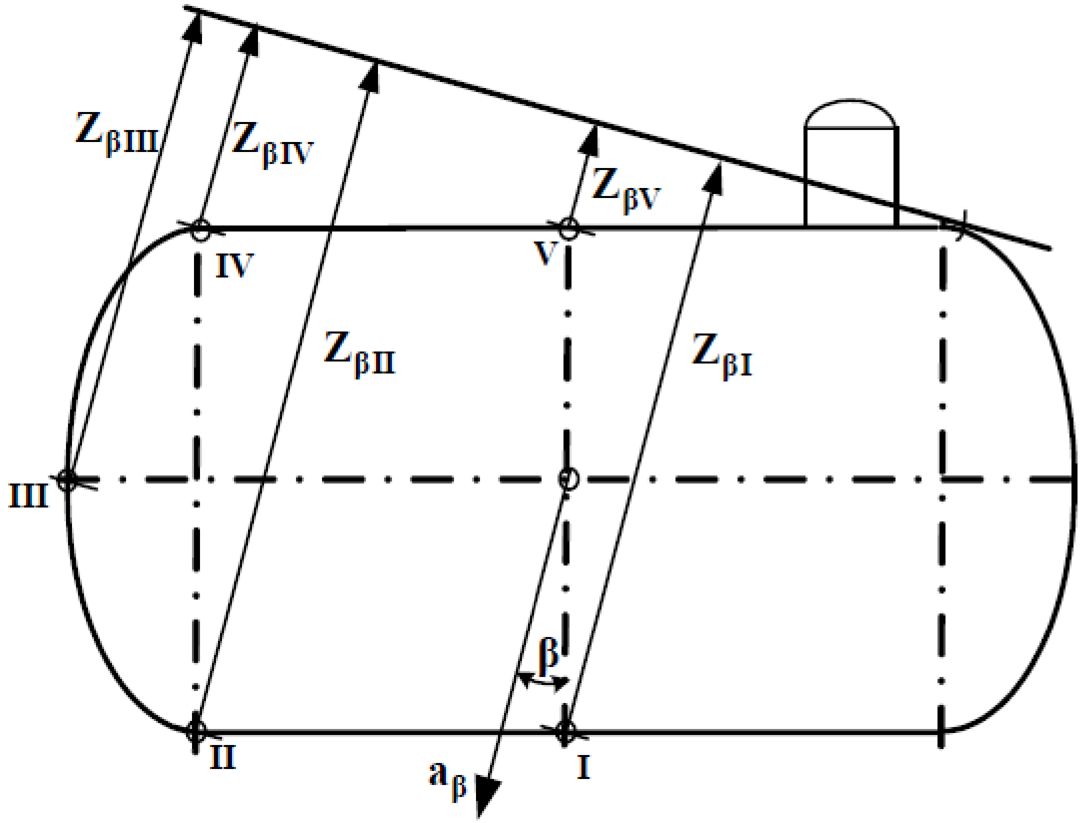


Figure 3.5.2: Liquid heights, Z_β, for check points I-V, in the β-direction.

5.1.7.7. Loads are required as usually for membrane tanks when detailed studies of wave induced, semi-membrane tanks and independent tanks type B, the loads given in 5.1.7.8, 5.1.7.9 and 5.1.7.10 shall be utilized.

5.1.7.8. The loads are normally to be taken as the most probable largest loads in 10^8 wave encounters (probability level $Q = 10^{-8}$) for a ship operating on the North Atlantic, for design against plastic deformations and buckling.

All types of wave-induced loads and motions exerted by the hull and the cargo on the tank structure are to be considered.

Generally, these types of loads are:

- Vertical, transverse and longitudinal acceleration forces
- Internal liquid pressure in the tank (full and partially full)
- External water pressure on the hull
- Vertical and horizontal bending of the hull girder
- Torsion of the hull girder.

5.1.7.9. The load spectrum is normally to be taken as the most probable largest load spectrum the ship will experience, for design against fatigue during, 108 wave encounters on the North Atlantic.

Generally, the load spectrum shown in Fig.3.5.3 may be utilized. This load spectrum may be replaced by a number of 8 fatigue loads, each of which is represented by a certain number of cycles, n_i, and an alternating load • }P_i

Corresponding values of P_i and n_i are given by:

$$P_i = \frac{17 - 2_i}{16} P_0$$

$$n_i = 0.9.10^i$$

i = 1, 2, 3, 4, 5, 6, 7, 8

P_0 = load on probability level Q = 10^{-8}

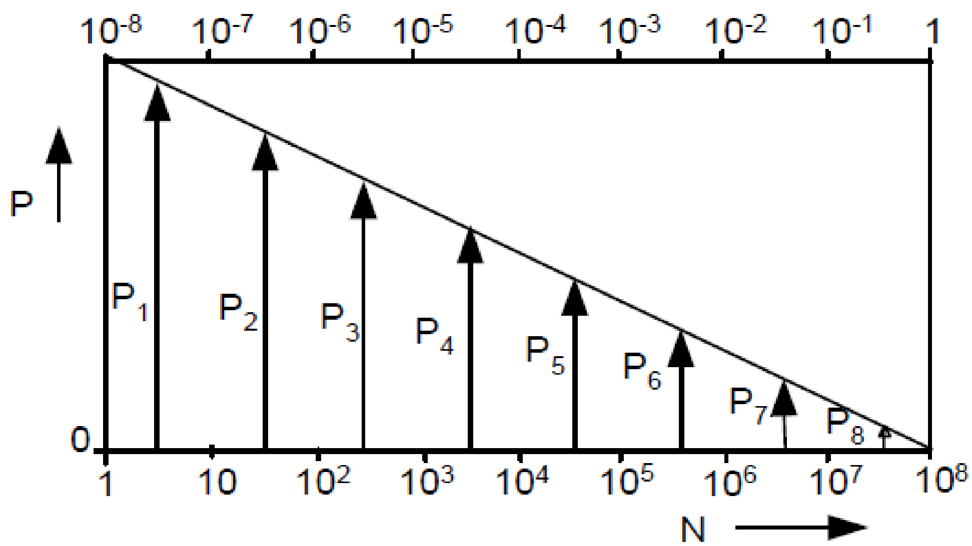


Figure 3.5.3: Long term wave-induced load spectrum

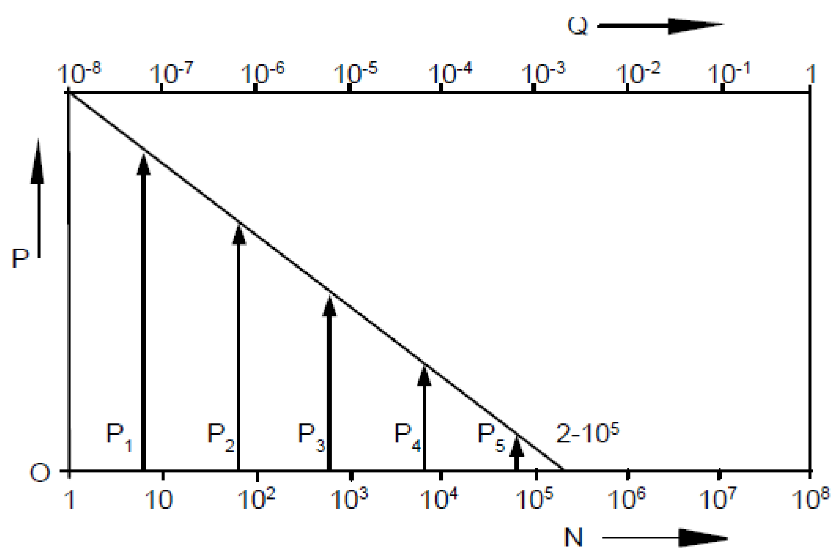


Figure 3.5.4: Load spectrum representing the worst period of 15 days in the long term induced load spectrum

5.1.7.10. The load spectrum is normally to be taken as the load spectrum, for design against crack propagation, representing the worst period of 15 days in the most probable largest load spectrum the ship will experience during 10^8 wave encounters on the North Atlantic. Generally the load spectrum shown in Fig.3.5.4 may be used. This load spectrum may be replaced by a number of 5 fatigue loads, each of which is represented by a certain number of cycles, n_i, and an alternating load ± P_i.

Corresponding values of P_i and n_i are given by:

i = 1, 2, 3, 4, 5

P_0 = load on probability level Q = 10^{-8}.

5.1.8. Sloshing loads

5.1.8.1. The risk of significant loads due to sloshing induced by any of the ship motions mentioned in 5.1.7.3 shall be considered, when partial tank filling is contemplated.

5.1.8.2. Special tests and or calculations will be required, when risk of significant sloshing induced loads is found to be present.

5.1.9. Thermal loads

5.1.9.1. Consideration of transient thermal loads during cooling-down periods shall be done for tanks intended for cargoes with a boiling point below -55°C.

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

5.1.10. Vibration

5.1.10.1. Design of hull and cargo tanks, choice of machinery and propellers is to be aimed at keeping vibration exciting forces and vibratory stresses low. Calculations or other appropriate information pertaining to the excitation forces from machinery and propellers, may be needed for membrane tanks, semi-membrane tanks and independent tanks type B, and in special cases, for independent tanks type A and C. Full-scale measurements of vibratory stresses and or frequencies may be required.

5.1.11. Supports

5.1.11.1. Cargo tanks are to be supported by the hull in a manner which will avoid 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.

5.1.11.2. The supports are to be calculated for the most probable largest severe resulting acceleration taking into account rotational as well as translational effects. This acceleration in a given direction β may be determined as shown in Fig.3.5.1. The half axes of the “acceleration ellipse” are determined in accordance with 5.7.1.4.

5.1.11.3. Provisions shall be made to key the tanks against the rotational effects referred to in 5.1.11.2, for independent tanks and, where appropriate, for membrane and semi-membrane tanks.

5.1.11.4. The tanks with supports are to be designed for a static inclination of 30° without exceeding the allowable stresses specified for the various types of tanks.

5.1.11.5. Provision of suitable supports shall be done to withstand a collision force acting on the tank corresponding to one half of 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.

5.1.11.6. The loads mentioned in 5.1.11.4 and 5.1.11.5 need not be combined with each other or with wave-induced loads.

5.1.11.7. Provision of anti-flotation arrangements shall be done for independent tanks. The anti-floatation arrangements is to be suitable to withstand an upward force caused by an empty tank in a hold space flooded to the load draught of the ship, without plastic deformation likely to endanger the hull structure.

5.1.12. Corrosion allowance

5.1.12.1. If the contents of the tank are noncorrosive and the external surface is protected by inert atmosphere or by an appropriate insulation with an approved vapour barrier, for independent tanks no corrosion allowance is generally required. Paint or other thin coatings exposed to weather or mechanical damage will not be credited as external protection. No corrosion allowance will in general be required where austenitic stainless steel, aluminum alloys and other special alloys are used with acceptable corrosion resistance. The scantlings calculated according to subsections E, F, G, H and I shall be increased as appropriate, if the above conditions are not satisfied.

5.1.12.2. For integral tanks the corrosion allowance is in general to be according to Part 3. However, no corrosion allowance will be required on the internal surface, if the cargo is non-corrosive.

5.1.13. Fracture mechanics analysis

5.1.13.1. An analysis in accordance with 5.1.13.2 shall be carried out for independent tanks type B, and may be required in special cases, for semi-membrane tanks.

5.1.13.2. A fatigue crack propagation analysis is to be carried out for areas with high dynamic stresses. The analysis shall consider propagation rates in parent material, weld metal and heat-affected zone.

The analysis shall establish the size and shape of possible fatigue cracks at penetration of the tank wall, taking into account the stress distribution through the tank wall. The largest crack dimension at penetration is defined as a_i.

The crack dimension, a_d, to which a_i will extend under dynamic loading before detection by gas leakage is possible, shall be documented. Further, the length a_f to which this crack ad will grow under dynamic loading based on a stress spectrum corresponding to the worst period of 15 days in the long term spectrum as given in 5.1.7.10, shall be determined.

Consideration for the permissible length of a_f shall be given by the Society in each separate case, and shall be considerably less than the critical crack size a_c.

The above requirements to establishment of critical crack sizes and fatigue crack sizes and shapes may have to be documented by means of experiments, if necessary. The fracture toughness properties of the tank material and its welded joints in the thicknesses utilized in the design shall be well documented to allow determination of the critical crack sizes or conservative estimates of critical crack sizes for important parts of the tanks. The determination of critical crack sizes, a_c, shall be performed using recognised calculation procedures which have to be approved in each case.

The fracture toughness properties shall be expressed using recognised standards or practice e.g., ASTME 399 (latest issue) or BS 7448 (latest issue).

Depending on material, fracture toughness properties determined for loading rates similar to those expected in the tank system may be required.

The fatigue crack propagation rate properties shall be documented for the tank material and its welded joints for the relevant service conditions. These properties shall be expressed using a recognised fracture mechanics practice relating the fatigue crack propagation rate to the variation in stress intensity (ΔK) at the crack tip. The effect of stresses produced by static loads as given in 5.1.6 shall be taken into account when establishing the choice of fatigue crack propagation rate parameters.

5.1.14. Fatigue analysis

5.1.14.1. An analysis in accordance with 5.1.14.1 and 5.1.14.3 shall be carried out for independent tanks type B and may, in special cases, be required for independent tanks type C and semi-membrane tanks.

5.1.14.2. A fatigue analysis shall be carried out for parent material and welded connections at areas where high dynamic stresses or large stress concentrations may be expected.

The fatigue properties shall be well documented for the parent material and welded connections being used in the design. The data on fatigue properties shall be determined experimentally, for less investigated and documented materials. Due attention shall be paid to the effect of:

- specimen size and orientation
- stress concentration and notch sensitivity
- type of stress
- mean stress
- type of weld
- welding condition
- working temperature.

The number of specimens to be tested at each stress level shall not be less than 6.

The fatigue strength of the structure considered shall be illustrated by Wøhler curves (S-N curves).

5.1.14.3. The fatigue analysis shall be based on the fatigue loading given in 5.1.7.9. The number of complete stress cycles due to loading and unloading is in general to be 1000. The cumulative effect of the various fatigue loads shall satisfy the following requirement:

$$0.9\sum_{i=1}^{i=8}\left(\frac{10^i}{N_i}\right)+\frac{10^3}{N_9}<C_W$$

N_i = number of cycles to fracture for wave-induced fatigue load number i, according to Wøhler curves

N_9 = number of cycles to fracture for the fatigue load due to loading and unloading

The effect of stresses produced by static load as given in 600 shall be taken into account.

$C_W \le 0.5$. Subject to special consideration a value greater than 0.5 but not greater than 1.0 may be used, dependent on the test procedure and data used to establish the Wøhler curve (S-N curve).

5.2. Integral Tanks

5.2.1. General

5.2.1.1. Reference is made to Part.3.
5.2.1.2. Tanks for cargoes with density below 1000 kg/m^3 shall have scantlings at least as tanks constructed for liquid cargoes with density equal to that of seawater.
5.2.1.3. Tanks for cargoes with density above 1000 kg/m^3 see Part.3.
5.2.1.4. The minimum thickness requirements will be considered in each case, for materials other than mild steel.

5.3. Membrane Tanks

5.3.1. General

5.3.1.1. The effects of all static and dynamic loads shall be considered to determine the suitability of the membrane and of the associated insulation with respect to plastic deformation and fatigue, for membrane tanks.

5.3.1.2. A model of both the primary and secondary barrier is normally to be tested, including corners and joints, to verify that it will withstand the expected combined strains due to static, dynamic and thermal loads, before approval is granted. Test conditions shall represent the most extreme service conditions the tank will see in its life. Material tests shall ensure that ageing is not liable to prevent the materials from carrying out their intended function.

5.3.1.3. A complete analysis of the particular motions, accelerations and response of ships and tanks shall be performed in accordance with [51.7], as applicable, For the purpose of the test referred to in 5.3.1.2, unless these data are available from similar ships.

5.3.1.4. Special attention is to be paid to the possible collapsing of the membrane due to an overpressure in the inter barrier space, to a possible vacuum in the tanks, to the sloshing effects and to hull vibration effects.

5.3.1.5. The structural analysis of the hull shall be performed according to the rules for hull structure given in Part.3. However, special attention is, to be paid to deflections of the hull and their compatibility with the membrane and associated insulation.

5.3.1.6. The permissible stresses for the membrane, membrane supporting material and insulation will be determined in each particular case.

5.3.1.7. It shall be possible by means of a dependable and efficient method to control that the primary or the secondary barrier is free from small leakages, which may be difficult to detect by visual inspection. Submission for a description of the proposed leakage detection method shall be done for consideration.

5.4. Semi-Membrane Tanks

5.4.1. General

5.4.1.1. Structural analysis shall be performed according to the requirements for membrane tanks or independent tanks, as appropriate, taking into account the internal pressure as projected in [5.1.7.5 & 5.1.7.6].

5.5. Independent Tanks Type A

5.5.1. Tanks constructed mainly of plane surfaces

Independent tanks type A, primarily constructed of plane surfaces (gravity tanks), shall be designed in accordance with 5.5.1 and 5.5.2.

5.5.2. Tank shell plating and stiffeners

5.5.2.1. The thickness requirement for the tank shell plating corresponding to lateral pressure is given by:

$$t_R = \frac{15.8s\sqrt{p}}{\sqrt{215f_1}}\ (mm)$$

p = pressure as given in 5.1.7.5 (kN/m^2) (1 bar = 100 kN/m^2)
s = stiffener spacing measured along the plating (m)
t_R shall not be taken less than 10 s mm but not less than 8.0 mm.

5.5.2.2. The section modulus requirement for simple stiffeners is given by:

$$Z_{st} = \frac{1000\ {l_{st}}^2 sp}{m\sigma}\ (cm^3)$$

p = pressure as given in A705 (kN/m^2) (1 bar = 100 kN/m^2)
l_{st} = stiffener span (m)
s = stiffener spacing measured along the plating (m)
σ = stress in N/mm^2 taken as the lower of σ_B/2.66 and $\sigma_{0.2}$/1.33.

m-values normally to be applied:
m = 7.5 for vertical stiffeners simply supported at one or both ends
= 10 for transverse stiffeners and vertical stiffeners which may be considered fixed at both ends
= 12 for longitudinal stiffeners which may be considered fixed at both ends.
The m-value may be adjusted for members with boundary condition not corresponding to the above specification or a direct calculation including the supporting boundary structure may be done, see Part 3.

5.5.2.3. Stiffeners supported by end bulkheads or swash bulkheads or stringers subject to relatively large deflections shall be checked by direct stress calculation using allowable stress of 160 f_1 N/mm^2 in the static loads and 215 f_1 N/mm^2 in the condition with static and dynamic loads.

5.5.2.4. Connection area of stiffeners shall be in accordance with Part 3. The design pressure load p may then be taken in accordance with 5.7.1.5 and 5.7.1.6, applying half values for a_x, a_y and a_z in the calculation of a_β.

5.5.2.5. The web and flange thickness shall not be less than the larger of:

$$t_{wf} = 5.0 + \frac{k}{\sqrt{f_1}}$$

$$t_{wf} = \frac{h}{g}$$

$k = 0.02\, L_1$ (= 5.0 maximum)
h = profile height (mm)
g = 70 for flanged profile
g = 20 for flat bar profiles.

5.5.2.6. The sloshing load on wash bulkheads shall be in accordance with Part 3. The requirement for structures should be as given in Part 3.

5.5.3. Girder systems

5.5.3.1. A structural analysis shall be carried out to ensure that the stresses are acceptable, for webs, girders and stringers. Application of calculation methods shall be taken into account the effects of bending, shear, axial and torsional deformations as well as the hull cargo tank interaction forces due to the deflection of the double bottom and cargo tank bottom.

5.5.3.2. The following loads and stresses shall be taken into consideration:

- Static loads according to 5.1.6
- Dynamic additional loads due to the ship's movement in a seaway.
- Thermal stresses.

5.5.3.3. The dynamic, additional, external water pressure on the hull of the ship shall be taken as:

- For load points below the summer load waterline:

$$p_{ed} = 2\, p_{dp}$$

- For load points above the summer load waterline:

$p_{ed} = 2\ p_2$

p_{dp} and p_2 = dynamic pressure as given in Part 3.

L_1 = L, maximum 300 m.

5.5.3.4. If a tank may be partly filled, dynamic forces due to liquid movement shall be taken into consideration as given in Part 3.

5.5.3.5. The vertical load on the supporting structure is given by:

$$P_Z = (1 + a_Z) M_{TK}\ g_0\ (kN)$$

a_Z = vertical acceleration

M_{Tk}= mass of tank and content in t.

The load on keys designed to take transverse forces is given by:

$$P_y = a_y M_{TK} g_0 \text{ (kN)}$$

a_y = transverse acceleration.

The point of attack of the force is at the tank's centre of gravity.

The load on keys designed to take longitudinal forces is given by:

$$P_x = a_x M_{TK}\ g_0 \text{ (kN)}$$

a_x = longitudinal acceleration.

The point of attack of the force is at the tank's centre of gravity.

Formulae for the accelerations a_x, a_y and a_z are given in 5.7.1.4. For static inclination and longitudinal collision load.

5.5.3.6. The allowable nominal stresses, for the main structure of the tank (webs, stringers and girders) as well as the supporting and keying structure, when the tanks are loaded as described in 5.5.3.1 to 5.5.3.5, are given below:

Static load:

σ_e shall not exceed 150 f_1 N/mm^2

τ_m shall not exceed 80 f_1 N/mm^2

Static and dynamic load:

σ_e shall not exceed 215 f_1 N/mm^2

τ_m shall not exceed 115 f_1 N/mm^2

τ_m = mean shear stress over a net cross section

σ_e = equivalent stress defined in Part 3

f_1 = material factor as given in Part 3.

For tanks supported in such a way that the deflections of the hull affects significantly the stresses of the tank, that part of the hull structure which supports the tank shall be defined as supporting structure and dimensioned according to that.

The criteria provided in this paragraph and 5.5.3.8 are applicable to cargo tank structures and double bottom structures that is loaded by a cargo tank filled with liquefied gas.

The supporting structure in way of empty cargo tanks may generally be dimensioned using loads according to Part 3 and strength criteria according to the requirements of Part 3, for load cases considered in 5.1.5 where one or more cargo tanks are empty.

For independent tanks type A, with tank supports distributed on the inner bottom, the whole double bottom may be regarded as supporting structure, depending on the load case considered.

5.5.3.7. The stiffening of webs, stringers and girders shall be in accordance with the requirements given in Part 3.

The web and flange thickness shall not be less than:

$$t_{wf} = 5.0 + \frac{k}{\sqrt{f_1}}$$

$k = 0.02\, L_1$ (= 5.0 maximum)

5.5.3.8. Submission of a complete stability analysis of plates, stiffeners and girders defined in 5.5.3.6 shall be done when deemed necessary by the Society. Buckling control shall be carried out according to Part 3, but with the following usage factors when the local load, or local and global load shall 10^{-8} probability level:

- for plates in uniaxial compression $\eta = 0.95$
- for stiffeners $\eta = 0{,}90$
- for plates in biaxial compression η_x, $\eta_y = 1.0$

5.5.4. Tanks constructed mainly of bodies of revolution

5.5.4.1. Independent tanks type A, will be dealt with in each individual case, constructed primarily of bodies of revolution, but the requirements given for independent tanks type C with respect to internal pressure, buckling and stresses in way of supports, are in general applicable.

5.6. Independent Tanks Type B

5.6.1. General

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

- Plastic deformation
- Buckling
- Fatigue failure
- Crack propagation and brittle fracture.

5.6.1.2. A complete analysis of the particular ship accelerations and motions in irregular waves in accordance with A700 and of the response of ship and tanks to these forces and motions shall be performed, unless these data are available from similar ships.

5.6.1.3. The structural analysis shall be carried out using analytical tools such as:

- Finite element analysis
- Shell theory
- Frame work analysis (beam theory), when appropriate.

5.6.1.4. A 3-dimensional analysis shall be carried out, for the evaluation of the overall structural response of the tank. The model is to include the cargo tank with its supporting and keying systems as well as a reasonable part of the hull.

5.6.1.5. Appropriate models shall be utilized, when performing the structural analysis of the various parts forming the cargo tank.

5.6.1.6. Buckling analysis shall take into account the loads mentioned in 5.1.6.3 and 5.7.1.8, and other miscellaneous compressive loads to which the tank 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 deflections..

5.6.1.7. Buckling analysis shall consider the maximum construction tolerances.

5.6.1.8. For design against brittle fracture, a fracture mechanics analysis in accordance with 5.1.13 is required.

5.6.1.9. For design against fatigue failure, a fatigue analysis in accordance with 5.1.14 is required.

5.6.1.10. Model tests may be required to determine stress concentration factors and fatigue life of structural elements.

5.6.1.11. In order to obtain the natural frequencies for the significant modes of vibration, a vibration analysis shall be carried out for the various structural components of the tank.

Due attention is to be given to the effect of liquid, rotational restraint, flange stiffness and cut-outs on the natural frequencies.

The natural frequencies for the significant modes of vibration of a structural component shall comply with the following requirements:

Motor-driven ships: $f\Delta \geq 1.1\ f_{lh}$

Turbine-driven ships: $f\Delta \geq 1.1\ F$ or $f\Delta \leq 0.55\ f_{lh}$

f = natural frequency for the actual mode of vibration in air (Hz.)

Δ = reduction factor for the natural frequency when the structural component is immersed in liquid

f_{lh}= highest local excitation frequency expected to be of significance plus 10% (Hz.)

5.6.1.12. Post-weld heat treatment may be needed for parts of tanks depending upon construction, material thickness and type of material utilized.

5.6.1.13. Only plus-tolerances are permitted on the design wall thickness.

5.6.2. Equivalent stress and summation of static and dynamic stresses

5.6.2.1. The equivalent stress shall be calculated in accordance with the formula:

$$\sigma_e = \sqrt{{\sigma_x}^2 + {\sigma_{yt}}^2 - \sigma_x \sigma_y + 3{\tau_{xy}}^2}$$

σ_x = total normal stress in x-direction

σ_{yt} = total normal stress in y-direction

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

The method to be utilized for determining σ_x, σ_y and τ_{xy}, shall be considered in each separate case. The methods given in the Guidances below may be utilized in special cases.

Guidance note:

Total stresses in given directions in any point of a structure may be calculated in accordance with the following formulae:

$$\sigma_x = \sigma_{xs} \pm \sqrt{\sum (\sigma_{xdn})^2}$$

$$\sigma_{yt} = \sigma_{ys} \pm \sqrt{\sum \left(\sigma_{ydn}\right)^2}$$

$$\tau_{xy} = \tau_{xys} \pm \sqrt{\sum \left(\tau_{xydn}\right)^2}$$

σ_{xs}, σ_{ys} and τ_{xys} are static stresses.

σ_{xdn}, σ_{ydn} and τ_{xydn} are dynamic component stresses determined separately from acceleration components and hull strain components due to deflection and torsion.

If the dynamic component stresses in a given direction may not be assumed to act independently, coupling effects shall be considered.

Note:

By considering the ship in dynamic equilibrium total stresses in given directions in any point of the structure may be determined directly. The instantaneous response of the structure considered is determined for the ship moving in a design wave, by this method. By comparing the transfer function for a given wave length with the long term distribution value the design wave is determined, thus obtaining a design wave height. This wave height is utilized as a magnifying factor for all loads. The wave length which gives the worst combination of the most important loads shall be utilized.

5.7. Independent Tanks Type B, Primarily Constructed of Bodies of Revolution

5.7.1. Terms used for stress analysis

5.7.1.1. Terms utilized for stress analysis are defined in 5.7.1.2 to 5.7.1.10. Stress categories and stress limits are given in 5.7.3.2 to 5.7.3.6.

5.7.1.2. *Normal stress*- the component of the stress normal to the section of reference.

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

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

5.7.1.5. *Shear stress* - the component of the stress acting in the plane of reference.

5.7.1.6. *Primary stress*- a primary stress is one produced by the imposed loading and which is necessary to balance the external forces and moments. Not being self-limiting is the basic characteristic of a primary stress. Primary stresses which considerably exceed the yield strength will result in failure or at least gross deformations.

Primary membrane stresses are divided into two categories that is “general” and “local” categories. A general primary membrane stress is one which is so distributed in the structure that no redistribution of load occurs as the result of yielding.

5.7.1.7. *Primary local membrane stress*- cases arise in which 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 load to other portions of the structure. Such a stress is to be classified as a primary local membrane stress even though it has some characteristics of a secondary stress. A stressed region may be considered as local if:

$$s_1 \leq 0.5\sqrt{R_{Vm}t}$$

And

$$s_2 \geq 2.5\sqrt{R_{Vm}t}$$

s_1 = distance in the meridional direction over which the equivalent stress exceeds 1.1 f

s_2 = distance in the meridional direction to another region where the limits of general primary membrane stress are exceeded

R_{Vm} = mean radius of the vessel

t = wall thickness at the location where the general primary membrane stress limit is exceeded

σ_{apm} = allowable primary membrane stress, as given in 5.7.2.1.

5.7.1.8. *Secondary stress*- a normal stress or shear stress developed by the constraint of adjacent parts or by self-constraint of a structure. Being self-limiting is the basic characteristic of a secondary stress. Local yielding and minor distortions can fulfill the conditions which cause the stress to occur.

5.7.1.9. *Peak stress* - the basic characteristic of a peak stress is that it does not cause any noticeable distortion and is objectionable only as a possible source of a fatigue crack or a brittle fracture.

5.7.1.10. *Thermal stress*- a self-balancing stress that is produced by a non-uniform distribution of temperature or by differing thermal coefficient of expansion.

Thermal stresses may be divided into two types:

1) The association of the General thermal stress is with distortion of the structure in which it occurs. General thermal stresses are classified as secondary stresses.
2) Association of the local thermal stress is with almost complete suppression of the differential expansion and thus produces no significant distortion. Such stresses may be classified as local stresses and need only to be considered from a fatigue standpoint.

Guidance note:

Examples of local thermal stresses are:

Stress from radial temperature gradient in a cylindrical or spherical shell, stress in a cladding material which has a coefficient of expansion different from that of the base material, stress in a small cold point in a vessel wall.

5.7.2. Design stresses

5.7.2.1. The design equivalent stresses shall not exceed the values given in 5.7.3, For design against excessive plastic deformation and bursting:

σ_{apm} = the lesser of $\frac{\sigma_B}{A}\, or\, \frac{\sigma_F}{B}$

F= the lesser of $\frac{\sigma_B}{C}\, or\, \frac{\sigma_F}{D}$

A, B, C and D have the values as given in Table 3.5.1:

Table 3.5.1

Material	**A**	**B**	**C**	**D**
C-Mn steels and Ni-steels	3	2	3	1.5

Austenitic Steels	3.5	1.6	3	1.5
Aluminum alloys	4	1.5	3	1.5

For σ_B and σ_F, see 5.1.3.

The mechanical properties of the welded joint in certain cases must be taken into consideration when determining the design stress, see 5.1.4.

5.7.2.2. For certain materials, advantage may be taken of enhanced yield stress and tensile strength at temperatures below -105°C, subject to special consideration by the Society.

5.7.2.3. Stresses may be lowered below the value given in 5.7.2.1 by fatigue analysis, crack propagation analysis and buckling criteria.

5.7.2.4. In each separate case, allowable stresses for materials other than those referred to in Ch 3, Sec.2 will be subject to approval.

5.7.3. Summation of static and dynamic stresses, equivalent stress and stress limits

5.7.3.1. The calculated stresses for different loading conditions are grouped into five stress categories, σ_m, σ_L, σ_b, σ_g and σ_f.

These symbols do not represent single quantities, but for a 3-dimensional stress condition a set of three normal and three shear stress components in an orthogonal system of coordinates. The combinations of these unidirectional components are done to form the three principal stresses, σ_1, σ_2 and σ_3. The equivalent stress at a point is equal to:

$$\frac{1}{\sqrt{2}}\sqrt{(\sigma_1-\sigma_2)^2+(\sigma_1-\sigma_3)^2+(\sigma_2-\sigma_3)^2}$$

In a two-dimensional stress condition the above formula with $\sigma_3 = 0$ or the formula in 5.6.2.1 may be utilized.

5.7.3.2. General primary membrane stress category - the stresses in this category are designated by the symbol σ_m and are those defined in 5.7.1.6.

The equivalent stress shall not exceed:

$\sigma_m \le f$

5.7.3.3. Local primary membrane stress category - the stresses in this category are designated by the symbol σ_L and are those defined in 5.7.1.7.

The equivalent stress shall not exceed:

$\sigma_L \le 1.5\ f$

5.7.3.4. General or local primary membrane plus primary bending stress category. The stresses in the primary bending stress category are designated by the symbol σb. The equivalent stress shall not exceed:

$\sigma_b \le 1.5\ F$

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

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

5.7.3.5. Primary plus secondary stress category - the stresses in the secondary stress category are designated by the symbol σ_g and are those defined in 5.1.7.8.

The equivalent stress shall not exceed:

$\sigma_m + \sigma_b + \sigma_g \leq 2.8\ F$

$\sigma_L + \sigma_b + \sigma_g \leq 2.8\ F$

5.7.3.6. Peak stress category (σ_f) - the stresses falling within this category are a combination of all primary, secondary and peak stresses produced by pressure and other loads, and by general and local thermal effects and including the effect of structural discontinuities. The allowable value of equivalent stress shall not exceed the fatigue limit of the material for the specified number of loadings, see 5.1.14.

5.8. Independent Tanks Type B, Constructed Mainly of Plane Surfaces

5.8.1. General

5.8.1.1. The application of these requirements are done to independent tanks type B, primarily constructed of plane surfaces, where internal loads are carried mainly in bending of plates and stiffeners.

5.8.1.2. Application of the following rules shall be done, in addition to requirements given under 5.6.1 to 5.6.2.

5.8.1.3. The scantlings of the tank's strength members is to be based on a complete structural analysis of the tank and are generally not to be less than those for independent tanks type A.

5.8.1.4. The structural analysis of the various strength members forming the cargo tank shall be carried out utilizing appropriate models. Bulkhead panels, bracket zones, etc., where results obtained by applying the beam theory are unreliable, finite element analysis or equivalent methods shall be applied, for deep girders.

5.8.1.5. Due attention shall be given to:

- Boundary conditions
- Elastic supports formed by the adjoining strength members.

5.8.1.6. The calculation methods applied shall take into account the effect of bending, shear, axial and torsional deformations, if frame work analysis is utilized. Due attention shall be given to:

- Shear area variation
- Moment of inertia variation
- Effective flange.

5.8.2. Definition of strength member types

5.8.2.1. Primary members are supporting members such as webs, stringers and girders consisting of web plate, face plate and effective plating.

Secondary members are stiffeners and beams, consisting of web plate, face plate (if any) and effective plating.

Tertiary members are plate panels between stiffeners.

5.8.3. Equivalent stress and summation of static and dynamic stresses

5.8.3.1. See 5.6.2, for summation of stresses from different loading conditions and calculation of the equivalent stress.

5.8.3.2. Equivalent stresses shall be calculated at the points given below:

- Primary and secondary members:

  At the point of maximum equivalent stress

- Tertiary members:

  At the centre of the plate panel

The stresses shall not exceed the limits given in 5.8.4.1.

5.8.4. Design criteria

5.8.4.1. *Design stresses*. Nominal stresses shall not exceed the values given in Table 3.5.2 to 3.5.4.

Notations:

σ_e = equivalent stress as given in 5.8.3.

σ_F, $\sigma_{0.2}$ and σ_B are defined in 5.1.3

Table 3.5.2 C-Mn steels and Ni-steels		
Type of strength member	**Design Load condition Item 5.1.7.8 and 5.1.6**	
	σ_e/σ_F	σ_e/σ_B
Primary	0.70	0.50
Secondary	0.75	0.525
Tertiary	0.80	0.56

Table 3.5.3 Austenitic steels		
Type of strength member	**Design Load condition Item 5.1.7.8 and 5.1.6**	
	$\sigma_e/\sigma_{0.2}$	σ_e/σ_B
Primary	0.80	0.375
Secondary	0.85	0.40
Tertiary	0.90	0.425

Table 3.5.4 Aluminum alloys		
Type of strength member	**Design Load condition Item 5.1.7.8 and 5.1.6**	
	$\sigma_e/\sigma_{0.2}$	σ_e/σ_B
Primary	0.75	0.35
Secondary	0.80	0.375
Tertiary	0.85	0.40

Nominal stresses for the load condition 5.1.6 shall not extend 70% of the values given in Table 3.5.2 to 3.5.4.

In each case, allowable stresses in sub-regions and design details will be considered by the Society.

Thermal stresses shall be specially considered.

5.8.4.2. *Stability analysis*. Structures subjected to compressive stresses and or high shear stresses are to be checked against stability. See also 5.6.1.6 and 5.6.1.7. The following buckling modes shall be taken into consideration:

- Local buckling of plate between stiffeners
- Local buckling of web plate or flange of girders and stiffeners
- Torsional buckling of girders and stiffeners
- Overall lateral buckling of stiffened plates.

The stability factor is given by:

$$\eta = \sqrt{\left(\frac{\sigma_x}{\sigma_{xcr}}\right)^2 + \left(\frac{\sigma_y}{\sigma_{ycr}}\right)^2 + \left(\frac{\sigma_{xy}}{\sigma_{xycr}}\right)^2}$$

σ_x = actual normal stress in x-direction
σ_y = actual normal stress in y- direction
τ_{xy} = actual shear stress in the x-y plane.
σ_{xcr}, σ_{ycr} and τ_{xycr} are the critical values of the stress components σ_x, σ_y and τ_{xy}.
The critical stresses shall be calculated separately for each component according to the following:
$\sigma_{xcr} = \sigma_{xel}$ if $\sigma_{xel} \leq 0.5\ \sigma_F$

$$= \sigma_F\left(1 - \frac{\sigma_F}{4\sigma_{xel}}\right) \text{if } \sigma_{xel} > 0.5\ \sigma_F$$

$\sigma_{ycr} = \sigma_{yel}$ if $\sigma_{yel} \leq 0.5\ \sigma_F$

$$= \sigma_F\left(1 - \frac{\sigma_F}{4\sigma_{yel}}\right) \text{if } \sigma_{yel} > 0.5\ \sigma_F$$

$$\tau_{xycr} = \tau_{el} \text{ if } \tau_{el} \leq 0.5\ \sigma_F/\sqrt{3}$$

$$= \frac{\sigma_F}{\sqrt{3}}\left(1 - \frac{\sigma_F}{4\sqrt{3\tau_{el}}}\right) if\ \tau_{el} \leq 0.5\sigma_F/\sqrt{3}$$

σ_{xel}, σ_{yel} and τ_{el} are the ideal Euler buckling stresses according to the classical theory of buckling.

σ_F (or $\sigma_{0.2}$) is defined in 5.1.3.

Table 3.5.5 Allowable stability factor η

	Design Load condition A600	**Design Load condition A708 and A600**
Local buckling failure	0.6	1.0
Overall or torsional buckling failure	0.4	0.7

5.9. Independent Tanks Type C

5.9.1. Loads

5.9.1.1. The loads given in 5.1.6, 5.1.7.4, 5.1.7.5, 5.1.7.6, 5.1.8, 5.1.9, 5.1.10, 5.1.11 and Ch 3, Sec.1, [5.4.7] shall be considered in the design of the tank.

5.9.1.2. The internal pressure p utilized for determining the thickness of any specific part of the tank is given by:

$$p_{eq} = p_0 + (p_{gd})_{max}$$

p_{eq} is determined as detailed in 5.1.7.5 and 5.1.7.6.

5.9.1.3. The wave-induced loads may be required to be calculated as given in 5.1.7.8, for tanks supported in such a way that the deflection of the hull transfers significant stresses to the tank.

The supports are also to be calculated for the most severe resulting acceleration, for saddle-supported tanks.
The most probable resulting acceleration in a given direction β may be found as shown in Fig.3.5.1. The half axes in the “acceleration ellipse” may be found from the formulae given in 5.1.7.4.

5.9.2. General requirements for design

5.9.2.1. For design against excessive plastic deformation, cylindrical and spherical shells, dished ends and openings and their reinforcement shall be calculated in accordance with 5.9.4, 5.9.5 and 5.9.6 when subjected to internal pressure only, and in accordance with 5.9.7.4, 5.9.8.4 and 5.9.9 when subjected to external pressure only.

5.9.2.2. An analysis of the stresses imposed on the shell from supports is always to be carried out, see 5.9.10.

Submission of analysis of stresses from other local loads, thermal stresses and stresses in parts not covered by 400 and 500 may be required. For the purpose of these calculations the stress limits given in 5.7.3 apply.

5.9.2.3. For design against elastic instability, the requirements in 5.9.7.3, 5.9.8.3 and 5.9.9 apply.

5.9.2.4. A fatigue analysis according to 5.1.14 may be required, in special cases.

5.9.2.5. Only plus-tolerances are permitted on the design wall thickness.

5.9.2.6. The thickness, including corrosion allowance, after forming of any shell and head, shall not be less than 5 mm for C-Mn steels and Ni-steels, 3 mm for austenitic steel or 7 mm for aluminum alloy.

5.9.3. Design equivalent primary membrane stress

5.9.3.1. The equivalent primary membrane stress, for design against excessive plastic deformation and bursting, σ_t shall not exceed the lowest of the following values:

$$\frac{\sigma_B}{A} \; or \; \frac{\sigma_F}{B}$$

A and B have the values as given in Table 3.5.6:

Table 3.5.6

Material	A	B
C-Mn steels and Ni-steels	3	2
Austenitic steels	3.5	1.6
Aluminium alloys	4	1.5

σ_F and σ_B are defined in 5.1.3.

In certain cases the mechanical properties of the welded joint must be taken into consideration when determining the design stress. See, Ch 3, Sec 5,[5.1.4.]

5.9.3.2. For certain materials, subject to special consideration by the Society, advantage may be taken of enhanced yield strength and tensile strength at temperatures below -105°C.

5.9.3.3. Allowable stresses for materials other than those referred to in Ch 3 Sec.2, will be subject to approval in each separate case.

5.9.4. Cylindrical and spherical shells under internal pressure only

5.9.4.1. *Symbols*

t_{shca}= minimum required thickness of shell, exclusive of corrosion allowance (mm)
p_{0a} = maximum allowable vapour pressure defined in 5.1.3 (bar)
R_{Sh} = inside radius of shell or shell section (mm)
e = efficiency (expressed as a fraction) of welded joints
M_X = longitudinal bending moment (Nm), e.g. due to:

- Mass loads in a horizontal vessel
- Eccentricity of the centre of working pressure relative to the neutral axis of the vessel
- Friction forces between the vessel and a saddle support.

W = axial force on shell, positive if tensile, excluding pressure load due to p_0 (N)
E = modulus of elasticity (N/mm^2).

5.9.4.2. The minimum thickness of a cylindrical, conical and spherical shell for pressure loading only is to be determined from the formulae in Pt.4 Ch.7 Sec.4. The design pressure is given in 5.9.1.2.

The nominal design stress, σ_t, is given in 5.9.3.

The joint efficiency for welded joints is: e = 1.0.

5.9.4.3. The longitudinal stress in a cylindrical shell is to be calculated from the following formula:

$$\sigma_Z = \frac{p_{0a} {R_{Sh}}^2}{10(2R_{Sh} + t_{shca})t_{shca}} + \frac{W}{\pi(2R_{Sh} + t_{shca})t_{shca}} + \frac{4M_X.10^3}{\pi(2R_{Sh} + t_{shca})^2 t_{shca}}$$

For design against excessive plastic deformation, σ_z shall not exceed 0.8 $\sigma_{t\ e}$.

Value for σ_t, based on values for σ_B and $\sigma_{0.2}$ in cold worked or tempered condition will be considered. The longitudinal compressive stress, for design against buckling, σ_z shall not exceed:

$$\sigma_Z = \frac{0.20E\frac{t_{shca}}{R_{Sh}}}{1 + 0.004\frac{E}{\sigma_F}}$$

If applicable, σ_z is also to be checked for $p_{0a} = 0$.

5.9.5. Dished ends concave to pressure

5.9.5.1. The minimum thickness of dished ends subjected to pressure on the concave side is to be calculated from the formula in Part 6.

The design pressure is given in 5.9.1.2.

The nominal design stress, σ t, is to be equal to the design primary membrane stress given in 5.9.3.

The joint efficiency for welded joints is: e = 1.0.

5.9.6. Openings and their reinforcement

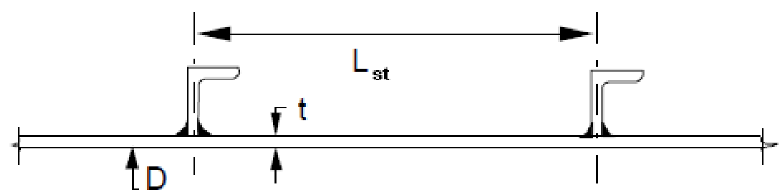
5.9.6.1. Openings and their reinforcement is to comply with Part 4

5.9.7. Cylindrical shells under uniform external pressure

5.9.7.1. *Symbols*

D = outside diameter (mm)
D_S = diameter to the neutral axis of stiffener (mm)
t_{plca} = thickness of plate, exclusive of corrosion allowance (mm)
E = modulus of elasticity at room temperature (N/mm^2)
σ_F = defined in 5.1.3
p_{ed} = external design pressure, see 5.1.6.3 (bar)
n = integral number of waves (≥ 2) for elastic instability
L_{st}= effective length between stiffeners, see Fig.5 (mm)
L_S = length of shell contributing to the moment of inertia of a stiffener (mm)
v = Poisson's ratio
Z = coefficient =
I_X = moment of inertia of stiffening ring (mm^4).

5.9.7.2. Checking of the cylindrical shell shall be done so that elastic instability or membrane yield does not occur. The allowable design pressure shall be the smaller of the values obtained in 5.9.7.3 and 5.9.7.4.



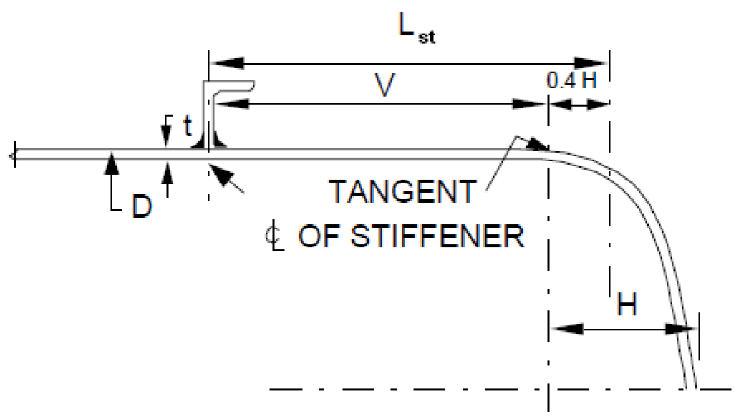


Fig 3.5.5: Effective length of cylinders subject to external pressure

5.9.7.3. *Calculation of elastic instability*

The pressure p_c, corresponding to elastic instability of an ideal cylinder, is to be determined from the following formula:

$$p_c = \frac{20E}{(n^2-1)\left[1+\left(\frac{n}{Z}\right)^2\right]^2}\frac{t}{D} + \frac{20E}{3(1-\nu^2)}\left(n^2-1+\frac{2n^2-1-\nu}{\left(\frac{n}{Z}\right)^2-1}\right)\left(\frac{t}{D}\right)^3$$

where n is chosen to minimise p_c. The formula is only applicable when n > Z. Alternatively, pc may be obtained from Fig.3.5.6.

The design pressure shall not exceed:

$$p_{ed} = \frac{p_c}{4}$$

5.9.7.4. *Calculation of membrane yield*

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

$$p_y = 20\frac{\sigma_F t}{D}$$

The design pressure shall not exceed:

$$p_{ed} = \frac{p_y}{3}$$

5.9.7.5. *Stiffening rings*

Stiffening rings those are composed of structural shapes welded continuously to the inside or outside of the shell, shall have a moment of inertia, I_X, for the combined shell and structural shape of not less than:

$$I_X = \frac{0.18 D p_{ed} L_{st} D_S^2}{10E}$$

The permissible length, L_S, of the shell contributing to the moment of inertia of the stiffening section, shall be:

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

Stiffening rings shall extend completely around the circumference of the shell.

5.9.8. Spherical shells under uniform external pressure

5.9.8.1. *Symbols*

R = outside radius of sphere (mm)
t_{plca} = thickness of plate, exclusive of corrosion allowance (mm)
E = modulus of elasticity in N/mm^2 at room temperature
σ_F = defined in 5.1.3
p_{ed} = external design pressure, see 5.1.6.3 (bar).

5.9.8.2. Checking of the spherical shell shall be done so that elastic instability or membrane yield stress does not occur.

The allowable design pressure shall be the lesser of the values obtained in 5.9.8.3 and 5.9.8.4.

5.9.8.3. Calculation of elastic instability. The pressure p_c, corresponding to elastic instability of a spherical shell, is to be determined from the following formula:

$$P_c = 2.4E\left(\frac{t_{plca}}{R}\right)^2$$

The design pressure shall not exceed:

$$p_{ed} = \frac{p_c}{3}$$

5.9.8.4. Calculation of membrane yield. The pressure py corresponding to general membrane yield, shall be determined from the following formula:

$$p_y = 20\frac{\sigma_F^t}{R}$$

The design pressure shall not exceed:

$$p_{ed} = \frac{p_y}{3}$$

5.9.9. Dished ends convex to pressure

5.9.9.1. Hemispherical ends shall be designed as spherical shells as given in 5.9.8.

5.9.9.2. Taking the crown radius as the spherical radius, torispherical ends is to be designed as spherical shells as given in 5.9.8, and in addition, the thickness shall not be less than 1.2 times the thickness required for an end of the same shape subject to internal pressure.

5.9.9.3. Taking the maximum radius of the crown as the equivalent spherical radius, ellipsoidal ends shall be designed as spherical shells as given in 5.9.8, and in addition, the thickness shall not be less than 1.2 times the thickness required for an end of the same shape subject to internal pressure.

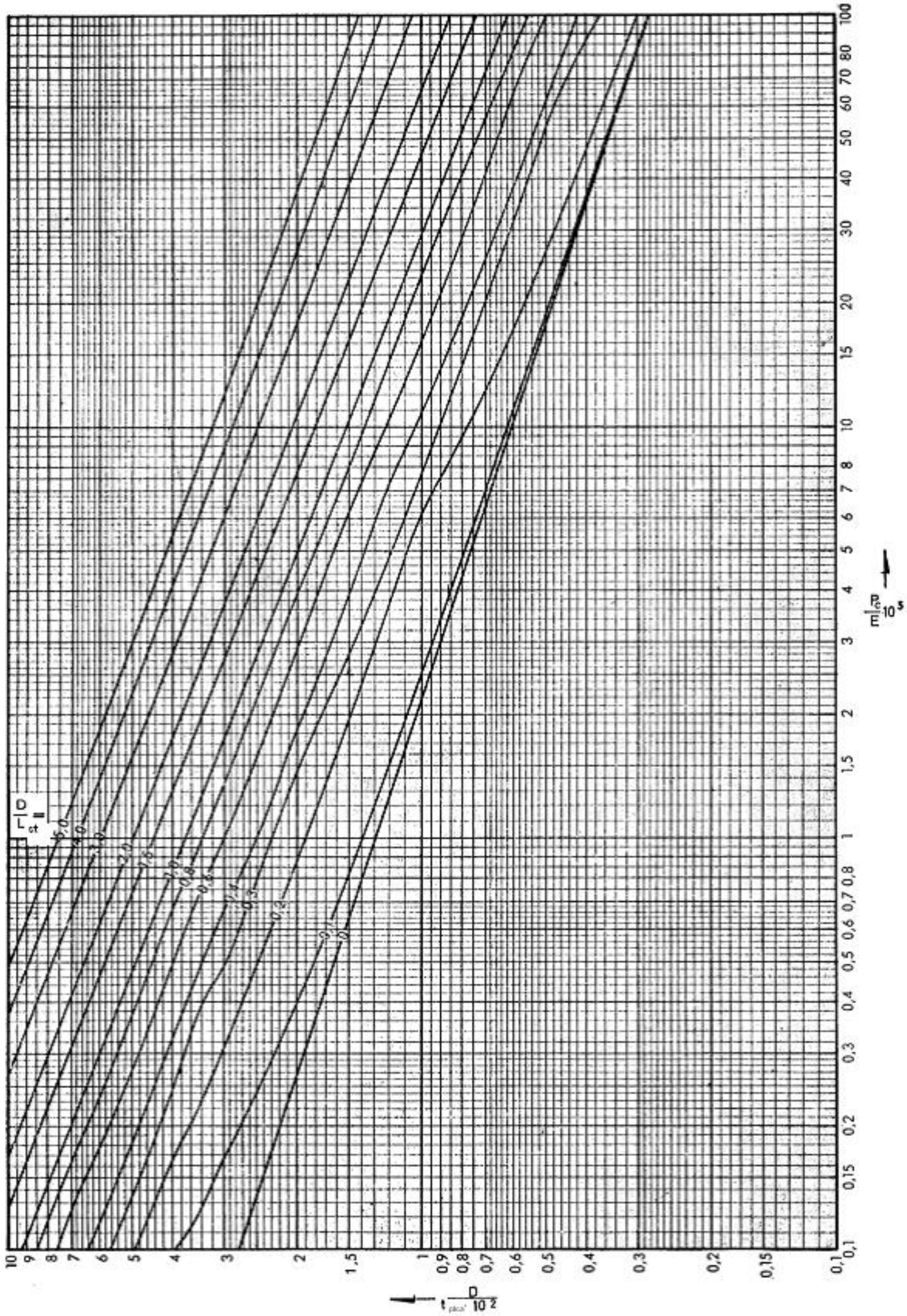


Figure3.5.6: Calculation of p_c

5.9.10. Supports

5.9.10.1. Arrangement of the supporting members shall be done in such a way as to provide for the maximum imposed loads given in 5.9.1.

The possibility of buckling shall be investigated in designs where significant compressive stresses are present.

The tank is to be able to expand and contract due to temperature changes without undue restrains.

5.9.10.2. The deflection of the hull girder shall be considered, where more than two supports are used.

Horizontal tanks supported by saddles shall preferably be supported by two saddle supports only.

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

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

- Longitudinal stresses at midspan and at supports
- Tangential shear stress at supports and in dished ends, if applicable
- Circumferential stresses at supports.

5.9.10.5. A three-dimensional analysis for the evaluation of the overall structural response of the tank may have to be carried out as required for tanks type B, for tanks supported in such a way that deflections of the hull transfer significant stresses to the tank. In that case the same stress limits as given in 5.7.3 for tanks type B apply.

5.9.10.6. The circumferential stresses at supports are to be calculated by a procedure acceptable to the Society for a sufficient number of load cases as defined in 5.9.1.3.

From case to case, the acceptance of calculations based on methods given in recognised standards will be considered.

The equivalent stress in stiffening rings shall not exceed the following values for horizontal cylindrical tanks made of C-Mn steel supported in saddles, if calculated using finite element method:

$$\sigma_e = \sqrt{(\sigma_n + \sigma_b)^2 + 3\tau_{str}^2} \qquad \leq 0.57\,\sigma_b \text{ or } 0.85\,\sigma_F$$

σ_e = equivalent stress (N/mm^2)

σ_n = normal stress in the circumferential direction of the stiffening ring (N/mm^2)

σ_b = bending stress in the circumferential direction of the stiffening ring (N/mm^2)

τ_{str}= shear stress in the stiffening ring (N/mm^2).

The buckling strength of the stiffening ring shall be examined.

The following assumptions may be made when calculating stresses in stiffening rings of horizontal cylindrical tanks:

1) The stiffening ring may be considered as a circumferential beam formed by web, face plate, doubler plate, if any, and associated shell plating.

The effective width of the associated plating may be taken as:

- For cylindrical shells:

  an effective width (mm) not greater than on each side of the web. A doubler plate, if any, may be included within that distance.

  r_{Cym} = mean radius of the cylindrical shell (mm)

  t_{sh} = shell thickness (mm).

- For longitudinal bulkheads (in the case of lobe tanks):

  The effective width should be determined according to established standards. A value of 20 t_b on each side of the web may be taken as a guidance value.

  t_b = bulkhead thickness (mm).

2) The stiffening ring is to be loaded with circumferential forces, on each side of the ring, due to the shear stress, determined by the bi-dimensional shear flow theory from the shear force of the tank.

3) For calculation of the reaction forces at the supports the following factors shall be taken into account:

   - Elasticity of support material (intermediate layer of wood or similar material)
   - Change in contact surface between tank and support, and of the relevant reactions, due to:
     - thermal shrinkage of tank
     - Elastic deformations of tank and support material.

The final distribution of the reaction forces at the supports should not show any tensile forces.

5.9.11. Manufacture and workmanship

5.9.11.1. The tanks are to be manufactured by works that is approved by the Society for manufacturing of class I pressure vessels.

5.9.11.2. Compliance of the workmanship shall be with the requirements in Pt.4 Ch.7 Sec.8, for class I pressure vessels. Special precautions are to be taken to avoid notches as undercutting, excessive reinforcement, cracks and arc flashes. All welds, nozzle welds included, are to be full penetration welds, unless specially approved for small nozzle diameters.

5.9.11.3. Tanks made of carbon and carbon-manganese steel is to be thermally stress-relieved after welding if the design temperature is below -10°C.

The soaking temperature and holding time is to be as given in Pt.2 Ch.3, Table 3.4.4. The requirements for heat treatment will be considered in each case for nickel alloy steels and austenitic stainless steel.

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 subject to the following conditions:

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

2) The mechanical stress relieving process is to be carried out preferably during the hydrostatic pressure test required by 5.14.3.4, by applying a higher pressure than the test pressure required by 5.1.4.3.4. The pressurizing medium shall be water.

3) For the water temperature, 5.14.3.4 applies.

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

5) The maximum stress relieving pressure shall be held for two hours per 25 mm of thickness but in no case less than two hours.

6) The upper limits placed on the calculated stress levels during stress relieving shall be the following:
   - equivalent general primary membrane stress: 0.9 R_e
   - equivalent stress composed of primary bending stress plus membrane stress: 1.35 R_e

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

7) Strain measurements will normally be required to prove these limits for at least the first tank of a series of identical tanks built consecutively. The location of strain gauges is to be included in the mechanical stress relieving procedure.

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

9) Checking for high stress areas in way of geometrical discontinuities such as nozzles and other openings shall be done for cracks by dye penetrant or magnetic particle inspection after mechanical stress relieving. Particular attention in this respect shall be given to plates exceeding 30 mm in thickness.

10) Steels which have a ratio of yield stress to ultimate tensile strength greater than 0.8 shall generally not be mechanically stress relieved. If, however, the yield stress is raised by a method giving high ductility of the steel, slightly higher rates may be accepted upon consideration in each case.

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

12) The thickness of the shell and heads of the tank shall not exceed 40 mm. Higher thicknesses may be accepted for parts which are thermally stress relieved.

13) Local buckling shall be guarded against particularly when tori-spherical heads are used for tanks and domes.

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

5.9.11.4. Out of roundness shall not exceed the limit given in Part 2.

Irregularities in profile is not to extend the limit given in Part 2 or 0.2% of D, whichever is the greater, with a maximum equal to the plate thickness. D is the diameter of the shell. Measurements shall be made from a segmental circular template having the design inside or outside radius, and having a chord length corresponding to the arc length obtained from Fig.3.5.7. For spheres, L is one half the outside diameters. The chord length need not exceed 0.17 D for shells under internal pressure.

5.10. Internal Insulation Tanks

5.10.1. General

5.10.1.1. The effects of all static and dynamic loads shall 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 shear strength.

Statistical wave load analysis, finite element analysis or similar methods and fracture mechanics analysis or an equivalent approach shall be carried out.

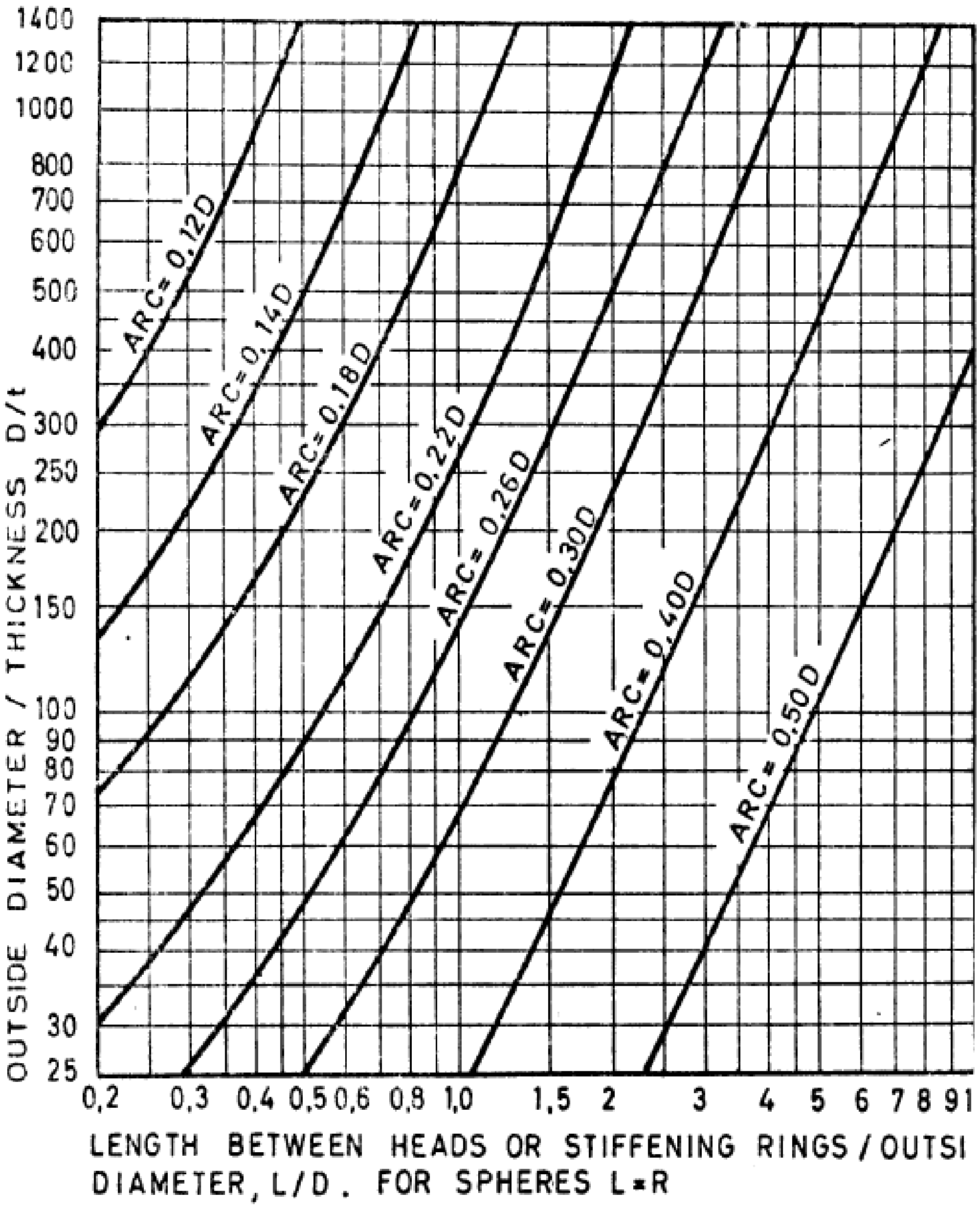


Figure 3.5.7: Arc length for determining deviation for true form

5.10.1.2. A complete analysis of the response of ship, cargo and any ballast to accelerations and motions in irregular waves of the particular ship is to be performed in accordance with 5.1.7 unless such analysis is available for a similar ship.

5.10.1.3. The effects of fatigue loading are to be determined according to 5.1.14or by an equivalent method.

5.10.2. Interaction internal insulation and supporting structure

5.10.2.1. Special attention shall be provided 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 shall be carried out to the satisfaction of the Society. 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 shall also take into account the internal pressure as indicated in 5.1.7.6. The analysis shall take account of the dynamic loads caused by water ballast under the influence of ship motions, where water ballast spaces are adjacent to the inner hull forming the supporting structure of the internal insulation tank.

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

5.10.2.3. Thicknesses of plating of the inner hull or of an independent tank shall take into account the internal pressure as indicated in 5.1.7.6. Tanks constructed of plane surfaces shall comply with the rules for deep tanks.

5.10.3. Prototype testing

5.10.3.1. Prototype testing of composite models including structural elements shall be carried out under combined effects of static, dynamic and thermal loads in order to confirm the design principles.

5.10.3.2. Test conditions shall 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).

5.10.3.3. Models is to be representative of the actual construction including corners, joints, pump mounts, piping penetrations and other critical areas, and shall take into account variations in tank material properties, workmanship and quality control.

5.10.3.4. Combined tension and fatigue tests are to 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, the crack area shall be subjected to the maximum hydrostatic pressure of the ballast water, where applicable.

5.10.4. Quality control procedures during fabrication

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

5.10.4.2. 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 shall be to the Society's satisfaction.

5.10.4.3. The inspection and non-destructive testing of the inner hull or the independent tank structures supporting internal insulation tanks shall take into account the design criteria as given in 5.10.2. The schedule for inspection and non-destructive testing shall be to the Society's satisfaction.

5.10.5. Repair procedure

5.10.5.1. Repair procedures shall be developed during the prototype testing programme for both the insulation material and the inner hull or the independent tank structure, for internal insulation tanks.

5.11. Welding Procedure Tests

5.11.1. Cargo tanks and cargo process pressure vessels

5.11.1.1. The requirements for welding procedure tests for cargo tanks and cargo process pressure vessels are given in Pt.2 Ch.3 Sec.2.

5.11.2. Secondary barriers

5.11.2.1. Welding procedure tests are needed for secondary barriers and shall be similar to those required for cargo tanks.

5.12. Weld Production Tests

5.12.1. General

5.12.1.1. Weld production tests are to be carried out to the extent given in 5.12.2 for the different types of tanks. The test requirements are given in 5.12.4.

5.12.1.2. Production tests are generally to be performed for approximately each 50 m of butt weld joints and shall be representative of each welding position and plate thickness for all cargo process pressure vessels and cargo tanks except integral and membrane tanks.

5.12.1.3. The same type production tests as required for primary tanks shall be performed, except that the number of tests may be reduced subject to agreement with the Society, for secondary barriers.

5.12.1.4. Tests other than those specified in 5.12.2, may be required for cargo tanks or secondary barriers at the discretion of the Society.

5.12.2. Extent of testing

5.12.2.1. For independent tanks types A and B and semi-membrane tanks, the production tests shall include the following tests:

- Two bend tests, macro etching and when required for procedure tests, one set of three Charpy V-notch tests shall be made for each 50 m of weld. The Charpy V-notch tests shall be made with specimen 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). If only one production test is required, Charpy V-notch tests shall be made for both centre of weld and heat-affected zone. For austenitic stainless steel, all notches shall be in the centre of the weld.

5.12.2.2. For independent tanks type C and cargo process pressure vessels, transverse weld tensile tests are required in addition to those tests listed in 5.12.2.1.

5.12.2.3. Production tests for integral and membrane tanks will be dealt with in each separate case.

5.12.3. Preparation of production weld test

5.12.3.1. One production weld test consists of two plates which is to be cut from the plate or the plates from which the tank or pressure vessel is to be made.

The plates are to be fastened well to the tank material and have sufficient dimensions to give cooling conditions as far as possible the same as for the production welding. Each plate is at least to be 150 x 300 mm.

The test pieces shall not be detached from the shell plate until they have been properly marked and stamped by the surveyor.

5.12.3.2. The two halves of the test assembly are to be tack welded to the tank or pressure vessel in such a manner that the weld of the test assembly forms a direct continuation of the joints in the product. The main rolling direction for the plates in the production weld test is to be parallel to the main rolling direction for the tank material at the place where the production weld test is located. The weld in the test assembly is to be laid at the same time as the weld in the product, by the same welder, and the same welding parameters is to be utilized.

5.12.3.3. If the production weld test cannot be made as a direct continuation of the weld in the tank or pressure vessel (e.g. a circumferential joint) it is, to be similar to the weld in the product, as far as possible.

5.12.3.4. The production weld test is to be heat-treated as the product.

5.12.3.5. The weld reinforcement is to be machined flush with the plate surface on both sides of the test assembly.

5.12.4. Test requirements

5.12.4.1. The dimensions of test pieces are to be as required for the welding procedure test detailed in Part 2.

5.12.4.2. Test requirements are given in Part 2.

5.13. Requirements for Weld Types and Non-Destructive Testing (NDT)

5.13.1. General

5.13.1.1. Non-destructive testing, NDT, shall be performed according to approved procedures. All test procedures shall be according to recognised standards.

5.13.1.2. Basic requirements are given in Part 2.

5.13.2. Extent of testing

5.13.2.1. The requirements to weld type and extent of non-destructive testing are given in Table 3.5.7.

5.13.2.2. The repair of defects revealed during non-destructive testing is to be carried out in accordance with agreement with the surveyor. All such weld -Repairs is to be examined using the relevant testing method. The extent of testing shall be increased to the satisfaction of the surveyor, if defects are detected.

5.13.2.3. Two further exposures shall be made, preferably one on each side of the initial one, when random radiographic testing is performed and the radiograph reveals unacceptable defects.

The entire length of the weld in question shall be radiographed, when two or more radiographs (including possible additional ones) of the same weld reveal an unacceptable defect level.

5.13.3. Acceptance criteria

5.13.3.1. The quality of the welds in aluminum shall comply with ISO 10042 quality level B, and the quality of the welds in steel shall comply with ISO 5817 quality level B.

<table>
<tr><th colspan="4">Table 3.5.7 Requirements for tank welds and non-destructive testing</th></tr>
<tr><th rowspan="2">Tank Type</th><th rowspan="2">Weld type requirement</th><th colspan="2">Non-destructive testing</th></tr>
<tr><th>Radiography</th><th>Ultrasonic testing
Surface crack detection</th></tr>
<tr><td>Integral</td><td>Full penetration</td><td colspan="2" rowspan="2">Special weld inspection procedures and acceptable standards shall be submitted by the design for approval</td></tr>
<tr><td>Membrane</td><td>Subject to special consideration</td></tr>
<tr><td>Semi-membrane</td><td>As for independent tanks or for membrane tanks as appropriate</td><td rowspan="2">Radiography:
a) Cargo tank design temperature lower than -20^{0}C
All full penetration welds of the shell plating 100%
b) Cargo tank design temperature higher than -20^{0}C
All full penetration welds in way of intersections and at least 10% of the remaining full penetrations welds of tank shell.
c) Butt welds of face plates and web plates of girders, stiffening rings etc. shall be radiographed as considered necessary.</td><td rowspan="4">Ultrasonic testing:
-reinforcement rings around holes 100%.
Surface crack detection:
-all butt welds in shells 100%
- reinforcement rings around holes, nozzles etc. 100%.

The remaining tank structure including the welding of girders, stiffening rings and other fittings and attachments, shall be examined by ultrasonic and surface crack detection as considered necessary.</td></tr>
<tr><td>Independent type A</td><td rowspan="3">For dome to shell connections, tee welds of the full penetration type are acceptable.
All welded joints of the shell shall be of the butt weld full penetration type. The same applies to the joints of face plates and web plates of girders and stiffening rings.

Except for small penetrations on domes, nozzle welds are also generally to be designed with full penetration.

For tank type C, see also 5.9.11.2.</td></tr>
<tr><td>Independent type B</td><td rowspan="2">Radiography:
a) All butt welds in shell plates 100%.
b) Butt welds of face plates and web plates of girders, stiffening rings etc. shall be radiographed as considered necessary.</td></tr>
<tr><td>Independent type C</td></tr>
<tr><td>Internal insulation tanks and supporting structure</td><td></td><td colspan="2">Quality control procedures according to 5.10.4</td></tr>
<tr><td>Secondary barriers</td><td></td><td>Radiography:
When the outer shell of the hull is part of the secondary barrier, intersection of all vertical butt welds and seams in the side shell shall be tested. Where the sheer strake forms a part of the secondary barrier, all vertical butt welds in the sheer strake shall be tested. See Part 2</td><td>Surface crack detection:
-See Part 2</td></tr>
</table>

5.14. Testing of Tanks

5.14.1. Integral tanks

5.14.1.1. All cargo tanks are to be subjected to a hydrostatic structural test according to Part 2. In addition, each tank shall be subjected to a leak test and the leak test may be performed in combination with the structural test or separately. Tank boundary welds is not to be painted before the leak test is carried out.

5.14.1.2. If a vapour pressure higher than p_{0a} is to be utilized under harbour conditions as allowed by 5.1.6.1, or if the design vapour pressure p_0 is higher than the normal value 0.25 bar, but less than 0.7 bar as allowed by Ch 3, Sec.1, [1.4.1], the structural test will be considered in each case. The test which may be a hydrostatic or a hydropneumatic test, is in general to be performed so that the stresses approximate, as far as practicable, the design stresses and so that the pressure at the top of the tanks correspond at least to the MARVS or the increased vapour pressure allowed in harbour conditions.

5.14.2. Membrane and semi-membrane tanks

5.14.2.1. Cofferdams and all spaces which may normally contain liquid and are adjacent to the hull structure supporting the membrane, shall be hydrostatically or hydro pneumatically tested according to Part 2, for ships fitted with membrane or semi-membrane tanks. In addition, any other ship hold structure supporting the membrane is to be given a leak test. Pipe tunnels and other compartments which do not normally contain liquid, are not needed to be tested hydrostatically.

5.14.2.2. Each tank shall be subjected to an adequate leak test.

5.14.3. Independent tanks

5.14.3.1. Each independent tank shall be subjected to a hydrostatic or hydropneumatic test.

5.14.3.2. For tanks type A, this test is to 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 or the higher vapour pressure allowed in harbour condition (see 5.1.6.1). When hydropneumatic test is performed, the conditions shall simulate the actual loading of the tank and of its supports, as far as possible.

5.14.3.3. The test is to be performed as for tanks type A, for tanks type B. Moreover, the maximum primary membrane stress or maximum bending stress in primary members under test conditions shall not exceed 90% of the yield strength of the material (as fabricated) at the test temperature. When calculations indicate that this stress exceed 75% of the yield strength, to ensure that this condition is satisfied, the prototype test shall be monitored by the use of strain gauges or other suitable equipment.

5.14.3.4. When completely manufactured, each tank type C shall be subjected to a hydrostatic test at a pressure measured at the top of the tanks, of not less than 1.5 p_0, but in no case during the pressure test is the calculated primary membrane stress at any point to exceed 90% of the yield stress of the material (as fabricated) at the test temperature. The prototype test shall be monitored by the use of strain gauges or other suitable equipment in pressure vessels except simple cylindrical and spherical pressure vessels, to ensure that this condition is satisfied where calculations indicate that this stress will exceed 0.75 times the yield strength.

Further:

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

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

5.14.3.5. With the specific approval of the Society, a hydropneumatic test may be carried out under the conditions prescribed in 5.1.4.3.4, where necessary for tanks type C.

5.14.3.6. All tanks shall be subjected to a leak testing, which may be performed in combination with the structural test mentioned above or separately.

5.14.3.7. At least one tank and its support shall be instrumented to confirm stress levels, on ships using independent tanks type B, unless the design and arrangement for the size of the ship involved are supported by full scale experience.

Dependent on their configuration and on the arrangement of their supports and attachments, similar instrumentation may be required by the Society for independent tanks type C.

5.14.4. Internal insulation tanks

5.14.4.1. All inner hull structure shall be hydrostatically or hydropneumatically tested taking into account the MARVS, in ships fitted with internal insulation tanks where the inner hull is the supporting structure.

5.14.4.2. In ships fitted with internal insulation tanks where independent tanks are the supporting structure, the independent tanks shall be tested according to 5.1.4.3.

5.14.4.3. A leak test of these structures shall be carried out using techniques to the satisfaction of the Society, for internal insulation tanks where the inner hull structure or an independent tank structure acts as a secondary barrier.

5.14.4.4. These tests in 5.14.4.1 to 5.14.4.3 shall be performed before the application of the materials which will form the internal insulation tank.

5.14.4.5. Requirements as to leak testing after completion will be determined in each separate case.

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

5.14.5. Secondary barriers

5.14.5.1. In each separate case, requirements with respect to pressure and leak testing of secondary barriers will be decided.

SECTION 6 PIPING SYSTEMS IN CARGO AREA

Contents

6.1. General

6.1.1. Application

The requirements of this Section are additional to those of Part 4. Regarding materials, see also Ch 3, Sec.2.

6.1.2. General

6.1.2.1. The temperature in a steam pipe and any other hot pipeline is not to exceed 220°C in hazardous space or area, or in any non-hazardous area protected by mechanical ventilation.

6.1.2.2. Pipe connections to engine or boiler rooms are not to pass through hold spaces serving as secondary barriers.

6.2. Pumping and Piping Systems for Bilge, Ballast and Fuel Oil

6.2.1. General

6.2.1.1. There is to be no connection between the piping systems serving the cargo area and the piping systems in the remainder of the ship, except as permitted in 6.2.1.2.

6.2.1.2. Ballast spaces, including wet duct keels utilized as ballast piping, fuel oil tanks and non-hazardous spaces shall be connected to pumps in the engine room. Dry duct keels with ballast piping passing through, (except for ships with integral tanks, see Ch 3, Sec.3, [3.3.4.4] may be connected to pumps in the engine rooms, 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 shall not be open to the engine room.

6.2.1.3. All normally dry spaces (not served by ballast, fuel or cargo system) within the cargo area is to be fitted with bilge or drain arrangements. Spaces not accessible at all times are to have sounding pipes. Spaces without permanent ventilation system or an approved pressure/vacuum relief system shall have air pipes.

6.2.2. Hold spaces, interbarrier spaces

6.2.2.1. Hold spaces shall be provided with suitable drainage arrangements not connected with the machinery space, where cargo is carried in a cargo containment system not requiring a secondary barrier. Means of detecting leakage into the hold space shall be provided.

6.2.2.2. Suitable arrangements for dealing with any leakage into the hold or insulation spaces through adjacent ship structure is to be provided where there is a secondary barrier. The suction is not to be lead to pumps inside the machinery space. Provision of means shall be done to detect such leakage.

6.2.2.3. The hold or inter-barrier spaces of type A independent tank ships is to be provided with a drainage system suitable to handle liquid cargo in the event of cargo tank leakage or rupture. Such arrangements should provide for the return of any cargo leakage to the liquid cargo piping. Such a system shall be provided with a removable spool piece.

6.2.2.4. In the case of internal insulation tanks, means or arrangements of detecting leakage and drainage are not needed for inter-barrier spaces and spaces between the secondary barrier and the inner hull or independent tank structure that are completely filled by insulation material, complying with Sec.7, [7.3.2.3].

6.3. Cargo Piping Systems

6.3.1. General

6.3.1.1. Application of these requirements shall be done in 6.3.2 to 6.3.6 to cargo and cargo process piping including vapour piping and vent lines of safety valves or similar piping. Instrument piping not containing cargo can be exempted from these requirements.

6.3.2. Materials and testing of materials

6.3.2.1. Materials for piping system for liquefied gases shall comply with the requirements of Ch 3, Sec.2, [2.4].

6.3.2.2. However, Some relaxation may be allowed in the quality of the material of open ended vent piping, provided the temperature of the cargo at atmospheric pressure is -55°C or higher, and provided no liquid discharge to the vent piping can occur. Similar relaxation may be allowed 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.

6.3.2.3. Materials having a melting point below 925°C, is not to be utilized for piping outside the cargo tanks except for short lengths of pipes attached to the cargo tanks, in which case fire-resisting insulation shall be provided.

6.3.3. Arrangement and general design

6.3.3.1. All pipes are to be mounted in such a way as to minimize the risk of fatigue failure due to temperature variations or to deflections of the hull girder in a seaway. They shall be equipped with expansion bends, if necessary. Use of expansion bellows will be especially considered. Acceptance of slide type expansion joints will not be given outside of cargo tanks. Expansion joints are to be protected against icing, if necessary.

6.3.3.2. Means for effective drainage and gas-freeing of the cargo piping systems is to be provided. Equipmentation of loading and discharge pipes shall be done with a connection leading to the escape gas pipe systems of the cargo tank pressure relief valves. This connection is to be equipped with a lockable shut-off valve or similar closing device which shall be closed under normal conditions. The connection is only to be open when pipes and tanks are being gas-freed.

6.3.3.3. All connections to independent tanks are normally to be mounted above the highest liquid level in the tanks and in the open air above the weather deck.

6.3.3.4. The connections to the tank shall be designed so as to reduce thermal stresses at cooling-down periods, when the temperature of cargo pipes may fall below -55°C.

6.3.3.5. All liquid and vapour connections, except safety relief valves and liquid level gauging devices, for cargo tanks with MARVS not exceeding 0.7 bar, shall consist of shutoff valves located as close to the tank as practicable. These valves may be remotely controlled but is to be capable of local manual operation and provide full closure. One or more remotely controlled emergency shutdown valves shall be provided on the ship for shutting down liquid and vapour cargo transfer between ship and shore. Arrangement of such valves may be done to suit the ship’s design and may be the same valve as required in 6.3.3.8 and shall comply with the requirements of 6.3.3.9.

6.3.3.6. For cargo tanks with a MARVS exceeding 0.7 bar, all liquid and vapour connections, except safety relief valves and liquid level gauging devices, is to be equipped with manually operated stop valve and a remotely controlled emergency shutdown valve. These valves is to be located as close to the tank as practicable. A single valve may be substituted for the two separate valves provided the valve complies with the requirements of 6.3.3.9, is capable of local manual operation and provides full closure of the line. The emergency shutdown valves shall be released as mentioned in 6.3.4.

6.3.3.7. The requirements for emergency shut-down valves given in 6.3.3.6 are not compulsory for the following connections:

- Manometer connections with bores 1.5 mm diameter or less
- Test cocks with bores 1.5 mm diameter or less.

6.3.3.8. Each liquid and vapour shore connecting point is to be equipped with a manually operated stop valve and an emergency shut-down valve fitted in series, or a combined manually operated stop valve and emergency shutdown valve. Each vapour connection is to be fitted with an emergency shut-down valve. The valve is to be remotely operable and also provided with means for local operation in case of loss of hydraulic or pneumatic power supply, e.g. by mechanical means or by portable hydraulic hand pump. The emergency shut-down valves are to be released as mentioned in 6.3.4.4.

6.3.3.9. Emergency shut-down valves shall be of the “fail-closed” (closed on loss of power) type and be capable of local manual closing operation. Emergency shutdown valves in liquid piping shall be fully closed under all service conditions within 30 s of actuation as measured from the time of manual or automatic initiation to full closure. This is called the total shut-down time and is made up of a signal response time and a valve closure time. The valve closure shall be such as to avoid surge pressures in pipelines. Information about the closing time of the valves and their operating characteristics is to be available on board and the closing time shall be verifiable and reproducible. Such valves are to close in such a manner as to cut off the flow smoothly.

6.3.3.10. The emergency shut-down valves required by 306 may be replaced by excess flow valves, in connections with pipe diameters less than 50 mm nominal inside diameter. Excess flow valves shall be closed automatically at the rated closing flow of vapour or liquid as specified by the manufacturer. The piping, including fittings, valves, and appurtenances protected by an excess flow valve, shall consist of 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 equalisation of pressure after an operating shut-down.

6.3.3.11. Installation of pressure relief valves shall be done in pipes where gas may be trapped, and the pipes are not designed for the saturation pressure corresponding to the temperature of +45°C of any cargo to be transported.

Pipelines or components which may be isolated in a liquid full condition are to be provided with relief valves.

Pressure relief valves as mentioned above are to be set to open at a pressure of 1.0 to 1.1 times the design pressure of the pipes.

6.3.3.12. Relief valves on cargo pumps shall discharge the pump suction. Relief valves discharging liquid cargo from the cargo piping system is to 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.

6.3.3.13. Provision of suitable means shall be given to relieve the pressure and remove liquid contents from cargo loading and discharging crossover headers to the cargo tanks or other suitable location prior to disconnecting the cargo hoses.

6.3.3.14. Where necessary, low temperature piping shall be thermally insulated from the adjacent hull structure to prevent the temperature of the hull from falling below the design temperature of the hull material.

6.3.3.15. Protection for the hull beneath shall be provided for ships intended to carry liquefied gases with boiling points lower than -30°C, where liquid piping is dismantled regularly, or where liquid leakage may be anticipated, such as at shore connections and at pump seals. The protecting arrangement shall consist of a liquid-tight insulation (a wooden deck or a free, elevated drip tray), or it shall be made from a steel grade corresponding to the requirements for secondary barriers. The insulation or special steel deck shall extend to the side of the ship and shall have a width of at least 1.2 m. Except on the deck corner side, the deck area shall be bounded by coamings on all sides.

The coaming height shall be at least 150 mm.

Elevated drip trays shall measure at least 1.2 x 1.2 m and have a volume of at least 200 litres. Such trays shall be drained over the side of the ship by a pipe which preferably leads down into the sea.

6.3.3.16. All cargo piping shall be electrically bonded to the hull of the ship. Bonding straps across stainless steel flanges with bolts and nuts of stainless steel are not needed. Carbon-manganese steel shall be checked for electric bonding, if it is not fitted with bonding straps across the flanges. The electrical bonding is adequate, when the electrical resistance between piping and the hull does not exceed 106 Ohm.

Cargo piping sections of piping components which are not permanently connected to the hull by permanent piping connections, or where such connections are removable e.g. for removal of spool pieces, shall be electrically bonded to the hull by special bonding straps.

Guidance note:

The value of resistance 106 Ohm may be accomplished without the use of bonding straps where cargo piping systems and equipment are directly, or via their supports, either welded or bolted to the hull of the ship. It will be generally necessary initially to achieve a resistance value below 106 Ohm, to permit for deterioration in service.

6.3.3.17. Sprayers or similar devices are to be fitted for even cooling of the tanks.

6.3.3.18. At least two separate means shall be provided to transfer cargo from each cargo tank, where cargo transfer is by means of cargo pumps not accessible for repair with the tanks in service. The design shall be such that failure of one cargo pump or means of transfer will not prevent the cargo transfer by another pump or pumps or other transfer means.

6.3.3.19. The procedure for transfer of cargo by gas pressurizations shall preclude lifting of the relief valves during such transfer. Acceptance of gas pressurizations may be given 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.

6.3.3.20. Stop of the pumps shall be alarmed at the centralized cargo control position, when pumps positioned in different tanks are discharging into a common header.

6.3.4. Control system for emergency shut-down valves

6.3.4.1. Arrangement for the emergency shut-down valves mentioned in 6.3.3.5, 6.3.3.6 and 6.3.3.8, shall be done for release from at least one position forward of and at least one position abaft the cargo area, and from an appropriate number of positions within the cargo area, dependent on the size of the ship. One of these locations is to be the cargo loading station or cargo control room.

6.3.4.2. The control system is also to be provided with fusible elements designed to melt at temperatures of approximately 100°C which will cause the emergency shut-down valves to close in the event of fire. Locations for such fusible elements shall include the tank domes and loading stations.

6.3.4.3. Arrangement of pumps and compressors shall be done to stop if the emergency shut-down valves mentioned in 6.3.3.6 or 6.3.3.8 are released.

6.3.5. Piping design

6.3.5.1. Application of these requirements shall be done to piping inside and outside the cargo tanks. However, the Society may accept relaxation from these requirements for piping inside cargo tanks and open ended piping.

6.3.5.2. Joining of the piping system shall be done by welding with a minimum of flange connections. Protection shall be given to the Gaskets against blow-out.

6.3.5.3. Pipe wall thicknesses shall be calculated in accordance with Part 4. The design pressure p, in the formula for t_0, is the maximum pressure to which the system may be subjected in service, as detailed in 6.3.5.4.

6.3.5.4. The greater of the following design conditions shall be used for piping, piping system and components as appropriate:

1) For vapor 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 Society (See Ch 3,Sec.5,[5.1.6.1]; 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 Society (See Ch 3,Sec.5 [5.1.6.1], 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 if of sufficient capacity; or
5) The maximum total discharge or loading head of the cargo piping system; or
6) The relief valve setting on a pipeline system if of sufficient capacity; or
7) A pressure of 10 bar except for open ended lines where it shall not be less than 5 bar.

6.3.5.5. For pipes made of steel including stainless steel, the permissible stress to be considered in the formula of Part 4 is the lower of the following values:

$$\frac{\sigma_B}{2.7} \text{ or } \frac{\sigma_F}{1.8}$$

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

σ_F = specified lower minimum yield stress or 0.2% proof stress at room temperature (N/mm^2).

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

6.3.5.6. The minimum thickness is to be according to Part 2 for austenitic stainless steel, and “Pipes in general” for C-Mn steel.

6.3.5.7. The wall thickness shall be increased over that required by 6.3.5.3, where necessary for mechanical strength to prevent damage, collapse, excessive sag or buckling of pipe due to superimposed loads from supports, ship deflection or other causes, or, if this is impractical or would cause excessive local stresses, these loads shall be reduced, protected against or eliminated by other design methods.

6.3.5.8. Flanges, valves, fittings, etc. shall be according to a recognised standard taking into account the design pressure defined under 6.3.5.4. Flanges not complying with a recognised standard shall be to the Society’s satisfaction.

A lower minimum design pressure than defined in 6.3.5.4 may be accepted, for bellows expansion joints utilized in vapour service.

6.3.5.9. The following types of connections may be considered for direct connection of pipe lengths (without flanges):

1) Butt welded joints with complete penetration at the root may be used in all applications. For design temperature below -10°C, butt welds shall be either double welded or equivalent to a double welded butt joint. This may be accomplished by use of a backing ring, consumable insert or inert gas back-up on the first pass. For design pressures in excess of 10 bar and design temperatures ≤ -10°C, backing rings shall be removed.
2) Slip-on welded joints with sleeves and related welding, having dimensions satisfactory to the Society, are only to be used for open-ended lines with external diameter of 50 mm or less and design temperatures not lower than -55°C.
3) Screwed couplings acceptable to the Society are only to be used for accessory lines and instrumentation lines with external diameters of 25 mm or less.

6.3.5.10. Flanges shall be of the welding neck, slip-on or socket welding type. For all piping (except open ended lines), the following restrictions apply:

1) For design temperatures < -55°C only welding neck flanges shall be used.
2) For design temperatures < -10°C slip-on flanges shall not be used in nominal sizes above 100 mm and socket welding flanges shall not be used in nominal sizes above 50 mm.

6.3.5.11. Acceptance may be given for piping connections other than those mentioned above, upon consideration in each case.

6.3.5.12. Post weld heat treatment is needed for all butt welds of pipes made with carbon, carbon-manganese and low-alloy steels. The Society may waive the requirement for thermal stress relieving of pipes having wall thickness less than 10 mm in relation to the design temperature and pressure of the piping system concerned.

6.3.5.13. A complete stress analysis for each branch of the piping system shall be submitted, when the design temperature is -110°C or lower. This analysis shall take into account all stresses due to weight of pipes with cargo (including acceleration if significant), internal pressure, thermal contraction and loads induced by movements of the ship. A stress analysis may be required by the Society, for temperatures above -110°C. In any case, consideration shall be given to thermal stresses, even if calculations need not to be submitted. The analysis shall be carried out in accordance with Part 4 or to a recognised code of practice.

6.3.6. Welding procedure and production tests

Welding procedure tests are required for cargo piping and are to be similar to those required for cargo tanks. The test requirements shall be in accordance with Part 4, unless especially agreed otherwise.

6.3.7. Testing

6.3.7.1. The requirements for testing apply to piping inside and outside the cargo tanks. However, acceptance for relaxation from these requirements may be given for piping inside cargo tanks and open ended piping.

6.3.7.2. In addition to normal controls before and during the welding and to the visual inspection of the finished welds, the following tests are required:

1) For butt welded joints for piping systems with design temperatures lower than -10°C and with inside diameters of more than 75 mm or wall thicknesses greater than 10 mm, 100% radiographic testing is required.
2) Upon special approval, the extent of radiographic inspection may be progressively reduced but in no case to less than 10% of the joints, when such butt welded joints of piping sections are made by automatic welding processes in the pipe fabrication shop. If defects are revealed the extent of examination shall be increased to 100% and shall include inspection of previously accepted welds. This special approval can only be granted if well-documented quality assurance procedures and records are available to enable the Society to assess the ability of the manufacturer to produce satisfactory welds consistently.
3) For other butt welded joints of pipes, spot radiographic tests or other non-destructive tests shall be carried out at the discretion of the Society depending upon service, position and materials. In general, at least 10% of butt welded joints of pipes shall be radiographed.

The radiographs is to be assessed in accordance with ISO 5817 “Arc-welded joints in steel - Guidance on quality levels for imperfections”, and are at least to meet the requirements for quality level B.

6.3.7.3. After assembly, all cargo and process piping shall be subjected to a hydrostatic test to at least 1.5 times the design pressure. However, the hydrostatic test may be conducted prior to installation aboard ship, when piping systems or parts of systems are completely manufactured and equipped with all fittings. Joints welded onboard shall 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 methods shall be submitted for approval.

6.3.7.4. Each cargo and process piping system shall be subjected to a leak test using air, after assembly onboard, halides or other suitable medium.

6.3.7.5. Emergency shut-down valves with actuators are to be function tested when the valve is subjected to full working pressure.

6.3.8. Prototype testing

Each type of valve is to be subjected to prototype tests as follows. Each size and each type of valve intended to be utilized at a working temperature below -55°C shall be subjected to a tightness test at the minimum design temperature or lower and to

6.3.8.1. and to a pressure not lower than the design pressure for the valves. During the test the good operation of the valve shall be ascertained.

6.3.8.2. The following prototype tests shall be performed on each type of expansion bellows intended for use on cargo piping, primarily on those used outside the cargo tank:

1) An overpressure test. A type element of the bellows, not pre-compressed, shall be pressure tested to a pressure not less than 5 times the design pressure without bursting. The duration of the test shall not be less than 5 minutes.
2) A pressure test on a type expansion joint complete with all the accessories (flanges, stays, articulations, etc.) at twice the design pressure at the extreme displacement conditions that is recommended by the manufacturer. No permanent deformations are permitted. The test may be required to be performed at the minimum design temperature depending on materials.
3) A cyclic test (thermal movements). The test is to be performed on a complete expansion joint, which shall 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. Permission shall be given for testing at room temperature, when conservative.
4) A cyclic fatigue test (ship deformation). The test shall be performed without internal pressure, on a complete expansion joint, by simulating the bellow movement corresponding to a compensated pipe length for at least $2 \cdot 10^6$ cycles at a frequency not higher than 5 Hz. This test is only required when, due to the piping arrangement, ship deformation loads are actually experienced.

6.3.8.3. The Society may waive performance of the tests specified in 6.3.8.2, provided that complete documentation is supplied to establish the suitability of the expansion joints to withstand the expected working conditions.

The documentation shall include sufficient tests data to justify the design method used, when the maximum internal pressure exceeds 1 bar, with particular reference to correlation between calculation and test results.

6.4. Cargo Hoses

6.4.1. General

6.4.1.1. Liquid and vapour hoses utilized for cargo transfer is to be compatible with the cargo and suitable for the cargo temperature.

6.4.1.2. Hoses subject to tank pressure, or the discharge pressure of pumps or vapour compressors, shall be designed for a bursting pressure not less than five times the maximum pressure the hose will be subjected to during cargo transfer.

6.4.1.3. Each new type of cargo hose, complete with end fittings, shall be prototype tested at a normal ambient temperature with 200 pressure cycles from zero to at least twice the specified maximum working pressure.

The prototype test shall demonstrate a bursting pressure of at least 5 times its specified maximum working pressure at the extreme service temperature after this cycle pressure test has been carried out. Hoses utilized for prototype testing is not to be utilized for cargo service. Thereafter, before being placed in service, each new length of cargo hose produced is to be hydrostatically tested at ambient temperature to a pressure not less than 1.5 times its specified maximum working pressure but not more than two-fifths its bursting pressure. The hose shall be stencilled or otherwise marked with the date of testing its specified maximum working pressure, and if utilized in other than ambient temperature services, its maximum and minimum service temperature, as applicable. The specified maximum working pressure is not to be less than 10 bar gauge.

6.5. Bow or Stern Loading and Unloading Arrangements

6.5.1. General

6.5.1.1. Subject to the approval of the Society, arrangement of cargo piping may be done to permit bow or stern loading and unloading.

6.5.1.2. Bow or stern loading and unloading lines which are led past accommodation spaces, service spaces or control stations shall not be utilized for the transfer of products requiring a type 1G ship. Bow or stern loading and unloading lines shall not be utilized for the transfer of toxic products unless specifically approved.

6.5.1.3. Portable arrangements are not allowed.

6.5.1.4. The following additional provisions apply to such cargo piping and related piping equipment:

1) Cargo piping and related piping equipment outside the cargo area shall consist of only welded connections. The piping outside the cargo area shall run on the open deck and it is to be at least of 760 mm inboard except for thwartships shore connection piping. Such piping shall be clearly identified and fitted with a shutoff valve at its connection to the cargo piping system within the cargo area. At this location, it is also to be capable of being separated by means of a removable spool piece and blank flanges when not in use.
2) The piping shall be full penetration butt welded, and fully radiographed regardless of pipe diameter and design temperature. Flange connections in the piping are only permitted within the cargo area and at the shore connection.
3) Arrangements shall be made to permit such piping to be purged and gas-freed after utilization. When not being utilized, the spool pieces shall be removed and the pipe ends be blank-flanged. The vent pipes connected with the purge shall be positioned in the cargo area.

6.5.1.5. Entrances, air inlets and openings to accommodation spaces, service spaces, machinery spaces and control stations shall be arranged in accordance with Ch3, Sec.3 [3.3.1.3].

6.5.1.6. Deck openings and air inlets to spaces within distances of 10 m from the cargo shore connection location is to be kept closed during the use of bow or stern loading or unloading arrangements.

6.5.1.7. Electrical equipment within a zone of 3 m from the cargo shore connection location shall be according to with Sec.12.

6.5.1.8. Fire-fighting arrangements for the bow or stern loading and unloading areas are to be according to Ch 3 Sec.11, 11. [2.2.13] and Sec.11, [11.2.3.7].

6.5.1.9. Means of communication between the cargo control station and the shore connection location shall be provided and if necessary certified safe.

6.6. Vapour Return Connections

6.6.1. General

6.6.1.1. Connections for vapour lines to the shore installation shall be provided.

6.7. Certification of Pumps

6.7.1. General

6.7.1.1. Delivery of the cargo pumps shall be done with INTLREG product certificate and shall be tested as given in Part 4 Pump housings shall be furnished with material certificates according to Ch 3 Sec.2.

6.7.1.2. For pumps utilized in the cargo related systems (not being cargo pumps) like pumps for glycol, ethanol and lubrication oil, maker's product certificate will be accepted.

6.8. Certification of Valves

6.8.1. General

6.8.1.1. The constructional requirements given in Part 4 apply as relevant. For valves intended for piping systems with a design temperature below - 55°C documentation of leak and functional test at design temperature (prototype test) in accordance with 6.3.8 is required.

6.8.2. Hydrostatic test and seat leakage test

Valves are to be subjected to the following tests at the manufacturer's:

- hydrostatic test of valve bodies at a pressure equal to 1.5 times the design pressure
- seat and stem seal leakage test at a pressure equal to 1.1 times the design pressure.

6.8.3. Certification of valves

6.8.3.1. INTLREG product certificate is required for valves with DN > 100 mm. For valves with DN ≤ 100 mm, manufacturer's product certificate may be accepted.

6.8.3.2. Valves shall be furnished with material certificates in accordance with Sec.2.

SECTION 7 CARGO PRESSURE AND TEMPERATURE CONTROL, CARGO HEATING ARRANGEMENTS, INSULATION

Contents

7.1. Cargo Pressure and Temperature Control

7.1.1. General

7.1.1.1. 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 is to be provided by one or more of the following means, except as otherwise provided in these rules:

- A system which regulates the pressure in the cargo tanks by the utilization of mechanical refrigeration
- A system whereby the boil-off vapour is utilized as fuel for shipboard use and or waste heat system subject to the provisions of Sec.16. This system may be used at all times, including while in port and while maneuvering, provided that a means of disposing of excess energy is provided, such as a steam dump system, that is acceptable to the Society
- A system allowing the product to warm up and increase in pressure. The insulation and or cargo tank design pressure shall be adequate to provide for a suitable margin for the operating time and temperatures involved
- Other systems acceptable to the Society.

7.1.1.2. The boil-off gas is normally to be burnt or in other ways rendered harmless before being expelled from the ship, if cargo cooling is achieved by means of evaporated gas and the gas is not re-liquefied or used as fuel for shipboard use.

7.1.1.3. The systems required by 7.1.1.1 shall be constructed, fitted and tested to the satisfaction of the Society. Materials used in their construction shall be suitable for use with the cargoes to be carried. For normal service, the upper ambient design temperatures shall be:

Sea 32°C

Air 45°C

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

7.1.1.4. Boil-off gas, being re-liquefied or utilized as boiler or engine fuel, is to be led through valves and pipes independent of the pressure relief valves on tanks. Regarding utilization of boil-off gas for combustion purposes in boilers or internal combustion engines, see Sec.16.

7.1.2. Cargo refrigeration and reliquefaction system

7.1.2.1. A refrigeration system is to consist of one or more units capable of maintaining the required cargo pressure and temperature under conditions of the upper ambient design temperatures see 7.1.1.3. A stand-by unit (or units) affording spare capacity at least equal to the largest required single unit shall be provided, unless an alternative means of controlling the cargo pressure and temperature is provided to the satisfaction of the Society. A stand-by unit shall 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 shall be provided, unless the normal heat exchanger for the unit has an excess capacity of at least 25% of the largest required capacity. Separate piping systems are not required.

7.1.2.2. Special consideration shall be given to the refrigeration systems to avoid the possibility of mixing cargoes, where two or more refrigerated cargoes, which may react chemically in a dangerous manner, are carried simultaneously. For the carriage of such cargoes, separate refrigeration systems, each complete with a standby unit as specified in 7.1.2.1, shall be provided for each cargo. However, where cooling is provided by an indirect or combined system (see 7.2.2.7 and 7.2.2.8) and leakage in the heat exchangers cannot cause mixing of the cargoes under any envisaged condition, separate refrigeration units need not be fitted.

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

7.1.2.4. An adequate supply shall be provided by a pump(s) used exclusively for this purpose where cooling water is required in refrigeration systems. Where practicable leading from sea chests one port and one starboard, this pump(s) shall have at least two sea suction lines. A spare pump of adequate capacity shall 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.

7.1.2.5. Arrangement of the refrigeration system may be done in one of the ways specified in 7.2.2.6 to 7.2.2.8.

7.1.2.6. A direct system where evaporated cargo is compressed, condensed and returned to the cargo tanks. (For certain cargoes specified in the *List of Cargoes*, this system shall not be utilized.)

7.1.2.7. An indirect system where cargo or evaporated cargo is cooled or condensed by refrigerant without being compressed.

7.1.2.8. A combined (cascade) system where evaporated cargo is compressed and condensed in a cargo or refrigerant heat exchanger and returned to the cargo tanks. (For certain cargoes specified in the *List of Cargoes*, this system shall not be utilized.)

7.1.2.9. 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.

7.1.2.10. The cooling system is to comply with the requirements given in Ch.10 to the extent these are applicable.

7.1.3. Certification and testing of compressors

7.3.1.1. Compressors utilized in the re-liquefaction system shall be certified as given in Part 6.

7.2. Cargo Heating Arrangements

7.2.1. General

7.2.1.1. Requirements for water systems and steam systems are identical to those of Part 6, unless otherwise stated.

7.2.1.2. Normally, the temperature of the heating medium is not to exceed 220°C.

7.2.1.3. The heating media shall be compatible with the cargo.

7.2.1.4. The heating medium shall not be returned to the engine room, for heating of cargoes where gas detection with regard to toxic effects is required by column d in the List of Cargoes. For heating of other cargoes, the medium may be returned to the engine room provided a degassing tank with gas detector is arranged. The degasing tank is to be positioned in the cargo area.

7.3. Insulation for Tanks, Hold Spaces and Pipelines

7.3.1. Insulation

7.3.1.1. Suitable insulation shall be provided to make sure that the hull steel significant temperature does not fall below the minimum allowable steel significant temperature for the concerned grade of steel, if required, as detailed in Ch 3 Sec.2.

7.3.1.2. In determining the insulation thickness, due regard shall be paid to the amount of acceptable boil-off in association with the cargo pressure and temperature control system as required in 7.1.1.

7.3.1.3. The insulation system is to be suitable for the mechanical and thermal loads imposed on it.

7.3.2. Insulating materials

7.3.2.1. In addition to the requirements in 7.2.2.2 to 7.2.2.5., reference is made to Ch.10, which shall be complied with to the extent applicable.

Organic foams is to be of a flame-retarding quality, i.e. with low ignition point and low flame-spread properties. Testing is to be carried out according to a recognised standard, e.g. DIN 4102 IB2, or equivalent. The test method chosen shall be suitable for the type of foam in question.

7.3.2.2. Materials utilized for thermal insulation shall be tested for the following properties as applicable, to make sure that they are satisfactory 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 vibration
- Resistance to fire and flame spread.

7.3.2.3. In addition to the above requirements insulation materials which contribute as cargo containment as defined in Ch 3,Sec.,[1.4.8] is to be tested for the following properties after simulation of ageing and thermal cycling to make sure 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 shall be taken into account
- Gas de-absorbing

7.3.2.4. The properties needed by 7.3.2.2 or 7.3.2.3 where applicable, is to 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.

7.3.2.5. The procedures for fabrication, storage, handling, erection, quality control and control against harmful exposure to sunlight of insulation materials shall be according to a specification that has been approved by the Society.

7.3.3. Fixing and protection of insulating materials

7.3.3.1. The insulation is to be fixed in place and protected against mechanical damage, moisture, etc. which may reduce its efficiency.

7.3.3.2. Due to location and or environmental conditions, where applicable, insulation materials is to have suitable properties of fire resistance and flame spread and shall be adequately protected against penetration of water vapour and mechanical damage.

7.3.3.3. The ship shall be built and equipped in such a way that moisture accumulation in the hold spaces is prevented, if the temperature in the tanks may drop below 0°C under normal operating conditions. Details of the arrangement to be forwarded in each case.

7.3.3.4. Insulation on the inner bottom and on the lower part of sides and bulkheads in hold spaces, arrangement shall be done in such a way that it will not be damaged if condensed water shall drip from the tanks.

7.3.3.5. The arrangement shall be such as to prevent compacting of the material due to vibration, where powder or granulated insulation is utilized. The design shall incorporate means to make sure that the material remains sufficiently buoyant to maintain the required thermal conductivity and also prevent any undue increase of pressure on the containment system.

7.3.4. Inspection of insulation

7.3.4.1. The insulation is to be arranged with due regard to access for regular inspections of the insulation itself and of the structures it covers to the extent deemed practicable for the respective cargo containment systems.

7.3.5. Non-cooled cargo tanks exposed to sun radiation

Guidance note:
Non-cooled cargo tanks exposed to direct sun radiation should preferably have a heat-reflecting surface, for example a light colour.

SECTION 8 MARKING OF TANKS, PIPES AND VALVES

Contents

8.1. General

8.1.1. Application

8.1.1.1. General requirements regarding marking of valves are given in Part 6.

8.2. Marking

8.2.1. Language

8.2.1.1. All marking is to be in the language of the registration country of the ship. On ships in international service, corresponding marking is also to be made in a language appropriate for the normal route of the ship, preferably in English.

8.2.2. Marking plates

8.2.2.1. Marking plates is to be made of corrosion-resistant materials, and shall be permanently fixed to valves handles, flanges or similar parts. Markings, bolt holes etc. in the tanks themselves is to be avoided. The lettering is to be impressed on the marking plate in letters of at least 5 mm height. The marking plates shall be placed in easily visible positions and is not to be painted.

8.2.3. Marking of tanks, pipes and valves

8.2.3.1. Every independent tank is to have a marking plate reading as follows:

- Tank no.
- Design pressure (bar)
- Maximum cargo density (kg/$m^{3)}$
- Lowest permissible temperature (°c)
- Capacity of the tank (m^3) (98% filled)
- Test pressure (bar)
- Name of builder
- Year of construction

The marking plate may also be utilized for the necessary markings of identification. For definitions of:

- Design pressure, see Ch 3, Sec.1,[1.2.1.14].
- Test pressure, see Sec.5, [5.14].

8.2.3.2. All valves are to be clearly marked to indicate where the connected pipelines lead.

8.2.4. Marking of tank connections

All intake and outlet connections, manometers and liquid level indicators are to be clearly marked except safety valves, to indicate whether the connection leads to the vapour or liquid phase of the tank.

SECTION 9 GAS-FREEING AND VENTING OF CARGO TANKS AND PIPING SYSTEM

Contents

9.1. Gas-Freeing

9.1.1. General

9.1.1.1. 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 are to be compatible chemically and operationally, at all temperatures likely to occur within the spaces to be inerted, with the materials of construction of the spaces and the cargo. The dew points of the gases are to be taken into consideration.

9.1.1.2. Arrangements suitable for the cargo carried is to be provided to prevent the back flow of cargo vapour into the inert gas system.

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

9.1.1.4. Connection of the piping from an inert gas plant shall be done to the cargo piping system or cargo containment system only for inerting or venting purposes and when these systems are at atmospheric pressure.

9.1.1.5. Permanent pipe connections between an inert gas plant and the cargo piping system or cargo containment system will normally not be accepted.

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

9.1.2. Cargo tanks

9.1.2.1. Provision of a piping system shall be done to enable each cargo tank to be safely gas-freed and to be safely purged with cargo gas from a gas-free condition. Arrangement in the system shall be done to minimize the possibility of pockets of gas or air remaining after gas-freeing or purging.

9.1.2.2. The ventilating system for cargo tanks is to be utilized exclusively for tank ventilating purposes.

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

9.1.2.4. For flammable gases, arrangement in the system shall be done to minimize the possibility of a flammable mixture existing in the cargo tank during any part of the gas-freeing operation utilizing an inerting medium as an intermediate step. In addition, the system shall 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.

9.1.3. Cargo piping system

9.1.3.1. Piping systems which may contain cargo is to be capable of being gas-freed and purged as provided in 9.1.2.1 and 9.1.2.4.

9.1.3.2. The connecting pipe shall have two valves, when a ventilating plant is connected to the cargo lines, one of which shall be a non-return valve or a flap valve, and the other a stop valve.

9.2. Tank Venting Systems

9.2.1. Definitions

9.2.1.1. In the following the term “pressure relief valve” denotes a safety valve which opens at a given internal pressure above atmospheric pressure, and the term “vacuum relief valve” denotes a safety valve which opens at a given internal pressure below atmospheric pressure. By P/V valves are meant combined pressure/vacuum relief valves.

9.2.2. Pressure relief systems

9.2.2.1. All tanks is to consist of at least two completely independent pressure relief valves when the tank volume is 20 m^3 or greater and at least one pressure relief valve when the tank volume is less than 20 m^3.

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

9.2.2.2. The valves are to be of approximately equal capacity, if two or more pressure relief valves are fitted.

9.2.2.3. Connection of the pressure relief valves shall be done to the highest part of the tank above deck level and so that they will remain in the vapour phase under conditions of 15° list and 0.015 L trim at the maximum allowable filling limit (FL) as defined in Sec.17. L is length of ship in m, defined as the distance between perpendiculars.

Arrangement of the pressure relief valves on cargo tanks with a design temperature below 0^0C is to be done to prevent them from becoming inoperative due to ice formation when they are closed. Due consideration shall be provided to the construction and arrangement of pressure relief valves on cargo tanks subject to low ambient temperatures.

Construction of valves shall be done of materials with a melting point above 925^0C. Consideration of lower melting point materials for internal parts and seals is to be given if their use provides significant improvement to the general operation of the valve.

9.2.2.4. Pressure relief valves are to be prototype tested for verification of capacity.

Each pressure relief valve is also to be tested for verification of set pressure. The set pressure deviation shall not ±10% for 0 to 1.5 bar, ± 6% for 1.5 to 3.0 bar and ± 3% for 3.0 bar and above.

The pressure relief valves shall be set and sealed in the presence of a surveyor.

9.2.2.5. More than one relief valve setting on cargo tanks may be accomplished by:

- 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
- Installing relief valves whose settings may be changed by the insertion of previously approved spacer pieces or alternate springs or by other similar means not requiring pressure testing to verify the new set pressure.

The changing of the set pressure under the provisions of 9.2.2.5 and the corresponding resetting of alarms referred to in Sec.13, [13.2.5.1] shall be carried out under the supervision of the master according to procedures approved by the Society and specified in the appendix of the ship to the classification certificate. Changes in set pressures shall 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.

9.2.2.6. Arrangement of an interlocking mechanism shall be done in order to prevent all pressure relief valves for the same tank from being out of service simultaneously, if stop valves or other means of blanking off pipes are fitted between the tanks and the pressure relief valves.

A device which automatically and in a clearly visible way indicates which of the pressure relief valves is out of service, is also to be fitted. The in service remaining pressure relief valves shall have the combined relieving capacity required by 13.2.3. However, this capacity may be provided by all valves if a suitably maintained spare valve is carried onboard.

9.2.2.7. Connection of each pressure relief valve installed on a cargo tank shall be done to a venting system which shall be so constructed that the discharge of gas will be unimpeded and directed vertically upwards at the exit and so arranged as to minimize the possibility of water or snow entering the vent system.

9.2.2.8. The outlets for escape gas from pressure relief valves are normally to be situated at a height not less than B/3 or 6 m, whichever is the greater, above the weather deck and 6 m above the working area, the fore and aft gangway, deck storage tanks and cargo liquid lines, where B means greatest moulded breadth of the ship in m. The outlets shall be located at a distance at least equal to B or 25 m, whichever is less, from the nearest:

- Air intake, air outlet or opening to accommodation, service and control station spaces, or other gas-safe spaces
- Exhaust outlet from machinery or from furnace installations onboard.

For ships less than 90 m in length, the Society may accept smaller distances.

9.2.2.9. Arrangement of all other cargo vent exits not dealt with in other chapters shall be done according to 9.2.2.8.

9.2.2.10. A separate pressure relief system shall be fitted for each cargo carried, if cargoes which react in a hazardous manner with each other are carried simultaneously.

9.2.2.11. In the piping system for escape gas, means for draining condensed water from places where it is liable to accumulate, preferably in the form of special condensation pots, shall be fitted. The pressure relief valves and pipes for escape gas is to be so arranged that condensed water under no circumstances remains accumulated in or near the pressure relief valves.

9.2.2.12. Protection screens that are suitable shall be fitted on vent outlets to prevent the ingress of foreign objects.

9.2.2.13. All pipes for escape gas is to be so arranged in such a way that they will not be damaged by temperature variations in the pipes or by the ship's motion in a seaway.

9.2.2.14. The back pressure in the vent lines from the pressure relief valves shall be taken into account in determining the flow capacity required by 9.2.3.

The pressure drop in the vent line from the tank to the pressure relief valve inlet is not to exceed 3% of the valve set pressure. The back pressure in the discharge line shall not exceed 10% of the gauge pressure at the relief valve inlet with the vent lines under fire exposure as referred to in 9.2.3, for unbalanced pressure relief valves.

9.2.2.15. The sufficiency of the vent system fitted on tanks loaded according to Sec.17, [17.1.1.6] is be demonstrated using the guidelines given in IMO Res. A.829 (19) “Guidelines for the evaluation of the adequacy of type C tank vent systems”. A “Certificate of increased loading limit” will be issued by the Society, if the vent system is found acceptable.

For the purpose of this paragraph, vent system means:

1) The tank outlet and the piping to the pressure relief valve.
2) The pressure relief valve.
3) The piping from the pressure relief valve to the location of discharge to the atmosphere and including any interconnections and piping which joins other tanks.

9.2.3. Size of valves

9.2.3.1. Pressure relief valves is to consist of a combined relieving capacity for each cargo tank to discharge the greater of the following with not more than a 20% rise in cargo tank pressure above the maximum allowable relief valve setting of the cargo tank (MARVS):

1) The maximum capacity of the cargo tank inerting system if the maximum attainable working pressure of the cargo tank inerting system exceeds the MARVS of the cargo tanks, or

2) Vapours generated under fire exposure computed utilizing the following formula:

$Q = F_{Tk} G \mathrm{A}_{\mathrm{tk}}^{0.82}$ (m^3/s)

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

F_{Tk} = fire exposure factor for different cargo tank types

= 1.0 for independent tanks without insulation located on deck

= 0.5 for independent tanks above the deck with insulation. (Acceptance of this value will be based on the use of an approved fire-proofing material, the thermal conductance of insulation and its stability under fire exposure)

= 0.5 for uninsulated independent tanks installed in holds

= 0.2 for insulated independent tanks in holds (or uninsulated independent tanks in insulated holds)
= 0.1 for insulated independent tanks in inerted holds (or uninsulated independent tanks in inerted, insulated holds)
= 0.1 for membrane and semi-membrane tanks.
Partly protruding through the open deck, the fire exposure factor shall be determined on the basis of the surface area above and below deck, for independent tanks.

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

L_H = latent heat of the product being vapourised at relieving conditions (kJ/kg)

D = constant based on relation of specific heats (k), shown in Table 3.9.1

If k is not known, D = 0.606 should be used. The constant D may also be calculated by the following formula:

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

M = molecular mass of the product

G gas factor 12.4

A_{tk} = external surface area of the tank (m^2). To be calculated for the different tank types as given below:

9.2.4. Vacuum protection systems

9.2.4.1. Cargo tanks designed to withstand a maximum external pressure differential exceeding 0.25 bar and capable of withstanding the maximum external differential pressure 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.

9.2.4.2. Cargo tanks designed to endure a maximum external pressure differential not exceeding 0.25 bar, or tanks which cannot withstand the maximum external differential pressure 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, shall be fitted with:

- 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 external design differential pressure of the cargo tank, or
- 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
- Other vacuum relief systems acceptable to the society

For body of revolution type tanks:

A_{tk}= 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:

1) Insulation on the ship's structure:
   A_h = external surface area of the hold less its projected bottom area
2) Insulation on the tank structure:
   A_{pv} = external surface area of the array of pressure vessels excluding insulation as shown in Fig.3.9.1, less the projected bottom area.

Table 3.9.1

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

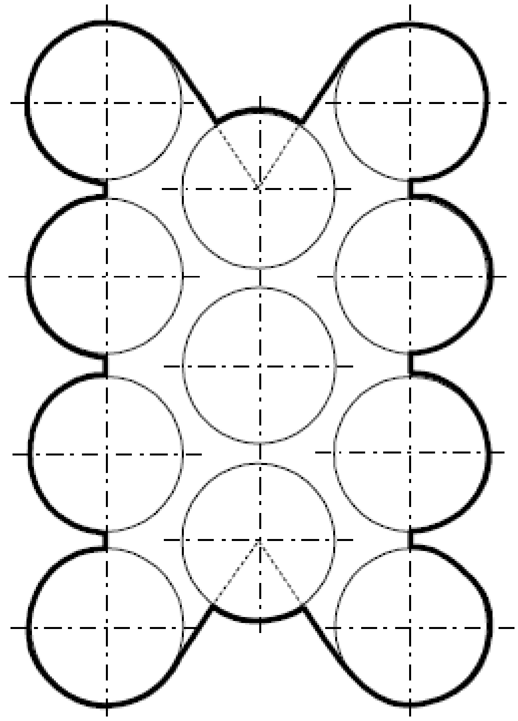


Figure 3.9.1: External surface area of the array of pressure vessels

9.2.4.3. *The vacuu*m relief valves shall admit an inert gas, cargo vapour or air to the cargo tank and shall be arranged to minimize the possibility of the entrance of water or snow, subject to relevant requirements of *Sec.15*. Cargo vapour shall be from a source other than the cargo vapour lines, if it is admitted.

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

9.2.5. Additional pressure relieving system for liquid level control

9.2.5.1. An additional pressure relieving system to prevent the tank from becoming liquid full at any time during relief under the fire exposure conditions referred to in 9.2.3 shall be fitted to each tank, where required by Ch 3, Sec.17, [17.1.10.5]. This pressure relieving system shall consist of:

1) One or more relief valves set at a pressure corresponding to the gauge vapour pressure of the cargo at the reference temperature defined in Ch 3 Sec.17,[17.1.10.5}and;
2) An override arrangement, whenever necessary, to prevent its normal operation. This arrangement shall include fusible elements designed to melt at temperatures between 98°C and 104°C and to cause relief valves specified in 9.2.4.1 to become operable. The fusible elements shall be located, in particular, in the vicinity of relief valves. The system shall become operable upon loss of system power if provided. The override arrangement shall not be dependent on any source of ship's power.

Table 3.9.2: Factor m

Product	$m = - d_i / d \rho_r$ (kJ / kg)
Ammonia, anhydrous	3 400
Butadiene	1 800
Butane	2 000
Butylenes	1 900
Ethane	2 100
Ethylene	1 500
Methane	2 300
Methyl chloride	816
Nitrogen	400
Propane	2 000
Propylene	1 600
Propylene oxide	1 550
Vinyl chloride	900
The values in this table may be used for set pressures not higher than 2.0 bar.	

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

9.2.5.2. The total relieving capacity of the additional pressure relieving system at the pressure mentioned in 9.2.4.1 shall not be less than:

$Q' = F_{Tk} G' A_{tk}^{0.82}$ (m³/s)

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

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

r = gradient of decrease of liquid phase enthalpy against increase of liquid phase density (kJ/kg) at relieving conditions. For set pressures not higher than 2.0 bar the values in Table 3.9.2 may be used. For products not listed in the table and for higher set pressures, the value of m shall be calculated on the basis of the thermodynamic data of the product itself

i = enthalpy of liquid (kJ/kg)

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

F_{Tk}, A_{tk}, L, D, Z and M are defined in 9.2.3.

9.2.5.3. Compliance with 9.2.4.1 requires changing of the setting of the relief valves provided for in this section.

This shall be accomplished in accordance with the provisions of 9.2.3.

9.2.5.4. Relief valves mentioned under 9.2.4.1 above may be the same as the pressure relief valves mentioned in 9.2.2, provided the setting pressure and the relieving capacity are in compliance with the requirements of this section.

9.2.5.5. The exhaust of such pressure relief valves may be led to the venting system referred to in 9.2.2.7and 9.2.2.8.

If separate venting arrangements are fitted these shall be in accordance with the requirements of 9.2.2.7 to 9.2.2.14.

9.3. Certification of Pressure Relief Valves

9.3.1. General

Manufacturer's catalogue with specification shall be submitted for information. Pressure relief valves shall have been prototype tested for verification of capacity according to 9.3.2.4.

9.3.2. Production testing of each valve

9.3.2.1. All new valves shall be subjected to the following tests at the manufacturer:

- hydrostatic test at a pressure equal to 1.5 times the design pressure
- verification of set pressure
- seat leakage test at 90% of the set pressure.

The set pressure shall be sealed by the use of a robust non-corrosive wire.

9.3.3. Certification of pressure relief valves

9.3.3.1. INTLREG product certificate is needed for all pressure relief valves on cargo tanks. For other pressure relief valves utilized in the cargo systems, INTLREG product certificate is required for valves with DN > 75 mm. For valves with DN ≤ 75 mm manufacturer's product certificate may be accepted.

9.3.3.2. The safety relief valves is to be furnished with material certificates according to Sec 2.

SECTION 10 MECHANICAL VENTILATION IN CARGO AREA

Contents

10.1. System Requirements

10.1.1. General

10.1.1.1. Any ducting utilized for the ventilation of hazardous spaces is to be separated from that utilized for the ventilation of non-hazardous spaces. Ventilation systems within the cargo area are to be independent of other ventilation systems.

10.1.1.2. Air inlets for hazardous enclosed spaces shall be taken from areas which would be non-hazardous in the absence of the considered inlet.

Air inlets for non-hazardous enclosed spaces are to be taken from non-hazardous areas at least 1.5 m away from the boundaries of any hazardous area.

The duct shall have over-pressure relative to this space, where the inlet duct passes through a more hazardous space, unless mechanical integrity and gas-tightness of the duct will ensure that gases will not leak into it.

10.1.1.3. Air outlets from non-hazardous spaces shall be positioned outside hazardous areas.

10.1.1.4. In the absence of the considered outlet, air outlets from hazardous enclosed spaces shall be positioned in an open area which would be of the same or lesser hazard than the ventilated space.

10.1.1.5. Ventilation ducts for spaces within the cargo area is not to be led through non-hazardous spaces. For exceptions, see Sec.16.

10.1.1.6. Non-hazardous enclosed spaces shall be arranged with ventilation of the overpressure type, where mechanical ventilation is required, while hazardous spaces shall have ventilation with under pressure relative to the adjacent less hazardous spaces.

10.1.1.7. Wire mesh screens of not more than 13 mm square mesh shall be fitted in outside openings of ventilation ducts. Protection screens are also to be fitted inside of the fan to prevent the entrance of objects into the fan housing, for ducts where fans are installed.

10.1.1.8. Spare parts are to be carried for each type of fan referred to in this section. Normally one motor and one impeller is required carried on board for each type of fan serving cargo handling spaces, unless there is a standby fan. Wear parts for motor and impeller is considered sufficient, for spaces served by more than one fan.

10.1.2. Fans serving hazardous spaces

10.1.2.1. Installation of electric fan motors shall not be done in ventilation ducts for hazardous spaces unless the motor is certified for the same hazard zone as the space served.

10.1.2.2. Starters for fans for ventilation of non-hazardous spaces, shall be located outside the cargo area or on open deck.

The ventilation capacity shall be great enough to prevent the temperature limits specified in Part 6, If electric motors are installed in such rooms, from being exceeded, taking into account the heat generated by the electric motors.

10.1.2.3. Fans shall be designed with the least possible risk for spark generation.

10.1.2.4. Minimum safety clearances between the casing and rotating parts are to be such as to avoid any friction with each other.

In no case is the radial air gap between the impeller and the casing to be less than 0.1 times the diameter of the impeller shaft in way of the bearing but not less than 2 mm. It need not be more than 13 mm.

10.1.2.5. The parts of the rotating body and of the casing shall be made of materials which are recognised as being spark proof, and they shall have antistatic properties.

Furthermore, the installation on board of the ventilation units is to be such as to make sure the safe bonding to the hull of the units themselves. Resistance between any point on the surface of the unit and the hull, shall not be greater than 106 ohm.

The following combinations of materials and clearances used in way of the impeller and duct are considered to be non-sparking:

- Impellers and or housings of non-metallic material, due regard being paid to the elimination of static electricity
- Impellers and housings of non-ferrous metals
- Impellers of aluminum alloys or magnesium alloys and a ferrous (including austenitic stainless steel) housing on which a ring of suitable thickness of non-ferrous materials is fitted in way of the impeller, due regard being paid to static electricity and corrosion between ring and housing,
- Impellers and housing of austenitic stainless steel
- Any combination of ferrous (including austenitic stainless steel) impellers and housings with not less than 13 mm tip design clearance.

10.1.2.6. Any combination of an aluminum or magnesium alloy fixed or rotating component and a ferrous fixed or rotating component, regardless of tip clearance, is considered a sparking hazard and is not to be utilized in these places.

10.2. Ventilation Arrangement and Capacity Requirements

10.2.1. General

The required capacity of the ventilation plant is normally based on the total volume of the room. An increase in required ventilation capacity may be necessary for rooms having a complicated form.

10.2.2. Non-hazardous spaces

10.2.2.1. Spaces with opening to a hazardous area, shall be arranged with an air-lock, and be maintained at overpressure, relative to the external hazardous area. The overpressure ventilation shall be arranged according to the following requirements:

1) During initial start-up or after loss of overpressure ventilation, it is required before energising any electrical installations not certified safe for the space in the absence of pressurisation, to:

- Proceed with purging (at least 5 air changes) or confirm by measurements that the space is nonhazardous, and
- Pressurise the space

2) Operation of the overpressure ventilation shall be monitored.
3) In the event of failure of the overpressure ventilation:

- An audible and visual alarm shall be given at a manned location
- If overpressure cannot be immediately restored, automatic or programmed disconnection of electrical installations is required according to iec 60092-502, table 5

10.2.3. Cargo handling spaces

10.2.3.1. *Cargo handling spaces* are pump rooms, compressor rooms and other enclosed spaces which contain cargo handling equipment and similar spaces in which work is performed on the cargo.

10.2.3.2. Installation of a permanent mechanical ventilation system shall be done that is capable of circulating sufficient air to give at least 30 air changes per hour. Arrangement of ventilation inlets and outlets shall be done to ensure sufficient air movement through the space to avoid the accumulation of vapours and to ensure a safe working environment.

10.2.3.3. The ventilation systems shall allow extraction from either the upper and lower parts of the spaces, or from both the upper and lower parts, depending on the density of the vapours of the products carried.

10.2.3.4. The exhaust outlets, which shall discharge upwards, shall be positioned at least 4 m above deck and at least 10 m in the horizontal direction from ventilation inlets and other openings to accommodation, service and control station spaces and other non-hazardous spaces.

10.2.3.5. Ventilation systems for pump and compressor rooms are to be in operation when pumps or compressors are working.

Pumps and compressors shall not be started before the ventilation system in the electric motor room has been in operation for 15 minutes. Warning notices to this effect shall be located in an easily visible position near the control stand.

10.2.3.6. When the space is dependent on ventilation for its area classification, the following requirements apply:

1) During initial start-up, and after loss of ventilation, the space shall be purged (at least 5 air changes), before connecting electrical installations which are not certified for the area classification in absence of ventilation.
2) Operation of the ventilation shall be monitored.
3) In the event of failure of ventilation, the following requirements apply;

- The disconnection an audible and visual alarm shall be given at a manned location
- Immediate action shall be taken to restore ventilation
- Electrical installations shall be disconnected if ventilation cannot be restored for an extended period

Shall be made outside the hazardous areas, and be protected against unauthorized reconnection, e.g. by lockable switches.

Intrinsically safe equipment suitable for Zone 0 is not requisite to be switched off. Certified flameproof lighting may have a separate switch-off circuit.

10.2.4. Other hazardous spaces normally entered

10.2.4.1. Air lock spaces are to be mechanically ventilated at an overpressure relative to the adjacent open deck hazardous area.

10.2.4.2. Acceptance may be given for other spaces positioned on or above cargo deck level (e.g. Cargo Handling Gear lockers) with natural ventilation only.

10.2.5. Spaces

10.2.5.1. Spaces not normally entered are cofferdams, double bottoms, duct keels, pipe tunnels, spaces containing cargo tanks and other spaces where cargo may accumulate.

10.2.5.2. A mechanical ventilation system (permanent or portable) is to be provided capable of circulating adequate air to the compartments concerned. The capacity of the ventilation system is normally to give at least 8 air changes per hour. Provided it can be demonstrated that the space concerned can be satisfactorily gas-freed in less than 5 hours, for hold spaces containing independent tanks a lower capacity may be accepted.

For inerted spaces an increase of the oxygen content from 0% to 20% in all locations of the space within 5 hours would be acceptable.

10.2.5.3. If necessary, ducting shall be fitted, to ensure efficient gas-freeing.

10.2.5.4. Fans shall be installed clear of access openings.

10.2.6. Certification of fans

Fans and portable ventilators covered by this section shall be delivered with a INTLREG product certificate.

Manufacturer's certificate will be accepted for type approved fans.

SECTION 11 FIRE PROTECTION AND EXTINCTION

Contents

11.1. General

11.1.1. Application

11.1.1.1. The fire safety measures in SOLAS related to tankers in general, will apply depending on flag state authorization.

11.1.1.2. Fire safety measures applicable to gas tankers are specified in 11.2 below and in Sec.6, [6.5].

11.1.2. Firefighter's outfit

11.1.2.1. All ships are to be provided with at least two firefighter's outfits complying with Part 11 of Fire Safety Systems Code as defined in Pt.4 Ch.10.

In ships carrying flammable products of a cargo capacity of less than 5000 m^3 two additional firefighter's outfits shall be provided and on ships of a cargo capacity of 5000 m^3 and over three additional firefighter's outfits shall be provided.

11.1.2.2. Additional requirements for safety equipment are given in Ch 3, Sec.19.

11.2. Fire Extinction

11.2.1. Fire water main equipment

11.2.1.1. All ships, irrespective of size, carrying products which are subject to this chapter must comply with requirements to fire pumps, fire main, hydrants and hoses in SOLAS Reg. II-2/10.2 for ships above 2000 gross tonnage, except that the required fire pumps capacity and fire main and water service pipe diameter is not to be limited when the fire pump and fire main are utilized as part of the water spray system.
In addition, the requirement to minimum pressure at hydrants shall be 5.0 bar.

11.2.1.2. The arrangement is to be such that at least 2 jets of water not emanating from the same hydrant, one of which shall be from a single length of hose can reach any part of the deck in the cargo area and those portions of the cargo containment systems and tank covers above the deck. Hose lengths shall not exceed 33 m.

11.2.1.3. Stop valves is to be fitted in any crossover provided and in the fire main or mains at the poop front and at intervals of not more than 40 m between hydrants on the deck in the cargo area for the purpose of isolating damaged sections of the main.

11.2.1.4. All water nozzles provided for fire-fighting use is to be of an approved dual-purpose type capable of producing either a spray or a jet. All pipes, valves, nozzles and other fittings in the firefighting systems shall be resistant to the effect of fire and corrosion by seawater, for example by use of galvanized pipe.

11.2.1.5. Arrangements shall 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, where the ship's engine room is unattended.

11.2.2. Water spray system

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

1) Exposed cargo tank domes and exposed parts of cargo tanks.
2) Exposed on-deck storage vessels for flammable or toxic products.
3) Cargo liquid and vapour discharge and loading manifolds and the area of their control valves and any other areas where essential control valves are situated and which shall be at least equal to the area of the drip trays provided.
4) Boundaries of superstructures, deckhouses normally manned, cargo compressor rooms, cargo pump rooms, store rooms containing high fire risk items and cargo control rooms facing the cargo area. Boundaries of

unmanned forecastle structures not containing high fire risk items or equipment do not require water spray protection.

11.2.2.2. The system shall have the capability of covering all areas mentioned in 11.2.2.1 with a uniformly distributed water spray of at least 10 l/m^2 per minute for horizontal projected surfaces and 4 l/m^2 per minute for vertical surfaces.

For structures having no clearly defined horizontal or vertical surfaces, the capacity of the water spray system shall be determined by the greater of the following:

- Projected horizontal surface multiplied by 10 l/m^2 per minute; or
- 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 is to be fitted at intervals in the spray main for the purpose of isolating damaged sections. Alternatively, the system may be divided into two or more sections which may be operated independently provided the necessary controls are located together, aft of the cargo area. A section protecting any area included in 11.2.2.1, items 1 and 2, shall cover the whole of the athwartship tank grouping which includes that area.

11.2.2.3. The capacity of the water spray pump shall be enough to deliver the required amount of water to all areas simultaneously or, where the system is divided into sections, the arrangements and capacity shall be such as to simultaneously supply water to any one section and to the surfaces specified in 11.2.2.1, items 3 and 4.

Alternatively, the main fire pumps may be used for this service, provided that their total capacity is increased by the amount needed for the spray system. In either case, a connection through a stop valve shall be made between the fire main and water spray main outside the cargo area.

11.2.2.4. Water pumps normally being utilized for other services may be arranged to supply the water spray main.

11.2.2.5. The pipes, valves, nozzles and other fittings in the water spray system is to be resistant to corrosion by seawater, for example by galvanized pipe, and to the effect of fire.

11.2.2.6. Remote starting of pumps supplying the water spray system and remote operation of any normally closed valves in the system shall be arranged in suitable locations outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the areas protected.

Guidance note:

Water spray pipes shall be provided with drain holes at the lowest points.

11.2.3. Dry chemical powder fire extinguishing system

11.2.3.1. If applicable, ships intended to carry flammable products is to be fitted with a fixed dry chemical powder type extinguishing system for the purpose of fighting fire on the deck in the complete cargo area and bow or stern cargo handling areas.

The system shall be of approved type and tested for its purpose.

11.2.3.2. The system shall be capable of delivering powder from at least two hand hose lines or a combination monitor and hand hose line(s) to any part of the above-deck exposed cargo area including above-deck product piping.

Activation of the system shall be done by an inert gas, such as nitrogen, utilized exclusively for this purpose and stored in pressure vessels adjacent to the powder containers.

11.2.3.3. The system shall consist of at least two independent, self-contained dry chemical powder units with associated controls, pressurizing medium, fixed piping, monitors or hand hose lines. Consideration may be given to allow only one such unit to be fitted, for ships with a cargo capacity of less than 1 000 m^3. Provision of a monitor shall be done and so arranged as to protect the cargo loading and discharge manifold areas and be capable of actuation and discharge locally and remotely. The monitor is not required to be remotely aimed if it can deliver the necessary powder to all required areas of coverage from a single position. All hand hose lines and monitors shall be capable of actuation at the hose storage reel or monitor. At least one hand hose line or monitor shall be situated at the after end of the cargo-area.

11.2.3.4. A fire-extinguishing unit having two or more monitors, hand hose lines, or combinations thereof, shall have independent pipes with a manifold at the powder container. The arrangement shall be such that any or all of the monitors and hand hose lines shall be capable of simultaneous or sequential operation at their rated capacities, where two or more pipes are attached to a unit.

11.2.3.5. The capacity of a monitor is not to be less than 10 kg/s. Hand hose lines shall be non-kinkable and be fitted with a nozzle capable of on/off operation and discharge at a rate not less than 3.5 kg/s. The maximum discharge rate is to be such as to allow operation by one man. The length of a hand hose line shall not exceed 33 m. Where fixed piping is provided between the powder container and a hand hose line or monitor, the length of piping shall not surpass that length which is capable of maintaining the powder in a fluidised state during sustained or intermittent use, and which can be purged of powder when the system is shut down. Hand hose lines and nozzles shall be of weather-resistant construction or stored in weather-resistant housing or covers and be readily accessible.

11.2.3.6. A sufficient quantity of dry chemical powder is to be stored in each container to provide a minimum 45 s discharge time for all monitors and hand hose lines attached to each powder unit. Coverage from fixed monitors shall be according to the following requirements:

Consideration to the hand hose lines shall be given to have a maximum effective distance of coverage equal to the length of hose. Special consideration shall be given where areas to be protected are substantially higher than the monitor or hand hose reel locations.

11.2.3.7. Ships those are fitted with bow or stern loading and discharge arrangements shall be provided with an additional dry chemical powder unit complete with at least one monitor and one hand hose line. This additional unit shall be positioned to protect the bow or stern loading and discharge arrangements. The area of the cargo line forward or aft of the cargo area shall be protected by hand hose lines.

11.2.4. Cargo compressor and pump-rooms

11.2.4.1. Provision of carbon dioxide system as specified in Ch.5 of Fire Safety Systems Code as defined in Part 11 shall be done to the cargo compressor and pump-rooms of any ship. A notice shall be exhibited at the controls stating that the system is only to be utilized for fire extinguishing and not for inerting purposes, due to the electrostatic ignition hazard. The alarms referred to in Fire Safety Systems Code as defined in Part 11 shall be safe for utilization in a flammable cargo vapour-air mixture. An extinguishing system shall be provided which is suitable for machinery spaces, for the purpose of this requirement. However, the amount of carbon dioxide gas carried shall be adequate to provide a quantity of free gas equal to 45% of the gross volume of the cargo compressor and pump-rooms in all cases.

11.2.4.2. Cargo compressor and pump-rooms of ships which are dedicated to the carriage of a restricted number of cargoes shall be protected by an appropriate fire extinguishing system approved by the Society.

SECTION 12 AREA CLASSIFICATION AND ELECTRICAL INSTALLATIONS

Contents

12.1. General

12.1.1. Application

The requirements in this chapter are additional to those given in Part 6 and apply to tankers with the additional class notation **Tanker for Liquefied Gas**. The requirements may be made wholly or partly valid also for tankers for other cargoes (**Tanker for C**) in some cases.

Acceptance may be given for relaxation from these rules for ships built to carry only non-flammable products.

12.2. Electrical Installations in Cargo Area and Adjacent to this Area

12.2.1. General

12.2.1.1. Installation of electrical equipment and wiring are in general not to be done in hazardous areas unless essential for operational purposes. The type of equipment and installation requirements shall comply with Part 6 in accordance with the area classification as specified in 12.3.

In addition, installations as specified in 12.2.1.2 are accepted.

12.2.1.2. *In Zone 1:*

Impressed cathodic protection equipment is accepted provided the following is complied with:

- such equipment shall be of gas-tight construction or be housed in a gas tight enclosure
- cables shall be installed in steel pipes with gas-tight joints up to the upper deck
- corrosion resistant pipes, providing adequate mechanical protection, shall be used in compartments which may be filled with seawater (e.g. permanent ballast tanks)
- wall thickness of the pipes shall be as for overflow and sounding pipes through ballast or fuel tanks, in accordance with Part 6.

In Zone 0:

Submersible electrically driven pumps are accepted provided the following is complied with:

- at least two independent means of shutting down automatically in the event of low liquid level, and prevention from being energized when not submerged
- the supply circuit to the pumps shall be automatically disconnected and/or shall be prevented from being energized in the event of an abnormally low level of insulation resistance or high level of leakage current
- the protective systems shall be arranged so that manual intervention is necessary for the reconnection of the circuit after disconnection after a short circuit, overload or earth-fault condition.

12.2.1.3. Additional requirements may apply for certain cargoes according to IGC Code Ch.17 and Ch.19.

12.3. Area Classification

12.3.1. General

12.3.1.1. Area classification is a mode of analyzing and classifying the areas where explosive gas atmospheres may occur. The object of the classification is to permit the selection of electrical apparatus able to be operated safely in these areas.

12.3.1.2. Hazardous areas are divided into zones 0, 1 and 2 according to the principles of the standards IEC 60079-10 and guidance and informative examples given in IEC 60092-502, in order to facilitate the selection of appropriate electrical apparatus an the design of suitable electrical installations. Main features of the guidance are given in 12.3 and 12.4.

12.3.1.3. Areas and spaces other than those classified in 12.2 and 12.3, is to be subject to special consideration. Application of the principles of the IEC standards shall be done.

12.3.1.4. Area classification of a space may be dependent of ventilation as specified in IEC 60092-502, Table 1. Requirements to such ventilation are given in Sec.10 – [10.3.4 to 10.3.6.]

12.3.1.5. A space with opening to an adjacent hazardous area on open deck, may be made into a less hazardous or non-hazardous space, by means of overpressure. Requirements to such pressurization are given in Sec.10, [10.2.2.1 to 10.2.2.5].

12.3.1.6. Ventilation ducts is to consist of the same area classification as the ventilated space.

12.3.2. Tankers carrying flammable liquefied gases

12.3.2.1. *Hazardous areas Zone 0*

The interiors of cargo tanks, slop tanks, any pipework of pressure-relief or other venting systems for cargo and slop tanks, pipes and equipment containing the cargo or developing flammable gases or vapours.

Instrumentation and electrical apparatus in contact with the gas or liquid shall be of a type suitable for zone 0.

Temperature sensors installed in thermo wells, and pressure sensors without additional separating chamber shall be of intrinsically safe type Ex-ia.

12.3.2.2. *Hazardous areas Zone 1*

1) Void spaces adjacent to, above and below integral cargo tanks.
2) Hold spaces containing independent cargo tanks.
3) Cofferdams and permanent (for example, segregated) ballast tanks adjacent to cargo tanks.
4) Cargo compressor room arranged with ventilation according to Sec.10, [10.2.3.5].
5) Enclosed or semi-enclosed spaces, immediately above cargo tanks (for example, between decks) or having bulkheads above and in line with cargo

tanks bulkheads, unless protected by a diagonal plate acceptable to the appropriate authority.

6) Spaces, other than cofferdam, adjacent to a cargo tank boundary or a secondary barrier (for example, trunks, passageways and hold).
7) Areas on open deck, or semi- enclosed spaces on deck, within 3 m of any cargo tank outlet, gas or vapour outlet (see note), cargo manifold valve, cargo valve, cargo pipe flange, cargo pump-room ventilation outlets and cargo tank openings for pressure release provided to allow the flow of small volumes of gas or vapour mixtures caused by thermal variation.

   Such areas are, for example, all areas within 3 m of cargo tank hatches, sight ports, tank cleaning openings, ullage openings, sounding pipes, cargo vapour outlets.

8) Areas on open deck, or semi-enclosed spaces on open deck above and in the vicinity of any cargo gas outlet intended for the passage of liquefied gas or large volumes of vapour mixture during cargo loading and ballasting or during discharging, within a vertical cylinder of unlimited height and 6 m radius centred upon the centre of the outlet, and within a hemisphere of 6 m radius below the outlet.
9) Areas on:

   - Open deck or semi-enclosed spaces on deck, within 1.5 m of cargo pump room entrances,
   - Cargo pump room ventilation inlet,
   - Openings into cofferdams or other zone 1 spaces

10) Areas on the open deck within spillage coamings surrounding cargo manifold valves and 3 m beyond these, up to a height of 2.4 m above the deck.
11) Areas where structures are obstructing the natural ventilation e.g. by semi-enclosed spaces, up to a height of 2.4 m above the deck and structure. This applies to:

   - areas in the cargo area on open deck (including also areas above ballast tanks within the cargo area),
   - to the full breadth of the ship,
   - 3 m fore and aft of the forward-most and after-most cargo tank bulkhead.

12) Compartments for cargo hoses.
13) Enclosed or semi-enclosed spaces in which pipes containing cargoes are located.

12.3.2.3. *Hazardous areas Zone 2*

1) Areas within 1.5 m surrounding open or semi-enclosed spaces of zone 1 as specified in 12.3.2.2, if not otherwise specified in this standard.
2) Spaces 4 m beyond the cylinder and 4 m beyond the sphere defined in 12.3.2.2 8).
3) The spaces forming an air-lock as defined in Sec.1, [1.2.1.2] and Sec.3, [3.4.1. 5] and 3.4.1.6.
4) Areas on open deck extending to the coamings fitted to keep any spills on deck and away from the accommodation and service areas and 3 m beyond these up to a height of 2.4 m above deck.

5) Areas on open deck over all tanks (including all ballast tanks within the cargo tank area) where unrestricted natural ventilation is guaranteed and to the full breadth of the ship plus 3 m fore and aft of the forward-most and aft-most cargo tank bulkhead, up to a height of 2.4 m above the deck surrounding open or semi-enclosed spaces of zone 1
6) Spaces forward of the open deck areas to which reference is made in 12.3.2.2 11) and 12.3.2.35), below the level of the main deck, and having an opening on to the main deck or at a level less than 0.5 m above the main deck, unless:

- The entrances to such spaces do not face the cargo tank area and, together with all other openings to the spaces, including ventilating system inlets and exhausts, are situated at least 10 m horizontally from any cargo tank outlet or gas or vapour outlet; and
- The spaces are mechanically ventilated.

12.4. Inspection and testing

12.4.1. General

12.4.1.1. Before the electrical installations in hazardous areas are put into service or considered ready for use, they shall be inspected and tested. All equipment, cables, etc. shall be verified to have been installed in accordance with installations procedures and guidelines issued by the manufacturer of the equipment, cables, etc., and that the installations have been carried out in accordance to Part 7.

12.4.1.2. For spaces protected by pressurization it shall be inspected and tested that the purging can be effected.

Purge time at minimum flow rate shall be documented. Required shutdowns and / or alarms upon ventilation overpressure falling below prescribed values shall be tested.

For other spaces where area classification depends on mechanical ventilation it shall be tested that ventilation flow rate is sufficient, and that and required ventilation failure alarm operates correctly.

12.4.1.3. For equipment for which safety in hazardous areas depends upon correct operation of protective devices (for example overload protection relays) and / or operation of an alarm (for example loss of pressurisation for an Ex(p) control panel) it shall be verified that the devices have correct settings and / or correct operation of alarms.

12.4.1.4. Where interlocking and shutdown arrangements are required (such as for submerged cargo pumps), they shall be tested.

12.4.1.5. To ensure that the equipment and wiring are correctly installed, intrinsically safe circuits shall be verified.

12.4.1.6. Verification of the physical installation shall be documented by yard. The documentation shall be available for the Society's surveyor at the site.

12.5. Maintenance

12.5.1. General

12.5.1.1. The maintenance manual referred to in Ch 3,Sec.1,[1.3.2.5], shall be in accordance with the recommendations in IEC 60079-17 and 60092-502 and shall contain necessary information on:

- Overview of classification of hazardous areas, with information about gas groups and temperature class
- Records sufficient to enable the certified safe equipment to be maintained in accordance with its type of protection (list and location of equipment, technical information, manufacturer's instructions, spares etc.)
- Inspection routines with information about detailing level and time intervals between the inspections, acceptance/rejection criteria
- Register of inspections, with information about date of inspections and name(s) of person(s) who carried out the inspection and maintenance work.

12.5.1.2. With records of date and names of companies and persons who have carried out inspections and maintenance, updated documentation and maintenance manual shall be kept onboard.

Inspection and maintenance of installations shall be carried out only by experienced personnel whose training has included instruction on the various types of protection of apparatus and installation practices to be found on the vessel. Appropriate refresher training is to be given to such personnel on a regular basis.

12.6. Signboards

12.6.1. General

12.6.1.1. Where electric lighting is provided for spaces in hazardous areas, a signboard at least 200 x 300 mm shall be fitted at each entrance to such spaces with text:

BEFORE A LIGHTING FITTING IS OPENED ITS SUPPLY CIRCUIT SHALL BE DISCONNECTED

Alternatively a signboard with the same text can be fitted at each individual lighting fitting.

12.6.1.2. Where electric lighting is provided in spaces where the ventilation must be in operation before the electric power is connected, a signboard at least 200 x 300 mm shall be fitted at each entrance, and with a smaller signboard at the switch for each lighting circuit, with text:

BEFORE THE LIGHTING IS TURNED ON THE VENTILATION MUST BE IN OPERATION

12.6.1.3. Where socket-outlets are installed in cargo area or adjacent area, a signboard shall be fitted at each socket-outlet with text:

PORTABLE ELECTRICAL EQUIPMENT SUPPLIED BY FLEXIBLE CABLES SHALL NOT BE USED IN AREAS WHERE THERE IS GAS DANGER

Alternatively signboards of size approximately 600 x 400 mm, with letters of height approximately 30 mm, can be fitted at each end of the tank deck.

12.6.1.4. Where socket-outlets for welding apparatus are installed in areas adjacent cargo area, the socket outlet shall be provided with a signboard with text:

WELDING APPARATUS NOT TO BE USED UNLESS THE WORKING SPACE AND ADJACENT SPACES ARE GAS-FREE

12.6.1.5. For electrical installations in the cargo area, a warning signboard should be fitted with text:

WARNING: THIS PANEL DOES CONTAIN ELECTRICAL EQUIPMENT. ANY SERVICING MUST BE UNDERTAKEN ONLY BY QUALIFIED PERSONNEL AND WITH THE POWER SUPPLY DISCONNECTED.

SECTION 13 INSTRUMENTATION AND AUTOMATION

Contents

13.1. General Requirements

13.1.1. General

13.1.1.1. The requirements in this chapter are additional to those given in Part 6 for instrumentation and automation, including computer based control and monitoring. The control and monitoring systems shall be certified in accordance with Part 6 for the following:

- Cargo tank level measurement system
- Cargo tank overflow protection system
- Cargo valves and pumps control and monitoring system
- Flammable gas detection system (permanent system only)
- Inert gas control and monitoring system
- Cargo and vapour pressure control and monitoring system
- Oxygen indication equipment (permanent system only)

13.1.1.2. Remote reading systems for cargo temperature and pressure shall not permit the cargo or vapour to reach gas-safe spaces. Acceptance for direct pipe connections will not be given.

13.1.1.3. All controls and indicators associated with a given cargo tank shall be concentrated in one control position, if the loading and unloading of the ship are performed by means of remotely controlled valves and pumps.

13.1.1.4. Permanently installed instrumentation shall be provided to detect when the primary barrier fails to be liquid-tight at any location or when liquid cargo is in contact with the secondary barrier at any location, where a secondary barrier is required. This instrumentation shall be appropriate gas detecting devices in accordance with 13.2.3. However, the instrumentation need not be capable of locating the area where liquid cargo leaks through the primary barrier or where liquid cargo is in contact with the secondary barrier.

13.1.1.5. Instruments shall be tested to make sure reliability in the working conditions and recalibrated at regular intervals. Testing procedures for instruments and the intervals between recalibration is to be approved by the Society.

13.1.1.6. Where components in remote control systems are required to be designed with redundancy, or to be independent of each other, e.g. gas compressors and cargo pumps, redundancy or independence has also to be provided for in the control system.

13.2. Indicating and Alarm Systems

13.2.1. Cargo tank level gauging

13.2.1.1. By *gauging device* is meant an arrangement for defining the amount of cargo in tanks. Consideration of the hazard and physical properties of each cargo will give the base for selecting one of the types defined in 13.2.1.1 to13.2.1.8:

13.2.1.2. Indirect devices, which determine the amount of cargo by means such as weighing or pipe flow meters.

13.2.1.3. Closed devices, which do not penetrate the cargo tank, such as devices utilizing radio isotopes or ultrasonic devices.

13.2.1.4. 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. A closed gauging device shall be provided with a shut-off valve located as close as possible to the tank, if it is not mounted directly on the tank.

13.2.1.5. Restricted devices, which penetrate the tank, and when in use allow a small quantity of cargo vapour or liquid to escape to the atmosphere, such as fixed tube and slip tube gauges. The devices shall be kept completely closed when not in use. The design and installation shall ensure that no dangerous escape of cargo can take place when opening the device. Such gauging devices is to be so designed that the maximum opening does not exceed 1.5 mm or equivalent area, unless the device is provided with an excess flow valve.

13.2.1.6. Types of gauging for individual cargoes shall be according to the requirement in column (c) in the List of Cargoes.

13.2.1.7. Each cargo tank shall be fitted with at least one liquid level gauging device, designed to operate within the allowable tank pressure and temperature range. Where only one liquid level gauge is fitted, arrangement of it shall be done so that any necessary maintenance can be carried out while the cargo tank is in service.

13.2.1.8. Tubular gauge glasses shall not be fitted. Gauge glasses of the robust type as fitted on high pressure boilers and fitted with excess flow valves, may be allowed for deck tanks.

13.2.1.9. Sighting ports with a suitable protective cover and positioned above the liquid level with an internal scale, may be accepted as a secondary means of gauging for cargo tanks which are designed for a pressure not higher than 0.7 bar.

13.2.2. Overflow control

13.2.2.1. Cargo tanks are to be equipped with high-level alarm, which is released when the tank is filled up to about 95% of the tank volume. The alarm shall be activated by a level sensing device independent of the level gauging device required in 13.2.1.7.

13.2.2.2. Provision of a level sensing device shall be done which automatically actuates the shut-off of the flow of cargo to the tank in a manner which will both avoid excessive liquid pressure in the loading line and prevent the tank from becoming liquid full. This level sensing device is to be independent of the one which activates the high level alarm required by 13.2.2.1.

The emergency shutdown valve referred to in Ch 3, Sec.6, [6.3.3.5], [6.3.3.6] C306 or [6.3.3.8] may be utilize, d for this purpose. The same information as referred to in Ch 3 Sec.6, [6.3.3.9] shall be available on board, if another valve is used for this purpose.

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 State Authority may agree to alternative arrangements such as limiting the loading rate, etc.

13.2.2.3. A high liquid level alarm and automatic shut-off of cargo tank filling need not be installed when the cargo tank is either:

- A pressure tank with a volume of not more than 200 m^3, or
- Designed to withstand the maximum possible pressure during the loading operation, and such pressure is below that of the set pressure of the cargo tank relief valve

13.2.2.4. Stop of the pumps shall be alarmed at the centralized cargo control position, when pumps situated in different tanks discharge into a common header.

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

13.2.3. Vapour contents indication and alarm

13.2.3.1. Gas detection equipment suitable for the gases to be carried, shall be provided in accordance with column (d) of the *List of Cargoes*.

13.2.3.2. A permanently installed system of gas detection equipped with audible and visual alarms shall be provided for:

- Cargo pump rooms
- Cargo compressor rooms
- Motor rooms for cargo handling machinery
- Cargo control rooms unless designated as gas-safe
- Other enclosed spaces in the cargo area where cargo vapour may accumulate including hold spaces and interbarrier spaces
- Ventilation hoods and gas ducts where required by Sec.16
- Air locks
- Degassing tank for cargo heating medium if fitted. See Ch 3 Sec.7,[7.2.1.4]

13.2.3.3. The use of portable equipment may be accepted, in the case of products which are toxic or toxic and flammable, except when column (f) in the List of Cargoes refers to Ch 3, Sec.15, [15.1.10], for toxic detection as an alternative to a permanently installed system. In such cases, a permanently installed piping system for obtaining gas samples from the spaces is to be fitted.

13.2.3.4. Activation of the alarms shall be done for flammable products before the vapour concentration reaches 30% of the lower flammable limit, for the spaces listed in 13.2.3.2. Gas detection instruments for flammable products capable of measuring gas concentrations below the lower flammable limit may be accepted except for spaces as specified in 13.2.3.5.

13.2.3.5. In the case of flammable products, where cargo containment systems other than independent tanks are utilized, hold spaces and/or interbarrier spaces shall be provided with a permanently installed system of gas detection capable of measuring gas concentrations of 0 to 100% by volume. Activation of alarms shall be done before the vapour concentration reaches the equivalent of 30% of the lower flammable limit in air, or such other limits as may be approved in the light of particular cargo containment arrangements.

13.2.3.6. Audible and visual alarms from the gas detection equipment, if required by this section shall be situated on the bridge, in the cargo control position required by 13.1.1.2and at the gas detector readout location.

13.2.3.7. The gas detection equipment shall be capable of sampling and analyzing from each sampling head location sequentially at intervals not exceeding 30 minutes, except that in the case of gas detection for the hoods and gas ducts where required by Sec.16, sampling shall be continuous. Provision of separate sampling lines to the detection equipment shall be done.

13.2.3.8. The suction capacity for every suction period and every suction point shall be adequate to secure effectively that the gas is analyzed in the same period as it is drawn into the system.

13.2.3.9. Gas detection equipment is to be so designed that it may readily be tested and calibrated. Testing and calibration shall be carried out at regular intervals. Suitable span gas for the products carried is to be available onboard. Permanent connections for such equipment should be fitted where practicable.

13.2.3.10. In every installation the positions of fixed sampling points shall 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.

13.2.3.11. Pipe runs from sampling heads shall not be led through gas-safe spaces except as permitted by 13.2.3.12.

13.2.3.12. Gas detection equipment may be located in the cargo control position required by 13.1.1.2 on the bridge or at other suitable location. When located in a gas-safe space, the following conditions shall be met:

1) Sampling lines shall not run through gas safe spaces, except where permitted under sub item 5 below.

2) The gas sampling pipes shall be equipped with flame arresters of an approved type. The flame arresters shall be located in safe area, either inside or outside the gas detection unit. Sample gas shall be led to the atmosphere with outlets arranged in a safe location.

3) Bulkhead penetrations of sample pipes between safe and dangerous areas shall be of approved type and have the same fire integrity as the division penetrated. A manual isolating valve shall be fitted in each of the sampling lines at the bulkhead on the gas safe side.

4) The gas detection equipment including sample piping, sample pumps, solenoids, gas detection sensors etc. shall be located in a reasonably gas tight enclosure (e.g. a fully enclosed steel cabinet with a gasketed door) which shall be monitored by its own sampling point. At gas concentrations above 30% of lower flammable limit inside the enclosure an alarm shall be issued, and the electrical equipment not being of certified safe type shall be automatically de-energized.

5) Where the enclosure cannot be arranged directly on the bulkhead facing the gas dangerous space or zone, sample pipes in safe areas outside the cabinet shall be of steel or other equivalent material and without detachable connections, except for the connection points for isolating valves at the bulkhead and gas detection units, and be routed in the shortest way possible.

13.2.3.13. Two sets of portable gas detection equipment suitable for the products carried shall be provided.

13.2.3.14. A suitable instrument for the measurement of oxygen levels in inert atmospheres shall be provided.

13.2.4. Temperature indication and alarm

13.2.4.1. Each cargo tank is to 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 is to be marked to show the lowest temperature for which approval of the cargo tank has been given.

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

13.2.4.3. If cargo shall be carried at temperatures lower than -55°C, the cargo tank boundaries, if appropriate for the design of the cargo containment system, shall be fitted with temperature indicating devices as follows:

- a sufficient number of sensors to establish that an unsatisfactory temperature gradient does not occur

- on one tank a number of devices in excess of those required above in order to verify that the initial cool down procedure is satisfactory. The devices may be either temporary or permanent. When a series of similar ships is built, the second and successive ships need not comply with these requirements.

13.2.5. Pressure indication and alarm

13.2.5.1. Each tank is to be provided with at least one local indicating instrument for pressure on each tank and remote pressure indication in the cargo control position required by 13.1.1.2. The manometers and indicators is to be clearly marked with the highest and lowest pressure allowed in the tank.

Provision of a low pressure alarm shall be done on the bridge in addition a high pressure alarm if vacuum protection is required.

Activation of the alarms shall be done before the set pressures are reached. For cargo tanks fitted with pressure relief valves, which can be set at more than one set pressure according to Ch 3, Sec.9,[3.9.2.5], high-pressure alarms shall be provided for each set pressure.

13.2.5.2. Manometers shall be fitted to cargo pump discharge lines and to the main loading and discharge vapour and liquid lines.

13.2.5.3. Local reading manifold pressure gauges shall be provided to indicate the pressure between stop valves and connections to the shore.

13.2.5.4. Hold spaces and interbarrier spaces without open connection to the atmosphere shall be provided with pressure gauges.

13.2.6. Hold leakage alarm

Provision of a device shall be done in each hold space surrounding independent cargo tanks for giving alarm in case of leakage of water, oil or cargo into the holds.

SECTION 14 TESTS AFTER INSTALLATION

Contents

14.1. General Requirements

14.1.1. General

14.1.1.1. All systems covered by this chapter are to be tested in operation. These tests shall be performed at the building yard, as far as practicable.

14.1.1.2. Function tests and capacity tests, which cannot be carried out without a full load of cargo on board, may be carried out in connection with the first cargo loading or transport with a representative cargo.

For LNG Carriers the performance of the cargo system should be verified during first loading and discharging, ref. IGC Code 4.10.14 and IACS Unified Interpretation GC 13 (Jan 2008) “Examination before and after the first loaded voyage”.

14.1.1.3. Ships equipped with reliquefaction or refrigeration plant, which:

- Is designed for maintaining the cargo at a pressure below the tank design pressure, or
- Is designed for keeping the cargo at a specified condition at port of discharging, or
- Is important to safeguard the quality of cargo, or
- Is important for the safety, shall be tested to demonstrate that the capacity of the plant is sufficient at design conditions.

This test may be performed during a loaded voyage while observing necessary parameters as compressor running time and working conditions, cargo temperature, air and seawater temperature, etc.

14.1.1.4. Heating arrangements, if fitted according to Ch 3, Sec.2 [14.2.6.1] shall be tested for heat output and heat distribution.

14.1.1.5. Function tests and capacity tests shall be carried out in accordance with a test programme set up by the builder and approved by the Society.

14.1.1.6. The hull shall be inspected for cold spots following the first loaded voyage, if applicable for the cargo containment system concerned.

14.1.2. Secondary barrier testing requirements

14.1.2.1. For containment systems with glued secondary barriers:

- A tightness test should be carried out in accordance with approved system designers' procedures before and after initial cool down
- If significant differences in the results before and after cool down for each tank or between tanks or if other anomalies are observed, an investigation is to be carried out and additional testing such as differential pressure, thermographic or acoustic emissions testing should be carried out as necessary
- The values recorded should be used as reference for future assessment of secondary barrier tightness.

14.1.2.2. For containment systems with welded metallic secondary barriers, a tightness test after initial cool down is not required.

SECTION 15 ADDITIONAL REQUIREMENTS FOR CERTAIN CARGOES

Contents

15.1. General Requirements

15.1.1. Application

15.1.1.1. The provisions of this section are applicable where specific reference is made in the *List of Cargoes*. The requirements may be constructional or operational or both dependent on the particular cargo. It is assumed that these operational requirements are complied with during operation of the ship.

15.1.2. Materials

15.1.2.1. Materials as listed in 15.1.2.2 to 15.1.2.7 shall not be used for cargo tanks and associated pipelines, valves, fittings and other items of equipment when reference is made in the *List of Cargoes*.
15.1.2.2. Mercury, copper and copper alloys and zinc.
15.1.2.3. Copper, silver, mercury, magnesium and other acetylide-forming metals.
15.1.2.4. Aluminium and aluminum alloys.
15.1.2.5. Copper, copper alloys, zinc or galvanized steel.
15.1.2.6. Aluminium or copper or alloys of either.
15.1.2.7. Copper and copper bearing alloys with greater than 1% copper.

15.1.3. Independent tanks

15.1.3.1. Products shall be carried in independent tanks only.
15.1.3.2. Products are to be carried in independent tanks type C. The cargo containment systems shall be capable of withstanding the full vapour pressure of the cargo under conditions of the upper ambient design temperatures irrespective of any system that has been provided for dealing with boil-off gas. The design pressure of the cargo tank shall take into account any padding pressure and/or vapour discharge unloading pressure.

15.1.4. Not used

15.1.5. Refrigeration systems

15.1.5.1. Only the indirect system described in Ch 3, Sec.7,[7.1.2.7] may be utilized.
15.1.5.2. Recondensed cargo is not allowed to form stagnant pockets of uninhibited liquid, for ships carrying products which readily form dangerous peroxides. This may be achieved either by:

- Using the indirect system described in Ch 3 Sec.7,[7.1.2.7] with the condenser inside the cargo tank, or
- Using the direct system, the combined system or the indirect system described in Ch 3 Sec.7,[7.1.2.6] to [7.1.2.8] with the condenser outside the cargo tank, and designing the condensate system to avoid any places in which liquid could collect and be retained. Where this is impossible, inhibited liquid shall be added upstream of such a place.

15.1.5.3. All uninhibited liquid shall be removed prior to the ballast voyage, if the ship shall carry consecutive cargoes of such products as mentioned in 15.1.5.2, with a ballast passage between. If a second cargo shall be carried between such consecutive cargoes, the reliquefaction system shall be thoroughly drained and purged before loading the second cargo. Purging shall be carried out using either inert gas or vapour from the second cargo, if compatible. Practical steps shall be taken to ensure that polymers or peroxides do not accumulate in the system of the ship.

15.1.6. Deck cargo piping

100% radiography of all butt welded joints in cargo piping exceeding 75.0 mm in diameter is required.

15.1.7. Bow or stern loading and discharge lines

15.1.7.1. Bow or stern loading and discharging lines shall not be led past accommodation, service or control station spaces.
15.1.7.2. Unless specifically approved by the Society, bow or stern loading and discharging lines shall not be used for the transfer of toxic cargoes.

15.1.8. Exclusion of air from vapour spaces

Removal of the air shall be done from the cargo tanks and associated piping before loading and then subsequently excluded by:

1) Introducing inert gas to maintain a positive pressure. Storage or production capacity of the inert gas shall be adequate to meet normal operating requirements and relief valve leakage. The oxygen content of the inert gas is at no time to be greater than 0.2% by volume, or
2) Control of cargo temperature such that a positive pressure is maintained at all times.

15.1.9. Moisture control

Moisture control is required to ensure that cargo tanks are dry before loading and that during discharge, dry air or cargo vapour shall be introduced to prevent negative pressures, for gases which are non-flammable and may become corrosive or react dangerously with water. For the purposes of these requirements dry air is air which has a dew point of -45°C or below at atmospheric pressure.

15.1.10. Permanently installed toxic gas detectors

15.1.10.1. Gas sampling lines is not to be led into or through gas-safe spaces. Activation of alarms referred to in Ch 3 Sec.13, [13.2.3.2] shall be done when the vapour concentration reaches the threshold limiting value.
15.1.10.2. The alternative of utilizing portable equipment according to Ch 3, Sec.13, [13.2.2.3] is not allowed.

15.1.11. Flame screens on vent outlets

Provision of Cargo tank vent outlets shall be given with readily renewable and effective flame screens or safety heads of an approved type when carrying a cargo referenced to in this section. Due attention shall be paid in the design of flame screens and vent heads to the possibility of the blockage of these devices by the freezing of cargo vapour or by icing up in adverse weather conditions. Ordinary protection screens shall be fitted after removal of the flame screens.

15.1.12. Maximum allowable quantity of cargo per tank

The quantity of the cargo shall not exceed 3 000 m^3 in any one tank, when carrying a cargo referenced to in this section.

15.2. Additional Requirements for Some Liquefied Gases

15.2.1. Ethylene oxide

15.2.1.1. For the carriage of ethylene oxide the requirements of 15.2.8 apply, with the additions and modifications as given in this section.
15.2.1.2. Deck tanks shall not be utilized for the carriage of ethylene oxide.
15.2.1.3. Stainless steels types 15.2.4.6 as well as cast iron shall not be utilized in ethylene oxide cargo containment and piping systems.
15.2.1.4. Tanks shall be thoroughly and effectively cleaned to remove all traces of previous cargoes from tanks and associated pipework, except where the immediate prior cargo has been ethylene oxide, propylene oxide or mixtures of these products, before loading. Particular care shall be taken in the case of ammonia in tanks made of steel other than stainless steel.
15.2.1.5. Ethylene oxide is to be discharged only by deep well pumps or inert gas displacement. The arrangement of pumps shall comply with 15.2.8.13.
15.2.1.6. Ethylene oxide is to be carried refrigerated only and maintained at temperatures of less than 30°C.
15.2.1.7. Pressure relief valves shall be set at a pressure of not less than 5.5 bar gauge. The maximum set pressure approval is to be specially given by the Society.
15.2.1.8. The protective padding of nitrogen gas as required by 15.2.8.23 shall be such that the nitrogen concentration in the vapour space of the cargo tank will at no time be less than 45% by volume.
15.2.1.9. The cargo tank shall be inerted with nitrogen, before loading and at all times when the cargo tank contains ethylene oxide liquid or vapour.
15.2.1.10. The water spray system required by 15.2.8.25 and that required by Ch 3, Sec.11 [11.2.3] shall operate automatically in a fire involving the cargo containment system.
15.2.1.11. Provision of a jettisoning arrangement shall be done to allow the emergency discharge of ethylene oxide in the event of uncontrollable self-reaction.

15.2.2. Methylacetylene-propadiene mixtures

15.2.2.1. Methyl acetylene-propadiene mixtures are to be suitably stabilized for transport.
15.2.2.2. A ship carrying methyl acetylene-propadiene mixtures is preferably to consist of an indirect refrigeration system as specified in Ch 3, Sec.7, [7.1.2.7]. 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 compositions given in the IGC Code, the features in 7.1.2.3 to 7.1.2.7 shall be provided.
15.2.2.3. A vapour compressor that does not raise the temperature and pressure of the vapour above 60° and 17.5 bar gauge during its operation, and that does not allow vapour to stagnate in the compressor while it continues to run.
15.2.2.4. Discharge piping from each compressor stage or each cylinder in the same stage of a reciprocating compressor shall consist of:

1) Two temperature actuated shutdown switches set at 60°C or less.
2) A pressure actuated shutdown switch set to operate at 17.5 bar or less.
3) A safety relief valve set ro relieve at 18.0 bar gauge or less.

15.2.2.5. The relief valve required by 15.2.2.4.3 shall vent to a mast meeting Ch 3, Sec.9, [3.9.2.7 and 3.9.2.8, 3.9.2.9, 3.2.9.12 and 3.2.9.13 and is not to relieve into the compressor suction line.

15.2.2.6. An alarm that sounds in the cargo control station and in the wheelhouse when a high pressure switch or a high temperature switch operates.

15.2.2.7. The piping system, including the cargo refrigeration system, for tanks those are to be loaded with methyl acetylene-propadiene mixtures shall be either independent (as defined in Ch 3,Sec.1,[1.2.1.22] or separate (as defined in Ch 3,Sec.1,[1.2.1.22] from piping and refrigeration systems for other tanks. This segregation applies to all liquid and vapour vent lines and any other possible connections, such as common inert gas supply lines.

15.2.3. Nitrogen

Materials of construction and auxiliary equipment, such as insulation, shall be resistant to the effects of high oxygen concentrations caused by condensation and enrichment at the low temperatures attained in parts of the cargo system. Due consideration shall be given to ventilation in such areas where condensation might occur to avoid the stratification of oxygen enriched atmosphere.

15.2.4. Ammonia

15.2.4.1. Anhydrous ammonia may cause stress corrosion cracking in containment and process systems made of carbon-manganese steel or nickel steel. Measures detailed in 15.2.4.2 to 15.2.4.8 shall be taken, as appropriate, to minimize the risk of this occurring.

15.2.4.2. Cargo tanks, process pressure vessels and cargo piping shall be made of fine-grained steel with a specified minimum yield strength not exceeding 355 N/mm^2 and with actual yield strength not exceeding 440 N/mm^2, where carbon-manganese steel is utilized. One of the following constructional or operational measures shall also be taken:

1) Lower strength material with a specified minimum tensile strength not exceeding 410 N/mm^2 shall be used.
2) Cargo tanks, etc., shall be post-weld stress relief heat treated.
3) Carriage temperature shall be maintained preferably at a temperature close to the product's boiling point of -33°C but in no case at a temperature above -20°C.
4) The ammonia shall contain not less than 0.1% w/w water.

15.2.4.3. If carbon-manganese steels with higher yield properties are utilized other than those specified in 15.2.4.2 the completed cargo tanks, piping, etc., shall be given a post-weld stress relief heat treatment.

15.2.4.4. Process pressure vessels and piping of the condensate part of the refrigeration system shall be given a post-weld stress relief heat treatment when made of materials mentioned in 15.2.4.1.

15.2.4.5. The tensile and yield properties of the welding consumables shall exceed those of the tank or piping material by the smallest practical amount.

15.2.4.6. Nickel steel containing more than 5% nickel and carbon-manganese steel not complying with the requirements of 15.2.4.1 and 15.2.4.3 are particularly susceptible to ammonia stress corrosion cracking and shall not be utilized in containment and piping systems for the carriage of this product.

15.2.4.7. Nickel steel containing not more than 5% nickel may be used provided the carriage temperature complies with the requirements specified in 15.2.4.2.3.

15.2.4.8. It is advisable to keep the dissolved oxygen content below 2.5 ppm w/w, in order to minimize the risk of ammonia stress corrosion cracking. This can best be achieved by reducing the average oxygen content in the tanks prior to the introduction of liquid ammonia to less than the values given as a function of the carriage temperature T_C in Table 3.15.1.

Table 3.15.1: Calculation for reduction in ammonia stress corrosion cracking

T_C (°C)	O_2 (% v/v)
-30 and below	0.90
-20	0.50
-10	0.28
0	0.16
+10	0.10
+20	0.05
+30	0.03

Oxygen percentages for intermediate temperatures may be obtained by linear interpolation.

15.2.5. Vinyl chloride monomer

Any inert gas utilized for the purposes of 15.1.8.1 shall not contain more oxygen than 0.1%, in case no or insufficient inhibitor has been added. Samples of the inert atmosphere in cargo tanks and cargo piping shall be analyzed prior to loading. A positive pressure is always to be maintained in the tanks, when vinyl chloride monomer is carried, also during ballast voyages between successive carriages.

15.2.6. Chlorine

15.2.6.1. The capacity of each tank is not to surpass 600 m^3 and the total capacity of all cargo tanks shall not exceed 1200 m^3.

15.2.6.2. The tank design vapour pressure p_0 of the cargo tanks shall not be less than 13.5 bar (see also 15.1.3.2).

15.2.6.3. Parts of tank protruding above the upper deck shall be provided with protection against thermal radiation taking into account total engulfment by fire.

15.2.6.4. Each tank is to be provided with two safety relief valves. A bursting disc of appropriate material shall be installed between the tank and the safety relief valves. The rupture pressure of the bursting disc shall be 1 bar lower than the opening pressure of the safety relief valve, which shall be set at the design vapour pressure of the tank but not less than 13.5 bar. The space between the bursting disc and the relief valve is to be connected through an excess flow valve to a pressure gauge and a gas detection system. Provision shall be made to keep this space at or near the atmospheric pressure during normal operation.

15.2.6.5. Arrangement of outlets from safety relief valves shall be done in such a way as to minimize the hazards on board the ship as well as to the environment. To reduce the gas concentration as far as possible, leakage from the relief valves shall be led through the absorption plant.

Arrangement of the relief valve exhaust line shall be done 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.

15.2.6.6. Cargo discharge shall 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 shall not exceed 10.5 bar. Acceptance will not be given for cargo discharge compressors or on deck pumps on board ships.

15.2.6.7. The design pressure of the cargo piping system shall not be of lesser value than 21 bar. The internal diameter of the cargo pipes shall not surpass 100 mm.

Acceptance for only pipe bends will be given for compensation of pipe line thermal movement. Use of flanged joints shall be restricted to a minimum, and when used the flanges shall be of the welding neck type that consists of tongue and groove.

15.2.6.8. Relief valves of the cargo piping system shall discharge to the absorption plant.

15.2.6.9. The cargo tanks and cargo piping systems shall 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. The tanks shall be thermally stress relieved. Acceptance of mechanical stress relief will not be given as an equivalent.

15.2.6.10. The ship shall be provided with a chlorine absorbing plant with connections to the cargo piping system and the cargo tanks. The absorbing plant shall be capable of neutralizing at least 2% of the total cargo capacity at a reasonable absorption rate.

15.2.6.11. During the gas freeing of cargo tanks, vapours shall not be discharged to the atmosphere.

15.2.6.12. As gas detecting system shall be provided capable of monitoring chlorine concentrations of at least 1 ppm by volume. Suction points shall be located:

- near the bottom of the 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, machinery spaces and control stations
- on deck at the forward end, in the middle and at the aft end of the cargo area. (These points are only for use during cargo handling and gas freeing operations.)

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

15.2.6.13. Each cargo tank is to be fitted with a high pressure alarm that gives audible alarm at a pressure equal to 10.5 bar.

15.2.6.14. The enclosed space requisite by Ch 3, Sec.19,[19.3.1.5] shall be easily and quickly reachable from the open deck and the accommodation and shall be capable of being rapidly closed gas-tight. This space can be accessed from the deck and the remainder of the accommodation by means of an air lock. The space shall be so designed as to accommodate the entire crew of the ship and it shall be provided with a source of uncontaminated air for a period of not less than four hours. One of the decontamination showers required by Ch 3, Sec.19,[19.3.1.3] shall be located near the air lock to the space.

15.2.6.15. The maximum cargo tank filling limit shall be determined in accordance with Ch 3 Sec.17, [17.1.1.2] and Ch 3, Sec.17,[17.1.5.1].

15.2.6.16. The chlorine content of the gas in the vapour space of the cargo tank after loading shall be greater than 80% by volume.

National regulations may require that chlorine is carried in the refrigerated state at a specified maximum pressure.

15.2.7. Diethyl Ether and Vinyl Ethyl Ether

15.2.7.1. The cargo is to be discharged only by deep well pumps or by hydraulically operated submerged pumps.

These pumps shall be of a type designed to avoid liquid pressure against the shaft gland.

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

15.2.8. Propylene oxide and mixtures of ethylene oxide-propylene oxide with ethylene oxide content of not more than 30% by weight

15.2.8.1. Products transported under the provision of this section shall be acetylene free.

15.2.8.2. Unless cargo tanks are properly cleaned, these products shall not be carried in tanks which have contained as one of the three previous cargoes any product known to catalyze polymerization, such as:

- Ammonia, anhydrous and ammonia solutions
- Amines and amine solutions
- Oxidizing substances (e.g. Chlorine)

15.2.8.3. Tanks shall be thoroughly and effectively cleaned to remove all traces of previous cargoes from tanks and associated pipework, before carrying these products, except where the immediate prior cargo has been propylene oxide or ethylene oxide propylene oxide mixtures. Particular care is to be taken in the case of ammonia in tanks made of steel other than stainless steel.

15.2.8.4. In all cases the effectiveness of cleaning procedures for tanks and associated pipework shall be inspected by suitable testing or inspection to ascertain that no trace of acidic or alkaline materials remain that might create a hazardous situation in the presence of these products.

15.2.8.5. Tanks shall be entered and examined prior to each initial loading of these products to ensure freedom from contamination, including heavy rust deposits and any visible structural defects. Inspections shall be performed at intervals of not more than two years, when cargo tanks are in continuous service for these products.

15.2.8.6. Tanks for the carriage of these products shall be of steel or stainless steel construction.

15.2.8.7. Tanks which have contained these products may be utilized for other cargoes after thorough cleaning of tanks and associated pipework systems by washing or purging.

15.2.8.8. All valves, flanges, fittings and accessory equipment shall be of a type suitable for use with these products and construction shall be of steel or stainless steel or other material acceptable to the Society. The chemical composition of all material used shall be submitted to the Society for approval prior to fabrication.

Discs or disc faces, seats and other wearing parts of valves shall be made of stainless steel containing not less than 11% chromium.

15.2.8.9. Construction of gaskets shall be done of material 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 is to be polytetrafluoroethylene (PTFE) or a material that gives 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 Society.

15.2.8.10. If utilized, insulation and packing shall be of a material which does not react with, or dissolve in, or lower the auto-ignition temperature of these products.

15.2.8.11. 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 Society:

- Neoprene of natural rubber if it comes in contact with the products
- Materials containing oxides of magnesium such as mineral wools.

The use of asbestos is prohibited. (SOLAS II-1 3-5.2).

15.2.8.12. Filling and discharge piping shall extend to within 100 mm of the bottom of the tank or any sump pit.

15.2.8.13. Loading and discharging

1) The products shall be loaded and discharged in such a manner that venting of the tanks to atmosphere does not occur. If vapour return to shore is used during tank loading, the vapour return system connected to a containment system for the product shall be independent of all other containment systems.
2) During discharging operations, the pressure in the cargo tank shall be maintained above 0.07 bar.
3) The cargo shall be discharged only by deep well pumps, hydraulically operated submerged pumps, or inert gas displacement. Each cargo pump shall be arranged to ensure that the product does not heat significantly if the discharge line from the pump is shut off or otherwise blocked.

15.2.8.14. Tanks carrying these products are to be vented independently of tanks carrying other products. Facilities are to be provided for sampling the tank contents without opening the tank to atmosphere.

15.2.8.15. Cargo hoses used for transfer of these products shall be marked

"FOR ALKYLENE OXIDE TRANSFER ONLY."

15.2.8.16. Monitoring of hold spaces shall be done for these products. Hold spaces surrounding type A and B independent tanks are also to be inerted and monitored for oxygen. The oxygen content of these spaces shall be maintained below 2%. Portable sampling equipment is satisfactory.

15.2.8.17. Prior to disconnecting shore-lines, the pressure in liquid and vapour lines is to be relieved through suitable valves installed at the loading header. Liquid and vapour from these lines shall not be discharged to atmosphere.

15.2.8.18. Tanks shall be designed for the maximum pressure expected to be encountered during loading, conveying and discharging cargo.

15.2.8.19. Tanks for the carriage of propylene oxide with a design vapour pressure of less than 0.6 bar and tanks for the carriage of ethylene oxide-propylene oxide mixtures with a design vapour pressure of less than 1.2 bar shall consist of a cooling system to maintain the cargo below the reference temperature. For reference temperature see Ch 3, Sec.17. [17.1.1.5].

15.2.8.20. Pressure relief valve settings shall not be less than 0.2 bar and for type C independent cargo tanks not greater than 7.0 bar for the carriage of propylene oxide and not greater than 5.3 bar for the carriage of ethylene oxide-propylene oxide mixtures.

15.2.8.21. Piping segregation

1) The piping system for tanks to be loaded with these products shall be completely separate from piping systems for all other tanks, including empty tanks, and from all cargo compressors. If the piping system for the tanks to be loaded with these products is not independent as defined in Ch 3,Sec.1 ,[1.2.1.22], the required piping separation shall be accomplished by the removal of spool pieces, valves, or other pipe sections, and the installation of blank flanges at these locations. The required separation applies to all liquid and vapour piping, liquid and vapour vent lines and any other possible connections such as common inert gas supply lines.
2) The products shall be transported only in accordance with cargo handling plans that have been approved by the Society. Each intended loading arrangement shall be shown on a separate cargo handling plan. Cargo handling plans shall show the entire cargo piping system and the locations for installation of blank flanges needed to meet the above piping separation requirements. A copy of each approved cargo handling plan shall be kept onboard the ship. The International Certificate of Fitness for the Carriage of Liquefied Gases in Bulk shall be endorsed to include reference to the approved cargo handling plans.
3) Before loading the product, certification verifying that the required piping separation has been achieved shall be obtained from a responsible person acceptable to the port Administration and carried on board the ship. Each connection between a blank flange and pipeline flange shall be fitted with a wire and seal by the responsible person to ensure that inadvertent removal of the blank flange is impossible.

15.2.8.22. The maximum allowable tank limits for loading of each cargo tank shall be indicated for each loading temperature which may be applied and for the applicable maximum reference temperature, on a list to be approved by the Society. A copy of the list shall be permanently kept on board by the master.

15.2.8.23. The cargo shall be carried under a protective padding of nitrogen gas that is suitable. An automatic nitrogen make-up system shall be installed to prevent the tank pressure falling below 0.07 bar in the event of product temperature fall due to ambient conditions or malfunctioning of refrigeration system. Adequate nitrogen is to be available on board to satisfy the demand of the automatic pressure control. Nitrogen of commercially pure quality (99.9% v/v) shall be used for padding. A battery of nitrogen bottles connected to the cargo tanks through a pressure reduction valve satisfies the intention of the expression automatic in this context.

15.2.8.24. The cargo tank vapour space shall be tested prior to and after loading to ensure that the oxygen content is 2% (v/v) or less.

15.2.8.25. A water spray system of adequate capacity shall be provided to blanket effectively the area surrounding the loading manifold, the exposed deck piping associated with product handling and the tank domes. The arrangement of piping and nozzles shall be such as to give a uniform distribution rate of 10 l/m^2 per minute. The water spray system shall be capable of both local and remote manual operation and the arrangement shall make sure that any spilled cargo is washed away. Arrangement of remote manual operation shall be done such that remote starting of pumps supplying water spray system and remote operation of any normally closed valves in the system can be carried out from a suitable location outside the cargo area, adjacent to the accommodation spaces and readily accessible and operable in the event of fire in the areas protected. Additionally, a water hose with pressure to the nozzle, when atmospheric temperatures permit, shall be connected ready for immediate use during loading and unloading operations.

15.2.9. Isopropylamine and monoethylamine

Separate piping systems shall be provided as defined in Ch 3, Sec.1,[1.2.1.33].

15.2.10. Carbon dioxide

15.2.10.1. Following Rule requirements in this chapter do not apply:

- Requirements to ship arrangements, Sec.3,[3.2 & 3.3] Sec.6,[6.5.1.7]
- Requirements to electrical bonding Sec.6,[6.3.1.6]
- Requirements to mechanical ventilation in cargo area: Sec.10
- Requirements to fire protection and fire extinction as given in Sec.11
- Requirements to area classification and electrical installations as given in Sec.12
- Requirements to protection screens as given in Sec.9,[9.2.1.12]
- Requirements to fusible elements as given in Sec.6, [6.3.4.2], Sec.9, [9.2.5.12].

15.2.10.2. Hold spaces shall be separated from machinery, boiler spaces and accommodation spaces by at least A-0 class.

15.2.10.3. Oxygen deficiency monitoring shall be fitted for cargo compressor rooms and cargo hold spaces. Audible and visual alarm shall be located on the navigation bridge, in the cargo control room, the engine control room and the cargo compressor room.

15.2.10.4. Cargo compressor rooms are to be mechanically ventilated by 30 air changes per hour.

15.2.10.5. Entrances to hold spaces containing cargo tanks and compressor rooms shall be preferably from open deck. Acceptance shall not be given for direct access from accommodation spaces, service spaces and control stations. In case the entrance is from any enclosed space other than the spaces specified above shall consist of audible and visual alarm for oxygen deficiency of the hold spaces and the compressor rooms. The access door shall be open outwards.

15.2.10.6. Acceptance for restricted level gauging based on “bleeding” principles may be given.

15.2.10.7. Monitoring of cargo tank pressure for low pressure shall be provided. Audible and visual alarm shall be provided at the cargo control position and at the navigation bridge. A further decrease in tank pressure shall cause manifold valves, liquid valves and vapour valves, to close automatically and cargo pumps and cargo compressors shall be automatically stopped. The set pressure for low pressure alarms and automatic actions shall be well above the saturation point.

15.2.10.8. The materials utilized in cargo tanks and cargo piping shall be suitable for the lowest design temperature that may take place in the cargo system.

15.2.10.9. The materials of construction used in the cargo system shall take account of the possibility of corrosion, in case of reclaimed quality carbon dioxide cargo contain impurities such as water, sulphur dioxide etc... which can cause acidic corrosion.

15.2.10.10. Provision of four safety relief valves shall be done to each cargo tank. Means of easy isolation of each safety relief valve shall be fitted. Two valves shall always be in operation.

15.2.10.11. Discharge piping from safety relief valves shall be designed to prevent blockage. In particular shall protective screens not be fitted to the outlets.

SECTION 16 GAS OPERATED PROPULSION MACHINERY

Contents

16.1. General

16.1.1. Application

16.1.1.1. Methane (LNG) is the only cargo whose vapour or boil-off gas may be used in machinery spaces of category A but where it may be utilized only in inert gas generators, boilers, combustion engines and gas turbines.

16.1.1.2. These provisions do not prohibit the use of gas fuel for auxiliary services in other locations. However, such services and locations are subject to Society's special consideration.

16.1.1.3. Machinery made for gas operation shall satisfy the requirements given in Part 6 in addition to the requirements of this section. These regulations are especially applicable to boiler and diesel engine plants, but may also apply to gas turbines to the extent they are applicable.

16.1.1.4. Alarm and safety systems shall conform to the requirements given in Part 6.

16.1.2. Documentation

16.1.2.1. For approval, following plants and particulars shall be submitted:

- Description of installation
- Ventilation arrangement
- Arrangement of piping for gas and fuel oil
- Arrangement of gastight boiler casing with funnel
- Arrangement of engine room installation
- Details showing burner equipment for gas or fuel oil for burners and combustion equipment for engines
- Arrangement and details of installation for preparation of gas before combustion.

Further drawings may be required to evaluate safety of the gas firing system, if necessary.

16.1.2.2. For requirements for documentation of instrumentation and automation, including computer based control and monitoring, see Sec.1.

16.2. Gas Supply to Boilers. Arrangement of Engine and Boiler Rooms. Electrical Equipment

16.2.1. Gas make-up plant and related equipment

16.2.1.1. The installation for the suction of gas from cargo tanks shall be such that it effectively prevents building up of vacuum that may arise due to suction of gases.

16.2.1.2. The temperature of the gas in the supply lines shall not be lower than the ambient temperature.

16.2.1.3. All equipment (heaters, compressors, filters, etc.) for making-up the gas for its utilization as fuel, and the related storage tanks shall be located in the cargo area. If the equipment is in an enclosed space the space shall be ventilated as per Sec.10 and be equipped with a fixed fire extinguishing system as per Sec.11,[11.2.3] and with a gas detection system as per Sec.13,[13.2.3], or as applicable.

16.2.1.4. The compressors shall be capable of being remotely stopped from an easily accessible location even from the engine room. In addition, compressors shall be capable of automatically stopping when the suction pressure reaches a certain value depending on the set pressure of the vacuum relief valves of the cargo tanks. There must be a manual resetting for the automatic shutdown device of the compressors. Volumetric compressors shall be fitted with pressure relief valves discharging into suction line of the compressor. The size of pressure relief valves shall be determined in such a way that, with the delivery valve kept closed, maximum pressure does not exceed more than 10% the maximum working pressure. The requirements of Sec.6, [6.3.4.3] are applicable to these compressors.

16.2.1.5. If heating medium for the gas fuel evaporator or heater is returned to spaces outside the cargo area, it shall first go through a degassing tank that shall be located in the cargo area. Provisions to detect and alarm the presence of gas in the tank shall be made. The vent outlet shall be in a safe position and also fitted with a flame screen.

16.2.1.6. At all actual loads, the gas pressure in the supply line to the burner shall be kept within the specified range.

16.2.1.7. Pressure vessels in the gas fuel conditioning system shall conform to requirements for cargo tanks type C in Sec.5. Piping shall conform to Sec.6.

16.2.2. Gas supply lines

16.2.2.1. Gas fuel piping shall not pass through accommodation spaces, service spaces or control stations. Gas fuel piping may pass through or extend into other spaces provided they fulfill one of the following:

1) The gas piping shall be a double wall piping system with the gas fuel contained in the inner pipe. The space between the concentric pipes shall be pressurized with inert gas at a pressure greater than the gas fuel pressure. Suitable alarms shall be provided to indicate a loss of inert gas pressure between the pipes.
2) The gas fuel piping shall be installed within a ventilated pipe or duct. The air space between the gas fuel piping and the inner wall of this pipe or duct shall be equipped with mechanical exhaust ventilation having a capacity of at least 30 air changes per hour. The ventilation system shall be arranged to maintain a pressure less than the atmospheric pressure. The fan motors shall be placed outside the ventilated pipe or duct. The ventilation outlet shall be covered by a *protection screen* and placed in a position where no flammable gas-air mixture may be ignited. The ventilation is always to be in operation when there is gas fuel in the piping. Continuous gas detection shall be provided to indicate leaks and to alarm and subsequently shut down the gas fuel supply to the machinery space in accordance with 16.2.2.5 and 16.2.2.6. The master gas fuel valve required by 16.2.2.6 is to close automatically, if the required air flow is not established and maintained by the exhaust ventilation system.

16.2.2.2. The double wall piping system or the ventilated pipe or duct provided for the gas fuel lines shall terminate at a ventilation hood or casing arranged to cover the areas occupied by flanges, valves, etc., and the gas fuel piping at the gas fuel utilization units, such as boilers, diesel engines or gas turbines. If this ventilation hood or casing is not served by the exhaust ventilation fan serving the ventilated pipe or duct as specified in 16.2.2.1, then it shall be equipped with an exhaust ventilation system and continuous gas detection shall be provided to indicate leaks and to alarm and subsequently shut down the gas fuel supply to the machinery space in accordance with 16.2.2.5 and 16.2.2.6. The master gas fuel valve required by 16.2.2.6 shall close automatically if the required air flow is not established and maintained by the exhaust ventilation system.

The ventilation hood or casing shall be installed or mounted to permit the ventilating air to sweep across the gas utilization unit and be exhausted at the top of the ventilation hood or casing.

16.2.2.3. The ventilation air inlet and discharge for the required ventilation systems shall be respectively from and to a safe location.

16.2.2.4. Gas detection systems provided in accordance with the requirements of 16.2.2.1 and 16.2.2.2 shall comply with applicable parts of Sec.13, 13.2.3].

16.2.2.5. Alarm shall be given at:

- Abnormal pressure in the gas fuel supply line
- Gas concentration of maximum 30% of lower explosion limit in the vented duct (16.2.2.1), ventilation hood (16.2.2.2) or in the engine room
- Failure of the valve control actuating medium

16.2.2.6. The main supply lines for gas shall be equipped with a manually operated stop valve and an automatically operated master gas fuel valve coupled in series or a combined manually and automatically operated stop valve.

The valves shall be positioned in the part of the piping which is outside engine room or boiler room, and placed as near as possible to the installation for heating the gas. The valve is automatically to cut off the gas supply when:

- There is abnormal pressure in the supply line for gas, see 106
- The fire alarm onboard is sounded (with time delay)
- The engine room ventilation capacity on either supply or exhaust is reduced by more than 50% (with time delay)
- Gas concentration of maximum 60% of the lower explosion limit in the vented duct 16.2.2.1 or ventilation hood 16.2.2.2 is detected.

The automatic master gas fuel valve shall be manually operable from a reasonable number of places in the engine room and from a room outside the engine casing.

16.2.2.7. Each gas utilization unit shall be provided with a set of three automatic valves. Two of these valves shall be in series in the gas fuel pipe to the consuming equipment. The third valve is to be in a pipe that vents to a safe location in the open air, that portion of the gas fuel piping that is between the two valves in series. Arrangement of these valves shall be done so that the following conditions will cause the two gas fuel valves which are in series to close automatically and the vent valve to open automatically:

- The conditions specified in 16.2.2.6
- Failure of the necessary forced draught
- Loss of flame on boiler burners
- Failure of the valve control actuating medium

Alternatively, the function of one of the valves in series and the vent valve can be incorporated into one valve body so arranged that, when one of the above conditions occurs, flow to the gas utilization unit will be blocked and the vent opened. The three shut-off valves shall be arranged for manual reset.

16.2.2.8. In the branch lines for the gas supply to each burner, there shall be a screw-down non-return valve.

16.2.2.9. It shall be clearly indicated on all shut-off valves whether the valves are open or closed.

16.2.2.10. It shall be possible for the complete pipe system for gas supply, including ventilation ducts, hood and casing, to be gas-freed and air-freed effectively by means of inert gas.

Provision of warning and notice plate shall be done, which clearly indicates that gas-freeing shall not take place through a recently extinguished combustion chamber. Measures shall be taken to prevent ingress of air through pipe connections between the gas supply pipe and the atmosphere.

16.2.2.11. The gas supply shall not be opened, if the gas supply is shut off on account of release of an automatic valve, until the reason for the disconnection is ascertained and the necessary precautions taken. A readily visible notice giving instruction to this effect is to be placed at the operating station for the shut-off valves in the gas supply lines.

16.2.2.12. The gas fuel supply shall not be operated until the leak has been found and repaired, if a gas leak occurs. Instructions to this effect are to be placed in a prominent position in the machinery space.

16.2.2.13. The gas supply lines outside the cargo area are to be designed for a pressure at least 50% higher than the normal working pressure. Both wall thickness and diameter of the piping, as well as the arrangement, shall be such that the pipes will not suffer damage from external loading to which they may be subjected. As far as practicable, the piping shall have welded joints. Those parts of the gas fuel piping, which are not enclosed in a ventilated pipe or duct in accordance with 16.2.2.1 and are on the open deck outside the cargo area shall have full penetration butt welded joints and shall be fully radiographed.

The material in the inner piping shall satisfy the requirements given in Part 6 for pipes in class I.

The gas supply lines shall be hydraulically tested according to Part 6. A tightness test is also to be carried out for the outer pipe or duct.

16.2.3. Arrangement of engine and boiler rooms, etc.

16.2.3.1. Combined boiler and engine rooms will be considered specially in each separate case with regard to ventilation and other safety precautions.

16.2.3.2. Spaces in which gas fuel is utilized shall be fitted with a mechanical ventilation system and be arranged in such a way as to prevent the formation of dead spaces. Such ventilation to be particularly effective in the vicinity of electrical equipment and machinery or of other equipment and machinery which may generate sparks.

Such a ventilation system shall be separated from those intended for other spaces. (IGC Code 16.2.1)

16.2.3.3. The engine room and boiler room are each to have at least two completely independent exits.

16.2.3.4. The engine and boiler room shall have to simple geometrical shape as possible.

16.2.3.5. There shall be gas detectors or suctions for such in all places where there is a danger that gas pockets may be formed, in engine room and boiler room where gas operation is utilized. The gas detectors in engine room and boiler room shall not be incorporated in the ship's remaining gas detector system and shall comply with Sec.13-[13.3]. There is in addition to the alarm system mentioned in Sec.13 Sec.13-[13.3], for gas detectors or suction points for these, to be arranged a readily audible alarm in the engine room and boiler room. This alarm shall give signal if any of these show a gas content of maximum 30% of the lower explosion limit.

The gas detector system shall be in continuous operation when the main shut-off valves for the gas system are open. The period shall not surpass 15 minutes with alternating readings taken from the various suction points.

16.2.4. Electrical equipment

16.2.4.1. The location of electrical equipment and the ventilation of spaces where electrical equipment is installed are generally to be such that the possibility of gas accumulation in such spaces is a minimum. This application is particularly done to equipment which produces sparks (e.g. switchboards and other switchgear such as motor starters, machines with slip rings or commutators). Alternatively, after consideration in each case, special requirements to enclosure and or separate ventilation of electrical equipment can be made.

16.2.4.2. Electrical equipment located in the double wall pipe or duct specified in 16.2.4.1 shall be of the intrinsically safe type.

16.3. Gas Fired Boiler Installations

16.3.1. Burners for gas firing

16.3.1.1. Boiler installations may have supply by boil-off fuel during low loading and maneuvering conditions, if approved means of disposing of the excess steam are provided.

16.3.1.2. The burners for gas shall be of such construction that they effectively maintain complete and stable combustion under all operating conditions.

16.3.1.3. The burner systems shall be of dual fuel type, suitable to burn either oil fuel or gas fuel alone or oil and gas fuel simultaneously. Only oil fuel shall be used during maneuvering and port operations unless automatic transfer from gas to oil burning is provided in which case the burning of a combination of oil and gas or gas alone may be allowed provided the system is demonstrated to the satisfaction of the Society.

To demonstrate acceptability of dual fuel of gas only operation during maneuvering, testing under varying loads should be carried out.

The details of the testing will depend on the design and functionality of the combustion control and burner management system.

As a guide, the following maneuvering tests may be considered:

- From full ahead and “gas only” operation reduce stepwise to stop.
- Increase stepwise to full ahead.
- From full ahead, reduce directly to a load just above the limit for auto transfer to “fuel-only” and run at this load for approximately 3 min.
- Increase again directly to full ahead.
- From full ahead and “gas only” operation reduced stepwise to stop.
- Check auto transfer to dual fuel as applicable.
- After approximately 3 minutes stop, go to slow astern and increase stepwise to half astern.
- Run for approximately 3 minutes and then to stop.
- After 3 minutes stop, go direct to half ahead.

Demonstrations of auto transfer “gas only” to “dual fuel” and from “dual fuel” to “oil only” for various fault conditions should be carried out, in addition to the above maneuvering tests.

It shall be possible to change over easily and quickly from gas fuel operation to oil fuel operation. Gas nozzles shall be fitted in such a way that gas fuel is ignited by the flame of the oil fuel burner. Installation of a flame scanner is to be done and it shall be arranged to assure that gas flow to the burner is cut off unless satisfactory ignition has been established and maintained. A manually operated shut-off valve shall be fitted on the pipe of each gas burner.

An installation shall be provided for purging the gas supply piping to the burners by means of inert gas or steam, after the extinguishing of these burners.

16.3.1.4. Alarm devices shall be fitted in order to monitor a possible decrease in liquid fuel oil pressure or a possible failure of the related pumps.

16.3.1.5. Arrangements shall be made that, in case of flame failure of all operating burners for gas or oil or for a combination thereof, the combustion chambers of the boilers are automatically purged before relighting.

Arrangements are also to be made to enable the boilers to be manually purged and these arrangements shall be to the satisfaction of the Society.

16.3.1.6. At operating stations for the boilers, a readily visible signboard with following instruction shall be posted:

CAUTION:

NO BURNER TO BE FIRED BEFORE THE FURNACE HAS BEEN PROPERLY PURGED

16.3.2. Construction of the boilers

16.3.2.1. The construction of boilers shall be such that there is no danger that gas pockets will be formed in any part of the firing and flue gas part of the boiler.

16.3.2.2. Each boiler shall have a separate flue gas line led up to funnel’s top.

16.3.2.3. There shall be indication of oxygen content in the flue gas line.

16.3.2.4. Boilers for firing with gas shall be equipped with automatic regulation of air supply so as to attain complete combustion with adequate quantity of excess air.

16.3.3. Monitoring systems

For oil fired boilers, extent of monitoring of gas fired boilers shall conform to the requirements specified in Part 6

16.4. Gas-Operated Engine Installations

16.4.1. General

See Part 6 for gas fuelled engine installations.

The class notation **GAS FUELLED** is mandatory for gas carriers with gas fuelled engine installations, other than steam driven LNG carriers.

SECTION 17 FILLING LIMITS FOR CARGO TANKS

Contents

17.1. Filling Limits for Cargo Tanks

17.1.1. General

17.1.1.1. None of the cargo tanks shall have a higher filling limit (FL) than 98% at the reference temperature, except as permitted by 17.1.1.3.

17.1.1.2. The maximum loading limit (LL) to which a cargo tank may be loaded shall be determined by the formula given below:

LL= loading limit expressed in percent which means the maximum allowable liquid volume relative to the tank volume to which the tank may be loaded
FL= filling limit as specified in 17.1.1.1 or 17.1.1.3
ρR = relative density of cargo at the reference temperature
ρL = relative density of cargo at the loading temperature and pressure.

17.1.1.3. The Society may permit a higher filling limit (FL) than the limit of 98% that has been specified in 17.1.1.1 at the reference temperature taking into account arrangements of pressure relief valves, shape of the tank, accuracy of liquid 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.

17.1.1.4. The Society may stipulate a lower filling limit than 98% at the reference temperature, if conditions in Ch 3,Sec.9, [9.2.2.3] are unfulfilled.

17.1.1.5. For purpose of this section only, *reference temperature* means:

1) The temperature corresponding to vapour pressure of cargo at the set pressure of pressure relief valves when no cargo vapour pressure or temperature control as given in Sec.7 is provided.
2) The cargo temperature during transport or at unloading or upon termination of loading, whichever is the greater, when a cargo vapour pressure and temperature control system as given in Sec.7,[7.1.1.], is provided. If this reference temperature would result in the cargo tank becoming liquid full prior to cargo reaches a temperature corresponding to the vapour pressure of the cargo at the set pressure of the relief valves required in Sec.9,[9.2.2], an additional pressure relief system conforming to Sec.9,[9.2.5] shall be fitted.

17.1.1.6. The Society may permit type C tanks to be loaded as per the following formula, provided that the tank vent system has been approved as indicated in Ch 3,Sec.9,[9.2.15]:

LL= loading limit as specified in 17.1.1.2
FL= filling limit as specified in 17.1.1.1 or 17.1.1.2
ρR = relative density of cargo at the highest temperature which the cargo may reach upon termination of loading, during transport, or at unloading, under the ambient design temperature conditions described in Ch 3,Sec.7,[7.1.1.3]
ρL = as specified in 17.1.1.2.
This paragraph does not apply to products requiring a type 1G ship.

17.1.2. Information to be provided to the master

The maximum allowable tank filling limits for each cargo tank shall be indicated for each product which may be carried, on a list that is to be approved by Society, for each loading temperature which may be applied and for the applicable maximum reference temperature. The list shall also state pressures at which the pressure relief valves, including those valves required by Ch 3,Sec.9,[9.2.5] have been set. The master shall keep a copy of this list permanently on board.

SECTION 18 INERT GAS PLANTS

Contents

18.1. General

18.1.1. Application

Application of these rules shall be done in this section to inert gas systems for cargo containment systems, inerting of cargo piping systems and void spaces in the cargo area, if fitted.

18.1.2. General

18.1.2.1. The applicable requirements as stated in Part 8.A apply in addition to those given in 18.1.2.2 to 18.1.2.5. Table 3.18.1 and 3.18.2 contains certification requirements for components in inert gas systems and nitrogen systems based on separation of air.

The requirements from Ch.3 Sec.11 given below are considered applicable: 18.1.2, 18.2.1, 18.3.1, 18.3.2.6, 18.3.2.7, 18.3.6,18.4.1.1,18.4.6.1,18.4.6.1, 18.4.6.4,18.5.1.1,18.1.2,18.2.1,18.3.1,18.3.2.16..

The requirement to deck water seal referred to in Part 8.A, however, is not applicable to gas carriers.

Two non-return valves in series or equivalent solutions will be accepted when no permanent connection is arranged to hold space or cargo tank.

Gas carriers built to carry oil with flashpoint less than 60°C shall also conform to the inert gas requirements of SOLAS as for oil tankers, or for chemical tankers,.

18.1.2.2. Redundancy of inert gas system isn’t required.

18.1.2.3. Where inert gas is made using an onboard process of fractional distillation of air which requires storage of the cryogenic, liquefied nitrogen for subsequent release, the liquefied gas entering the storage vessel shall be checked for traces of oxygen to avoid possible initial high oxygen enrichment of the gas when released for inerting purposes.

18.1.2.4. Spaces which house inert gas generating plants shall not have direct access to accommodation, service or control station spaces, but may be in machinery spaces or other spaces outside the cargo area. Two non-return valves or equivalent devices shall be fitted in the inert gas main in the cargo area. Inert gas piping shall not pass through accommodation, service or control station spaces.

The inert gas system shall be made separate from the cargo system in the cargo area, when not in use.

18.1.2.5. The flame burning equipment for generating inert gas shall not lie within the cargo area. Its location is given special considerations using the catalytic combustion process.

18.1.2.6. A continuous reading oxygen content meter shall be fitted to the inert gas supply from the equipment and shall have an alarm set at a maximum of 5% oxygen content by volume, subject to the requirements of Sec.15.

Table 3.18.1: Inert gas system

Component	Certificate	Comment
Inert gas generator	IR	
Air blower	W	
Scrubber	W	
Cooling water pump for scrubber	W	
Refrigerant type drier	W	Pressure vessel, IR
Absorption drier	W	Pressure vessel, IR
Control & monitoring system	IR or T	
Electrical motor and motor starter serving	IR/T/W	Part 6
IR = INTLREG product certificate, W = Maker's (Works) certificate, T = Type approval		

Table 3.18.2: Nitrogen System

Component	Certificate	Comment
Membrane separation vessels	IR	Pressure vessels
Air compressor ≤ 100 kW	W	
Air compressor > 100 kW	IR	
Control & monitoring system	W	
Electrical motor and motor starter serving	IR/T/W	Part 6
IR = INTLREG product certificate, W = Maker's (Works) certificate, T = Type approval		

SECTION 19 PERSONNEL PROTECTION

Contents

19.1. General

19.1.1. Protective equipment

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

19.1.2. Safety equipment

19.1.2.1. Besides, the firefighter's outfits required by Ch 3, Sec.11,[11.1.2], adequate, but not less than two complete sets of safety equipment, each of which permits personnel to enter and work in a gas-filled space, shall be provided.

19.1.2.2. Every complete set of safety equipment shall have:

- i) One (1) self-contained air-breathing apparatus, not using stored oxygen and having at least 1,200 l of free air capacity.
- ii) Protective clothing, gloves, boots and tight-fitting goggles.
- iii) Steel-cored rescue line with belt.
- iv) Explosion-proof lamp.

19.1.2.3. Provision for adequate supply of compressed air shall be available and consist either of:

- i) One set of fully charged spare air bottles for each breathing apparatus required by 19.1.2.1; a special air compressor appropriate for the supply of high-pressure air of the required purity; and a charging manifold capable of dealing with sufficient spare breathing apparatus air bottles for the apparatus required by 19.1.2.1, or
- ii) Fully charged spare air bottles with a total of at least 6,000 l free air capacity for each breathing apparatus required by 19.1.1.

19.1.2.4. The Society may, alternatively, accept a low-pressure airline system with hose connection that is suitable for use along with breathing apparatus required by 19.1.2.1. This system shall provide sufficient high-pressure air capacity to supply, through pressure reduction devices, enough low-pressure air to let two men to work for at least 1 hour in a gas-dangerous space without using the air bottles of breathing apparatus. Means for recharging the fixed air bottles and the breathing apparatus air bottles from a special air compressor suitable for the supply of high-pressure of the required purity shall be provided as well.

19.1.2.5. Both the safety equipment required in 19.1.2.1 and protective equipment required in 19.1.1.1 shall be kept inside suitable and clearly marked lockers which are located in readily accessible places.

19.1.2.6. At least once a month, the compressed air equipment shall be inspected by a responsible officer and its details recorded in the ship's log-book. At least in a year, however, this inspection and testing shall be carried out by an expert.

19.2. First-aid Equipment

19.2.1. General

19.2.1.1. A stretcher which can hoist an injured person from spaces below deck shall be kept in a readily accessible location.

19.2.1.2. Based on the guidelines developed by IMO, ship shall have on board medical first-aid equipment, including antidotes and oxygen resuscitation equipment for cargoes to be carried.

Reference to the Medical First Aid Guide for Use in Accidents Involving Dangerous Goods (MFAG) is to be made and this provides advice on the treatment of casualties depending on the symptoms exhibited as well as equipment and antidotes that may be appropriate for treating the casualty.

19.3. Personnel Protection Requirements for Individual Products

19.3.1. General

19.3.1.1. Provisions of 19.3.1.1 are applicable to ships carrying products for which those paragraphs are listed in column 'f' in the Table 3.20.1 of Section 20.

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

a) Filter type respiratory protection is unacceptable.
b) Self-contained breathing apparatus is normally to have a duration of service of at least 15 min.
c) Emergency escape respiratory protection shall not be used for fire-fighting or cargo handling purposes and should be marked to that effect.
d) Two additional sets of the above respiratory and eye protection shall be permanently located in the navigating bridge.

19.3.1.3. Suitably marked decontamination showers and eyewash shall be available on deck in convenient locations. The showers and eyewash shall be operable in all ambient conditions. (IGC Code 14.4.3)

The eye wash units and decontamination shower should be located on ship's both sides in the cargo manifold area and in way of entrance to the compressor room.

19.3.1.4. In ships of a cargo capacity of 2000 m^3 and over, two complete sets of safety equipment is to be provided in addition to the equipment required by Sec.11, [11.1.2]. At least three spare charged air bottles shall be provided, for each self-contained air-breathing apparatus required above.

19.3.1.5. Personnel are to be protected against the effects of a major cargo release by the provision of a space within the accommodation area designed and equipped to satisfaction of the Society.

19.3.1.6. The cargo control room is to be of only the gas-safety type for some highly dangerous products.

SECTION 20 LIST OF CARGOES (TANKER FOR LIQUEFIED GAS)

Contents

20.1. List of Cargoes

20.1.1. General

Table A1 provides a summary of some minimum construction requirements for the specific cargoes.

20.1.2. Marking

20.1.2.1. Cargoes marked with * in the first column of Table 3.20.1, are cargoes covered by IMO International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk.

20.1.2.2. Cargoes marked with + in the first column of Table 3.20.1, are cargoes which are covered by both IMO International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk and IMO International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk.

20.1.3. Abbreviations

Gauging systems, type permitted (column c):

I Indirect or closed as described in Sec.13, 13.2.1.2 or 13.2.1.3.

C Indirect or closed, as described in Ch 3,Sec.13 ,[13.2.1.2],[13.2.1.3],[13.2.1.4]

R Indirect, closed or restricted, as described in Ch 3,Sec.13,[13.2.1.2], Ch 3,Sec.13[13.2.1.3], Sec.13,[13.2.1.4] and Sec.13,[13.2.1.5.].

Vapour detection required (column d):

F Flammable vapour detection

T Toxic vapour detection

O Oxygen analyzer

Table 3.20.1. Summary of some minimum construction requirements for special cargoes

		a	b	c	d	e	f
	Name and chemical formula	**Ship type**	**D Liquid density (kg/m^3).**	**Gauging system**	**Vapour detection**	**Control of vapour space within tank**	**Remarks. Special requirements**
*	ACETALDEHYDE CH_3CHO	2G/2PG	(20.8°C) 780	C	F + T	Inert	Ch 3,Sec.15,[15.1.5.1, 15.1.7.2,15.1.8.1.1 , Sec 19,[19.3.1.3, 19.3.1.4]
*	AMMONIA (ANHYDROUS) NH_3	2G/2PG	(- 33.4°C) 680	C	T	-	Ch 3,Sec.15,[15.1.2.2] ,[15.1.2.2],[15.1.7. 2],[15.2.4] Sec.19 ,[19.3.1.2],[19.3.1. 3,19.3..1.4.
*	BUTADIENE 1.3 (inhibited) $CH_2CHCHCH_2$	2G/2PG	(- 4.5°C) 650	R	F+T	-	Sec.15,[15.1.2.3, 15.1.5.2,15.1.5.3, and 15.1.8.
*	BUTANE C_4H_{10}	2G/2PG	(- 0.5°C) 600	R	F	-	
*	BUTANE/PROPANE mixtures	2G/2PG		R	F	-	
*	BUTYLENES	2G/2PG	(- 6.3; 3.7°C) 630; 640	R	F	-	
*	CARBON DIOXIDE	3G		R	-	-	Sec.15 ,[15.1.3.2,15.2.1]
*	CHLORINE Cl_2	1G	(- 34°C) 1 560	I	T	Dry	Sec.15,[15.1.5.1,15.1.6, 15.1.7, 15.1.9,15.1.10, 15.2.6] , Sec [19.3]
*	DICHLOROMONOFLUOROMETHANE $CHFCl_2$ Refrigerant gas (R-21)	3G	(8.9°C) 1480	R	-	-	
*	DICHLOROTETRAFLUOROETHANE C_2F4Cl_2 Refrigerant gas (R-114)	3G	(3.8°C) 1 510	R	-	-	

	Name and chemical formula	a Ship type	b D Liquid density (kg/m³).	c Gauging system	d Vapour detection	e Control of vapour space within tank	f Remarks. Special requirements
+	DIETHYL ETHER $C_2H_5O\ C_2H_5$	2G/2PG	(34.6°C) 640	C	F + T	Inert	Sec.15 ,[15.1.2.7], [15.1.3.1], [15.1.7.2], [15.1.8.1.1], 15.1.11, 15.1.12, 15.2.7, Sec.19,[19.3.1.2 & 19.3.2.3
	DIMETHYL ETHER	2G/2PG	(-23°C) 668	C	F + T	-	
*	DIMETHYLAMINE $(CH_3)_2NH$	2G/2PG	(6.9°C) 670	C	F + T	-	Sec.15,15.1.2.2 15.1.7.2, Sec.19,[19.3.1.2, 19.3.1.2, 19.3.1.3, 19.3.1.4
*	ETHANE C_2H_6	2G	(- 88°C) 550	R	F	-	
*	ETHYL CHLORIDE CH_3CH_2Cl	2G/2PG	(12.4°C) 920	R	F + T	-	Sec.15 ,[15.1.7.2]
*	ETHYLENE C_2H_4	2G	(-104°C) 560	R	F	-	
*	ETHYLENE OXIDE $(CH_2)_2O$	1G	(10.4°C) 870	C	F + T	Inert	Sec.15 ,15.1.2.3, 15.1.3.2, 15.1.5.1,15.1.6,15. 1.7.1 ,15.8.1.1, 15.2.1, Sec.19 19.3.1.2, 19.3.1.3, 19.3.1.4, 19.3.1.6
+	ETHYLENE OXIDE/PROPYLEN E OXIDE mixture with ethylene oxide content of not more than 30% by weight	2G/2PG	-	C	F + T	Inert	Sec.15 ,15.1.3.1,15.1.5.1,1 5.1.7.1,15.1.8.1.1 15.1.11, 15.1.12,15.2.8,Sec. 19 ,19.3.1.3
+	ISOPRENE(inhibite d) $CH_2C(CH_3)CHCH_2$	2G/2PG	(34°C) 680	R	F	-	Sec.15,[15.1.11] Sec.19 ,[19.3.1.3]
+	ISOPROPYLAMINE $(CH_3)_2CHNH_2$	2G/2PG	(33°C) 710	C	F + T	-	Sec.15 ,[15.1.2.5], 15.1.7.2, 15.1.11, 15.1.12, 15.2.9, Sec.19,19.3.1.2,19. 3.1.3
*	METHANE CH_4 (LNG)	2G	(-164°C) 420	C	F	-	

	Name and chemical formula	a Ship type	b D Liquid density (kg/m^3).	c Gauging system	d Vapour detection	e Control of vapour space within tank	f Remarks. Special requirements
*	METHYL ACETYLENE - PROPADIENE MIXTURE	2G/2PG		R	F	-	Sec.15,[15.2.2]
*	METHYL BROMIDE CH_3Br	1G	1 730	C	F + T	-	Sec.15 ,15.1.3.2, 15.1.5.1, 15.1.6, Sec.19,19.3
*	METHYL CHLORIDE CH_3 Cl	2G/2PG	920	C	F + T	-	Sec.15 ,15.1.2.4, 15.1.7.2
*	MONOCHLORODI FLUOROMETHA NE $CHClF_2$ Refrigerant gas (R-22)	3G	(- 42°C) 1 420	R	-	-	
*	MONOCHLOROTE TRAFLUOROETH ANE C_2HF_4Cl Refrigerant gas	3G		R	-	-	
*	MONOCHLOROTR IFLUOROMETHA NE CF_3Cl Refrigerant gas (R-13)	3G	(-81.4°C) 1 520	R	-	-	
+	MONOETHYLAMIN E $C_2H_2NH_2$	2G/2PG	(16.6°C) 690	C	F + T	-	Sec.15 ,15.1.2.2, 15.1.3.1, 15.1.7.2, 15.1.11, 15.1.12, 15.2.9, Sec.19, 19.3.1.2, 19.3.1.3, 19.3.1.4
*	NITROGEN N_2	3G	(-196°C) 808	C	O	-	Sec.15 ,15.2.3
+	PENTANES (all isomers)	2G/2PG	630	R	F	-	Sec.15,[5.1.11,Sec. 19 ,19.3.1.4
+	PENTENES (all isomers)	2G/2PG	650 Sec.19 C104	R	F	-	Sec.15,15.1.11, Sec.19 ,19.23.1.4
*	PROPANE C_3H_8	2G/2PG	(-42.3°C) 590	R	F	-	
*	PROPYLENE C_3H_6	2G/2PG	(- 47.7°C) 610	R	F	-	
+	PROPYLENE OXIDE CH_3CHOCH_2	2G/2PG	860	C	F + T	Inert	Sec.15,15.1.3.1,15 .1.5.1,1.15.7.2,15.1 .8.1.1,15.1.11,15.1. 12,15.2.8, Sec.19 ,19.3.1.3

	Name and chemical formula	a Ship type	b D Liquid density (kg/m³).	c Gauging system	d Vapour detection	e Control of vapour space within tank	f Remarks. Special requirements
*	SULPHUR DIOXIDE (inhibited) SO_2	1G	(-10°C) 1 460	C	T	Dry	Sec.15,15.1.3.22 15.1.3.2, 15.1.6, 15.1.7.1, 15.1.19, 15.1.10, Sec.19 ,19.3
*	VINYL CHLORIDE MONOMER CH_2CHCl (inhibited)	2G/2PG	(- 13.9°C) 970	C	F + T	-	Sec.15,15.1.2.3, 15.1.2.4, 15.1.5.2, 15.1.5.3, 15.1.7.3, 15.1.8, 15.2.5, Sec.19,[19.3.12], [19.3.1.3]
+	VINYL ETHYL ETHER $CH_2CHOC_2H_5$ (inhibited)	2G/2PG	754	C	F + T	Inert	Sec.15 ,[15.1.2.3, 15.1.3.1, 15.1.7.2, 15.1.8.1.1, 15.1.11, 15.1.12, 15.2.7 Sec.19 ,19.3.1.2 & 19.3.1.3,
+	VINYLIDENE CHLORIDE $C_2H_2CCl_2$ (inhibited)	2G/2PG	1 250	R	F + T	Inert	Sec.15 ,15.1.2.6, 15.1.7.2, 15.1.8.1.1, 15.1.11, 15.1.12, Sec.19 ,19.3.1.2, 19.3.1.3