PART 4 Specialized Vessels

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CHAPTER 1 Oil Tankers

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SECTION 1 General

1.1 Application

1.1.1 This Chapter applies to the arrangements and scantlings within the cargo tank region of seagoing tankers having integral tanks and intended for the carriage of oil having a flash point not exceeding 60°C (closed cup test).

1.1.2 Where only oils having flash points exceeding 60°C are to be carried, the Rule requirements and Class notation will be modified accordingly.

1.1.3 For the purpose of this Chapter "oil" means petroleum in any form including crude oil, refined products, sludge, oil refuse and other liquid products presenting similar hazards.

1.1.4 For the purpose of this Chapter "crude oil" means any liquid hydrocarbon mixture whether or not treated to render it suitable for transportation and includes:
(a) crude oil from which certain distillate fractions may have been removed, or
(b) crude oil to which certain distillate fractions may have been added.

1.1.5 The scantlings of structural items may be determined by direct calculation. Where the length of the ship exceeds 200 m, certain scantlings will be required to be assessed by direct calculation. In such cases the calculations are to be submitted for approval.

1.2 Ship arrangement

1.2.1 The requirements contained in this Chapter apply primarily to single deck tankers with machinery aft, having two continuous longitudinal bulkheads with either single or double bottom in the cargo tank region (see Figure 1.1.1).

Figure 1.1.1

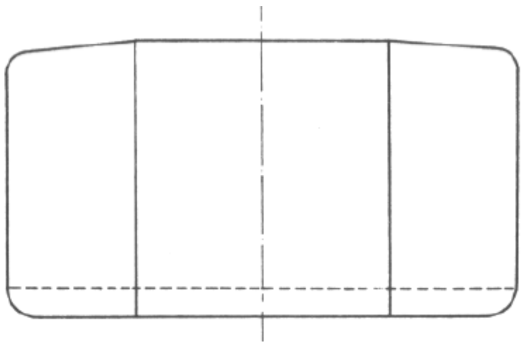
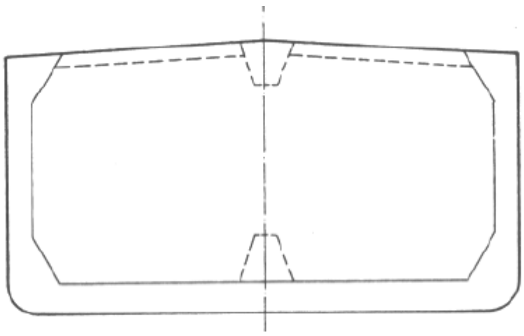


Figure 1.1.2



1.2.2 The requirements also apply to arrangements incorporating a double skin and/or double deck which may be in association with a centreline bulkhead (see Figure 1.1.2).

1.2.3 The bottom and deck are to be framed longitudinally in the cargo tank region where the length of the ship exceeds 75 m. However, consideration will be given to alternative proposals for ships of special design.

1.2.4 The side shell and the longitudinal bulkheads are generally to be longitudinally framed where the length of ship exceeds 150 m, but alternative proposals, taking account of resistance to buckling, will be considered.

1.2.5 Where the side shell is longitudinally framed, the longitudinal bulkheads are to be similarly constructed, or, provided the length of ship does not exceed 200 m, may be horizontally corrugated. Vertically corrugated centreline bulkheads may also be considered on the basis of direct calculations.

1.2.6 Alternative arrangements, which are proposed as being equivalent to the Rules, will receive individual consideration. Particular attention is to be paid to deflection of members and to the ability of the structure to resist buckling. Where necessary, additional calculations will be required.

1.2.7 Cofferdams

(a) Cofferdams of adequate extent so as to cover the end bulkheads of the cargo tanks region, are to be provided at the forward and after ends of the oil cargo spaces.
(b) Cofferdams are also to be arranged so as to separate the oil tanks from engine rooms, spaces containing electrical equipment, boiler rooms, dry cargo holds and accommodation spaces.
(c) Cofferdams are to be of adequate width, not less than 0,76 m.
(d) Cofferdams are to be provided with corrosion protection, drainage and gas - freeing arrangements.
(e) Pump rooms, water ballast tanks or oil fuel tanks containing oil having a flash point above 60°C, may be accepted in lieu of cofferdams.
(f) Where a corner-to-corner situation occurs, protection may be formed by a diagonal plate across the corner.

SECTION 2 Special requirements

2.1 Size of cargo tanks

2.1.1 In cargo tanks, oiltight bulkheads are to be arranged such that the capacity of each tank does not exceed the limits required by hypothetical outflow of oil due to damage and by tank size. These are specified as follows:

(a) For the purpose of calculating hypothetical oil outflow from oil tankers, the dimensions of the extent of damage of a parallelepiped on the side and bottom of the ship are assumed as given in Table 1.2.1.
(b) The hypothetical outflow of oil in the case of side damage Oc and bottom damage Os is to be calculated by the following formulae. These values are not to exceed the limits specified in 2.1.1(c).
   (i)
   (a) Side damages:
   Formula I

$$O_c = \sum W_i + \sum K_i \cdot C_i$$

   (b) Bottom damages:
   Formula II

$$O_S = \frac{1}{3} \cdot \left(\sum Z_i \cdot W_i + \sum Z_i \cdot C_i\right)$$

However, in case where bottom damage simultaneously involves 4 centre tanks, the value of Os may be calculated according to the formula below:

Formula III

$$O_S = \frac{1}{4} \cdot \left(\sum Z_i \cdot W_i + \sum Z_i \cdot C_i \right)$$

Table 1.2.1: Damage assumptions for hypothetical outflow of oil

Damage Positions \ Extents		Longitudinal Extent	Transverse Extent	Vertical Extent (From Base Line)
Side Damage		$1/3L_f^{2/3}$ or 14,5 m whichever is less	0,2B_f or 11,5 m whichever is less (1)	Upwards without limit
Bottom Damage	For 0,3L from FP of the ship	0,1L	1/6B_f or 10 m whichever is less, but not less than 5 m	1/15B_f or 6 m whichever is less
	Elsewhere	0,1L or 5 m whichever is less	5 m	

NOTE:
1. Transverse extent of side damage is measured inboard from the ship's side at right angles to the centreline at the level corresponding to the assigned summer freeboard

where:

W_i = Volume of a wing tank assumed to be breached by the damage as specified in the 2.1.1(a) above, m^3; Wi for a segregated ballast tank may be taken equal to zero.

C_i = Volume of a centre tank assumed to be breached by the damage as specified in the 2.1.1(a) above, m^3; C_i for a segregated ballast tank may be taken equal to zero.

Lf = Length, m, of ship for freeboard, equal to 96 per cent of the total length on a waterline at 85 per cent of the least moulded depth measured from the top of the keel, or to the length from the fore side of the stem to the axis of the rudder stock on that waterline, if that is greater. In ships designed with a rake of keel, the waterline on which this length is measured is to be parallel to the designed waterline.

Bf = Breadth of ship for freeboard, equal to the maximum horizontal distance measured at the middle of the length of the ship for freeboard, L_f, to the moulded line of the frame of the ship, m.

K_i = $1 - (b_i/t_c)$; when b_i is equal to or greater than t_c, K_i is to be taken equal to zero.

Z_i = $1 - (h_i/v_s)$; when h_i is equal to or greater than v_s, Z_i is to be taken equal to zero.

b_i = Width of wing tank under consideration measured inboard from the ship's side at right angles to the centreline at the level corresponding to the assigned summer freeboard, m.

t_c = Assumed transverse extent of side damage, as specified in 2.1.1(a), m.

h_i = Minimum depth of the double bottom under consideration, m; where no double bottom is fitted h_i is to be taken equal to zero.

v_s = Assumed vertical extent from the baseline of bottom damage as specified in 2.1.1(a), m.

(ii) If a void space or segregated ballast tank of length less than the assumed longitudinal extent of side damage as defined in the 2.1.1(a) located between wing oil tanks, O_c in Formula I of 2.1.1(b)(i)(1) may be calculated on the basis of volume, W_i being the actual volume of one such tank (where they are of equal capacity) or the smaller of two tanks (if they differ in capacity) adjacent to such space, multiplied by S_i as defined below and taking for all other wing tanks involved in such a collision the value of the actual full volume:

$$S = 1 - (l_i / l_c)$$

where:

l_i = Length of void space or segregated ballast tank under consideration, m.

l_c = Assumed longitudinal extent of side damage, m, as specified in 2.1.1

(iii)

(1) Credit is only to be given in respect of double bottom tanks which are either empty or carrying clean water when cargo is carried in the tank above.

(2) Where the double bottom does not extent for the full length and width of the tank involved, the double bottom is considered non-existent and the volume of the tanks above the area of the bottom damage is to be included in Formula II or Formula III of 2.1.1(b)(i)(2) even if the tank is not considered breached because of the installation of such a partial double bottom.

(3) Suction wells may be neglected in the determination of the value hi provided such wells are not excessive in area and extend below the tank for a minimum distance and in no case more than half the height of the double bottom. If the depth of such a well exceeds half the height of the double bottom, hi is to be taken equal to the double bottom height minus the well height. Piping serving such wells if installed within the double bottom is to be fitted with valves or other closing arrangements located at the point of connection to the tank served to prevent oil outflow in the event of damage to the piping. Such piping is to be installed as high from the bottom shell as possible. These valves are to be kept closed at sea at any time when the tank contains oil cargo except that they may be opened only for cargo transfer needed for the purpose of trimming of the ship.

(c) Cargo tanks of oil tankers are to be of such size and arrangements that the hypothetical outflow O_c or O_s calculated in accordance with the requirement in 2.1.1(b) anywhere in the length of the ship does not exceed 30000 m^3 or 400 $(DW)^{1/3}$, whichever is the greater, but subject to a maximum of 40000 m^3 , where DW is the difference of the displacements between the summer load waterline and lightweight waterline of the ship in m^3.

(d) The volume and size of each cargo tank is not to exceed the following limits:

(i) The volume of any one wing cargo oil tank of an oil tanker is not to exceed 75 per cent of the limits of the hypothetical oil outflow referred to in 2.1.1(c). The volume of any one centre cargo oil tank is not to exceed 50000 m^3. However, in segregated ballast oil tankers as defined in 2.2, the permitted volume of a wing cargo oil tank situated between two segregated ballast tanks, each exceeding lc in length, may be increased to the maximum limit of hypothetical oil outflow provided that the width of the wing tanks exceeds tc.

(ii) The length of each cargo tank is not to exceed 10 m or the value given in Table 1.2.2, whichever is the greater.

Table 1.2.2: Permissible length of cargo tanks

No. of Longitudinal Bulkheads		Two or more provided: None on centreline	Two or more provided: One on centreline	One provided on centreline only	Not provided
Length of wing tank		$0{,}2L_f$	$0{,}2L_f$	$0{,}15L_f$	$0{,}1L_f$
Length of Centre tank	$b_i \geq 0{,}2 \cdot B_f$	$0{,}2L_f$	$0{,}2L_f$	-	
	$b_i < 0{,}2 \cdot B_f$	$\left(\frac{b_i}{2 \cdot B_f} + 0{,}1\right) \cdot L_f$	$\left(\frac{b_i}{4 \cdot B_f} + 0{,}15\right) \cdot L_f$	-	

where L_f, B_f, b_i as defined in 2.1.1(b).

(e) When the piping system interconnects two or more cargo tanks, valves or similar closing devices are to be provided in order not to exceed the limits of volume and size specified in 2.1.1(b) and (d). Lines of piping which run through cargo tanks in the position less than t_c from the ship's side or v_c from the ship's bottom are to be fitted with valves or similar closing devices at the point at which they open into any cargo tank, where t_c as defined in 2.1.1(b)(i) and v_c the assumed vertical extent of side damage as specified in 2.1.1(a).

2.2 Segregated ballast tanks

2.2.1 Every crude oil tanker of 20000 tons deadweight and above and every new product carrier of 30000 tons deadweight and above are to be provided with segregated ballast tanks capacity and arrangement of which are specified in 2.2.2 and 2.2.3.

2.2.2 The capacity of the segregated ballast tank is to be at least such that in any ballast condition at any part of the voyage, the ship's draughts and trim can meet requirements 2.2.2(i) to (iii) below:

(i) The moulded draught amidships d_m (without taking into account any hull deformation) is to be not less than:

$$d_m = 2{,}0 + 0{,}02 \cdot L_f, \qquad m$$

(ii) Trim by the stern is to be not greater than $0{,}015L_f$, m.

(iii) In no case is the draught at the aft perpendicular to be not less than that which is necessary to obtain full immersion of the propeller.

Notwithstanding the above, the capacities of oil tankers less than 150 m in length are to be considered by the Society.

2.2.3 The segregated ballast tanks which are located within the cargo tank length are to be in accordance with the following requirements 2.2.3(i) and (ii):

(i) Segregated ballast tanks and spaces other than oil tanks within the cargo tank length L_f are to be so arranged as to comply with the following requirement:

$$\sum PA_c + \sum PA_S > J \cdot [L_t \cdot (B_f + 2 \cdot D)]$$

where:

PA_c = The side shell area for each segregated ballast tank or space other than an oil tank based on projected moulded dimensions, m^2.

PA_s = The bottom shell area for each such tank or space based on projected moulded dimensions, m^2.

L_t = Length between the forward and after extremities of the cargo tanks, m.

J = 0,45 for oil tankers of 20000 tons deadweight, 0,30 for oil tankers of 200000 tons deadweight and above except the following 2.2.3(ii). For intermediate values of deadweight, J is to be determined by linear interpolation.

(ii) For tankers of 200000 tons and above the value of J may be reduced as follows:

$$J_{reduced} = \left[J - \left(a - \frac{O_C + O_S}{4 \cdot O_A}\right)\right]$$

= 0,2 , whichever is the greater

where:

a = 0,25 for oil tankers of 200000 tons deadweight
= 0,40 for oil tankers of 300000 tons deadweight
= 0,50 for oil tankers of 420000 tons deadweight and above

For intermediate values of deadweight, the value of "a" is to be determined by linear interpolation.

O_C, O_S = As defined in 2.1.1(b)

O_A = The allowable oil outflow as required by 2.1.1(c).

(iii) In the determination of PA_C and PA_S for segregated ballast tanks and spaces other than oil tanks the following are to be applied:

(1) The minimum width of each wing tank or space either of which extends for the full depth of the ship's side or from the deck to the top of the double bottom is to be not less than the value given in Table 1.2.3. The width is to be measured inboard from the ship's side at right angles to the centreline. Where a lesser width is provided the wing tank or space is not to be taken into account when calculating the protecting area PA_C. and

(2) The minimum vertical depth of each double bottom tank or space is to be than that given in Table 1.2.4. When a lesser depth is provided the bottom tank or space is not to be taken into account when calculating the protecting area PA_S.

The minimum width and depth of wing tanks and double bottom tanks are to be measured clear of the bilge area and, in the case of minimum width, they are to be measured clear of any rounded gunwale area.

Table 1.2.3: Minimum wing tank width, w

DWT ≤ 600	none required
600 < DWT ≤ 3000	w = 0,76 m (1)
3000< DWT ≤ 5000	w = 0,.4+2,4 DWT/20000, m (1)
5000< DWT ≤ 10000	w = 1,0m
10000< DWT ≤ 30000	w = 0,5+DWT/20000, m
DWT > 30000	w = 2,0m
NOTE: 1. Oil tankers of less than 5000 DWT do not require wing ballast/void tanks provided that the capacity of each cargo tank does not exceed 700 m³.	

Table 1.2.4: Minimum double bottom height, h

For:	DWT < 600	none required
For:	600 ≤ DWT ≤ 5000 where	B ≤ 11,4 m h = 0,76 m B > 11,4 m h = B/15 m
For:	DWT > 5000 where	B ≤ 15 m h = 1,0 m 15 < B ≤ 30 m h = B/15 m B > 30 m h = 2,0 m

The regulation above applies to all new tankers of 600 DWT and above which:
- are contracted on or after 6 July 1993, or
- have their keel laid on or after 6 January 1994, or (in absence of contract)
- are delivered on or after 6 July 1996, or
- have undergone a major conversion for which:
  - (a) contract is placed after 6 July 1993, or
  - (b) work is begun after 6 January 1994, or (in absence of contract)
  - (c) work is completed after 6 July 1996.

2.3 Slop tanks

2.3.1 Oil tankers of 150 gross tonnage and above are to be provided with a slop tank or combination of slop tanks which have suitable capacity to retain the dirty ballast residue and slops generated by tank washing etc. Oil tankers over 70000 tons deadweight are to be provided with at least two slop tanks.

2.3.2 Slop tanks are to be so designed particularly in respect of the position of inlets, outlets, baffles or weirs where fitted, so as to avoid excessive turbulence and entrainment of oil or emulsion with the water.

SECTION 3 Longitudinal strength

3.1 General

3.1.1 The calculations of the longitudinal bending moments and shear forces as well as of the midship section modulus are to be carried out according to Part 3, Chapter 2.

3.2 Loading conditions

3.2.1 The following main loading conditions are to be included in the Loading Manual and examined for longitudinal strength:

(a) The homogeneous load conditions (excluding dry and clean ballast tanks) and light and heavy ballast or part-loaded conditions for both departure and arrival.
(b) Any specified non-uniform distributions of loading.
(c) Mid-voyage conditions relating to tank cleaning or other operations where these differ significantly from the ballast conditions.
(d) Docking condition afloat.

3.2.2 The Loading Manual is to contain the calculated still water bending moments and shear forces for the conditions proposed and the maximum permissible values calculated in accordance with Part 3, Chapter 2.

3.2.3 In a single bottom, where a centreline non-primary docking girder is arranged, the docking condition is to be included in the Loading Manual, together with the spacing and size of blocks used in the docking investigation.

3.2.4 Where bottom forward strengthening has not been arranged, at least one ballast departure and one ballast arrival condition providing for a forward draught of at least 0,045L is to be included in the Loading Manual.

3.2.5 Where part-loaded conditions are proposed with a forward draught less than that for which the bottom forward arrangements and scantlings have been approved, the Loading Manual is to provide for the addition of ballast as necessary to attain the required draught in heavy weather.

3.2.6 Conditions which provide for wing and centre tanks abreast to be filled with adjacent wing and centre tanks empty, should in general be avoided. Where such conditions are contemplated, they will be subject to special consideration which may involve additional calculations in respect of the resultant effects on transverse strength.

3.2.7 Any dry tanks or tanks intended for water ballast only and thus empty in the loaded condition, are to be indicated in the Loading Manual.

SECTION 4 Double bottom construction

4.1 General

4.1.1 The scantlings and arrangements in the double bottom are to be as required by Part 3, Chapter 3 except as otherwise specified in this Section.

4.1.2 Longitudinal framing is to be adopted in accordance with 1.2.3.

4.1.3 Increases in scantlings may be required where tanks other than double bottom tanks are designed to be empty with the vessel in a loaded condition.

4.1.4 Arrangements are to be provided to enable double bottom tanks situated below cargo tanks to be filled with water ballast to assist in gas freeing these tanks.

4.1.5 Access to the double bottom tanks in way of cargo oil tanks is to be provided by trunks from the exposed deck led down the bulkheads. Alternative proposals will, however be considered provided that the integrity of the inner bottom is maintained.

4.1.6 Where a duct keel or pipe tunnel is fitted, access is to be provided from each end and at least one other point at approximately mid-length. Access is to be directly from the exposed deck. Where an after access is to be provided from the pump room to the duct keel, the access manhole from the pump room to the duct keel is to be provided with an oiltight cover plate. Mechanical ventilation is to be provided and such spaces are to be adequately ventilated prior to entry. Notices to this effect are to be posted at access locations. In addition, the atmosphere in the duct keel or tunnel should be sampled by a reliable gas monitor, and where an inert gas system is fitted in cargo tanks, an oxygen monitor should also be provided.

4.2 Girders and floors

4.2.1 In general the thickness of floors and girders is to be as required in Part 3, Chapter 3. Where tanks adjacent to the double bottom are designed to be empty with the vessel in a loaded condition, the floors and girders in the double bottom are to be specially considered.

4.2.2 Plate floors are to be arranged in way of transverse bulkheads and bulkhead stools and elsewhere at a spacing which is generally not to exceed 3,8 m. Where a floor spacing of greater than 3,8 m is proposed, a bracket floor intermediate to the main floor will generally be required. In addition, calculations will be required to verify the scantlings and arrangements and these should clearly show that the greater concentration of loads involved are adequately scarfed into the structure.

4.2.3 Girders are to be arranged at the centreline or duct keel at the hopper side and in way of longitudinal bulkheads and bulkhead stools.

4.2.4 In way of vertically corrugated transverse bulkheads supported by stools, additional girders are to be arranged extending at least to the first plate floor adjacent to the bulkhead each side and spaced not more than 3,8 m.

4.3 Inner bottom

4.3.1 The thickness of the inner bottom plating is to be not less than required by Part 3, Chapter 9, SECTION 2 with a head to 1,2 m above the deck at side amidships or to the top of the hatch whichever is greater.

4.3.2 Adequate strength against buckling due to longitudinal and transverse stresses in the inner bottom is to be confirmed by direct calculation.

4.3.3 Transverse continuity of the inner bottom structure is to be maintained in way of the longitudinal bulkheads. Where a double bottom is fitted in the centre tank only, the inner bottom is to be suitably scarfed into the wing tanks.

4.3.4 Particular attention is to be given to the through-thickness properties and continuity at the connection of bulkhead stools to the inner bottom.

4.3.5 The scantlings of the inner bottom longitudinals are to be not less than required in 7.1.2 using C = 7,85. Where effective struts are fitted between inner bottom and bottom longitudinals, the inner bottom longitudinals are not to be less than required in 7.1.2 using C = 4,32.

SECTION 5 Hull envelope plating

5.1 General

5.1.1 The thickness of the hull envelope plating amidships is to be as necessary to comply with the hull section modulus and shear strength requirements of Part 3, Chapter 2, but is to be not less than that obtained from the formulae in this Section.

5.2 Deck plating

5.2.1 The midship thickness of deck plating is to be maintained for 0,4L amidships and tapered outside this region in association with the deck longitudinals. The midship thickness may, however, be required over an increased extent if it is shown to be necessary by the bending moment curves.

5.2.2 The strength deck thickness within the midship 0,4L is to be not less than that required from the following formula:

$$t = 0{,}02 \cdot L + 11 \cdot s, \quad mm$$

where:
s = Spacing of deck longitudinals, m, and it is not to be taken less than $0{,}4 + 0{,}0015 \cdot L$.

5.3 Sheerstrake

5.3.1 The thickness of the sheerstrake is to be not less than the thickness of the side shell plating, nor less than that required by 5.2.2.

5.3.2 The thickness is to be increased by 25 per cent in way of breaks of superstructures, but this increase need not exceed 6,5 mm.

5.3.3 Where a rounded sheerstrake is incorporated, the radius is not in general to be less than 15 times the thickness. The radius is to be made by careful cold rolling or bending.

5.4 Side shell plating

5.4.1 The thickness of the side shell plating is to be not less than obtained from (i) or (ii) below:
(i) Side shell above mid-depth:
$t = 4{,}5 \cdot s \cdot \sqrt{T} + t_k, \quad mm$

(ii) Side shell below mid-depth:
$t = 4{,}5 \cdot s \cdot \sqrt{T} + t_k, \; mm$, at mid-depth
$t = 5{,}4 \cdot s \cdot \sqrt{T} + t_k, \; mm$, at upper turn of bilge.
Intermediate thickness may be obtained by interpolation
where:
s = Spacing of side longitudinals, or vertical side frames, m.
T = Moulded draft to the summer load line, m.
t_k = Corrosion allowance, mm, as defined in Part 3, Chapter 1, 5.2.1.

5.4.2 After all other requirements are met the minimum thickness of the side shell plating amidships is not to be less than obtained from the following formula:

$$t = 0{,}9 \cdot s \cdot (0{,}06 \cdot L + 7), \quad mm$$

where:
s = Spacing of side longitudinals, or vertical side frames, m.

5.5 Bottom plating

5.5.1 The thickness of the bottom shell plating within the midship 0,4L is to be not less than that obtained from the following formulae:

(a) $t = 6 \cdot s \cdot \sqrt{T} + t_k$, mm,
(b) $t = s \cdot (0{,}06 \cdot L + 7)$, mm

where:
s = Spacing of bottom longitudinals, m.
T, t_k = As defined in 5.4.1.

5.5.2 The thickness of the flat plate keel is to be maintained constant throughout and should be at least 1,5 mm greater than the bottom shell thickness amidships. Where the bottom plating thickness exceeds 37 mm, this requirement may be modified. Where this strake is increased over the calculated value, after corrections for longitudinal strength the flat-plate keel may be gradually reduced, forward and abaft the midship 0,4L, to the requirement amidships.

SECTION 6 Bulkheads

6.1 General

6.1.1 The bulkheads are to be stiffened by vertical or horizontal stiffeners combined with horizontal or vertical girders or transverses or equivalent structures.

6.1.2 The longitudinal bulkheads may be plane or horizontally corrugated. The transverse bulkheads may be plane or with corrugations arranged horizontally or vertically.

6.1.3 Cofferdam bulkheads are to be oiltight. If they form boundaries of cargo tanks, they are to have the same strength as cargo tank bulkheads. Otherwise, their scantlings are to be determined as for ballast tank bulkheads in accordance with Part 3, Chapter 9.

6.1.4 Longitudinal bulkheads may be perforated inside cofferdams, excepting the strengthened top and bottom strakes. Beyond the ends of the cargo tanks, they are not to end abruptly and are to scarph into the adjoining bottom and deck side girders.

6.2 Scantlings

6.2.1 The plate thickness of the plane bulkheads is to be determined from Part 3, Chapter 9, where h is to be measured from the lower edge of the plate to the top of the hatch or to a point located 1,2 m above the deck at side amidships, whichever is greater.

6.2.2

(a) The thickness of the top strake of the longitudinal bulkhead is to be not less than that given in the following:

$$t = L/20 + 5, \qquad mm$$

(b) The breadth of the top strake of the longitudinal bulkhead is to be not less than that given in the following:

$$b = 100 \cdot D, \qquad mm$$

(c) The thickness of the strake below the top strake is to be not less than that given in the following:

$$t = L/30 + 5{,}5, \qquad mm$$

where:
L = Length of ship, m.
D = Depth of ship, m.

The section modulus of the stiffener is to be determined in accordance with 7.1.2.

6.3 Oiltight bulkheads

6.3.1 In vessels fitted with long tanks, the scantlings of oiltight transverse bulkheads in centre tanks are to be specially considered when the spacing between tight bulkheads, non-tight bulkheads, or partial bulkhead exceeds 12 m in the case of corrugated-type construction or 15 m in the case of flat-plate type construction.

6.3.2 Special consideration is to be given to the scantlings of longitudinal oiltight bulkheads forming the boundaries of wide tanks.

6.3.3 Where the length of the centre tanks exceeds 0,1L or the breadth exceeds 0,6B, non-oiltight bulkheads are to be fitted unless calculations are submitted to prove that no resonance due to sloshing will occur in service.

6.3.4 Reinforcements to the bulkheads and decks without non-oiltight bulkheads may be determined by an acceptable method of engineering analysis.

6.4 Non-oiltight bulkheads

6.4.1 Non-oiltight bulkheads are to be fitted in line with transverse webs, bulkheads or other structures with equivalent rigidity. They are to be suitably stiffened.

6.4.2 Openings in non-oiltight bulkheads are to have generous radii and their aggregate area is not to exceed 33 per cent nor to be less than 10 per cent of the area of the non-oiltight bulkhead.

6.4.3 Plating thickness is to be of not less than that required from the following formula:

$$t = L/35 + 6{,}5, \qquad mm$$

where:
L = Length of ship, m.

6.4.4 Section moduli of stiffeners and webs may be one half of the requirements for watertight bulkheads in Part 3, Chapter 8, 1.2.4 and 1.2.6.

6.4.5 The opening ratio and scantlings may be determined by an acceptable method of engineering analysis.

SECTION 7 Stiffening

7.1 Longitudinals, beams, frames and bulkhead stiffeners

7.1.1 Arrangement

The sizes of the longitudinals or stiffeners as given in this paragraph are based on the transverses or webs being regularly spaced. Longitudinals or horizontal stiffeners are to be continuous or attached at their ends to develop their sectional area effectively. This requirement may be modified in the case of stiffeners on transverse bulkheads. Longitudinals and stiffeners are to be attached to the transverses or webs to effectively transmit the loads onto these members. Consideration is to be given to the effective support of the plating in compression when selecting the size and spacing of longitudinals.

7.1.2 Structural sections

Each structural section for longitudinals, frames or bulkhead stiffeners, in association with the plating to which it is attached, is to have a section modulus not less than obtained from the following formula:

$$SM = C \cdot h \cdot s \cdot l^2, \quad cm^3$$

where:

C = 10,32 for bottom longitudinals,
= 7,50 for side longitudinals,
= 11,50 for deck longitudinals,
= 7,85 for vertical frames where web frames are fitted,
= 9,05 for vertical frames where web frames are not fitted,
= 7,85 for horizontal or vertical stiffeners on transverse bulkheads and vertical stiffeners on longitudinal bulkheads,
= 7,00 for horizontal stiffeners on longitudinal bulkheads.

h = Distance, m, from the longitudinals, or from the middle of l for vertical stiffeners, to a point located 1,2 m above the deck at side amidships in vessels of 60 m length, and to a point located 2,4 m above the deck at side amidships in vessels of 120 m length and above; at intermediate lengths h is to be measured to intermediate heights above the side of the vessel. The value of h for bulkhead stiffeners and deck longitudinals is not to be less than the distance, m from the longitudinal, or stiffener to the top of the hatch.

s = Spacing of longitudinals or stiffeners, m.

l = Length between supporting points, (see Figure 1.7.1), m.

Where an effective method of protection against corrosion is adopted, the section modulus may be reduced by 10 %.

7.2 Primary supporting members - Webs, girders, transverses and cross ties

7.2.1 The depth measured at the middle of the span l of the primary supporting members is to be not less than the following requirements:

a) The depth of side and deck transverses, the webs and the horizontal girders of the longitudinal bulkheads, and the stringers is to be not less than l/8.
b) The depth of deck centreline girders, the webs and the horizontal girders of the transverse bulkheads, the bottom transverses and the bottom centreline girders is to be not less than l/5.
c) The depth of side transverses and the vertical webs may be tapered from bottom to top by an amount not exceeding 20 per cent of the depth measured at the middle of the span l.
d) In no case is the depth of the member to be less than 3 times the depth of the slot for the longitudinals.

7.2.2 The thickness of webs is to be not less than that obtained from the following formula:

$$t = L/35 + 6,5, \quad mm$$

where:

L = Length of ship, m.

7.2.3 The section modulus of the member in association with an effective area of plating of width equal to s, or l/3, whichever is lesser, and the thickness equal to the mean thickness of the plating attached is to be not less than that given in the following:

$$SM = C \cdot h \cdot s \cdot l^2, \quad cm^3$$

where:

s = Spacing of transverses, webs and girders or width of area supported, m.

h = Depth of the ship D for bottom transverses and girders, m, and for others h is the vertical distance from the middle of the span l, or the centre of the area supported to a point located 1,2 m above the deck at side amidships in ships 60 m in length and under, and to a point located 2,4 m above the deck at side amidships in 120 m in length and above. For intermediate lengths, intermediate points may be used. The value of h is to be not less than the distance to the top of the hatch. For deck transverses and girders h is not to be less than 0,15D.

l = Unsupported span of transverses, webs, girders or stringers as shown in Figure 1.1.2, m. For deck and bottom transverses in wing tanks, l is to be not less than the half breadth of the wing tank. Where intercostal centreline bottom and deck girders are arranged, the span of the bottom and deck transverses in the centre tank is to be determined without consideration of the centreline bottom and deck girders.

C = 7,36, 4,0, 3,0, 2,5, and 3,5 for the side transverse and the vertical web of the longitudinal bulkhead where there is no cross tie, 1 cross tie, 2 cross ties, 3 or more cross ties, and 1 horizontal and 2 diagonal cross ties meeting at the side transverse respectively,
= 8,41 for the bottom transverse in the centre tank with continuous bottom centreline girder,
= 7,3 for the bottom transverse in the centre tank with intercostal bottom centreline girders,
= 5,6 for the bottom transverse in the centre tank with 3 continuous bottom girders,
= 9,5 for the continuous bottom centreline girder, the vertical web of the transverse bulkhead, the horizontal girder and the stringer,
= 11,8 for the bottom transverse in the wing tank, the deck transverse in the centre tank with continuous deck centreline girder and the continuous deck centreline girder,
= 8,72 for the deck transverse in the centre tank with intercostal centreline deck girder,
= 16,81 for the deck transverse in the wing tank.

In ships without a continuous bottom centreline girder, an intercostal centreline docking girder is to be provided having sufficient strength depending upon docking conditions and support arrangements.

7.2.4 The net sectional area of the web plate, including effective brackets where applicable, at any section of its length is to be not less than:

$$A = 0{,}117 \cdot F, \quad cm^2$$

where:

F = Shear force at the actual section under consideration obtained by means of an acceptable method of engineering analysis, kN.

7.2.5 The cross-sectional area of the cross ties is to be not less than:

$$A = \frac{P}{9{,}25 - 0{,}000278 \cdot \lambda^2}, \quad cm^2, \text{for } l \leq 130$$

$$A = \frac{P \cdot \lambda^2}{57000}, \quad cm^2, \text{for } l > 130$$

where:

λ = l/r = Slenderness ratio.
l = Unsupported span, cm.
r = Radius of gyration, cm.
P = 10.7 b h s, kN
b = Mean breadth, of the area supported, m.
s and h are to be as defined in 7.2.3.

7.2.6 The web of the transverse, the horizontal girder and the vertical web are to be efficiently stiffened and their face plates or flanges are to be properly supported by tripping brackets.

7.2.7 The lightening hole cut in the web of the primary supporting member is to be located at not less than 30 per cent of the depth of the web from the face plate and the corner of the notch and its diameter is not to exceed 25% of the depth of the web.

Figure 1.7.1: Unsupported span l for structural section

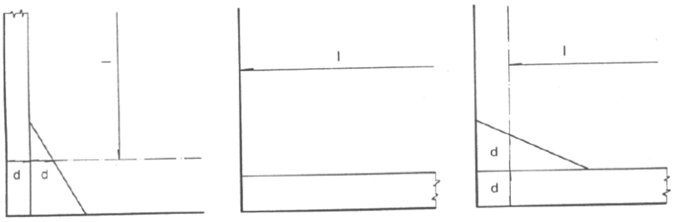
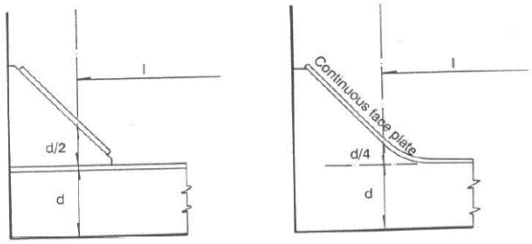


Figure 1.7.2: Unsupported span l for primary supporting member



SECTION 8 Structure at ends and structural details

8.1 Structural requirements beyond the cargo spaces and at the ends

8.1.1 The scantlings of the primary supporting members and the structural sections beyond the cargo spaces may be as required in way of the cargo oil spaces in association with the values of "h" in the various formulae measured to the upper deck, except:

(a) In way of deep tanks, the value of h for determining the scantlings of the structure is not to be less than the distance measured to the top of the overflow.

(b) In way of dry spaces:

  (i) The scantlings of the deck beams and longitudinals are to be as required in Part 3, Chapter 4, 2.2.1 and Chapter 5, 2.1.2.

  (ii) The section modulus of the deck transverses is to be obtained from the formula given in 7.2.3 by using:

  C = 6,0.

  h = As required in Part 3, Chapter 4, SECTION 2, 2.2.

8.1.2 For every oil tanker subject to Regulation 13 of MARPOL 73/78 Annex I, the strengthening of bottom forward is to be based on the draught obtained by using segregated ballast tanks only. (IACS UR S13 Rev. 2)

8.2 Structural details

8.2.1 All main structural members are to be so arranged that structural continuity is ensured.

8.2.2 The primary supporting members are as far as practicable, to be connected to one another so as to complete planes of stiffness.

8.2.3 If the edge of a primary supporting member is flanged, the arrangement at the junction of the member and the bracket is to be of careful design and execution.

8.2.4 The brackets of the primary supporting member are generally to be of the same thickness as the thinner of the two adjacent members.

8.2.5 Where members abut on both sides of the bulkhead or on other members, care is to be taken that they are properly aligned.

8.2.6 Where a bracket is attached to the unsupporting plating, a suitable arrangement is to adopted made to distribute the load effectively.

8.2.7 Notches are to have well-rounded corners and smooth edges and are not to be larger than necessary. When notches occur at such points as adjacent to the toe of a bracket where stress concentrations may develop, a welded collar or equivalent reinforcement is to be fitted. The collar is also to be fitted in way of the cross tie.

8.2.8 Small drain or air holes cut in the primary supporting members or the structural sections are to be kept clear of the toe of end brackets and their edges are to be well-rounded.

SECTION 9 Piping systems

9.1 General

9.1.1 For relevant requirements reference should be made to Part 5, Chapter 9, Section 14.

SECTION 10 Small tankers

10.1 General

10.1.1 Small tankers for the purpose of this Section are coastal tankers, bunkering boats and water tankers of less than 100 m in length. Unless otherwise mentioned in this Section, the requirements of SECTIONS 1-9 are applicable.

10.1.2 Small tankers may be framed either longitudinally or transversely, or a combined system may be adopted with the ship's sides being framed transversely and the bottom and strength deck longitudinally. For the strength deck, the longitudinal framing system should preferably be adopted.

10.1.3 Two oiltight longitudinal bulkheads, or else one oiltight centreline bulkhead, may be fitted, extending continuously through all cargo tanks from cofferdam to cofferdam.

10.1.4 The length of the cargo tanks shall not exceed:

$$L_t = 7 + 0{,}1 \cdot L, \qquad m$$

(See also SECTION 2)

10.2 Primary supporting members

10.2.1 The section modulus and the web sectional area of the following primary supporting members forming closed rings of support: centreline girder, side girders, bottom transverses, side transverses, girders at bulkheads, and stringers in way of cargo tanks are to be not less than:

$$SM = 4{,}32h \cdot s \cdot l^2 , \quad cm^3$$
$$A = 0{,}4 \cdot h \cdot s \cdot l^2 , \quad cm^2$$

where:

s = Spacing of primary supporting member, m.

l = Unsupported span of primary supporting members, m.

h = Distance, of load centre from top of overflow or from a point 2,4 m above tank top, whichever is the greater, m.

10.2.2 Where the primary supporting members mentioned in 10.2.1 do not form closed rings and are simply supported at one or both ends their section moduli and web sectional areas as per 10.2.1 are to be increased by 50 per cent.

10.2.3 The scantlings of deck transverses for longitudinal framing are to be determined in accordance with 7.2.3.

10.2.4 Deductions for navigation notations are not permitted for primary structural members.

10.3 Transverse framing

10.3.1 The section modulus of the transverse frames in the cargo tank area is obtained from the formula in 10.2.1, where s is the frame spacing in m.
The scantlings of the frame section are to be maintained throughout the whole depth D.

10.3.2 End attachments and connections

a) At their ends, the transverse frames are to be provided with flanged brackets. The bilge bracket is to fill the entire round of bilge and is to be connected to the adjacent bottom longitudinal. The bracket at the upper end of the frame is to be attached to the adjacent deck longitudinal.
b) Where the unsupported span is considerable, flats or brackets are to be fitted to support the frame against tripping. The transverse frames are to be attached to the stringers by means of flats or brackets extending to the face plate of the stringer in such a way that the lateral force of support is transmitted effectively.

10.4 Deck

10.4.1 The scantlings of the strength deck are to be as determined according to Part 3, Chapter 7.
The plate thickness is to be not less than:

$$t = s \cdot 10^3 /(85 - 0.15 \cdot L) , \ mm,$$ where longitudinal framing is adopted.

$$t = s \cdot 10^3 /(65 - 0.2 \cdot L), \ mm,$$ where transverse framing is adopted.

10.5 Shell plating

10.5.1 The thickness of the shell plating is to be determined according to Part 3, Chapter 6. The thickness of the shell plating is not to be less than the thickness required for tank bulkhead plating.

10.6 Longitudinals

10.6.1 The section modulus is to be determined according to Part 3, Chapter 5 and is not to be less than that according to 7.1.2.
10.6.2 Between 0,2L from forward and the forward cofferdam bulkhead the bottom longitudinal midway between the centreline girder and the side longitudinal bulkhead, as well as that midway between the side longitudinal bulkhead and the ship's side are to be increased in depth by 60 per cent. Additional bottom transverses of the same depth are to be fitted midway between the normal transverses.

10.7 Deck beams

10.7.1 The scantlings of the deck beams are to be determined according to Part 3, Chapter 4 and are to be not less than these obtained from Part 3, Chapter 9, SECTION 3, 3.1.

SECTION 11 Ships for the carriage of dry cargo or oil in bulk

11.1 General

11.1.1 For ships covered by this paragraph intended to carry dry cargo or oil in bulk, the regulations of this Section apply as well as the relevant regulations for the carriage of the respective dry cargo. For ships intended to also carry dry cargo in bulk the regulations of Chapter 4 of this Part also apply.

11.1.2 Dry cargo and liquid cargo with a flashpoint (closed cup test) of 60° and below are not to be carried simultaneously, excepting cargo oil contaminated water (slop) carried in slop tanks complying with 11.3.

11.1.3 Prior to employing the ship for the carriage of dry cargo the entire cargo area is to be cleaned and gas freed. Cleaning and repeated gas concentration measurements are to be carried out to ensure that dangerous gas concentrations do not occur within the cargo area during the dry cargo voyage.

11.1.4 In way of cargo holds for oil hollow spaces in which explosive gases may accumulate are to be avoided as far as possible.

11.1.5 Openings which may be used for cargo operations when bulk dry cargo is carried 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.

11.2 Reinforcements

11.2.1 In bulk or oil cargo holds the following requirements are to be fulfilled.

11.2.2 Frames
a) The scantlings of frames in oil cargo holds are to be determined according to Part 3, Chapter 9, SECTION 3, 3.1. Tripping brackets are to be fitted.
b) In cargo holds which may be partly filled frames may be required to be strengthened, depending on the filling ratio.

11.2.3 Cargo hold bulkheads
a) The scantlings of cargo hold bulkheads are to be determined according to Chapter 4, Section 5 of this Part as well as according to requirements for oil tankers. Their strength is also to comply with the requirements of Part 3, Chapter 9.

b) In cargo holds which may be partly filled the bulkheads may be required to be strengthened, depending on the filling ratio.

11.2.4 Hatchways

a) The scantlings of the hatchway covers are to be determined according to Part 3, Chapter 15.
b) Where cargo holds are intended to be partly filled the hatchway covers may be required to be strengthened, depending on the filling ratio and the location on board the ship.
c) The form and size of the hatchway covers and the sealing system shall be adapted to each other in order to avoid leakages caused by possible elastic deformations of the hatchways.

11.3 Slop tanks

11.3.1 The slop tanks are to be surrounded by cofferdams except where the boundaries of the slop tanks, where slop may be carried on dry cargo voyages, are the hull, main cargo deck, cargo pump room bulkhead or oil fuel bunker tank. These cofferdams are not to be open to double bottoms, pipe tunnels, the pump room or other enclosed spaces. Means are to be provided for filling the cofferdams with water and for draining them. Where the boundary of a slop tank is the cargo pump room bulkhead the pump room is not to be open to the double bottom, pipe tunnel or other enclosed space. However, openings provided with gastight bolted covers may be permitted.

11.3.2 Hatches and tank cleaning openings to slop tanks are only permitted on the open deck and shall be fitted with closing arrangements. Except where they consist of bolted plates with bolts at watertight spacing, these closing arrangements are to be provided with locking arrangements which must be under the control of the responsible ship's officer.

CHAPTER 2 Chemical Tankers

CONTENTS

SECTION 1 General

1.1 Classification

1.1.1 In accordance with Part 1, Chapter 2, 6.2.12 the Class notation **CHEMICAL TANKER** is to be assigned to vessels designed and specially fitted for the carriage of dangerous chemicals in bulk.

1.1.2 In addition to the applicable requirements of these Rules, the vessel is to comply with all requirements of the "International Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk" (International Bulk Chemical Code), as adopted by IMO resolution MSC. 4(48) on 17 June 1983, and amendments in force, except that personnel training is not within the scope of Classification. The vessel is also to comply with all relevant interpretations and amendments recommended by International Association of Classification Societies (IACS).

1.1.3 Several requirements contained in the IBC Code are not within the scope of Classification as defined in the Rules. Such requirements as ship survival capability (damage stability) and operational matters, are the responsibility of the National Authority or Administration responsible for issuing the Certificate of Fitness. When a vessel is issued an "International Certificate of Fitness for the Carriage of Dangerous Chemicals in Bulk" by the National Authority or Administration, such certificate will be accepted by LHR as evidence of compliance with the following requirements of the IBC Code:

- Damage assumptions.
- Flooding assumptions.
- Standard of damage.
- Survival requirements.

1.1.4 LHR does not require that ship survival capability or operational requirements be investigated for purposes of Classification. When authorized to issue a Certificate of Fitness, the Society will also be required to verify that the ship survival capability and location of cargo tanks requirements have been complied with, in addition to Classification requirements. In such cases, these requirements are deemed to be applicable for the purposes of Classification.

1.2 Class notations

1.2.1 Seagoing ships complying with the requirements of these Rules will be eligible to be assigned the Class notation **CHEMICAL TANKER** in association with a ship type notation and a list of defined cargoes.

1.2.2 Where a Certificate of Fitness has been issued by the Society, the notations ship type **1**, **2** or **3** will be assigned as appropriate.

1.2.3 Where a Certificate of Fitness is issued by the appropriate National Authority, the notations ship type **(1)**, **(2)** or **(3)** will be assigned. As the provisions outlined in 1.1.3 of these Rules are not required for Classification, a parenthesis indicates that the IBC Code requirements in these respects have not been verified by the Society for the purposes of Classification.

CHAPTER 3 Liquefied Gas Carriers

CONTENTS

SECTION 1 General

1.1 Classification

Currently LHR does not intend to classify Liquefied Gas Carriers. Therefore, this Chapter is intentionally left blank.

CHAPTER 4 Bulk or Ore Carriers

CONTENTS

SECTION 1 General

1.1 Application

1.1.1 The requirements of this Chapter apply to sea-going self-propelled ships with a single deck, either:

a) having double bottom, hopper side tanks and topside tanks and being of single skin construction and intended for carriage of dry cargoes in bulk (bulk carriers) (see Figure 4.1.1), or,
b) having two longitudinal bulkheads and a double bottom throughout the cargo region and intended for the carriage of ore cargoes in the centre holds only (ore carriers) (see Figure 4.1.2), or,
c) having two longitudinal bulkheads and a double bottom throughout the cargo region and intended for the carriage of ore cargoes in the centre holds or of oil cargoes in centre holds and wing tanks (ore or oil carriers) (see Figure 4.1.3), or,
d) having double bottom, hopper side tanks and topside tanks fitted below the upper deck, and being of double skin construction and intended for carriage of oil or dry cargoes, including ore, in bulk (OBOs) (see Figure 4.1.4).

1.2 Basic class notations

1.2.1 Ships complying with the requirements of this Chapter are to be surveyed according to the requirements of the Enhanced Survey Program and are to be assigned one of the following class notations, depending on their structural configuration:

BULK CARRIER:	ships described in 1.1.1(a)
ORE CARRIER:	ships described in 1.1.1(b)
ORE OR OIL CARRIER:	ships described in 1.1.1(c)
OIL/BULK/ORE (OBO) CARRIER:	ships described in 1.1.1(d)

Figure 4.1.1: Typical midship section of BULK CARRIER

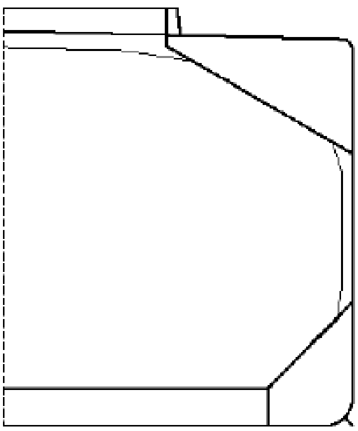


Figure 4.1.2: Typical midship section of ORE CARRIER

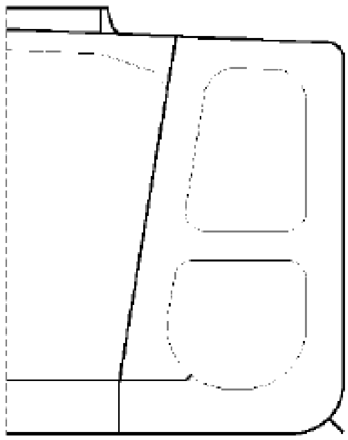


Figure 4.1.3: Typical midship section of ORE OR OIL CARRIERS

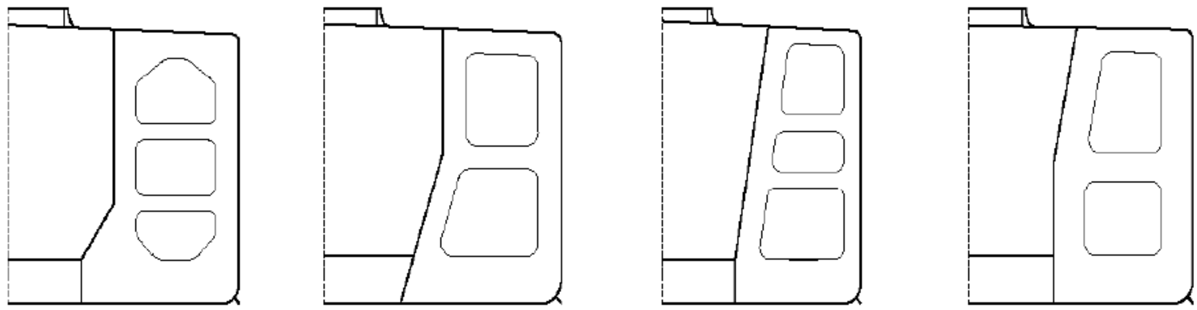
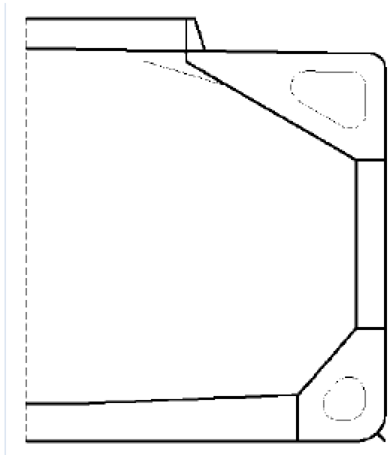


Figure 4.1.4: Typical midship section of OIL/BULK/ORE (OBO) CARRIER



1.3 Additional class notations

1.3.1 Requirements of 2.3.3 are to be applied to bulk carriers having length of 150 m or above and contracted for new construction on or after 1 July 2003.

1.4 Implementation of IACS Unified Requirements S19 (see subsection 6.4) and S22 (see subsection 3.5) for Existing Single Side Skin Bulk Carriers (IACS UR S23 Rev. 4)

1.4.1 Application and Implementation Timetable (see 1.4.1.1 to 1.4.1.6 for details)

a) 6.4 and 3.5 are to be applied in conjunction with the damage stability requirements set forth in 1.4.2. Compliance is required:

(i) for ships which were 20 years of age or more on 1 July 1998, by the due date of the first intermediate, or the due date of the first special survey to be held after 1 July 1998, whichever comes first;

(ii) for ships which were 15 years of age or more but less than 20 years of age on 1 July 1998, by the due date of the first special survey to be held after 1 July 1998, but not later than 1 July 2002;

(iii) for ships which were 10 years of age or more but less than 15 years of age on 1 July 1998, by the due date of the first intermediate, or the due date of the first special survey to be held after the date on which the ship reaches 15 years of age but not later than the date on which the ship reaches 17 years of age;

(iv) for ships which were 5 years of age or more but less than 10 years of age on 1 July 1998, by the due date, after 1 July 2003, of the first intermediate or the first special survey after the date on which the ship reaches 10 years of age, whichever occurs first;
(v) for ships which were less than 5 years of age on 1 July 1998, by the date on which the ship reaches 10 years of age.

b) Completion prior to 1 July 2003 of an intermediate or special survey with a due date after 1 July 2003 cannot be used to postpone compliance. However, completion prior to 1 July 2003 of an intermediate survey the window for which straddles 1 July 2003 can be accepted.

1.4.1.1 Surveys to be held
The term "survey to be held" is interpreted to mean that the survey is "being held" until it is "completed".

1.4.1.2 Due dates and completion allowance
a) Intermediate survey:
   1) Intermediate survey carried out either at the second or third annual survey: 3 months after the due date (i.e. 2nd or 3rd anniversary) can be used to carry out and complete the survey;
   2) Intermediate survey carried out between the second and third annual survey: 3 months after the due date of the 3rd Annual Survey can be used to carry out and complete the survey;

b) Special Survey: 3 months extension after the due date may be allowed subject to the terms / conditions of IACS PR 4;

c) ships controlled by “1 July 2002”: same as for special survey;

d) ships controlled by ”age 15 years” or “age 17 years”: same as for special survey.

1.4.1.3 Intermediate Survey Interpretations/Applications
a) If the 2nd anniversary is prior to or on 1 July 1998 and the intermediate survey is completed prior to or on 1 July 1998, the ship need not comply until the next special survey.
b) If the 2nd anniversary is prior to or on 1 July 1998 and the intermediate survey is completed within the window of the 2nd annual survey but after 1 July 1998, the ship need not comply until the next special survey.
c) If the 2nd anniversary is prior to or on 1 July 1998 and the intermediate survey is completed outside the window of the 2nd annual survey and after 1 July 1998, it is taken that the intermediate survey is held after 1 July 1998 and between the second and third annual surveys. Therefore, the ship shall comply no later than 3 months after the 3rd anniversary.
d) If the 2nd anniversary is after 1 July 1998 and the intermediate survey is completed within the window of the 2nd annual survey but prior to or on 1 July 1998, the ship need not comply until the next special survey
e) If the 3rd anniversary is prior to or on 1 July 1998 and the intermediate survey is completed prior to or on 1 July 1998, the ship need not comply until the next special survey.
f) If the 3rd anniversary is prior to or on 1 July 1998 and the intermediate survey is completed within the window of the 3rd annual survey but after 1 July 1998, the ship need not comply until the next special survey.
g) If the 3rd anniversary is after 1 July 1998 and the intermediate survey is completed within the window prior to or on 1 July 1998, the ship need not comply until the next special survey.

1.4.1.4 Special Survey Interpretations/Applications
If the due date of a special survey is after 1 July 1998 and the special survey is completed within the 3-month window prior to the due date and prior to or on 1 July 1998, the ship need not comply until the next relevant survey (i.e. special survey for ships under 20 years of age on 1 July 1998, intermediate survey for ships 20 years of age or more on 1 July 1998).

1.4.1.5 Early Completion of an Intermediate Survey (coming due after 1 July 1998 to postpone compliance is not allowed):

(a) Early completion of an intermediate survey means completion of the survey prior to the opening of the window (i.e. completion more than 3 months prior to the 2nd anniversary since the last special survey).

(b) The intermediate survey may be completed early and credited from the completion date but in such a case the ship will still be required to comply not later than 3 months after the 3^{rd} anniversary.

1.4.1.6 Early Completion of a Special Survey (coming due after 1 July 1998 to postpone compliance is not allowed):

(a) Early completion of a special survey means completion of the survey more than 3 months prior to the due date of the special survey.

(b) The special survey may be completed early and credited from the completion date, but in such a case the ship will still be required to comply by the due date of the special survey.

1.4.2 Damage Stability

(a) Bulk carriers which are subject to compliance with 6.4 and 3.5 shall, when loaded to the summer loadline, be able to withstand flooding of the foremost cargo hold in all loading conditions and remain afloat in a satisfactory condition of equilibrium, as specified in SOLAS regulation XII/4.3 to 4.7.

(b) A ship having been built with an insufficient number of transverse watertight bulkheads to satisfy this requirement may be exempted from the application of 6.4 and 3.5 and this requirement provided the ship fulfils the requirement in SOLAS regulation XII/9.

1.5 Structural configuration

1.5.1 Slop tanks of sufficient capacity are to be fitted. The slop tanks are to be surrounded by cofferdams which are to be capable of being flooded, except where the adjacent space is used as a pump room, fuel tank or cargo tank for oil or water ballast only.

1.5.2 Suitable arrangements for gas-freeing the double bottom, the hopper, side and topside tanks are to be provided. Similar arrangements are to be provided for cargo oil ducts which are used as pipe tunnels when the ship is carrying dry cargo.

1.5.3

(a) Manholes are not to be cut in the inner bottom in way of cargo holes. Access to the double bottom is to be provided from the exposed deck by trunks led down the oiltight bulkheads, or via double plate bulkheads. Alternative proposals will, however, be considered provided that the integrity of the inner bottom is maintained.

(b) Pipe tunnels and duct keels, to which access is normally required for operational purposes, are to be provided with means of access at each end and at least one other point at approximately mid-length of the tunnel or duct keel. Access openings are to be from positions inside a pump room or deep cofferdam provided an oiltight closure is fitted, or from a trunk led to the open deck. Similar arrangements are to be provided for cargo oil ducts which are used as pipe tunnels when the ship is carrying dry cargo.

1.5.4 Mechanical ventilation of the pipe tunnel is to be provided, and a notice board is to be fitted at each entrance to the tunnel stating that before any attempt is made to enter, the ventilating fan should have been in operation for an adequate period. In addition, the atmosphere in the tunnel should be sampled by a reliable gas monitor, and where an inert gas system is fitted in cargo tanks, an oxygen monitor should also be provided.

1.5.5 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 such openings are equipped with alternative approved means to ensure equivalent integrity.

1.5.6 Individual consideration may be required when the ship is fitted with double hull construction, large deck openings, or other special design features.

1.5.7 Longitudinal framing is to be adopted for the deck and the bottom whereas the sides may be either longitudinally or transversely framed. In addition, the sloped bulkheads of wing tanks.

1.6 Information required

1.6.1 In addition to the information and plans required in Part 3, the following are to be submitted:

- Cargo loadings on decks, hatchways and inner bottom if these are to be in excess of Rule requirements.
- The maximum pressure head in service on tanks, also details of any double bottom tanks interconnected with hopper and topside tanks.
- Details of the proposed depths of any partial fillings where water ballast or liquid cargo is intended to be carried in the holds.

SECTION 2 Longitudinal strength

2.1 General

2.1.1 Longitudinal strength calculations are to be made in accordance with Part 3, Chapter 2.

2.1.2 The combined still water and wave shear forces on the hull structure are to be investigated as for all ships and the scantlings and the structural arrangements are to be such that a shear stress of 120 N/mm² will never be exceeded.

2.1.3 Longitudinal framing is to be adopted for the deck and the arrangement of the structure between the hatches is to be such as to ensure continuity of the main deck to resist athwartship forces. In general transverse stiffening should be arranged.

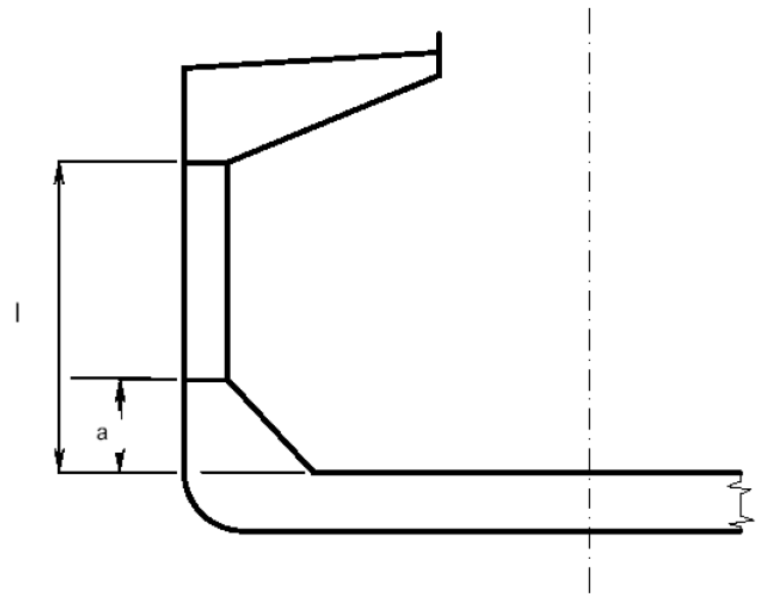
2.1.4 The scantlings of the deck structure such as plating thickness and required section moduli for girders and webs are to be in accordance with Part 3, Chapter 5 and Chapter 7.

2.1.5 Where the difference between the thickness of plating inside and outside the line of main hatches is more than 12 mm, a transitional plate of thickness equivalent to the adjacent plate thickness is to be fitted. The plate thickness outside the line of hatches is to be continued inboard between hatches beyond the end of the hatch corner curvature, to ensure that the chamfered plating is clear of the corner tangent point.

2.1.6 The thickness of the side shell plating is to be as required in Part 3, Chapter 6 and SECTION 4 of present Part.

2.1.7 The side shell may be longitudinally or transversely framed. The scantlings of the main frames in holds are to be in compliance with Part 3, Chapter 4, SECTION 1, 1.3 but with l and a as given in Figure 4.2.1. Requirements of SECTION 4 of present Part are also to be complied with.

Figure 4.2.1:



2.2 Longitudinal Strength of Hull Girder in flooded condition for Bulk Carriers (IACS UR S17 Rev.10)

2.2.1 General

The requirements of the present subsection are to be applied to non-CSR bulk carriers of 150 m in length and upwards, intending to carry solid bulk cargoes having a density of 1,0 t/m^3 or above, and with,

(a) Single side skin construction, or
(b) Double side skin construction in which any part of longitudinal bulkhead 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

which are contracted for construction from a date commencing not later than 1 July 2020.

Such ships are to have their hull girder strength checked for specified flooded conditions, in each of the cargo and ballast loading conditions defined in Part 3, Chapter 2, and in every other condition considered in the intact longitudinal strength calculations, including those according to Part 3, Chapter 2, SECTION 2, except that harbour conditions, docking condition afloat, loading and unloading transitory conditions in port and loading conditions encountered during ballast water exchange need not be considered.

2.2.2 Flooding conditions

2.2.2.1 Floodable holds

Each cargo hold is to be considered individually flooded up to the equilibrium waterline. This application is to be applied to self-unloading bulk carriers (SUBC) where the unloading system maintains the watertightness during seagoing operations. In SUBCs with unloading systems that do not maintain watertightness, the longitudinal strength in the flooded conditions are to be considered using the extent to which the flooding may occur.

2.2.2.2 Loads

The still water loads in flooded conditions are to be calculated for the above cargo and ballast loading conditions.

The wave loads in the flooded conditions are assumed to be equal to 80% of those given in Part 3, Chapter 2.

2.2.3 Flooding criteria

To calculate the weight of entered water, the following assumptions are to be made:

(a) The permeability of empty cargo spaces and volume left in loaded cargo spaces above any cargo is to be taken as 0,95.

(b) Appropriate permeabilities and bulk densities are to be used for any cargo carried. For iron ore, a minimum permeability of 0,3 with a corresponding bulk density of 3,0 t/m³ is to be used. For cement, a minimum permeability of 0,3 with a corresponding bulk density of 1,3 t/m³ is to 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.

2.2.4 Stress assessment

The actual hull girder bending stress σ_{fld} at any location is given by:

$$\sigma_{fld} = \frac{M_{sf} + 0{,}8 \cdot M_{WV}}{W} \cdot 10^3, \qquad N/mm^2,$$

where:

M_{sf} = still water bending moment in the flooded conditions for the section under consideration, kN-m,

M_{WV} = vertical wave bending moment as given in Part 3, Chapter 2, SECTION 3, 3.3.1 for the section under consideration, kN-m,

W_z = section modulus for the corresponding location in the hull girder, in cm³.

The shear strength of the side shell and the inner hull (longitudinal bulkhead) if any, at any location of the ship, is to be checked according to the requirements specified in Part 3, Chapter 2, SECTION 4, 4.3 in which F_S and F_W are to be replaced respectively by F_{SF} and F_{WF}, where:

F_{SF} = still water shear force in the flooded conditions for the section under consideration, kN

F_{WF} = 0.8 F_W

F_W = wave shear force as given in Part 3, Chapter 2, SECTION 3, 3.3.2 for the section under consideration, kN

2.2.5 Strength criteria

The damaged structure is assumed to remain fully effective in resisting the applied loading.
Permissible stress and axial stress buckling strength are to be in accordance with Part 3, Chapter 2.

SECTION 3 Bottom structure

3.1 General

3.1.1 The scantlings of the double bottom structure are to be in accordance with Part 3, Chapter 3 together with the requirements of this Section.

3.2 Floors and transverses

3.2.1 In general, transverse floors under the cargo holds are to be spaced not more than 3 m apart and their thickness is to be as required by Part 3, Chapter 3, SECTION 2.

3.3 Inner bottom

3.3.1 The double bottom is, in general, to be longitudinally framed, but special consideration will be given to proposals for a transverse framing system.

3.3.2 The requirements of Part 3, Chapter 3 are to be applied, together with the requirements of this Section.

3.3.3 For all bulk carriers where bulk cargoes are discharged by grabs the maximum recommended unladen weight of the grab corresponding to the approved inner bottom plating thickness is to be calculated using the following formula:

$$P = \left(\frac{s}{k}\right)^2 \cdot \frac{10^d}{1{,}775}, \qquad \text{tonnes}$$

where:

d = $\frac{40{,}875 \cdot (t-1{,}5) \cdot \sqrt{k} + 344{,}5}{s} - 5{,}7633$
P = unladen grab weight, in tonnes
s = spacing of inner bottom longitudinal, in mm
k = material factor as defined in Part 3, Chapter 2, 4.2.1.
t = thickness of inner bottom plating, in mm

The maximum recommended unladen weight of the grab rounded up to the next tonne above, is to be recorded in the Loading Manual, and does not preclude the use of heavier grabs. It is intended as an indication to the builders, owners and operators of the increased risk of local damage and the possibility of accelerated diminution of the plating thickness if grabs heavier than this are used regularly to discharge cargo.

3.4 Evaluation of Allowable Hold Loading for Bulk Carriers Considering Hold Flooding (IACS UR S20 Rev.6)

3.4.1 Application and definitions

These requirements are to be complied with in respect of the flooding of any cargo hold of bulk carriers, as defined in Part 3, Chapter 2, SECTION 3, 3.3, of 150m in length and above, and with,

(a) Single side skin construction, or
(b) double side skin construction, in which any part of longitudinal bulkhead 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,

which are contracted for construction from a date commencing not later than 1 July 2006

The loading in each hold is not to exceed the allowable hold loading in flooded condition, calculated as per 3.4.4, using the loads given in 3.4.2 and the shear capacity of the double bottom given in 3.4.3.

In no case is the allowable hold loading, considering flooding, to be taken greater than the design hold loading in intact condition.

3.4.2 Loading model

3.4.2.1 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.

The most severe combinations of cargo induced loads and flooding loads are to be used, depending on the loading conditions included in the loading manual:

- homogeneous loading conditions,
- non homogeneous loading conditions,
- packed cargo conditions (such as steel mill products).

For each loading condition, the maximum bulk cargo density to be carried is to be considered in calculating the allowable hold loading limit.

3.4.2.2 Inner bottom flooding head

The flooding head h_f (see Figure 4.3.1) is the distance, in m, measured vertically with the ship in the upright position, from the inner bottom to a level located at a distance d_f, in m, from the baseline equal to:

a) in general:
- D for the foremost hold
- 0,9·D for the foremost hold

b) for ships less than 50.000 tonnes deadweight with Type B freeboard:
- 0,95·D for the foremost hold
- 0,85·D for the other holds

where:

D = the distance from the baseline to the freeboard deck at side amidship (see Figure 4.3.1), m.

3.4.3 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 (see Figure 4.3.2).
- all double bottom girders adjacent to either stools, or transverse bulkheads if no stool is fitted.

Where in the end holds, girders or floors run out and are not directly attached to the boundary stool or hopper girder, their strength is to be evaluated for the one end only.

Note that 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 are not to be included.

When the geometry and/or the structural arrangement of the double bottom are such to make the above assumptions inadequate, to the Society's discretion, the shear capacity C of double bottom is to be calculated according to the Society's criteria.

In calculating the shear strength, the net thickness of floors and girders is to be used. The net thickness t_{net} is given by:

$$t_{net} = t - 2{,}5, \qquad \text{mm}$$

where:

t = thickness of floors and girders, mm.

3.4.3.1 Floor shear strength

The floor shear strength in way of the floor panel adjacent to hoppers S_{f1} 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} are given by the following expressions:

$$S_{f1} = 10^{-3} \cdot A_f \cdot \tau_a/\eta_1 \,, \qquad kN$$

$$S_{f2} = 10^{-3} \cdot A_{f,h} \cdot \tau_a/\eta_2 \,, \qquad kN$$

where:

A_f = sectional area of the floor panel adjacent to hoppers, mm²

$A_{f,h}$ = net sectional area of the floor panels in way of the openings in the outmost bay (i.e. that bay which is closer to hopper), mm²

τ_a = allowable shear stress to be taken equal to the lesser of

$$\tau_a = \frac{162 \cdot \sigma_F^{0,6}}{\left(\frac{s}{t_{net}}\right)^{0,8}} \,, \ N/mm^2 \ \text{ and } \ \tau_a = \frac{\sigma_F}{\sqrt{3}}, \ N/mm^2$$

For floors adjacent to the stools or transverse bulkheads, as identified in 3.4.3, τ_a may be taken $\frac{\sigma_F}{\sqrt{3}}$,

where:

σ_F = minimum upper yield stress of the material, N/mm²

s = spacing of stiffening members of panel under consideration, mm

η_1 = 1,10

η_2 = 1,20

η_2 may be reduced, to the Society's discretion, down to 1,10 where appropriate reinforcements are fitted to the Society's satisfaction.

3.4.3.2 Gear shear strength

The girder shear strength in way of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted) S_{g1}, in kN, and the girder shear strength in way of the largest opening in the outmost bay (i.e. that bay which is closer to stool, or transverse bulkhead, if no stool is fitted) S_{g2}, in kN, are given by the following expressions:

$$S_{g1} = 10^{-3} \cdot A_g \cdot \tau_a/\eta_1 \,, \qquad kN$$

$$S_{g2} = 10^{-3} \cdot A_{g,h} \cdot \tau_a/\eta_2 \,, \qquad kN$$

where:

A_g = minimum sectional area of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted), mm²

$A_{g,h}$ = net sectional area of the girder panel in way of the largest opening in the outmost bay (i.e. that bay which is closer to stool, or transverse bulkhead, if no stool is fitted), mm²

τ_a = allowable shear stress given in 3.4.3.1, N/mm²

η_1 = 1,10

η_2 = 1,15

η_2 may be reduced, to the Society's discretion, down to 1,10 where appropriate reinforcements are fitted to the Society's satisfaction.

3.4.4 Allowable hold loading

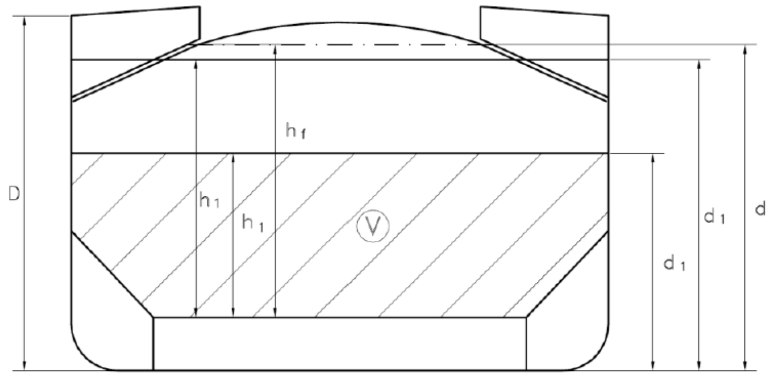
The allowable hold loading W, in tonnes, is given by:

$$W = \rho_c \cdot V \cdot \frac{1}{F}$$

where:

F	=	1,1 in general
	=	1,05 for steel mill products
ρ_c	=	cargo density for bulk cargoes see 3.4.2.1; for steel products, ρ_c is to be taken as the density of steel, t/m^3
V	=	volume occupied by cargo at a level h_1, m^3
h_1	=	$\frac{X}{\rho_c \cdot g}$
X	=	for bulk cargoes the lesser of X_1 and X_2 given by:
X_1	=	$\frac{Z + \rho \cdot g \cdot (E - h_f)}{1 + \frac{\rho}{\rho_c}(perm - 1)}$
X_2	=	$Z + \rho \cdot g \cdot (E - h_f \cdot perm)$
X	=	for steel products, X may be taken as X_1, using perm = 0
ρ	=	sea water density, t/m^3
g	=	9,81 m/s^2, gravity acceleration
E	=	ship immersion for flooded hold condition = d_f – 0,1·D, m
d_f, D	=	as given in 3.4.2.2
h_f	=	flooding head as defined in 3.4.2.2, in m,
perm	=	cargo permeability, (i.e. the ratio between the voids within the cargo mass and the volume occupied by the cargo); it needs not be taken greater than 0,3.
Z	=	the lesser of Z_1 and Z_2 given by:
Z_1	=	$\frac{C_h}{A_{DB,h}}$
Z_2	=	$\frac{C_e}{A_{DB,e}}$
C_h	=	shear capacity of the double bottom as defined in 3.4.3, considering, for each floor, the lesser of the shear strengths S_{f1} and S_{f2} (see 3.4.3.1) and, for each girder, the lesser of the shear strengths S_{g1} and S_{g2} (see 3.4.3.2), kN,
C_e	=	shear capacity of the double bottom as defined in 3.4.3, considering, for each floor, the shear strength S_{f1} (see 3.4.3.1) and, for each girder, the lesser of the shear strengths S_{g1} and S_{g2} (see 3.4.3.2), kN,
$A_{DB,h}$	=	$\sum_{i=1}^{i=n} S_i \cdot B_{DB,i}$
$A_{DB,e}$	=	$\sum_{i=1}^{i=n} S_i \cdot (B_{DB} - S_1)$
n	=	number of floors between stools (or transverse bulkheads, if no stool is fitted)
S_i	=	space of ith-floor, m
$B_{DB,i}$	=	$B_{DB} - s_1$ for floors whose shear strength is given by S_{f1} (see 3.4.3.1)
	=	$B_{DB,h}$ for floors whose shear strength is given by S_{f2} (see 3.4.3.1)
B_{DB}	=	breadth of double bottom between hoppers (see Figure 4.3.3), m
$B_{DB,h}$	=	distance between the two considered opening (see Figure 4.3.3), m
s_1	=	spacing of double bottom longitudinals adjacent to hoppers, m

Figure 4.3.1:



V = Volume of cargo

Figure 4.3.2:

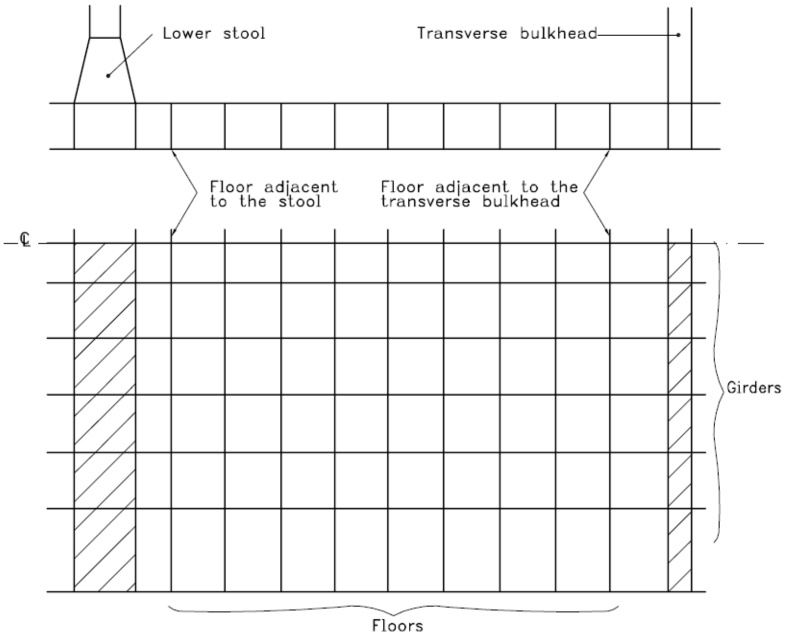
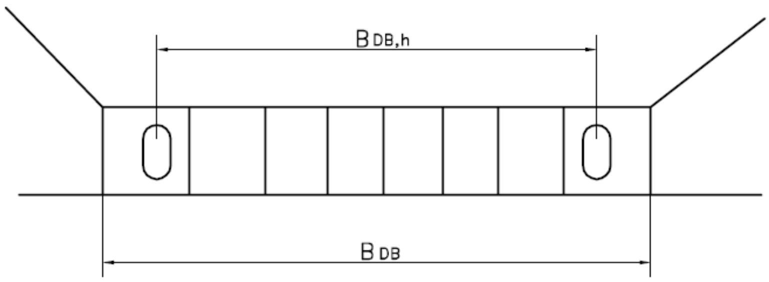


Figure 4.3.3:



3.5 Evaluation of Allowable Hold Loading of Cargo Hold No. 1 with Cargo Hold No. 1 Flooded, for Existing Bulk Carriers (IACS UR S22 Rev. 3)

3.5.1 Application and definitions

These requirements apply to all bulk carriers of 150 m in length and above, in the foremost hold, intending to carry solid bulk cargoes having a density of 1,78 t/m^3, or above, with single deck, topside tanks and hopper tanks, where:

a) the foremost hold is bounded by the side shell only for ships, which were contracted for construction prior to 1 July 1998, and have not been constructed in compliance with 3.4.
b) the foremost hold is double side skin construction less than 760 mm breadth measured perpendicular to the side shell in ships, the keels of which were laid, or which were at a similar stage of construction, before 1 July 1999 and have not been constructed in compliance with 3.4.

Early completion of a special survey coming due after 1 July 1998 to postpone compliance is not allowed.

The loading in cargo hold No. 1 is not to exceed the allowable hold loading in the flooded condition, calculated as per 3.5.4, using the loads given in 3.5.2 and the shear capacity of the double bottom given in 3.5.3.

In no case, the allowable hold loading in flooding condition is to be taken greater than the design hold loading in intact condition.

3.5.2 Load model

3.5.2.1 General

The loads to be considered as acting on the double bottom of hold No.1 are those given by the external sea pressures and the combination of the cargo loads with those induced by the flooding of hold No.1.

The most severe combinations of cargo induced loads and flooding loads are to be used, depending on the loading conditions included in the loading manual:

- homogeneous loading conditions;
- non-homogeneous loading conditions;
- packed cargo conditions (such as steel mill products).

For each loading condition, the maximum bulk cargo density to be carried is to be considered in calculating the allowable hold limit.

3.5.2.2 Inner bottom flooding head

The flooding head h_f (see Figure 4.3.4) is the distance, in m, measured vertically with the ship in the upright position, from the inner bottom to a level located at a distance d_f, in m, from the baseline equal to:

- D in general
- $0{,}95 \cdot D$ for ships less than 50.000 tonnes deadweight with Type B freeboard.

where:

D = the distance, in m, from the baseline to the freeboard deck at side amidship (see Figure 4.3.4).

3.5.3 Shear capacity of the double bottom of hold No. 1

The shear capacity C of the double bottom of hold No. 1 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 (see Figure 4.3.2).

– all double bottom girders adjacent to both stools, or transverse bulkheads if no stool is fitted.

The strength of girders or floors, which run out and are not directly attached to the boundary stool or hopper girder, is to be evaluated for the one end only.

Note that 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 are not to be included. When the geometry and/or the structural arrangement of the double bottom are such to make the above assumptions inadequate, to the Society's discretion, the shear capacity C of the double bottom is to be calculated according to the Society's criteria.

In calculating the shear strength, the net thicknesses of floors and girders are to be used. The net thickness t_{net} is given by:

$$t_{net} = t - t_c, \qquad mm$$

where:
t = as built thickness of floors and girders, mm
t_c corrosion diminution, equal to 2 mm, in general; a lower value of t_c may be adopted, provided that measures are taken, to the Society's satisfaction, to justify the assumption made

3.5.3.1 Floor shear strength
The floor shear strength in way of the floor panel adjacent to hoppers S_{f1} and the floor shear strength in way of the openings in the "outermost" bay (i.e. that bay which is closest to hopper) S_{f2} are given by the following expressions:

$$S_{f1} = 10^{-3} \cdot A_f \cdot \tau_a / \eta_1 , \qquad kN$$

$$S_{f2} = 10^{-3} \cdot A_{f,h} \cdot \tau_a / \eta_2 , \qquad kN$$

where:
A_f = sectional area of the floor panel adjacent to hoppers, mm²
$A_{f,h}$ = net sectional area of the floor panels in way of the openings in the "outermost" bay (i.e. that bay which is closest to hopper), mm²
τ_a = allowable shear stress, in N/mm², to be taken equal to:

$$\frac{\sigma_f}{\sqrt{3}}, \qquad N/mm^2$$

σ_F = minimum upper yield stress of the material, N/mm²
η_1 = 1,10
η_2 = 1,20
η_2 may be reduced, at the Society's discretion, down to 1,10 where appropriate reinforcements are fitted to the Society's satisfaction

3.5.3.2 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_{g1} and the girder shear strength in way of the largest opening in the "outermost" bay (i.e. that bay which is closest to stool, or transverse bulkhead, if no stool is fitted) S_{g2} are given by the following expressions:

$$S_{g1} = 10^{-3} \cdot A_g \cdot \frac{\tau_\alpha}{\eta_1}, \qquad kN$$

$$S_{g2} = 10^{-3} \cdot A_{g,h} \cdot \frac{\tau_\alpha}{\eta_2}, \qquad kN$$

where:

A_g = minimum sectional area of the girder panel adjacent to stools (or transverse bulkheads, if no stool is fitted), mm^2

$A_{g,,h}$ = net sectional area of the girder panel in way of the largest opening in the "outermost" bay (i.e. that bay which is closest to stool, or transverse bulkhead, if no stool is fitted), mm^2

τ_a = allowable shear stress as given in 3.5.3.1, N/mm^2

η_1 = 1,10

η_2 = 1,15

η_2 may be reduced, at the Society's discretion, down to 1,10 where appropriate reinforcements are fitted to the Society's satisfaction

3.5.4 Allowable hold loading

The allowable hold loading W is given by:

$$W = \rho_c \cdot V \cdot 1/F, \qquad t$$

where:

F = 1,05 in general

= 1,00 for steel mill products

ρc = cargo density; for bulk cargoes see 3.5.2.1 for steel products, p_c is to be taken as the density of steel, t/m^3

v = volume occupied by cargo at a level h_1, in m^3

h1 = $X/(\rho_c \cdot g)$

X = for bulk cargoes, the lesser of X_1 and X_2 given by

$$X_1 = \frac{Z + \rho \cdot g \cdot (E - h_f)}{1 + \frac{\rho}{\rho_c}\,(perm - 1)}$$

$$X_2 = Z + \rho \cdot g \cdot (E - h_f \cdot perm)$$

X = for steel products, X may be taken as X_1, using perm = 0

ρ = sea water density, t/m^3

g = 9,81 m/s^2, gravity acceleration

E = d_f -0,1·D

d_f,D = as given in 3.5.2.2

h_f = flooding head as defined in 3.5.2.2, m

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).

Z = the lesser of Z_1 and Z_2 given by:

$$Z_1 = \frac{C_h}{A_{DB,h}}$$

$$Z_2 = \frac{C_e}{A_{DB,e}}$$

C_h = shear capacity of the double bottom as defined in 3.5.3, considering, for each floor, the lesser of the shear strengths S_{f1} and S_{f2} (see 3.5.3.1) and, for each girder, the lesser of the shear strengths S_{g1} and S_{g2} (see 3.5.3.2), kN,

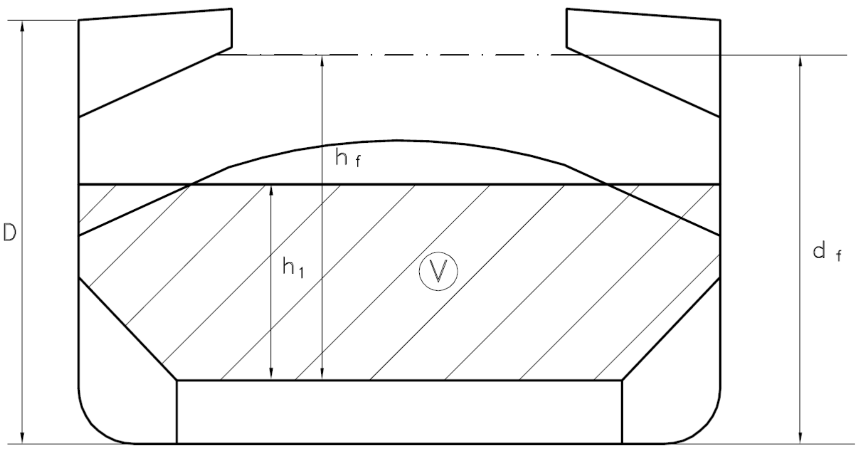
C_e = shear capacity of the double bottom as defined in 3.5.3, considering, for each floor, the shear strength S_{f1} (see 3.5.3.1) and, for each girder, the lesser of the shear strengths S_{g1} and S_{g2} (see 3.5.3.2), kN,

$$\mathbf{A_{DB,h}} = \sum_{I=1}^{i=n} \mathbf{S_i} \cdot \mathbf{B}_{DB,I}$$

$$\mathbf{A_{DB,e}} = \sum_{I=1}^{i=n} \mathbf{S}_i \cdot \mathbf{B}_{DB} - s$$

n = Number of floors between stools (or transverse bulkheads, if no stool is fitted)
S_i = space of ith-floor, m
$B_{DB,i}$ = B_{DB} – s , for floors whose shear strength is given by Sf1 (see 3.4.3.1)
$B_{DB,i}$ = $B_{DB,h}$, for floors whose shear strength is given by S_{f2} (see 3.4.3.1)
B_{DB} = breadth of double bottom between hoppers (see Figure 4.3.3) , m,
$B_{DB,h}$ = distance between the two considered opening (see Figure 4.3.3), m,
S = spacing of double bottom longitudinals adjacent to hoppers, m,

Figure 4.3.4:



V = Volume of cargo

SECTION 4 Side structures

4.1 Side structures in single side skin bulk carriers (IACS UR S12 Rev. 5)

4.1.1 Application and definitions
These requirements apply to side structures of cargo holds bounded by the side shell only of bulk carriers constructed with single deck, topside tanks and hopper tanks in cargo spaces intended primarily to carry dry cargo in bulk, which are contracted for construction on or after 1st July 1998.

4.1.2 Scantlings of side structures
The thickness of the side shell plating and the section modulus and shear area of side frames are to be determined according to the Society's criteria.

The scantlings of side hold frames immediately adjacent to the collision bulkhead are to be increased in order to prevent excessive imposed deformation on the shell plating. As an alternative, supporting structures are to be fitted which maintain the continuity of forepeak stringers within the foremost hold.

4.1.3 Minimum thickness of frame webs
The thickness of frame webs within the cargo area is not to be less than $t_{w,min}$ in mm, given by:

$$t_{w,min} = C \cdot (7{,}0 + 0{,}03 \cdot L)$$

C = 1,15 for the frame webs in way of the foremost hold;
1,0 for the frame webs in way of other holds.

where:

L = the Rule length, as defined in Part 3, Chapter 1, SECTION 3, 3.2.1 but need not be taken greater than 200m, m

4.1.4 Lower and upper brackets

The thickness of the frame lower brackets is not to be less than the greater of t_w and $t_{w,min}$+ 2 mm, where t_w is the fitted thickness of the side frame web. The thickness of the frame upper bracket is not to be less than the greater of t_w and $t_{w,min}$.

The section modulus SM of the frame and bracket or integral bracket, and associated shell plating, at the locations shown in Figure 4.4.1, is not to be less than twice the section modulus SM_F required for the frame midspan area.

The dimensions of the lower and upper brackets are not to be less than those shown in Figure 4.4.2.

Structural continuity with the upper and lower end connections of side frames is to be ensured within topsides and hopper tanks by connecting brackets as shown in Figure 4.4.3. The brackets are to be stiffened against buckling according to the Society's criteria.

The section moduli of the side longitudinals and sloping bulkhead longitudinals which support the connecting brackets are to be determined according to the Society's criteria with the span taken between transverses. Other arrangements may be adopted at the Society's discretion. In these cases, the section moduli of the side longitudinals and sloping bulkhead longitudinals are to be determined according to the Society's criteria for the purpose of effectively supporting the brackets.

4.1.5 Side frame sections

Frames are to be fabricated symmetrical sections with integral upper and lower brackets and are to be arranged with soft toes.

The side frame flange is to be curved (not knuckled) at the connection with the end brackets. The radius of curvature is not to be less than r given by:

$$r = \frac{0{,}4 \cdot b_f^2}{t_f}, \qquad mm$$

where:

b_f, t_f = the flange width and thickness of the brackets, respectively, mm. The end of the flange is to be sniped.

In ships less than 190 m in length, mild steel frames may be asymmetric and fitted with separate brackets. The face plate or flange of the bracket is to be sniped at both ends. Brackets are to be arranged with soft toes.

The web depth to thickness ratio of frames is not to exceed the following values:

- $60 \cdot k^{0,5}$ for symmetrically flanged frames
- $50 \cdot k^{0,5}$ for asymmetrically flanged frames

where:

k = 1,0 for ordinary hull structural steel and k < 1 for higher tensile steel according to Part 3, Chapter 2, SECTION 4, 4.2.1.

The outstanding flange is not to exceed $10 \cdot k^{0,5}$ times the flange thickness.

4.1.6 Tripping brackets

In way of the foremost hold, side frames of asymmetrical section are to be fitted with tripping brackets at every two frames, as shown in Figure 4.4.4.

4.1.7 Weld connections of frames and end brackets

Double continuous welding is to be adopted for the connections of frames and brackets to side shell, hopper and upper wing tank plating and web to face plates.

For this purpose, the weld throat is to be (see Figure 4.4.1):

- $0{,}44 \cdot t$ in zone "a"
- $0{,}4 \cdot t$ in zone "b"

where:

t = the thinner of the two connected members.

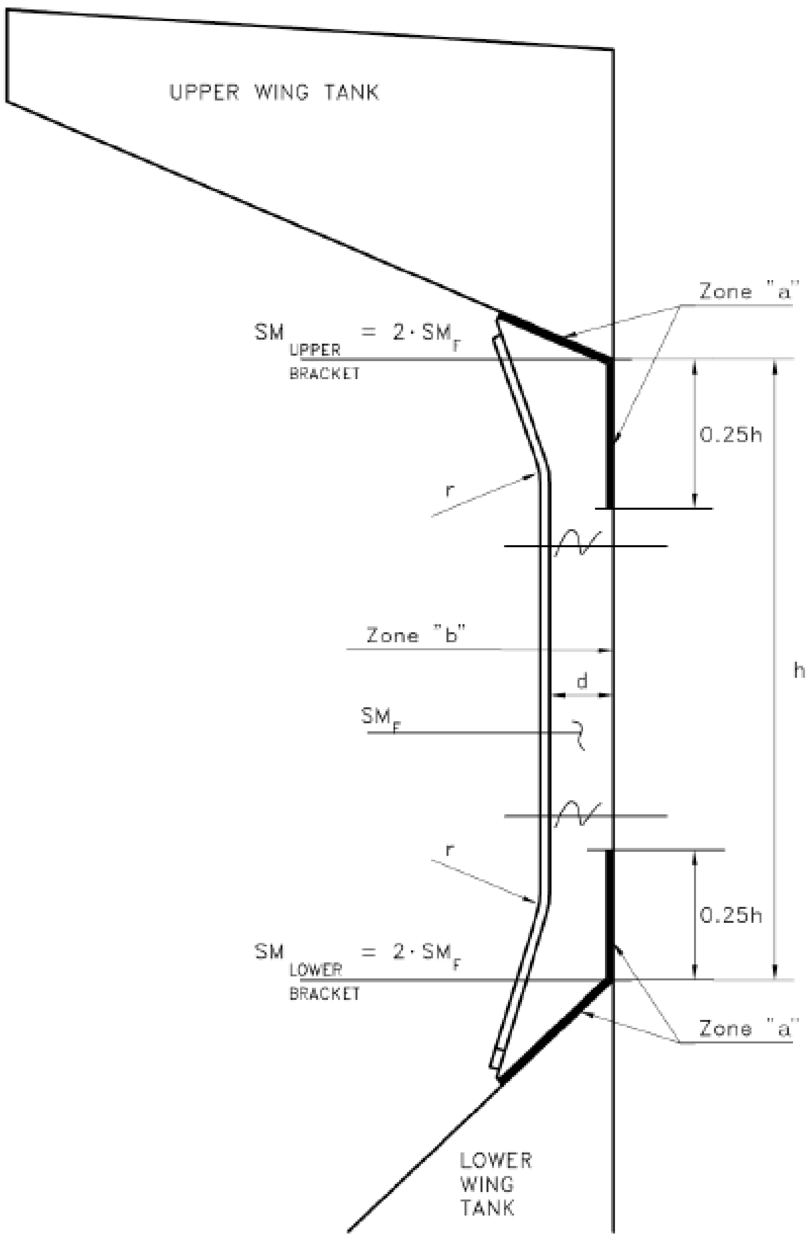
Where the hull form is such to prohibit an effective fillet weld, edge preparation of the web of frame and bracket may be required, in order to ensure the same efficiency as the weld connection stated above.

4.1.8 Minimum thickness of side shell plating

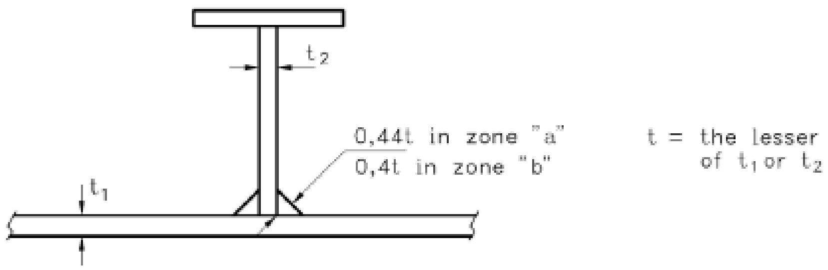
The thickness of side shell plating located between hopper and upper wing tanks is not to be less than $t_{p,min}$ given by:

$$t_{p,min} = \sqrt{L}, \quad mm$$

Figure 4.4.1:



UPPER WING TANK
Zone "a"
SM UPPER BRACKET = 2·SM F
0.25h
r
Zone "b"
d
h
SM F
r
0.25h
SM LOWER BRACKET = 2·SM F
Zone "a"
LOWER WING TANK



t2
0,44t in zone "a"
0,4t in zone "b"
t = the lesser of t1 or t2
t1

Figure 4.4.2:

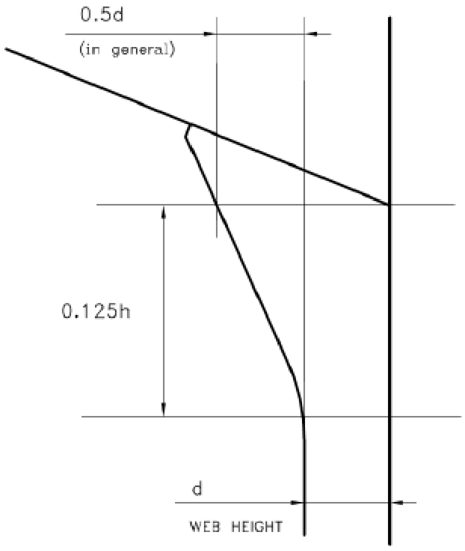


Figure 4.4.3:

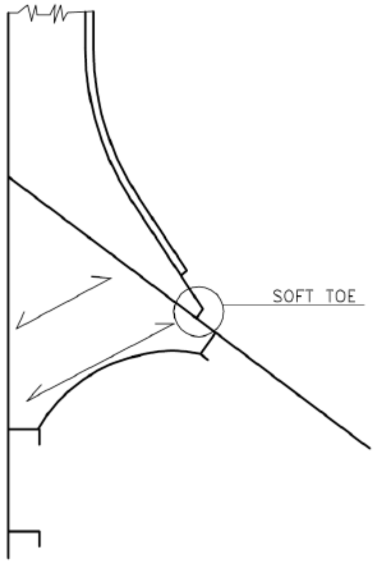
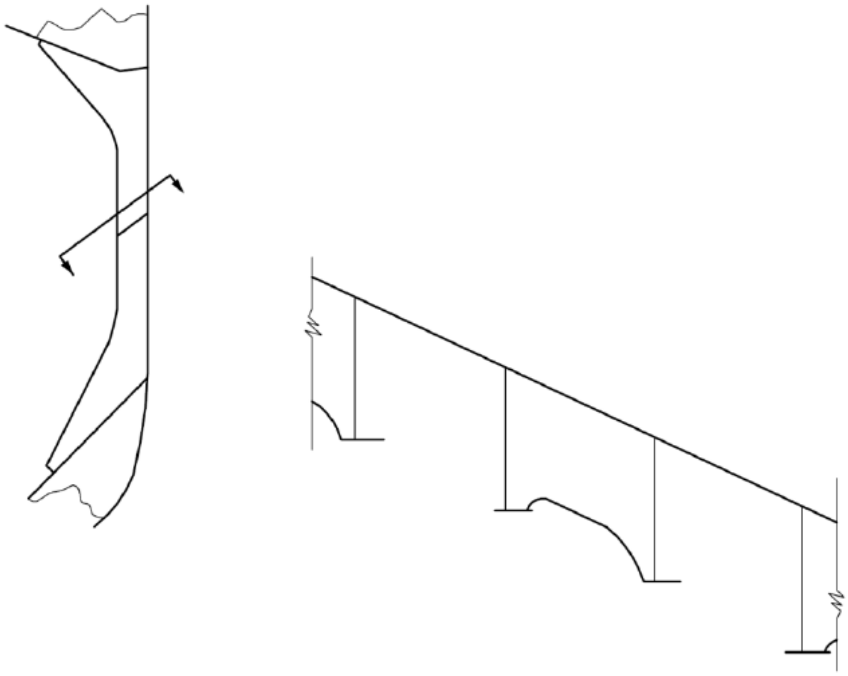


Figure 4.4.4: Tripping brackets to be fitted in way of foremost hold



4.2 Renewal Criteria for Side Shell Frames and Brackets in Single Side Skin Bulk Carriers not Built in accordance with 4.1 (IACS UR S31 Rev.4)

4.2.1 Application and definitions

These requirements apply to the side shell frames and brackets of cargo holds bounded by the single side shell of bulk carriers constructed with single deck, topside tanks and hopper tanks in cargo spaces intended primarily to carry dry cargo in bulk, which were not built-in accordance with 4.1.

In addition, these requirements also apply to the side shell frames and brackets of cargo holds bounded by the single side shell of Oil/Bulk/Ore(OBO) carriers, as defined in Part 1, Chapter 2, SECTION 6, 6.6 but of single side skin construction. For the purpose of 4.2, "ships" means both "bulk carriers" and "OBO carriers" as defined above, unless otherwise specified.

In the case a vessel as defined above does not satisfy above definition in one or more holds, the requirements in 4.2 do not apply to these individual holds.

This subsection is to be applied to bulk carriers and OBO carriers of single side skin construction, as defined above, in conjunction with Part 1, Chapter 3, SECTION 2. Part 1, Chapter 3, SECTION 2, 2.1.5 refers.

Bulk Carriers subject to these requirements are to be assessed for compliance with the requirements of this subsection and steel renewal, reinforcement or coating, where required in accordance with this subsection, is to be carried out in accordance with the following schedule and at subsequent intermediate and special surveys.

(i) For Bulk Carriers which will be 15 years of age or more on 1 January 2004 by the due date of the first intermediate or special survey after that date;

(ii) For Bulk Carriers which will be 10 years of age or more on 1 January 2004 by the due date of the first special survey after that date;

(iii) For Bulk Carriers which will be less than 10 years of age on 1 January 2004 by the date on which the ship reaches 10 years of age.

Completion prior to 1 January 2004 of an intermediate or special survey with a due date after 1 January 2004 cannot be used to postpone compliance. However, completion prior to 1 January 2004 of an intermediate survey the window for which straddles 1 January 2004 can be accepted.

OBO carriers subject to these requirements are to be assessed for compliance with the requirements of this subsection and steel renewal, reinforcement or coating, where required in accordance with this subsection, is to be carried out in accordance with the following schedule and at subsequent intermediate and special surveys.

(i) For OBO carriers which will be 15 years of age or more on 1 July 2005 by the due date of the first intermediate or special survey after that date;

(ii) For OBO carriers which will be 10 years of age or more on 1July 2005 by the due date of the first special survey after that date;

(iii) For OBO carriers which will be less than 10 years of age on 1 July 2005 by the date on which the ship reaches 10 years of age.

Completion prior to 1 July 2005 of an intermediate or special survey with a due date after 1 July 2005 cannot be used to postpone compliance. However, completion prior to 1 July 2005 of an intermediate survey the window for which straddles 1 July 2005 can be accepted.

These requirements define steel renewal criteria or other measures to be taken for the webs and flanges of side shell frames and brackets as per 4.2.2.

Reinforcing measures of side frames are also defined as per 4.2.2.3.

Finite element or other numerical analysis or direct calculation procedures cannot be used as an alternative to compliance with the requirements of this subsection, except in cases of unusual side structure arrangements or framing to which the requirements of this subsection cannot be directly applied. In such cases, the analysis criteria and the strength check criteria are to be in accordance with LHR's Rules.

4.2.1.1 Ice strengthened ships

4.2.1.1.1 Where ships are reinforced to comply with an ice class notation, the intermediate frames are not to be included when considering compliance with 4.2.

4.2.1.1.2The renewal thicknesses for the additional structure required to meet the ice strengthening notation are to be based on the Society's requirements.

4.2.1.1.3If the ice class notation is requested to be withdrawn, the additional ice strengthening structure, other than mentioned above, with the exception of tripping brackets (see 4.2.2.1.3(b) and 4.2.2.3), is not considered to contribute to compliance with 4.2.

4.2.2 Renewal or other measures

4.2.2.1 Criteria for renewal or other measures

4.2.2.1.1 Symbols used in 4.2.2.1

t_M	=	thickness as measured, mm
t_{REN}	=	thickness at which renewal is required. See 4.2.2.1.2
$t_{REN,d/t}$	=	thickness criteria based on d/t ratio. See 4.2.2.1.3
$t_{REN,s}$	=	thickness criteria based on strength. See 4.2.2.1.4
t_{coat}	=	$0{,}75 \cdot t_{s12}$
t_{s12}	=	thickness as required by 4.1 in 4.1.3 for frame webs and in 4.1.4 for upper and lower bracket webs, mm
t_{AB}	=	thickness as built, mm
t_C	=	See Table 4.4.1 below

Table 4.4.1: t_C values, in mm

Ships Length L, in m	Holds other than No.1		Hold No. 1	
	Span and upper brackets	Lower brackets	Span and upper brackets	Lower brackets
≤ 100	2,0	2,5	2,0	3,0
150	2,0	3,0	3,0	3,5
≥ 200	2,0	3,0	3,0	4,0
NOTE: For intermediate ship lengths, t_C is obtained by linear interpolation between the above values.				

4.2.2.1.2 Criteria for webs (Shear and other checks)

The webs of side shell frames and brackets are to be renewed when the measured thickness (t_M) is equal to or less than the thickness (t_{REN}) as defined below:

t_{REN} is the greatest of:

(a) $t_{coat} - t_C$

(b) $0{,}75 \cdot t_{AB}$

(c) $t_{REN,d/t}$ (applicable to Zone A and B only)

(d) $t_{REN,s}$, where required by 4.2.2.1.4

4.2.2.1.3 Thickness criteria based on d/t ratio

Subject to (b) and (c) below, $t_{REN,d/t}$ is given by the following equation:

$$t_{REN,d/t} = (\text{web depth in mm})/R$$

where:

R = for frames

$65 \cdot k^{0,5}$ for symmetrically flanged frames

$55 \cdot k^{0,5}$ for asymmetrically flanged frames

for lower brackets (see (a) below):

$87 \cdot k^{0,5}$ for symmetrically flanged frames

$73 \cdot k^{0,5}$ for asymmetrically flanged frames

k = 1,0 for ordinary hull structural steel and according to Part 3, Chapter 2, SECTION 4, 4.2.1 for higher tensile steel.

In no instance is $t_{REN,d/t}$ for lower integral brackets to be taken as less than $t_{REN,d/t}$ for the frames they support.

(a) Lower brackets

Lower brackets are to be flanged or face plate is to be fitted, refer to 4.2.2.1.7.

In calculating the web depth of the lower brackets, the following will apply:

- The web depth of lower bracket may be measured from the intersection of the sloped bulkhead of the hopper tank and the side shell plate, perpendicularly to the face plate of the lower bracket (see Figure 4.4.7).
- Where stiffeners are fitted on the lower bracket plate, the web depth may be taken as the distance between the side shell and the stiffener, between the stiffeners or between the outermost stiffener and the face plate of the brackets, whichever is the greatest.

(b) Tripping bracket alternative

When t_M is less than $t_{REN,d/t}$ at section (b) of the side frames, tripping brackets in accordance with 4.2.2.3 may be fitted as an alternative to the requirements for the web depth to thickness ratio of side frames, in which case $t_{REN,d/t}$ may be disregarded in the determination of t_{REN} in accordance with 4.2.2.1.2. The value of t_M is to be based on zone B according to 4.3, (see Figure 4.4.5).

(c) Immediately abaft collision bulkhead

For the side frames, including the lower bracket, located immediately abaft the collision bulkheads, whose scantlings are increased in order that their moment of inertia is such to avoid undesirable flexibility of the side shell, when their web as built thickness t_{AB} is greater than $1,65 \cdot t_{REN,S}$ the thickness $t_{REN,d/t}$ may be taken as the value $t'_{REN,d/t}$ obtained from the following equation:

$$t'_{REN,d/t} = \sqrt[3]{t^2_{REN,d/t} \cdot t_{REN,s}}$$

where:

$t_{REN,s}$ is obtained from 4.2.3.3.

4.2.2.1.4 Thickness criteria based on shear strength check

Where t_M in the lower part of side frames, as defined in Figure 4.4.5, is equal to or less than t_{coat}, $t_{REN,S}$ is to be determined in accordance with 4.2.3.3.

4.2.2.1.5 Thickness of renewed webs of frames and lower brackets

Where steel renewal is required, the renewed webs are to be of a thickness not less than t_{AB}, $1,2 \cdot t_{coat}$ or $1,2 \cdot t_{REN}$, whichever is the greatest.

4.2.2.1.6 Criteria for other measures

When $t_{REN} < t_M \le t_{coat,}$ measures are to be taken, consisting of all the following:

(a) Sand blasting, or equivalent, and coating (see 4.2.2.2),

(b) Fitting tripping brackets (see 4.2.2.3), when the above condition occurs for any of the side frame zones A, B, C and D, shown in Figure 4.4.5, Tripping brackets not connected to flanges are to have soft toe, and the distance between the bracket toe and the frame flange is not to be greater than about 50 mm, see Figure 4.4.8.

(c) Maintaining the coating in "as-new" condition (i.e. without breakdown or rusting) at Special and Intermediate Surveys.

The above measures may be waived if the structural members show no thickness diminution with respect to the as built thicknesses and coating is in "as-new" condition (i.e. without breakdown or rusting).

When the measured frame webs thickness t_M is such that $t_{REN} < t_M \le t_{COAT}$ and the coating is in GOOD condition, sand blasting and coating as required in (a) above may be waived even if not found in “as-new” condition, as defined above, provided that tripping brackets are fitted and the coating damaged in way of the tripping bracket welding is repaired.

4.2.2.1.7 Criteria for frames and brackets (Bending check)

When lower end brackets were not fitted with flanges at the design stage, flanges are to be fitted so as to meet the bending strength requirements in 4.2.3.4. The full width of the bracket flange is to extend up beyond the point at which the frame flange reaches full width. Adequate back-up structure in the hopper is to be ensured, and the bracket is to be aligned with the back-up structure.

Where the length or depth of the lower bracket does not meet the requirements in 4.1, a bending strength check in accordance with 4.2.3.4 is to be carried out and renewals or reinforcements of frames and/or brackets effected as required therein.

The bending check needs not to be carried out in the case the bracket geometry is modified so as to comply with the requirements of 4.1.

4.2.2.2 Thickness measurements, steel renewal, sand blasting and coating

For the purpose of steel renewal, sand blasting and coating, four zones A, B, C and D are defined, as shown in Figure 4.4.5. When renewal is to be carried out, surface preparation and coating are required for the renewed structures as given in Part 3, Chapter 1, SECTION 9, 9.1.3 of LHR Rules and Regulations requirements for cargo holds of new buildings.

Representative thickness measurements are to be taken for each zone and are to be assessed against the criteria in 4.2.2.1.

When zone B is made up of different plate thicknesses, the lesser thickness is to be used for the application of the requirements in this subsection.

In case of integral brackets, when the criteria in 4.2.2.1 are not satisfied for zone A or B, steel renewal, sand blasting and coating, as applicable, are to be done for both zones A and B.

In case of separate brackets, when the criteria in 4.2.2.1 are not satisfied for zone A or B, steel renewal, sand blasting and coating is to be done for each one of these zones, as applicable.

When steel renewal is required for zone C according to 4.2.2.1, it is to be done for both zones B and C. When sand blasting and coating is required for zone C according to 4.2.2.1, it is to be done for zones B, C and D.

When steel renewal is required for zone D according to 4.2.2.1, it needs only to be done for this zone. When sand blasting and coating is required for zone D according to 4.2.2.1, it is to be done for both zones C and D.

Special consideration may be given by the Society to zones previously renewed or re-coated, if found in "as-new" condition (i.e., without breakdown or rusting).

When adopted, on the basis of the renewal thickness criteria in 4.2.2.1, in general coating is to be applied in compliance with the requirements of Part 3, Chapter 1, SECTION 9, 9.3.1, as applicable.

Where, according to the requirements in 4.2.2.1, a limited number of side frames and brackets are shown to require coating over part of their length, the following criteria apply.

(a) The part to be coated includes:

- the web and the face plate of the side frames and brackets,
- the hold surface of side shell, hopper tank and topside tank plating, as applicable, over a width not less than 100 mm from the web of the side frame.

(b) Epoxy coating or equivalent is to be applied.

In all cases, all the surfaces to be coated are to be sand blasted prior to coating application.

When flanges of frames or brackets are to be renewed according to 4.2, the outstanding breadth to thickness ratio is to comply with the requirements in 4.1.5.

4.2.2.3 Reinforcing measures

Reinforcing measures are constituted by tripping brackets, located at the lower part and at midspan of side frames (see Figure 4.4.8). Tripping brackets may be located at every two frames, but lower and midspan brackets are to be fitted in line between alternate pairs of frames.

The thickness of the tripping brackets is to be not less than the as-built thickness of the side frame webs to which they are connected.

Double continuous welding is to be adopted for the connections of tripping brackets to the side shell frames and shell plating.

Where side frames and side shell are made of Higher Strength Steel (HSS), Normal Strength Steel (NSS) tripping brackets may be accepted, provided the electrodes used for welding are those required for the particular HSS grade, and the thickness of the tripping brackets is equal to the frame web thickness, regardless of the frame web material.

4.2.2.4 Weld throat thickness

In case of steel renewal the welded connections are to comply with 4.1.7.

4.2.2.5 Pitting and grooving

If pitting intensity is higher than 15% in area (see Figure 4.4.9), thickness measurement is to be taken to check pitting corrosion.

The minimum acceptable remaining thickness in pits or grooves is equal to:

- 75% of the as built thickness, for pitting or grooving in the frame and brackets webs and flanges
- 70% of the as built thickness, for pitting or grooving in the side shell, hopper tank and topside tank plating attached to the side frame, over a width up to 30 mm from each side of it.

4.2.2.6 Renewal of all frames in one or more cargo holds

When all frames in one or more holds are required to be renewed according to 4.2, the compliance with the requirements in 4.1 may be accepted in lieu of the compliance with the requirements in 4.2,, provided that:

– It is applied at least to all the frames of the hold(s)
– The coating requirements for side frames of "new ships" are complied with
– The section modulus of side frames is calculated according to the Society Rules.

4.2.2.7 Renewal of damaged frames

In case of renewal of a damaged frame already complying with 4.2, the following requirements apply:

– The conditions accepted in compliance with 4.2, are to be restored as a minimum.
– For localized damages, the extension of the renewal is to be carried out according to the standard practice of the Society.

4.2.3 Strength check criteria

In general, loads are to be calculated and strength checks are to be carried out for the aft, middle and forward frames of each hold. The scantlings required for frames in intermediate positions are to be obtained by linear interpolation between the results obtained for the above frames.

When scantlings of side frames vary within a hold, the required scantlings are also to be calculated for the mid frame of each group of frames having the same scantlings. The scantlings required for frames in intermediate positions are to be obtained by linear interpolation between the results obtained for the calculated frames.

4.2.3.1 Load model

The following loading conditions are to be considered:

– Homogeneous heavy cargo (density greater than 1,78 t/m^3)
– Homogeneous light cargo (density less than 1,78 t/m^3)
– Non homogeneous heavy cargo, if allowed
– Multi-port loading/unloading conditions need not be considered.

4.2.3.1.1 Forces

The forces $P_{fr,a}$ and $P_{fr,b}$ to be considered for the strength checks at sections a) and b) of side frames (specified in Figure 4.4.6; in the case of separate lower brackets, section b) is at the top of the lower bracket), are given by:

$$P_{fr,a} = P_S + \max(P_1, P_2), \qquad kN$$

$$P_{fr,b} = P_{fr,a} \cdot \frac{h - 2 \cdot h_B}{h}, \qquad kN$$

where:

P_s = still water force, kN

= $s \cdot h \cdot \left(\frac{p_{S,u} + p_{S,L}}{2}\right)$, when the upper end of the side frame span h (see Figure 4.4.5) is below the load water line

= $s \cdot h' \cdot \left(\frac{p_{S,L}}{2}\right)$ when the upper end of the side frame span h (see Figure 4.4.5) is at or above the load water line

P_1 = wave force in head sea, kN,

	=	$s \cdot h \cdot \left(\frac{p_{1,U} + p_{1,L}}{2}\right)$
P_2	=	wave force in beam sea, kN,
	=	$s \cdot h \cdot \left(\frac{p_{2,U} + p_{2,L}}{2}\right)$
h, h_B	=	side frame span and lower bracket length defined in Figure 4.4.5 and Figure 4.4.6, respectively, m
h'	=	distance between the lower end of side frame span h (see Figure 4.4.5) and the load water line, m,
s	=	frame spacing, m
$p_{s,u}$, $p_{s,L}$,	=	still water pressure at the upper and lower end of the side frame span h (see Figure 4.4.5), respectively, kN/m²,
$p_{1,u}$, $p_{1,L}$,	=	wave pressure as defined in 4.2.3.1.2(1)) below for the upper and lower end of the side frame span h, respectively, kN/m²,
$p_{2,u}$, $p_{2,L}$,	=	wave pressure as defined in 4.2.3.1.2(2)) below for the upper and lower end of the side frame span h, respectively, kN/m²

4.2.3.1.2 Wave Pressure

(1) Wave pressure p_1

– The wave pressure p_1 at and below the waterline is given by:

$$p_1 = 1{,}5\left[p_{11} + 135 \cdot \frac{B}{2 \cdot (B+75)} - 1{,}2 \cdot (T - z)\right], \qquad kN/m^2$$

$$p_{11} = 3 \cdot k_S \cdot C + k_f, \qquad kN/m^2$$

– The wave pressure p_1 above the water line is given by:

$$p_1 = p_{1wl} - 7{,}5 \cdot (z - T), \qquad kN/m^2,$$

(2) Wave pressure p_2

– The wave pressure p_2 at and below the waterline is given by:

$$p_2 = 13\left[0{,}5 \cdot B \cdot \frac{50 \cdot C_r}{2 \cdot (B+75)} + C_B \cdot \frac{0{,}5 \cdot B + k_f}{14} \cdot \left(0{,}7 + 2\frac{z}{T}\right)\right], \qquad kN/m^2$$

– The wave pressure p_2 above the water line is given by:

$$p_2 = p_{2wl} - 5{,}0 \cdot (z - T), \qquad kN/m^2,$$

where:

p_{1wl}	=	p_1 wave sea pressure at the waterline	
p_{2wl}	=	p_2 wave sea pressure at the waterline	
L	=	Rule length, as defined in Part 3, Chapter 1, SECTION 3, 3.2, m.	
B	=	greatest moulded breadth, m	
C_B	=	block coefficient, as defined in Part 3, Chapter 1, SECTION 3, 3.2, but not to be taken less than 0.6	
T	=	maximum design draught, m	
C	=	coefficient	
	=	$10{,}75 - \left(\frac{300-L}{100}\right)^{1{,}5}$,	for 90 ≤ L ≤ 300m
	=	10,75,	for 300 m < L
C_r	=	$\left(1{,}25 - 0{,}025 \cdot \frac{2 \cdot k_r}{\sqrt{GM}}\right) \cdot k$	
k	=	1,2	for ships without bilge keel
	=	1,0	for ships without bilge keel
k_r	=	roll radius of gyration. If the actual value of k_r is not available	
	=	0,39·B for ships with even distribution of mass in transverse section (e.g.	

alternate heavy cargo loading or homogeneous light cargo loading)

= 0,25·B for ships with uneven distribution of mass in transverse section (e.g. homogeneous heavy cargo distribution)

GM = 0,12·B if the actual value of GM is not available

z = vertical distance from the baseline to the load point, m

k_s = $C_B + \frac{0,83}{\sqrt{C_B}}$, at aft end of L

= C_B between 0,2·L and 0,6·L from aft end of L

= $C_B + \frac{1,33}{\sqrt{C_B}}$, at forward end of L

Between the above specified points, ks is to be interpolated linearly.

k_f = 0,8·C

4.2.3.2 Allowable stresses

The allowable normal and shear stresses σ_a and τ_a in the side shell frames and brackets are given by:

$$\sigma_\alpha = 0,90 \cdot \sigma_f, \quad N/mm^2$$

$$\tau_\alpha = 0,40 \cdot \sigma_f, \quad N/mm^2$$

where:

σ_f = the minimum upper yield stress of the material, N/mm².

4.2.3.3 Shear strength check

Where t_M in the lower part of side frames, as defined in Figure 4.4.5, is equal to or less than t_{coat} shear strength check is to be carried out in accordance with the following.

The thickness $t_{REN,S}$ is the greater of the thicknesses $t_{REN,sa}$ and $t_{REN,Sb}$ obtained from the shear strength check at sections a) and b) (see Figure 4.4.6 and 4.2.3.1) given by the following, but need not be taken in excess of $0,75 \cdot t_{s12}$.

- At section a): $t_{fREN,Sa} = \frac{100 \cdot k_s \cdot P_{fr,a}}{d_a \cdot \sin\phi \cdot \tau_\alpha}$, mm
- At section b): $t_{fREN,Sb} = \frac{100 \cdot k_s \cdot P_{fr,b}}{d_b \cdot \sin\phi \cdot \tau_b}$, mm

Where

k_s = shear force distribution factor, to be taken equal to 0.6

$P_{fr,a}$,$P_{fr,b}$ = pressures forces defined in 4.2.3.1.1

d_a,d_b = bracket and frame web depth at sections a) and b), respectively (see Figure 4.4.6), mm; in case of separate (non-integral) brackets, d_b is to be taken as the minimum web depth deducing possible scallops

φ = angle between frame web and shell plate

τ_a = allowable shear stress defined in 4.2.3.2, N/mm²

4.2.3.4 Bending strength check

Where the lower bracket length or depth does not meet the requirements in 4.1, the actual section modulus of the brackets and side frames at sections a) and b) is to be not less than:

– At section a): $Z_a = \frac{100 \cdot P_{fr,a} \cdot h}{m_a \cdot \sigma_a}$, cm^3
– At section b): $Z_b = \frac{100 \cdot P_{fr,a} \cdot h}{m_b \cdot \sigma_a}$, cm^3

Where:

$P_{fr,a}$ = pressures force defined in 4.2.3.1.1
H = side frame span defined in Figure 4.4.5, m,

σ_α = allowable normal stress defined in 4.2.3.2, N/mm²
m_a , m_b = bending moment coefficients defined in Table 4.4.2

The actual section modulus of the brackets and side frames is to be calculated about an axis parallel to the attached plate, based on the measured thicknesses. For pre-calculations, alternative thickness values may be used, provided they are not less than:

– t_{REN}, for the web thickness
– the minimum thicknesses allowed by the Society renewal criteria for flange and attached plating.

The attached plate breadth is equal to the frame spacing, measured along the shell at midspan h.

If the actual section moduli at sections a) and b) are less than the values Z_a and Z_b, the frames and brackets are to be renewed or reinforced in order to obtain actual section moduli not less than $1{,}2{\cdot}Z_a$ and $1{,}2{\cdot}Z_b$, respectively. In such a case, renewal or reinforcements of the flange are to be extended over the lower part of side frames, as defined in Figure 4.4.5.

Table 4.4.2: Bending moment coefficients ma and mb

	m_a	**m_b**		
		$h_B \le 0{,}08{\cdot}h$	**$h_B = 0{,}1{\cdot}h$**	**$h_B \ge 0{,}125{\cdot}h$**
Empty holds of ships approved to operate in non-homogeneous loading conditions	10	17	19	22
Other cases	12	20	22	26

NOTES:
1. Non homogeneous loading condition means a loading condition in which the ratio between the highest and the lowest filling ratio, evaluated for each hold, exceeds 1,20 corrected for different cargo densities.
2. For intermediate values of the bracket length h_B, the coefficient m_b is obtained by linear interpolation between the table values.

Figure 4.4.5: Lower part and zones of side shell fames / Zones of side shell frames and brackets

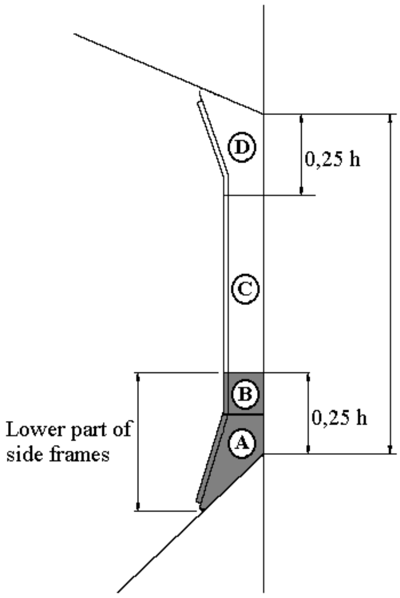


Figure 4.4.6: Sections a) and b)

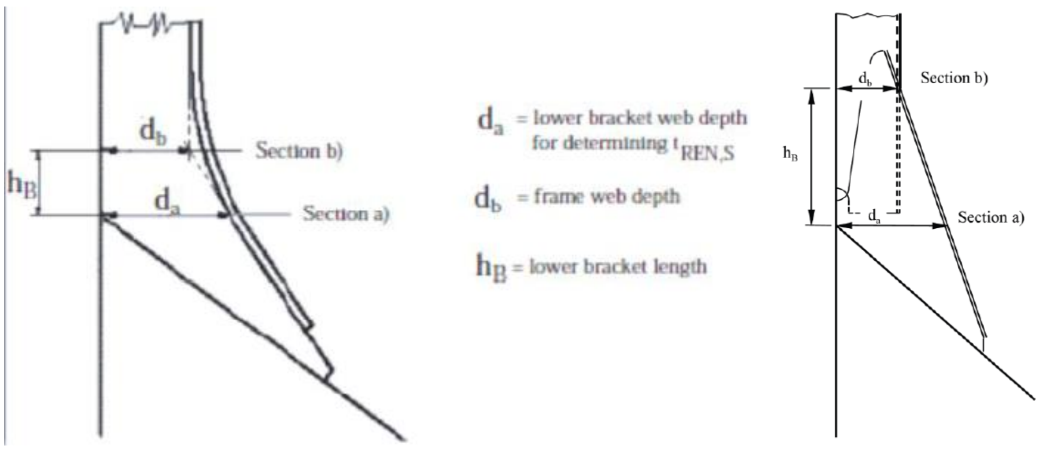


Figure 4.4.7: Definition of the lower bracket web depth for determining $t_{REN,d/t}$

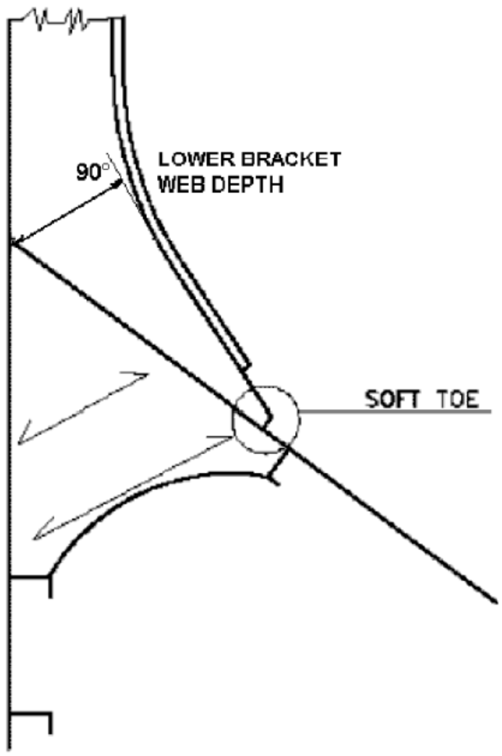


Figure 4.4.8: Tripping brackets

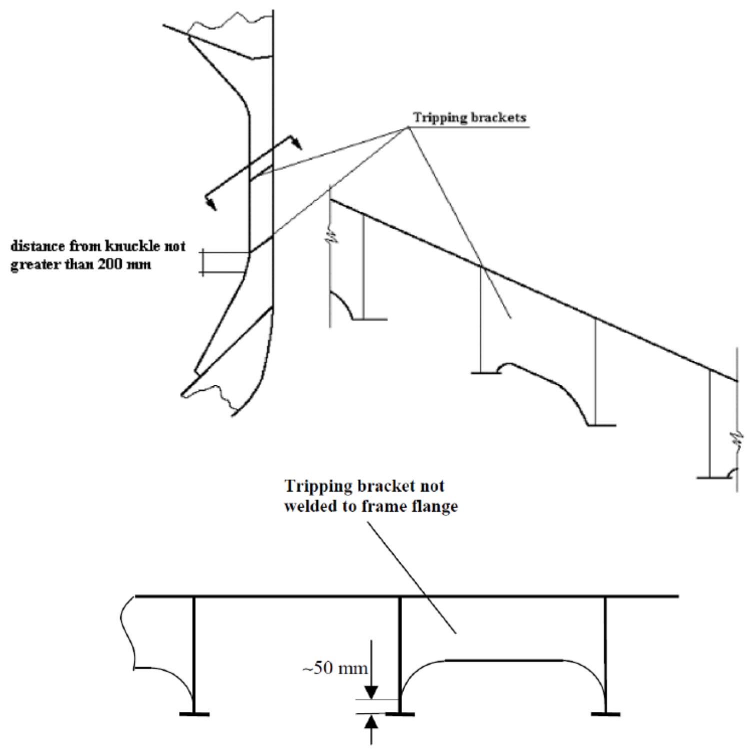
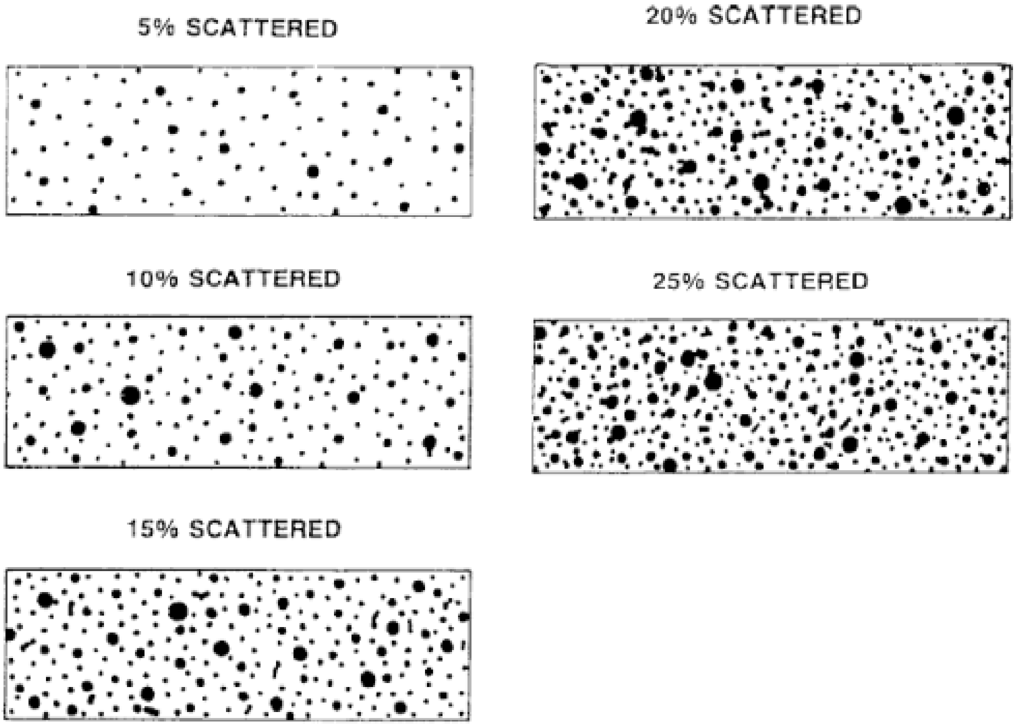


Figure 4.4.9: Pitting intensity diagrams (from 5% to 25% intensity)



4.3 Gauging of Side Shell Frames and Brackets in Single Side Skin Bulk Carriers required to comply with 4.2 (IACS UR Z10.2 ANNEX V Rev. 35)

4.3.1 General

Gauging is necessary to determine the general condition of the structure and to define the extent of possible steel renewals or other measures for the webs and flanges of side shell frames and brackets for verification of the compliance with 4.2.

4.3.2 Zones of Side Shell Frames and Brackets

For the purpose of steel renewal, sand blasting and coating, four zones A, B, C and D are defined, as shown in Figure 4.4.5.

Zones A & B are considered to be the most critical zones.

4.3.3 Pitting and grooving

Pits can grow in a variety of shapes, some of which would need to be ground before assessment.

Pitting corrosion may be found under coating blisters, which must be removed before inspection.

To measure the remaining thickness of pits or grooving the normal ultrasonic transducer (generally 10mm diameter) will not suffice. A miniature transducer (3 to 5 mm diameter) must be used. Alternatively, the gauging firm must use a pit gauge to measure the depth of the pits and grooving and calculate the remaining thickness.

4.3.3.1 Assessment based upon Area

This is the method specified in 4.2.2.5 and is based upon the intensity determined from Figure 4.4.9.

If pitting intensity is higher than 15% in an area, then thickness measurements are to be taken to check the extent of the pitting corrosion. The 15% is based upon pitting or grooving on only one side of the plate.

In cases where pitting is evident as defined above (exceeding 15%) then an area of 300mm diameter or more (or, where this is impracticable on the frame flange or the side shell, hopper tank plating or topside tank plating attached to the side frame, an equivalent rectangular area), at the most pitted part, is to be cleaned to bare metal, and the thickness measured in way of the five deepest pits within the cleaned area. The least thickness measured in way of any of these pits is to be taken as the thickness to be recorded.

The minimum acceptable remaining thickness in any pit or groove is equal to:

(a) 75% of the as built thickness, for pitting or grooving in the cargo hold side frame webs and flanges

(b) 70% of the as built thickness, for pitting or grooving in the side shell, hopper tank and topside tank plating attached to the cargo hold side frame, over a width up to 30mm from each side of it.

4.3.4 Gauging methodology

Numbers of side frames to be measured are equivalent to those of Special Survey or Intermediate Survey corresponding to the ship's age. Representative thickness measurements are to be taken for each zone as specified below.

Special consideration to the extent of the thickness measurements may be given by the Society, if the structural members show no thickness diminution with respect to the as built thicknesses and the coating is found in "as-new" condition (i.e., without breakdown or rusting).

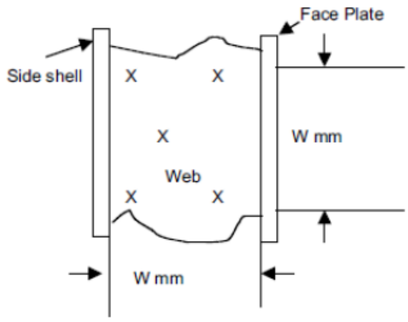
Where gauging readings close to the criteria are found, the number of hold frames to be measured is to be increased. If renewal or other measures according to 4.2 are to be applied on individual frames in a hold, then all frames in that hold are to be gauged.

There is a variety of construction methods used for side shell frames in bulk carriers. Some have faceplates (T sections) on the side shell frames, some have flanged plates and some have bulb plates. The use of faceplates and flanged sections is considered similar for gauging purposes in that both the web and faceplate or web and flange plate are to be gauged. If bulb plate has been used, then web of the bulb plate is to be gauged in the normal manner and the sectional modulus has to be specially considered if required.

4.3.4.1 Gaugings for Zones A, B & D Web plating

The gauging pattern for Zones A, B & D are to be a five-point pattern (see Figure 4.4.10). The five-point pattern is to be over the depth of the web and the same area vertically. The gauging report is to reflect the average reading.

Figure 4.4.10: Typical 5-point pattern on the web plate



4.3.4.2 Gaugings for Zone C

Web plating

Depending upon the condition of the web in way of Zone C, the web may be measured by taking 3 readings over the length of Zone C and averaging them. The average reading is to be compared with the allowable thickness. If the web plating has general corrosion, then this pattern should be expanded to a five-point pattern as noted above.

4.3.4.3 Gaugings for section a) and b) (flanges and side shell plating)

Where the lower bracket length or depth does not meet the requirements in SECTION 4.1, gaugings are to be taken at sections a) and b) to calculate the actual section modulus required in 4.2.3.4 (see Figure 4.4.6). At least 2 readings on the flange/faceplate are to be taken in way of each section. At least one reading of the attached shell plating is to be taken on each side of the frame (i.e. fore and aft) in way of section a) and section b).

SECTION 5 Wing tanks

5.1 Lower wing tanks

5.1.1 The thickness of the sloped bulkhead plating as well as the section modulus of the sloped bulkhead longitudinals of lower wing tanks are to be as required for the inner bottom.

5.1.2 Each transverse web in lower wing tanks, where fitted, is to have a section modulus not less than that given by the following formula:

$$SM = 7{,}2 \cdot h \cdot s \cdot l^2, \ \ cm^3$$

where:

l = Unsupported span, m.

s = Spacing, m

h = Distance from the middle of l to the load line, or to a point located two thirds of the distance from the keel to the deck, whichever is the greater, m

Transverse webs are to be in line with the solid floors and to have depths of not less than 0.15 ▪ l m.

5.1.3 Side shell longitudinals in lower wing tanks as well as bulkhead longitudinal in ore carriers are to have a section modulus equal to or greater than that required in Part 3, Chapter 5, 1.2.1.

5.2 Upper wing tanks

5.2.1 The thickness of the sloped bulkhead in upper wing tanks is to be as that required in Part 3, Chapter 9, 2.2 for Deep Tank bulkheads and at least equal to 7.5 mm.

5.2.2 Longitudinals in upper wing tank sloped bulkheads as well as deck and shell longitudinals are to have a section modulus not less than that given by the following formula:

$$SM = 8 \cdot s \cdot h \cdot l^2, \qquad cm^3$$

where:

l = Unsupported span, m.

s = Spacing, m

h = Distance from the longitudinal to the top of the tank or half the distance to the top of the overflow, whichever is the greater. In no case should h be less than 1.5 m.

5.2.3 The scantlings of the tank end bulkheads are to be as those given in Part 3, Chapter 9, 2.2.

SECTION 6 Bulkheads

6.1 General

6.1.1 The requirements of Part 3, Chapter 8 are generally to be applied.

6.1.2 In way of cargo oil or ballast holds the scantlings of the bulkheads are to comply the requirements of Part 3, Chapter 9 for Deep Tanks.

6.2 Stiffening arrangements

6.2.1 The stiffeners and brackets of transverse plane bulkheads and rectangular corrugations of transverse corrugated bulkheads are to be aligned with floors and inner bottom longitudinals.

6.2.2 In the case of non-rectangular corrugations the flanges are to be aligned with floors, or a combination of a floor and a transverse stiffener.

6.2.3 An efficient reinforcement is to be arranged in line with the transverse hold bulkheads in the double bottom tanks and in upper wing tanks.

6.3 Evaluation of Scantlings of Corrugated Transverse Watertight Bulkheads in Bulk Carriers Considering Hold Flooding (IACS UR S18 Rev.10)

6.3.1 Application and definitions

These requirements are to be complied with in respect of the flooding of any cargo hold of bulk carriers, as defined in Part 3, Chapter 2, SECTION 3, 3.3, of 150 m in length and above, intending to carry solid bulk cargoes having a density of 1.0 t/m3 or above, with vertically corrugated transverse watertight bulkheads, and with,

(a) Single side skin construction or
(b) Double side skin construction in which any part of longitudinal bulkhead 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,

which are contracted for construction from a date commencing not later than 1 July 2020.

The net thickness t_{net} is the thickness obtained by applying the strength criteria given in 6.3.4. The required thickness is obtained by adding the corrosion addition t_s, given in 6.3.6, to the net thickness t_{net}.

In this subsection, 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 1,20, to be corrected for different cargo densities.

6.3.2 Load model

6.3.2.1 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 is to be considered.

This application is to be applied to self-unloading bulk carriers (SUBC) where the unloading system maintains the watertightness during seagoing operations. In SUBCs with unloading systems that do not maintain watertightness, the combination loads acting on the bulkheads in the flooded conditions are to be considered using the extent to which the flooding may occur.

The most severe combinations of cargo induced loads and flooding loads are to 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 are to be represented by loading conditions defined by the Designer in the loading manual.

Non-homogeneous part loading conditions associated with multiport loading and unloading operations for homogeneous loading conditions need not to be considered according to these requirements.

Holds carrying packed cargoes are to 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/m^3, the maximum mass of cargo, which may be carried in the hold, shall also be considered to fill that hold up to the upper deck level at centreline.

6.3.2.2 Bulkhead corrugation flooding head

The flooding head h_f (see Figure 4.6.1) is the distance, in m, measured vertically with the ship in the upright position, from the calculation point to a level located at a distance d_f, in m, from the baseline equal to:

(a) in general:
– D for the foremost transverse corrugated bulkhead
– 0,9·D for the other bulkheads

Where the ship is to 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 bulkhead
– 0,85·D for the other bulkheads

(b) for ships less than 50,000 tonnes deadweight with Type B freeboard:
– 0,95·D for the foremost transverse corrugated bulkhead
– 0,85·D for the other bulkheads

Where the ship is to carry cargoes having bulk density less than 1,78 t/m^3 in non-homogeneous loading conditions, the following values can be assumed:

– 0,9·D for the foremost transverse corrugated bulkhead
– 0,8·D for the other bulkheads

where:

D = the distance from the baseline to the freeboard deck at side amidship (see Figure 4.6.1), m.

6.3.2.3 Pressure in the non-flooded bulk cargo loaded holds

At each point of the bulkhead, the pressure p_c is given by:

$$p_c = \rho_c \cdot g \cdot h_1 \cdot \tan^2\gamma, \qquad kN/m^2$$

where:

ρ_c = bulk cargo density, t/m^3
g = 9,81 m/s^2, gravity acceleration
h_1 = vertical distance, in m, from the calculation point to horizontal plane corresponding to the level height of the cargo (see Figure 4.6.1), located at a distance d1, in m, from the baseline
γ = $45^\circ - \frac{\phi}{2}$
φ = angle of repose of the cargo that may generally be taken as 35° for iron ore

and 25° for cement, degrees

The force F_C acting on a corrugation is given by:

$$F_c = \rho_C \cdot g \cdot s_1 \cdot \frac{(d_1 - h_{DB} - h_{LS})^2}{2} \cdot \tan^2\gamma, \qquad kN$$

where:

ρ_c, g, d_1, γ = as given above
s_1 = spacing of corrugations, m (see Figure 4.6.2(a))
h_{LS} = mean height of the lower stool from the inner bottom, m
h_{DB} = height of the double bottom, m

6.3.2.4 Pressure in the flooded holds

6.3.2.4.1 Bulk cargo holds

Two cases are to be considered, depending on the values of d_1 and d_f.

(a) $d_f \geq d_1$:

At each point of the bulkhead located at a distance between d_1 and d_f from the baseline, the pressure $p_{c,f}$ is given by:

$$p_{c,f} = \rho \cdot g \cdot h_f, \qquad kN/m^2$$

where:

ρ = sea water density, t/m^3
g = as given in 6.3.2.3
h_f = flooding head as defined in 6.3.2.2.

At each point of the bulkhead located at a distance lower than d_1 from the baseline, the pressure $p_{c,f}$ is given by:

$$p_{c,f} = \rho \cdot g \cdot h_f + [\rho_c - \rho \cdot (1 - perm)] \cdot g \cdot h_1 \cdot \tan^2\gamma, \qquad kN/m^2$$

where:

ρ,h_f = as given above
ρ_c, g, h_1, γ = as given in 6.3.2.3
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 given by:

$$F_{c,f} = s_1 \left[\rho \cdot g \cdot \frac{(d_f - d_1)^2}{2} + \frac{\rho \cdot g \cdot (d_f - d_1) + (p_{c,f})_{Ie}}{2} \cdot (d_1 - h_{DB} - h_{LS})\right], \qquad kN$$

where:

ρ = as given above
s_1, g, d_1, h_{DB}, h_{LS} = as given in 6.3.2.3
d_f = as given in 6.3.2.2

$(p_{c,f})_{le}$ = pressure at the lower end of the corrugation, kN/m².

(b) $d_f < d_1$:

At each point of the bulkhead located at a distance between d_1 and d_f from the baseline, the pressure $p_{c,f}$ is given by:

$$p_{c,f} = \rho_c \cdot g \cdot h_1 \cdot \tan^2\gamma, \ \ kN/m^2$$

where:

ρ_c, g, h_1, γ = as given in 6.3.2.3.

At each point of the bulkhead located at a distance lower than d_f from the baseline, the pressure $p_{c,f}$ is given by:

$$p_{c,f} = \rho \cdot g \cdot h_f + [\rho_c \cdot h_1 - \rho \cdot (1 - perm) \cdot h_f] \cdot g \cdot \tan^2\gamma, \qquad kN/m^2$$

where:

ρ, h_f, perm = as given in (a) above
ρ_c, g, h_1, γ = as given in 6.3.2.3

The force $F_{c,f}$ acting on a corrugation is given by:

$$F_{c,f} = s_1 \left[\rho_c \cdot g \cdot \frac{(d_1 - d_f)^2}{2} \cdot \tan^2\gamma + \frac{\rho_c \cdot g \cdot (d_1 - d_f) \cdot \tan^2\gamma + (p_{c,f})_{le}}{2} \cdot (d_f - h_{DB} - h_{LS})\right], \qquad kN$$

where:

s_1, ρ_c, g, d_1, γ, h_{DB}, h_{LS} = as given in 6.3.2.3
d_f = as given in 6.3.2.2
$(p_{c,f})_{le}$ = pressure at the lower end of the corrugation, kN/m

6.3.2.4.2 Pressure in empty holds due to flooding water alone

At each point of the bulkhead, the hydrostatic pressure p_f induced by the flooding head h_f is to be considered.

The force F_f acting on a corrugation is given by:

$$F_1 = s_1 \cdot \rho \cdot g \cdot \frac{(d_f - h_{DB} - h_{LS})^2}{2}, \qquad kN$$

where:

s_1, g, h_{DB}, h_{LS} = as given in 6.3.2.3
ρ = as given in 6.3.2.4.1(a)
d_f = as given in 6.3.2.2.

6.3.2.5 Resultant pressure and force

6.3.2.5.1 Homogeneous loading conditions

At each point of the bulkhead structures, the resultant pressure p to be considered for the scantlings of the bulkhead is given by:

$$p = p_{c,f} - 0{,}8 \cdot p_c, \qquad kN/m^2$$

The resultant force F acting on a corrugation is given by:

$$F = F_{c,f} - 0{,}8 \cdot F_c, \qquad kN$$

6.3.2.5.2 Non homogeneous loading conditions

At each point of the bulkhead structures, the resultant pressure p to be considered for the scantlings of the bulkhead is given by:

$$p = p_{c,f}, \qquad kN/m^2$$

The resultant force F acting on a corrugation is given by:

$$F = F_{c,f}, \qquad kN$$

6.3.3 Bending moment and shear force in the bulkhead corrugations

The bending moment M and the shear force Q in the bulkhead corrugations are obtained using the formulae given in 6.3.3.1 and 6.3.3.2. The M and Q values are to be used for the checks in 6.3.4.5.

6.3.3.1 Bending moment

The design bending moment M for the bulkhead corrugations is given by:

$$M = \frac{F \cdot \ell}{8}, \qquad kN$$

where:

F = resultant force as given in 6.3.2.5, kN

ℓ = span of the corrugation to be taken according to Figure 4.6.2(a) and Figure 4.6.2(b), m.
6.3.3.2 Shear force

The shear force Q at the lower end of the bulkhead corrugations is given by:

$$Q = 0{,}8 \cdot F, \qquad kN$$

where:

F = as given in 6.3.2.5

6.3.4 Strength criteria

6.3.4.1 General

The following criteria are applicable to transverse bulkheads with vertical corrugations (see Figure 4.6.2). For ships of 190m of length and above, these bulkheads are to be fitted with a bottom stool, and generally with a top stool below deck. For smaller ships, corrugations may extend from inner bottom to deck; if the stool is fitted, it is to comply with this subsection.

The corrugation angle φ shown in Figure 4.6.2(a) is not to be less than 55°.

Requirements for local net plate thickness are given in 6.3.4.7.

In addition, the criteria as given in 6.3.4.2 and 6.3.4.5 are to be complied with. The thicknesses of the lower part of corrugations considered in the application of 6.3.4.2 and 6.3.4.3 are to 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 thicknesses of the middle part of corrugations as considered in the application of 6.3.4.2 and 6.3.4.4 are to 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 is not to be less than 75% of that required for the middle part, corrected for different yield stresses.

(a) Lower stool

The 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 stool top plate is not to be less than those required for the bulkhead plating above. 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 is not to be less than the required flange plate thickness and material to meet the bulkhead stiffness requirement at lower end of corrugation. The thickness of the stool side plating and the section modulus of the stool side stiffeners is not to be less than those required by the Society on the basis of the load model in 6.3.2. The ends of stool side vertical stiffeners are to be attached to brackets at the upper and lower ends of the stool.

The distance from the edge of the stool top plate to the surface of the corrugation flange is to be in accordance with Figure 4.6.5. The stool bottom is to be installed in line with double bottom floors and is to have a width not less than 2,5 times the mean depth of the corrugation. The stool is to 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 are to be avoided.

Where corrugations are cut at the bottom stool, corrugated bulkhead plating is to be connected to the stool top plate by full penetration welds. The stool side plating is to be connected to the stool top plate and the inner bottom plating by either full penetration or deep penetration welds (see Figure 4.6.6). The supporting floors are to be connected to the inner bottom by either full penetration or deep penetration welds (see Figure 4.6.6).

(b) Upper stool

The upper stool, where fitted, is to have a height generally between 2 and 3 times the depth of corrugations. Rectangular stools are to 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 is to 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 is to have a width not less than 2 times the depth of corrugations. The thickness and material of the stool bottom plate are to be the same as those of the bulkhead plating below. The thickness of the lower portion of stool side plating is not to be less than 80% of that required for the upper part of the bulkhead plating where the same material is used. The thickness of the stool side plating and the section modulus of the stool side stiffeners is not to be less than those required by the Society on the basis of the load model in 6.3.2. The ends of stool side stiffeners are to be attached to brackets at upper and lower end of the stool. Diaphragms are to 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. Scallops in the brackets and diaphragms in way of the connection to the stool bottom plate are to be avoided.

(c) Alignment

At deck, if no stool is fitted, two transverse reinforced beams are to be fitted in line with the corrugation flanges.

At bottom, if no stool is fitted, the corrugation flanges are to be in line with the supporting floors.

Corrugated bulkhead plating is to be connected to the inner bottom plating by full penetration welds. The plating of supporting floors is to be connected to the inner bottom by either full penetration or deep penetration welds (see Figure 4.6.6).

The thickness and material properties of the supporting floors are to 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 are to be closed by collar plates. The supporting floors are to be connected to each other by suitably designed shear plates, as deemed appropriate by the Society.

Stool side plating is to align with the corrugation flanges and stool side vertical stiffeners and their brackets in lower stool are to align with the inner bottom longitudinals to provide appropriate load transmission between these stiffening members. Stool side plating is not to be knuckled anywhere between the inner bottom plating and the stool top.

6.3.4.2 Bending capacity and shear stress τ

The bending capacity is to comply with the following relationship:

$$10^3 \cdot \frac{M}{0{,}5 \cdot Z_{le} \cdot \sigma_{\alpha,le} + Z_m \cdot \sigma_{a,m}} \leq 0{,}95$$

where:

M = bending moment as given in 6.3.3.1, kN·m.

Z_{le} = section modulus of one-half pitch corrugation at the lower end of corrugations, to be calculated according to 6.3.4.3, cm³.

Z_m = section modulus of one-half pitch corrugation at the mid-span of corrugations, to be calculated according to 6.3.4.4, cm³.

$\sigma_{a,le}$ = allowable stress as given in 6.3.4.5, for the lower end of corrugations, N/mm².

$\sigma_{a,m}$ = allowable stress as given in 6.3.4.5, for the mid-span of corrugations, N/mm².

In no case Z_m is to be taken greater than the lesser of $1{,}15 \cdot Z_{le}$ and $1{,}15 \cdot Z'_{le}$ for calculation of the bending capacity, Z'_{le} being defined below.

In case shedders 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 thicknesses not less than 75% of that provided by the corrugation flange and material properties at least equal to those provided by the flanges.

or 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}, in cm^3, is to be taken not larger than the value Z'_{le}, in cm^3, given by:

$$Z'_{le} = Z_g + 10^3 \cdot \frac{Q \cdot h_g - 0{,}5 \cdot {h_g}^2 \cdot s_1 \cdot p_g}{\sigma_\alpha}$$

Where:

Z_g = section modulus of one-half pitch corrugation of the corrugations calculated, according to 6.3.4.4, in way of the upper end of shedder or gusset plates, as applicable, cm^3
Q = shear force as given in 6.3.3.2, kN
h_g = height of shedders or gusset plates, as applicable (see Figure 4.6.3(a), Figure 4.6.3(b), Figure 4.6.4(a) and Figure 4.6.4(b)), m
s_1 = as given in 6.3.2.3
p_g = resultant pressure as defined in 6.3.2.5, calculated in way of the middle of the shedders or gusset plates, as applicable, kN/m
σ_α = allowable stress as given in 6.3.4.5, in N/mm^2

Stresses τ are obtained by dividing the shear force Q by the shear area. The shear area is to 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 $\sin(\varphi)$, φ being the angle between the web and the flange.

When calculating the section modulus and the shear area, the net plate thicknesses are to be used.

The section modulus of corrugations is to be calculated on the basis of the following requirements given in 6.3.4.3 and 6.3.4.4.

6.3.4.3 Section modulus at the lower end of corrugations

The section modulus is to be calculated with the compression flange having an effective flange width, b_{ef}, not larger than as given in 6.3.4.6.

If 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 is to be calculated considering the corrugation webs 30% effective.

(a) Provided that effective shedder plates, as defined in 6.3.4.2, are fitted (see Figure 4.6.3(a) and Figure 4.6.3(b)), when calculating the section modulus of corrugations at the lower end (cross-section 1 in Figure 4.6.3(a) and Figure 4.6.3(b)), the area of flange plates may be increased by:

$$\left(2{,}5 \cdot a \cdot \sqrt{t_f \cdot t_{sh}}\right), \qquad cm^2$$

(not to be taken greater than $2{,}5 \cdot a \cdot t_f$)

where:

a = width of the corrugation flange (see Figure 4.6.2(a)), m
t_{sh} = net shedder plate thickness, mm
t_f = net flange thickness, mm

(b) Provided that effective gusset plates, as defined in 6.3.4.2, are fitted (see Figure 4.6.4(a) and Figure 4.6.4(b)), when calculating the section modulus of corrugations at the lower end (cross-section 1 in Figure 4.6.4(a) and Figure 4.6.4(b)), the area of flange plates may be increased by:

$$(7 \cdot h_g \cdot t_f), \qquad cm^2$$

where:

h_g = height of gusset plate (see Figure 4.6.4(a) and Figure 4.6.4(b)), not to be taken greater than

$$\left(\frac{10}{7} \cdot s_{gu}\right), \qquad m$$

where:

S_{gu} = width of the gusset plates, m

t_f = net flange thickness based on the as built condition, mm.

(c) If the corrugation webs are welded to a sloping stool top plate which have an angle not less than 45° 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, when 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.
For angles less than 45°, the effectiveness of the web may be obtained by linear interpolation between 30% for 0° and 100% for 45°.

6.3.4.4 Section modulus of corrugations at cross-sections other than the lower end

The section modulus is to 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 6.3.4.6.1.

6.3.4.5 Allowable stress check

The normal and shear stresses σ and τ are not to exceed the allowable values σ_a and τ_a given by:

$$\sigma_\alpha = \sigma_F, \qquad N/mm^2$$

$$\tau_\alpha = 0{,}5 \cdot \sigma_F, \qquad N/mm^2$$

where:

σ_F = the minimum upper yield stress of the material, in N/mm².

6.3.4.6 Effective compression flange width and shear buckling check

6.3.4.6.1 Effective width of the compression flange of corrugations

The effective width b_{ef} of the corrugation flange is given by:

$$b_{ef} = C_e \cdot a, \qquad m$$

where:

C_e = $\frac{2{,}25}{\beta} - \frac{1{,}25}{\beta^2}$, for β>1,25

C_e = 1,0 for β≤1,25

β = $10^3 \cdot \frac{a}{t_f} \cdot \sqrt{\frac{\sigma_F}{E}}$

t_f = net flange thickness, mm

a = width of the corrugation flange (see Figure 4.6.2(a) and Figure 4.6.2(b)), m,

σ_F = minimum upper yield stress of the material, N/mm²,

E = modulus of elasticity of the material to be assumed equal to 2,06·105 for steel, N/mm².

6.3.4.6.2 Shear

The buckling check is to be performed for the web plates at the corrugation ends. The shear stress τ is not to exceed the critical value τ_c obtained by the following:

$$\tau_c = t_E, \qquad \text{when } \tau_E \le \frac{\tau_F}{2}, \qquad N/mm^2$$

$$\tau_c = \tau_F \cdot \left(1 - \frac{\tau_F}{4 \cdot \tau_E}\right), \qquad \text{when } \tau_E > \frac{\tau_F}{2}, \qquad N/mm^2$$

where:

τ_f = $\frac{\sigma_F}{\sqrt{3}}$

σ_F = minimum upper yield stress of the material, N/mm²

τ_E = $0{,}9 \cdot k_t \cdot E \cdot \left(\frac{t}{1000 \cdot c}\right)^2, \qquad N/mm^2$

k_t, E, t and c are given by:

k_t = 6,34

E = modulus of elasticity of material as given in 6.3.4.6.1

t = net thickness of corrugation web, mm

c = width of corrugation web (See Figure 4.6.2(a)), m

6.3.4.7 Local net plate thickness

The bulkhead local net plate thickness t is given by:

$$t = 14{,}9 \cdot s_w \cdot \sqrt{\frac{1{,}05 \cdot p}{\sigma_F}}, \qquad mm$$

where:

s_w = plate width to be taken equal to the width of the corrugation flange or web, whichever is the greater (see Figure 4.6.2(a)), m

p = resultant pressure as defined in 6.3.2.5, at the bottom of each strake of plating; in all cases, the net thickness of the lowest strake is to 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, kN/m²

σ_F = minimum upper yield stress of the material, N/mm².

For built-up corrugation bulkheads, when the thicknesses of the flange and web are different, the net thickness of the narrower plating is to be not less than t_n given by:

$$t_n = 14{,}9 \cdot s_n \cdot \sqrt{\frac{1{,}05 \cdot p}{\sigma_F}}, \qquad mm$$

where:

s_n = the width, in m, of the narrower plating, m.

The net thickness of the wider plating is not to be taken less than the maximum of the following:

$$t_w = 14{,}9 \cdot s_w \cdot \sqrt{\frac{1{,}05 \cdot p}{\sigma_F}}, \qquad mm$$

and

$$t_w = \sqrt{\frac{440 \cdot s_w^2 \cdot 1{,}05 \cdot p}{\sigma_F} - t_{np}^2}, \qquad mm$$

where:

$t_{np} \leq$ actual net thickness of the narrower plating and not to be greater than

$$14{,}9 \cdot s_w \cdot \sqrt{\frac{1{,}05 \cdot p}{\sigma_F}}$$

6.3.5 Local details

As applicable, the design of local details is to comply with the Society requirements for the purpose of transferring the corrugated bulkhead forces and moments to the boundary structures, in particular to the double bottom and cross-deck structures.

In particular, the thickness and stiffening of effective gusset and shedder plates, as defined in 6.3.4.3, is to comply with the Society requirements, on the basis of the load model in 6.3.2.

Unless otherwise stated, weld connections and materials are to be dimensioned and selected in accordance with the Society requirements.

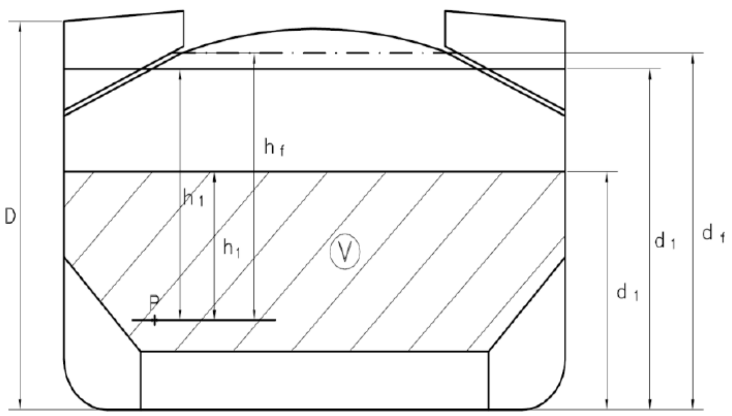
6.3.6 Corrosion addition and steel renewal

The corrosion addition t_s is to be taken equal to 3,5 mm.

Steel renewal is required where the gauged thickness is less than t_{net} + 0,5 mm.

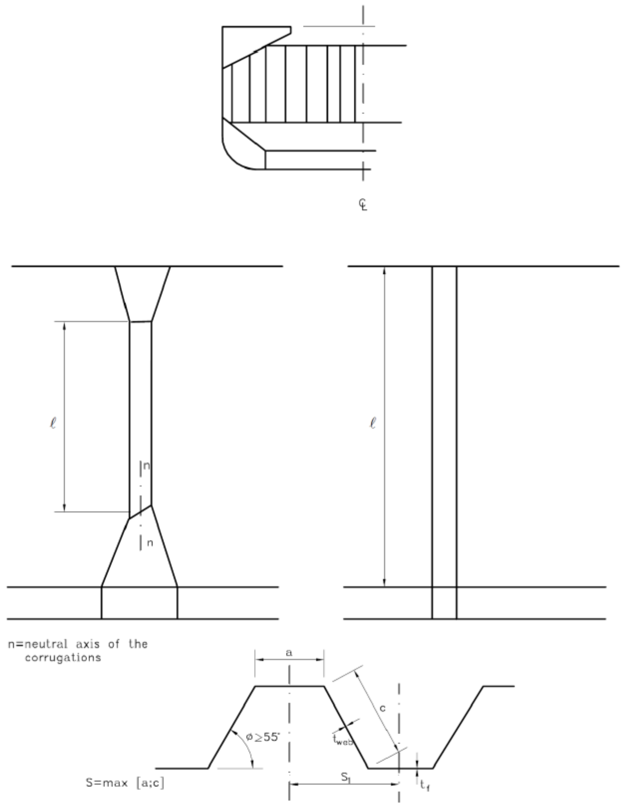
Where the gauged thickness is within the range t_{net} + 0,5 mm and t_{net} +1,0 mm, coating (applied in accordance with the coating manufacturer's requirements) or annual gauging may be adopted as an alternative to steel renewal.

Figure 4.6.1:

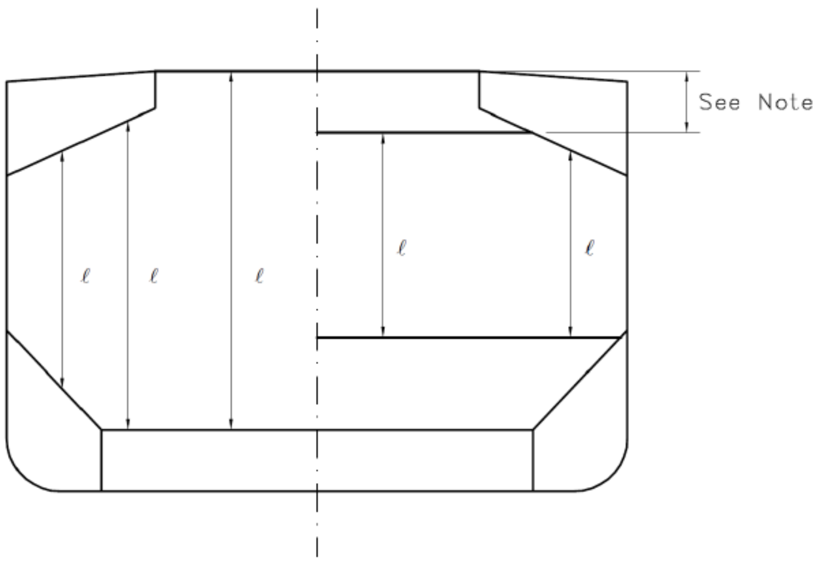


V = Volume of cargo
P = Calculation point

Figure 4.6.2
(a)



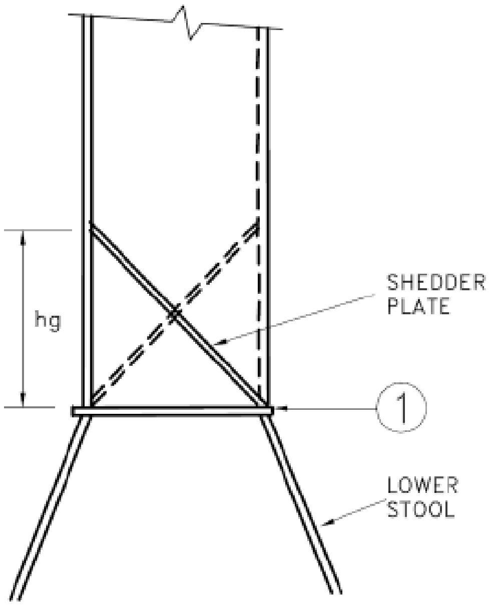
(b)



NOTE:
For the definition of l, the internal end of the upper stool is not to be taken more than a distance from the deck at the centre line equal to:
- 3 times the depth of corrugations, in general
- 2 times the depth of corrugations, for rectangular stool

Figure 4.6.3:

(a) Symmetric shedder plates



(b) Asymmetric shedder plates

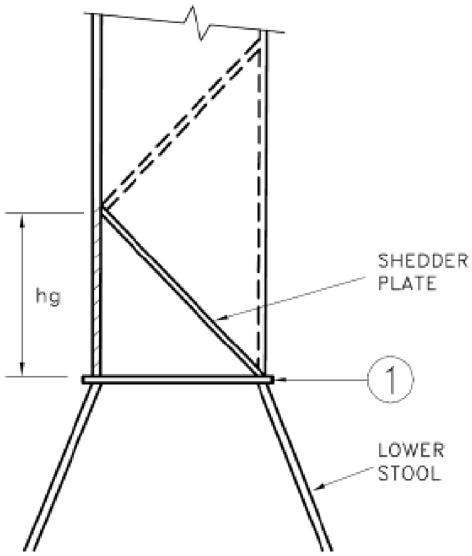
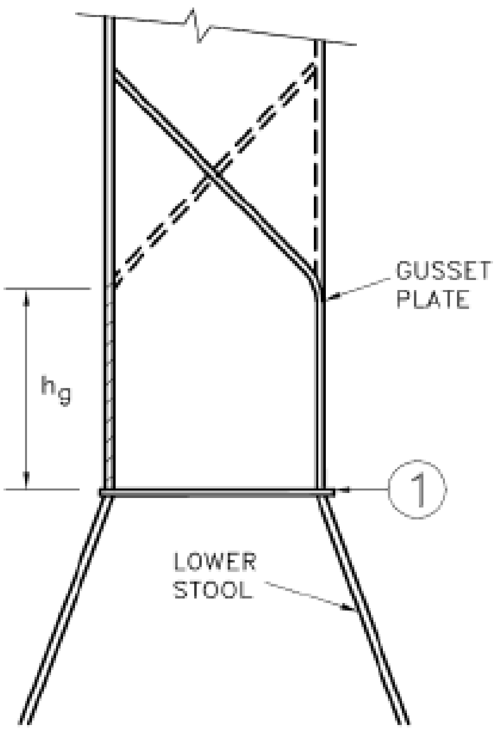


Figure 4.6.4:

(a) Symmetric gusset shedder plates



(b) Asymmetric gusset / shedder plates

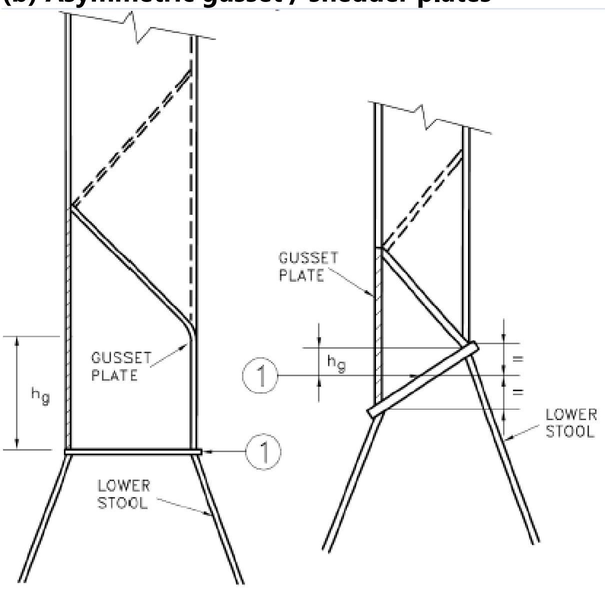


Figure 4.6.5: Permitted distance, d, from edge of stool top plate to surface of corrugation flange

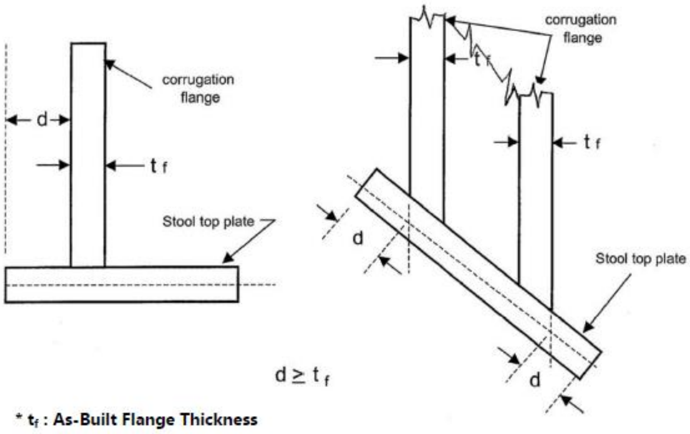
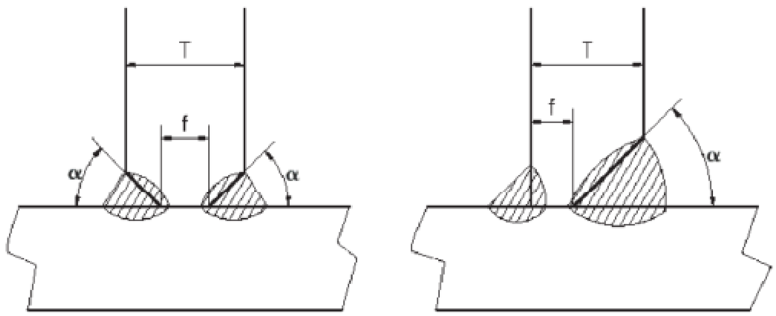


Figure 4.6.6:



6.4 Evaluation of Scantlings of the Transverse Watertight Corrugated Bulkhead between Cargo Holds Nos. 1 and 2, with Cargo Hold No. 1 Flooded, for Existing Bulk Carriers (IACS UR S19 Rev.5)

6.4.1 Application and definitions

These requirements apply to all bulk carriers of 150 m in length and above, in the foremost hold, intending to carry solid bulk cargoes having a density of 1,78 t/m^3, or above, with single deck, topside tanks and hopper tanks, fitted with vertically corrugated transverse watertight bulkheads between cargo holds No. 1 and 2 where:

(i) the foremost hold is bounded by the side shell only for ships, which were contracted for construction prior to 1 July 1998, and have not been constructed in compliance with 6.3.

(ii) the foremost hold is double side skin construction of less than 760 mm breadth measured perpendicular to the side shell in ships, the keels of which were laid, or which were at a similar stage of construction, before 1 July 1999 and have not been constructed in compliance with 6.3.

The net scantlings of the transverse bulkhead between cargo holds Nos. 1 and 2 are to be calculated using the loads given in 6.4.2, the bending moment and shear force given in 6.4.3 and the strength criteria given in 6.4.4.

Where necessary, steel renewal and/or reinforcements are required as per 6.4.6.

In these requirements, homogeneous loading condition means a loading condition in which the ratio between the highest and the lowest filling ratio, evaluated for the two foremost cargo holds, does not exceed 1,20, to be corrected for different cargo densities.

6.4.2 Load model

6.4.2.1 General

The loads to be considered as acting on the bulkhead are those given by the combination of the cargo loads with those induced by the flooding of cargo hold No.1.

The most severe combinations of cargo induced loads and flooding loads are to be used for the check of the scantlings of the bulkhead, depending on the loading conditions included in the loading manual:

– homogeneous loading conditions,
– non homogeneous loading conditions.

Non homogeneous part loading conditions associated with multiport loading and unloading operations for homogeneous loading conditions need not to be considered according to these requirements.

6.4.2.2 Bulkhead corrugation flooding head

The flooding head h_f (see Figure 4.6.7) is the distance, in m, measured vertically with the ship in the upright position, from the calculation point to a level located at a distance d_f, in m, from the baseline equal to:

(a) in general:
  – D
(b) for ships less than 50.000 tonnes deadweight with Type B freeboard:
  – 0,95·D

where:

D = the distance from the baseline to the freeboard deck at side amidship (see Figure 4.6.7), m.

(c) for ships to be operated at an assigned load line draught T_r less than the permissible load line draught T, the flooding head defined in (a) and (b) above may be reduced by T - T_r.

6.4.2.3 Pressure in the flooded hold

6.4.2.3.1 Bulk cargo loaded hold

Two cases are to be considered, depending on the values of d_1 and d_f, d_1 (see Figure 4.6.7) being a distance from the baseline given, in m, by:

$$d_1 = \frac{M_C}{\rho_c \cdot I_C \cdot B} + \frac{V_{LS}}{I_C \cdot B} + (h_{HT} - h_{DB}) \cdot \frac{b_{HT}}{B} + h_{DB}$$

where:

M_c = mass of cargo in hold No. 1, tonnes,
ρ_c = bulk cargo density, t/m^3,
l_c = length of hold No. 1, m,
B = ship's breadth amidship, m
V_{LS} = volume of the bottom stool above the inner bottom, m^3,
h_{HT} = height of the hopper tanks amidship from the baseline, m,
h_{DB} = height of the double bottom, m,

b_{HT} = breadth of the hopper tanks amidship, m.

(a) $d_f \geq d_1 b$

At each point of the bulkhead located at a distance between d_1 and d_f from the baseline, the pressure $p_{c,f}$ is given by:

$$p_{c,f} = \rho \cdot g \cdot h_f, \quad kN/m^2$$

where:

ρ = sea water density, t/m^3
g = 9,81 m/s^2, gravity acceleration
h_f = flooding head as defined in 6.4.2.2.

At each point of the bulkhead located at a distance lower than d_1 from the baseline, the pressure $p_{c,f}$ is given by:

$$p_{c,f} = \rho \cdot g \cdot h_f + [\rho_c - \rho \cdot (1 - perm)] \cdot g \cdot h_1 \cdot \tan^2\gamma, \qquad kN/m^2,$$

where:

ρ, g, h_f = as given above
p_c = bulk cargo density, t/m^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),
h_1 = vertical distance from the calculation point to a level located at a distance d_1, as defined above, from the base line (see Figure 4.6.7), m,
γ = 45° - (φ/2)
φ = angle of repose of the cargo and may generally be taken as 35° for iron ore, degrees.

The force $F_{c,f}$, in kN, acting on a corrugation is given by:

$$F_{c,f} = s_1 \cdot \left[\rho \cdot g \cdot \frac{(d_f - d_1)^2}{2} + \frac{\rho \cdot g \cdot (d_f - d_1) + (p_{c,f})_{le}}{2} \cdot (d_1 - h_{DB} - h_{LS})\right]$$

where:

s_1 = spacing of corrugations (see Figure 4.6.8(a)), m, ρ, g, d_1, h_{DB} = as given above
ρ, g, d_1, h_{DB} = as given above
d_f = as given in 6.4.2.2
$(p_{c,f})_{le}$ = pressure at the lower end of the corrugation, kN/m^2,
h_{LS} = height of the lower stool from the inner bottom, m.

(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 given by:

$$p_{c,f} = \rho_c \cdot g \cdot h_1 \cdot \tan^2\gamma, \qquad kN/m^2$$

where:

ρ_c, g, h_1, γ = as given in (a) above

At each point of the bulkhead located at a distance lower than d_f from the baseline, the pressure $p_{c,f}$ is given by:

$$p_{c,f} = \rho \cdot g \cdot h_f + [\rho_c \cdot h_1 - \rho \cdot (1 - perm) \cdot h_f] \cdot g \cdot \tan^2\gamma, \quad kN/m^2$$

where:

ρ_c, g, h_f, ρ_c , h_1, perm, γ = as given in (a) above

The force $F_{c,f}$ acting on a corrugation is given by:

$$F_{c,f} = s_1 \cdot \left[\rho_c \cdot g \cdot \frac{(d_1 - d_f)^2}{2} \cdot \tan^2\gamma + \frac{\rho_c \cdot g \cdot (d_1 - d_f) \cdot \tan^2\gamma + (p_{c,f})}{2} \cdot (d_f - h_{DB} - h_{LS})\right], \quad kN$$

where:

s_1, ρ_c, g, γ, $(p_{c,f})_{le}$, h_{LS} = as given in (a) above
d_1, h_{DB} = as given in 6.4.2.3.1
d_f = as given in 6.4.2.2.

6.4.2.3.2 Empty hold

At each point of the bulkhead, the hydrostatic pressure p_f induced by the flooding head h_f is to be considered.

The force F_f acting on a corrugation is given by:

$$F_f = s_1 \cdot \rho \cdot g \cdot \frac{(d_f - h_{DB} - h_{LS})^2}{2}, \quad kN$$

where:

s_1, ρ, g, h_{LS} = as given in 6.4.2.3.1(a),
h_{DB} = as given in 6.4.2.3.1,
d_f = as given in 6.4.2.2.

6.4.2.4 Pressure in the non-flooded bulk cargo loaded hold

At each point of the bulkhead, the pressure p_c is given by:

$$p_c = \rho_c \cdot g \cdot h_1 \cdot \tan^2\gamma, \quad kN/m^2,$$

where:

ρ_c, g, h_1, γ = as given in 6.4.2.3.1(a)

The force F_c acting on a corrugation is given by:

$$F_c = \rho_c \cdot g \cdot s_1 \cdot \frac{(d_1 - h_{DB} - h_{LS})^2}{2} \cdot \tan^2\gamma, \quad kN/m^2,$$

where:

ρ_c, g, s_1, h_{LS}, γ = as given in 6.4.2.3.1(a)
d_1, h_{DB} = as given in 6.4.2.3.1

6.4.2.5 Resultant pressure

6.4.2.5.1 Homogeneous loading conditions

At each point of the bulkhead structures, the resultant pressure p to be considered for the scantlings of the bulkhead is given by:

$$p = \rho_{c,f} - 0{,}8 \cdot \rho_c, \quad kN/m^2$$

The resultant force F acting on a corrugation is given by:

$$F = F_{c,f} - 0{,}8 \cdot F_c, \qquad kN$$

6.4.2.5.2 Non homogeneous loading conditions

At each point of the bulkhead structures, the resultant pressure p to be considered for the scantlings of the bulkhead is given by:

$$p = \rho_{c,f}, \qquad kN$$

The resultant force F acting on a corrugation is given by:

$$F = F_{c,f}, \qquad kN$$

In case hold No.1, in non-homogeneous loading conditions, is not allowed to be loaded, the resultant pressure p to be considered for the scantlings of the bulkhead is given by:

$$p = p_f, \qquad kN/m^2$$

and the resultant force F acting on a corrugation is given by:

$$F = F_f, \qquad kN$$

6.4.3 Bending moment and shear force in the bulkhead corrugations

The bending moment M and the shear force Q in the bulkhead corrugations are obtained using the formulae given in 6.4.3.1 and 6.4.3.2. The M and Q values are to be used for the checks in 6.4.4.

6.4.3.1 Bending moment

The design bending moment M for the bulkhead corrugations is given by:

$$M = \frac{F \cdot l}{8}, \qquad kNm$$

where:

F = resultant force as given in 6.4.2.5, kN,
l = span of the corrugation to be taken according to Figure 4.6.8(a) and Figure 4.6.8(b), m.

6.4.3.2 Shear force

The shear force Q at the lower end of the bulkhead corrugations is given by:

$$Q = 0{,}8 \cdot F, \qquad kN$$

where:

F = as given in 6.4.2.5

6.4.4 Strength criteria

6.4.4.1 General

The following criteria are applicable to transverse bulkheads with vertical corrugations (see Figure 4.6.8(a)).

Requirements for local net plate thickness are given in 6.4.4.7.

In addition, the criteria given in 6.4.4.2 and 6.4.4.5 are to be complied with.

Where the corrugation angle φ shown in Figure 4.6.8(a), if less than 50°, a horizontal row of staggered shedder plates is to be fitted at approximately mid depth of the corrugations (see Figure 4.6.8(a)) to help preserve dimensional stability of the bulkhead under flooding loads. The shedder plates are to be welded to the corrugations by double continuous welding, but they are not to be welded to the side shell.

The thicknesses of the lower part of corrugations considered in the application of 6.4.4.2 and 6.4.4.3 are to 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 thicknesses of the middle part of corrugations considered in the application of 6.4.4.2 and 6.4.4.4 are to 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.

6.4.4.2 Bending capacity and shear stress τ

The bending capacity is to comply with the following relationship:

$$10^3 \cdot \frac{M}{0{,}5 \cdot Z_{le} \cdot \sigma_{a,le} + Z_m \cdot \sigma_{a,m}} \leq 1{,}0$$

where:

M	=	bending moment as given in 6.4.3.1, kN·m
Z_{le}	=	section modulus of one-half pitch corrugation at the lower end of corrugations, to be calculated according to 6.4.4.3, cm^3.
Z_m	=	section modulus of one-half pitch corrugation at the mid-span of corrugations, to be calculated according to 6.4.4.4, cm^3
$\sigma_{a,le}$	=	allowable stress as given in 6.4.4.5, for the lower end of corrugations, N/mm^2
$\sigma_{a,m}$	=	allowable stress as given in 6.4.4.5, for the mid-span of corrugations, N/mm^2.

In no case Z_m is to be taken greater than the lesser of 1,15·Z_{le} and 1,15·Z'_{le} for calculation of the bending capacity, Z'_{le} being defined below.

In case effective shedders 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;
  or effective gusset plates are fitted which:
- are fitted in line with the stool side plating,
- have material properties at least equal to those provided for the flanges,

the section modulus Z_{le} is to be taken not larger than the value Z'_{le} given by:

$$Z'_{ie} = Z_g + 10^3 \cdot \frac{Q \cdot h_q - 0{,}5 \cdot h_g^2 \cdot s_1 \cdot p_g}{\sigma_\alpha}, \qquad cm^3$$

where:

Z_g	=	section modulus of one-half pitch corrugation according to 6.4.4.4, in way of the upper end of shedder or gusset plates, as applicable, cm^3,
Q	=	shear force as given in 6.4.3.2, kN,
h_g	=	height of shedders or gusset plates, as applicable (see Figures 4.6.(9a, 9b, 10a and 10b), m,
s_1	=	as given in 6.4.2.3.1(a),
p_g	=	resultant pressure as defined in 6.4.2.5, calculated in way of the middle of the shedders or gusset plates, as applicable, kN/m^2
σ_a	=	allowable stress as given in 6.4.4.5, in N/mm^2.

Stresses τ are obtained by dividing the shear force Q by the shear area. The shear area is to 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.

When calculating the section moduli and the shear area, the net plate thicknesses are to be used.

The section moduli of corrugations are to be calculated on the basis of the requirements given in 6.4.4.3 and 6.4.4.4.

6.4.4.3 Section modulus at the lower end of corrugations

The section modulus is to be calculated with the compression flange having an effective flange width, b_{ef}, not larger than as given in 6.4.4.6.1.

If 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 is to be calculated considering the corrugation webs 30% effective.

(a) Provided that effective shedder plates, as defined in 6.4.4.2, are fitted (see Figure 4.6.9(a) and Figure 4.6.9(b)), when calculating the section modulus of corrugations at the lower end (cross-section 1 in Figure 4.6.9(a) and Figure 4.6.9(b)), the area of flange plates may be increased by

$$\left(2{,}5 \cdot a \cdot \sqrt{t_f \cdot t_{sh}} \cdot \sqrt{\frac{\sigma_{Fsh}}{\sigma_{Ffl}}}\right), \qquad cm^2$$

(not to be taken greater than $2{,}5 \cdot a \cdot t_f$)

where:

a = width of the corrugation flange (see Figure 4.6.8(a)), m,
t_{sh} = net shedder plate thickness, mm,
t_F = net flange thickness, mm,
σ_{Fsh} = minimum upper yield stress of the material used for the shedder plates, N/mm^2,
σ_{Ffl} = minimum upper yield stress of the material used for the corrugation flanges, N/mm^2.

(b) Provided that effective gusset plates, as defined in 6.4.4.2, are fitted (see Figure 4.6.10(a) and Figure 4.6.10(b)), when calculating the section modulus of corrugations at the lower end (cross-section 1 in Figure 4.6.10(a) and Figure 4.6.10(b)), the area of flange plates may be increased by:

$$\left(7 \cdot h_g \cdot t_{gu}\right), \qquad cm^2$$

where:

h_g = height of gusset plate, see Figure 4.6.10(a) and Figure 4.6.10(b), not to be taken greater than:

$$\left(\frac{10}{7} \cdot s_{gu}\right), \qquad m$$

s_{gu} = width of the gusset plates, m,
t_{gu} = net gusset plate thickness not to be taken greater than tf, mm,
t_f = net flange thickness based on the as built condition, mm

(c) If the corrugation webs are welded to a sloping stool top plate, which is at an angle not less than 45° 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, when 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.

For angles less than 45°, the effectiveness of the web may be obtained by linear interpolation between 30% for 0° and 100% for 45°.

6.4.4.4 Section modulus of corrugations at cross-sections other than the lower end

The section modulus is to 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 6.4.4.6.1.

6.4.4.5 Allowable stress check

The normal and shear stresses σ and τ are not to exceed the allowable values σ_a and τ_a given by:

$$\sigma_a = \sigma_F, \qquad N/mm^2$$

$$t_a = 0{,}5 \cdot \sigma_F\,, \qquad N/mm^2$$

where:

σ_F = minimum upper yield stress of the material, N/mm^2.

6.4.4.6 Effective compression flange width and shear buckling check

6.4.4.6.1 Effective width of the compression flange of corrugations

The effective width b_{ef} of the corrugation flange is given by:

$$b_{ef} = C_e \cdot a$$

where:

C_e = $\frac{2,25}{\beta} - \frac{1,25}{\beta^2}$ for β > 1,25
C_e = 1,0 for β ≤ 1,25
β = $10^3 \cdot \frac{a}{t_f} \cdot \sqrt{\frac{\sigma_F}{E}}$
t_f = net flange thickness, mm
a = width of the corrugation flange (see Figure 4.6.8(a)), m
σ_F = minimum upper yield stress of the material, N/mm^2,
E = modulus of elasticity to be assumed equal to 2,06·105 N/mm^2 for steel, N/mm^2.

6.4.4.6.2 Shear

The buckling check is to be performed for the web plates at the corrugation ends. The shear stress τ is not to exceed the critical value τ_c obtained by the following:

$$\tau_c = t_E \text{ when } \tau_E \le \frac{\tau_F}{2}$$

$$\tau_c = \tau_F \cdot \left(1 - \frac{\tau_F}{4 \cdot \tau_E}\right) \text{ when } \tau_E > \frac{\tau_F}{2}\,, \qquad N/mm^2$$

$$\tau_F = \frac{\sigma_F}{\sqrt{3}}$$

where:

σ_F = minimum upper yield stress of the material, N/mm^2,
τ_E = $0{,}9 \cdot k_t \cdot E \cdot \left(\frac{t}{1000 \cdot c}\right)^2$, N/mm^2

k_t, E, t and c are given by:

k_t = 6,34
E = modulus of elasticity of material as given in 6.4.4.6.1
t = net thickness of corrugation web, mm,
c = width of corrugation web (See Figure 4.6.8(a)), m

6.4.4.7 Local net plate thickness

The bulkhead local net plate thickness t is given by:

$$t = 14{,}9 \cdot s_w \cdot \sqrt{\frac{p}{\sigma_F}}, \qquad \text{mm}$$

where:

s_w = plate width to be taken equal to the width of the corrugation flange or web, whichever is the greater (see Figure 4.6.8(a)), m,
p = resultant pressure, as defined in 6.4.2.5, at the bottom of each strake of plating; in all cases, the net thickness of the lowest strake is to 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, kN/m²,
σ_F = minimum upper yield stress of the material, N/mm².

For built-up corrugation bulkheads, when the thicknesses of the flange and web are different, the net thickness of the narrower plating is to be not less than t_n given by:

$$t_n = 14{,}9 \cdot s_n \cdot \sqrt{\frac{p}{\sigma_F}}, \qquad \text{mm}$$

where:

s_n = the width of the narrower plating, m.

The net thickness of the wider plating is not to be taken less than the maximum of the following values:

$$t_w = 14{,}9 \cdot s_w \cdot \sqrt{\frac{p}{\sigma_F}}, \qquad \text{mm}$$

$$t_w = \sqrt{\frac{440 \cdot s_w^2 \cdot p}{\sigma_F} - {t_{np}}^2}, \qquad \text{mm}$$

where:

t_{np} ≤ actual net thickness of the narrower plating and not to be greater than:

$$14{,}9 \cdot s_w \cdot \sqrt{\frac{p}{\sigma_F}}$$

6.4.5 Local details

As applicable, the design of local details is to comply with the Society's requirements for the purpose of transferring the corrugated bulkhead forces and moments to the boundary structures, in particular to the double bottom and cross-deck structures.

In particular, the thickness and stiffening of gusset and shedder plates, installed for strengthening purposes, is to comply with the Society's requirements, on the basis of the load model in 6.4.2.

Unless otherwise stated, weld connections and materials are to be dimensioned and selected in accordance with the Society's requirements.

6.4.6 Corrosion addition and steel renewal

Renewal/reinforcement shall be done in accordance with the following requirements and the guidelines contained in ANNEX A.

(a) Steel renewal is required where the gauged thickness is less than t_{net} + 0,5 mm, t_{net} being the thickness used for the calculation of bending capacity and shear stresses as given in 6.4.4.2 or the local net plate thickness as given in 6.4.4.7. Alternatively, reinforcing doubling strips may be used providing the net thickness is not dictated by shear strength requirements for web plates (see 6.4.4.5 and 6.4.4.6.2) or by local pressure requirements for web and flange plates (see 6.4.4.7).
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.

(b) Where steel renewal or reinforcement is required, a minimum thickness of t_{net} + 2,5 mm is to be replenished for the renewed or reinforced parts.

(c) When:

$$0{,}8 \cdot (\sigma_{Ffl} \cdot t_{fl}) \geq \sigma_{Fs} \cdot t_{st}$$

where:

σ_{Ffl} = minimum upper yield stress of the material used for the corrugation flanges, N/mm²,

σ_{Fs} = minimum upper yield stress of the material used for the lower stool side plating or floors (if no stool is fitted), N/mm²

t_{fl} = flange thickness, in mm, which is found to be acceptable on the basis of the criteria specified in (a) above or, when steel renewal is required, the replenished thickness according to the criteria specified in (b) above. The above flange thickness dictated by local pressure requirements (see 6.4.4.7) need not be considered for this purpose.

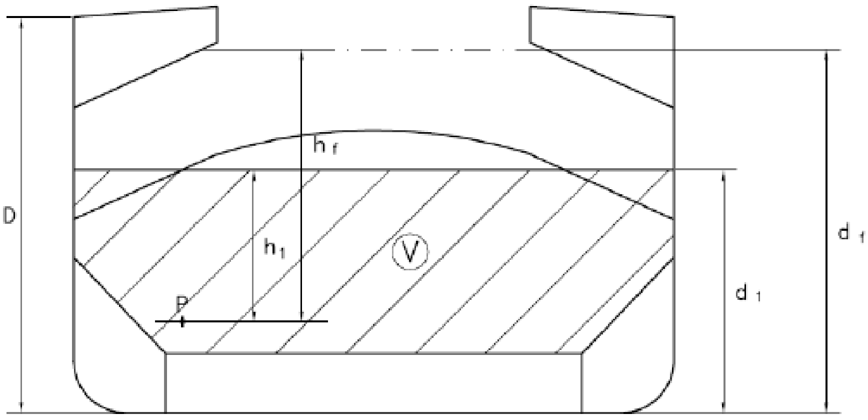
t_{st} = as built thickness of the lower stool side plating or floors (if no stool is fitted), mm.

Gussets with shedder plates, extending from the lower end of corrugations up to 0,1·l, or reinforcing doubling strips (on bulkhead corrugations and stool side plating) are to be fitted.
If gusset plates are fitted, the material of such gusset plates is to be the same as that of the corrugation flanges. The gusset plates are to be connected to the lower stool shelf plate or inner bottom (if no lower stool is fitted) by deep penetration welds (see Figure 4.6.11).

(d) Where steel renewal is required, the bulkhead connections to the lower stool shelf plate or inner bottom (if no stool is fitted) are to be at least made by deep penetration welds (see Figure 4.6.11).

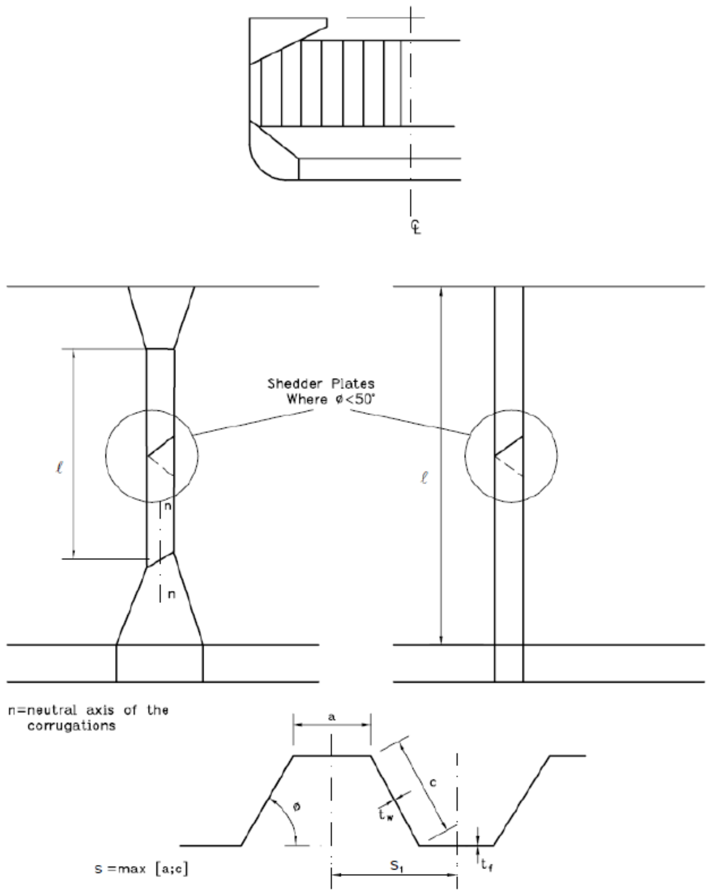
(e) Where gusset plates are to be fitted or renewed, their connections with the corrugations and the lower stool shelf plate or inner bottom (if no stool is fitted) are to be at least made by deep penetration welds (see Figure 4.6.11).

Figure 4.6.7:

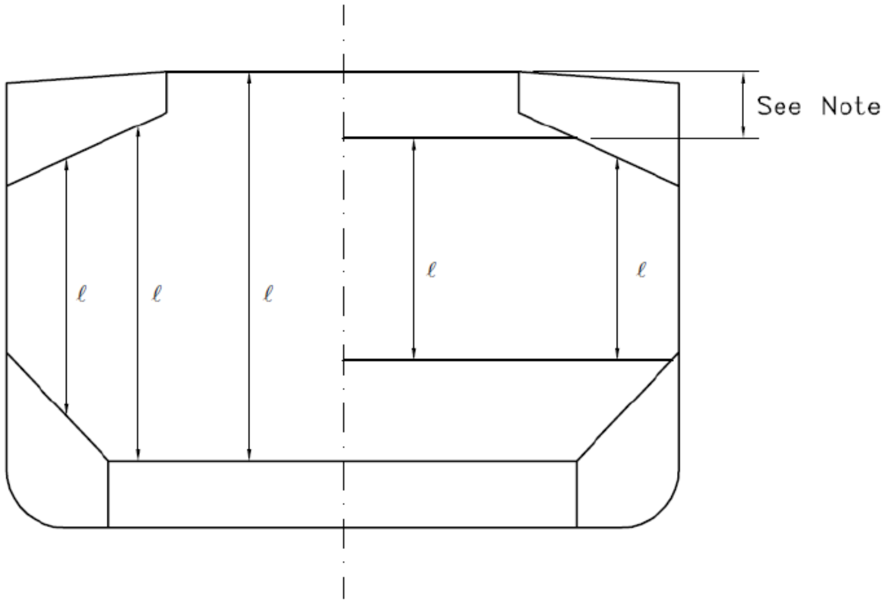


V = Volume of cargo
P = Calculation point

Figure 4.6.8:
(a)



(b)

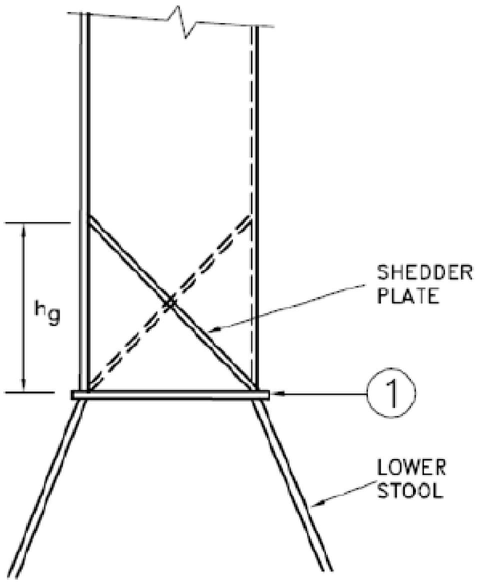


NOTE:
For the definition of ℓ, the internal end of the upper stool is not to be taken more than a distance from the deck at the centre line equal to:

- 3 times the depth of corrugations, in general
- 2 times the depth of corrugations, for rectangular stool

Figure 4.6.9:

(a) Symmetric shedder plates



(b) Asymmetric shedder plates

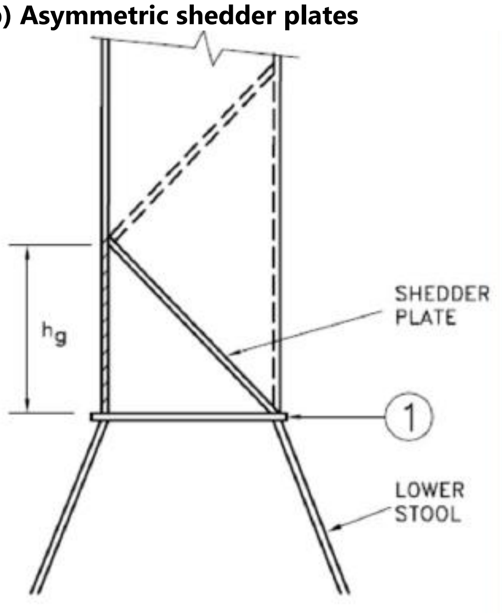


Figure 4.6.10:
(a) Symmetric gusset / shedder plates **(b) Asymmetric gusset / shedder plates**

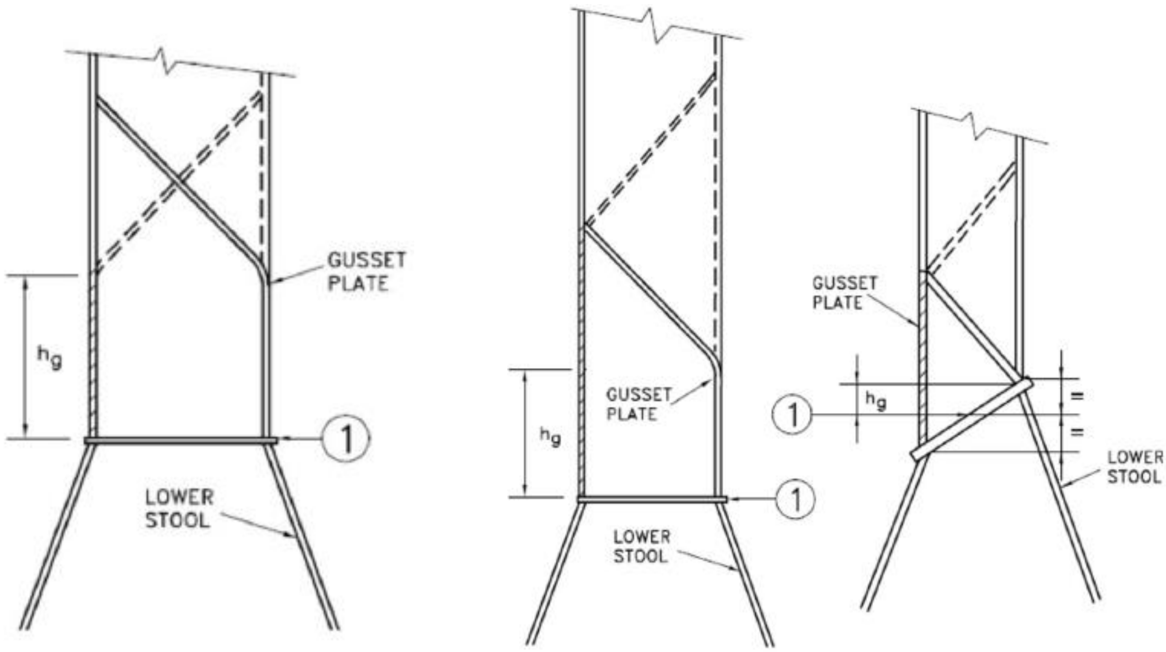
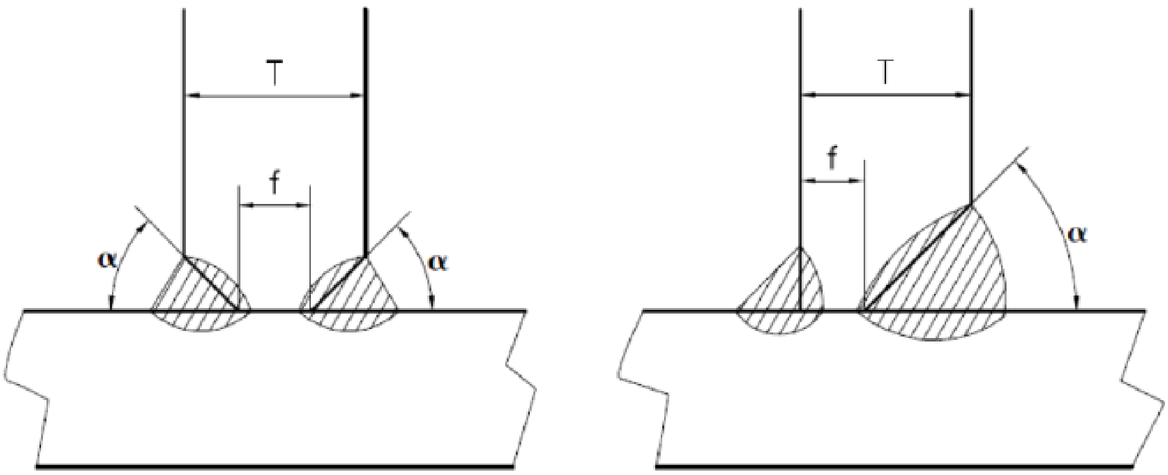


Figure 4.6.11:



ANNEX A **to subsection 6.4:**

Guidance on renewal/reinforcement of vertically corrugated transverse watertight bulkhead between cargo holds Nos. 1 and 2

A1 The need for renewal or reinforcement of the vertically corrugated transverse watertight bulkhead between cargo holds Nos. 1 and 2 will be determined by the Society on a case-by-case basis using the criteria given in 6.4 in association with the most recent gaugings and findings from survey.

A2 In addition to class requirements, the 6.4 assessment of the transverse corrugated bulkhead will take into account the following:

(a) Scantlings of individual vertical corrugations will be assessed for reinforcement/renewal based on thickness measurements obtained in accordance with the relevant Society's requirements, at their lower end, at mid-depth and in way of plate thickness changes in the lower 70%. These considerations will take into account the provision of gussets and shedder plates and the benefits they offer, provided that they comply with 6.4.4.2 and 6.4.6.

(b) Taking into account the scantlings and arrangements for each case, permissible levels of diminution will be determined and appropriate measures taken in accordance with 6.4.6.

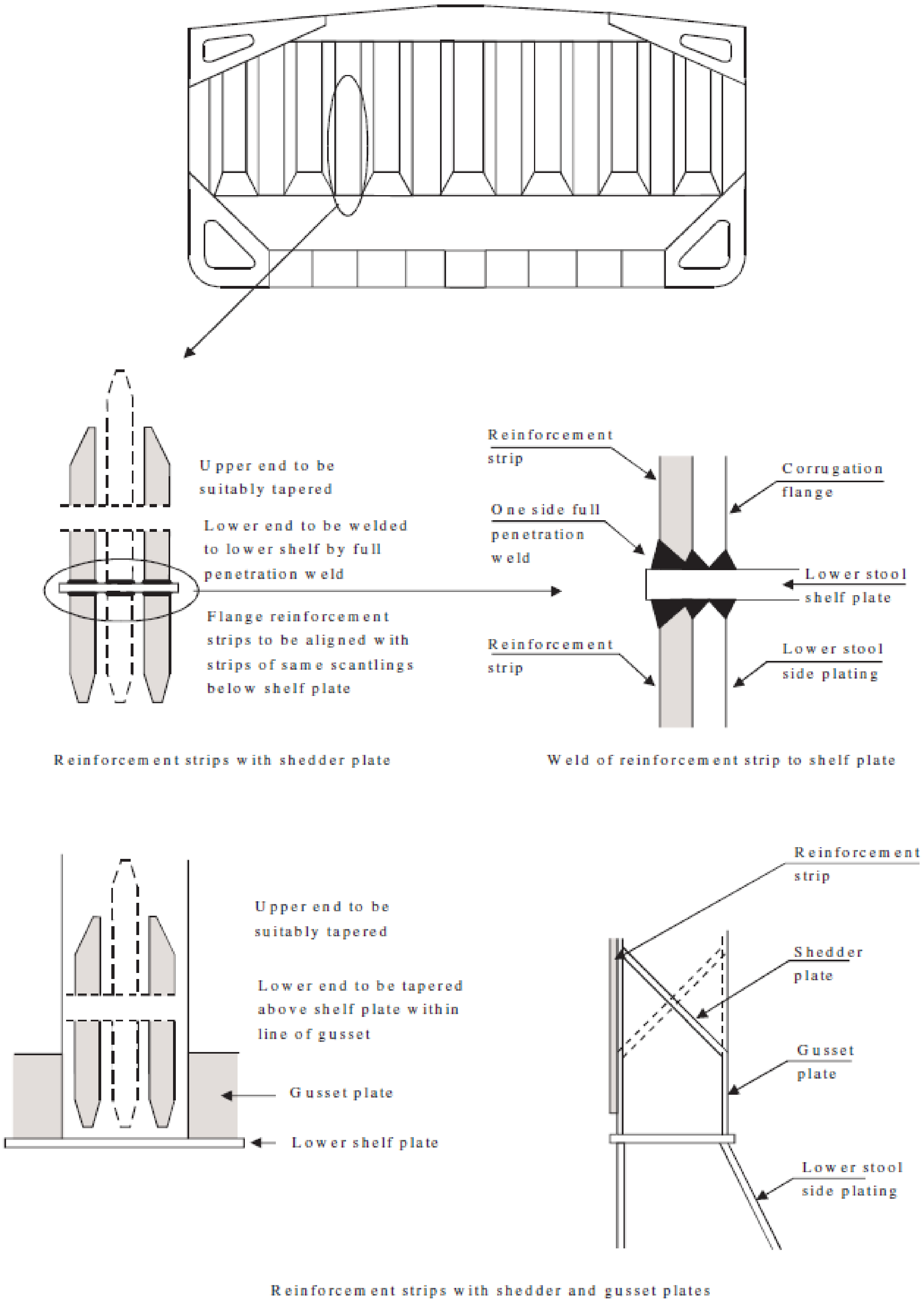
A3 Where renewal is required, the extent of renewal is to be shown clearly in plans. The vertical distance of each renewal zone is to be determined by considering 6.4 and in general is to be not less than 15% of the vertical distance between the upper and lower end of the corrugation measured at the ship's centreline.

A4 Where the reinforcement is accepted by adding strips, the length of the reinforcing strips is to be sufficient to allow it to extend over the whole depth of the diminished plating. In general, the width and thickness of strips should be sufficient to comply with the 6.4 requirements. The material of the strips is to be the same as that of the corrugation plating. The strips are to be attached to the existing bulkhead plating by continuous fillet welds. The strips are to be suitably tapered or connected at ends in accordance with Society practice.

A5 Where reinforcing strips are connected to the inner bottom or lower stool shelf plates, one side full penetration welding is to be used. When reinforcing strips are fitted to the corrugation flange and are connected to the lower stool shelf plate, they are normally to be aligned with strips of the same scantlings welded to the stool side plating and having a minimum length equal to the breadth of the corrugation flange.

A6 Figure 4.6.12 gives a general arrangement of structural reinforcement.

Figure 4.6.12:



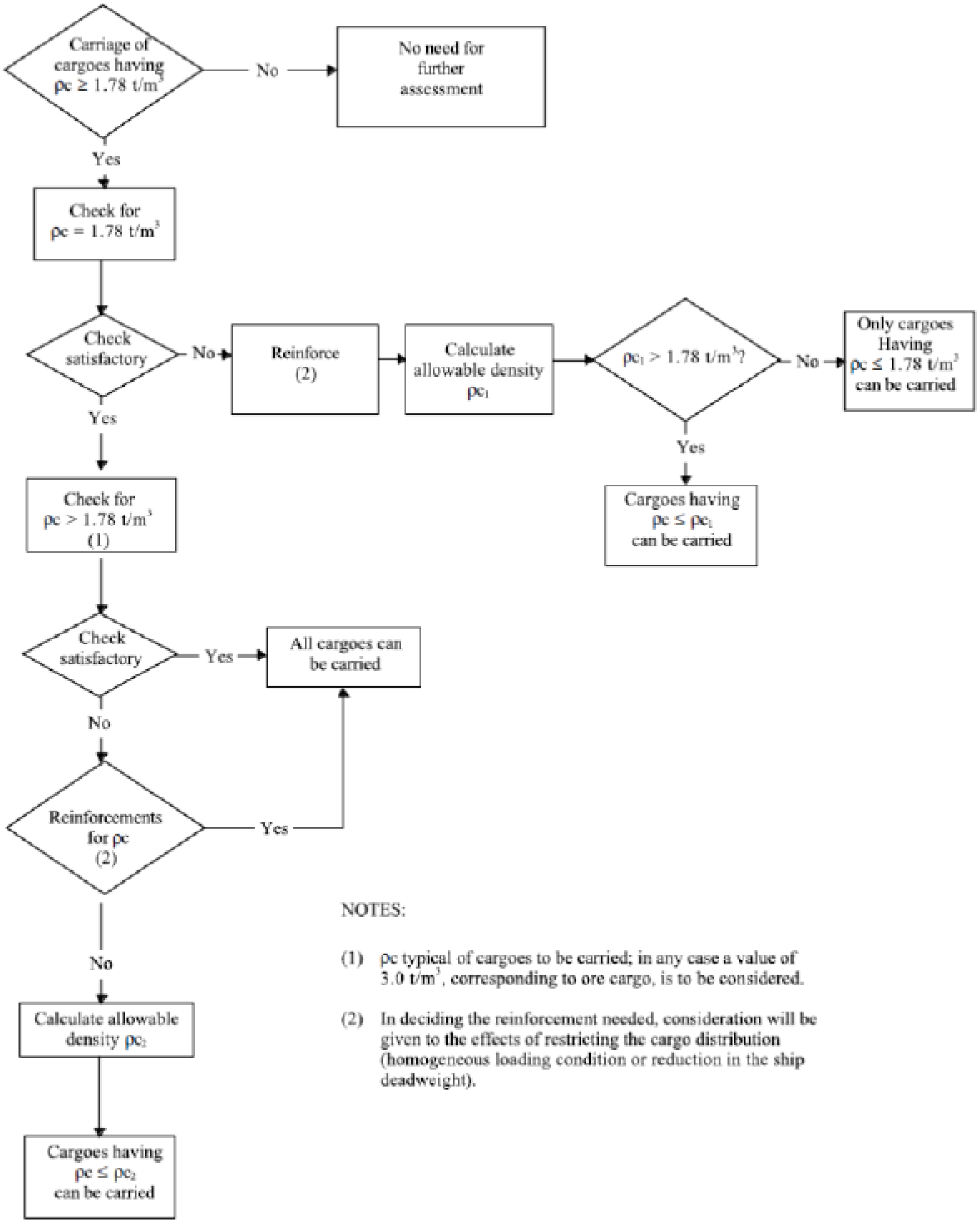
Upper end to be suitably tapered
Lower end to be welded to lower shelf by full penetration weld
Flange reinforcement strips to be aligned with strips of same scantlings below shelf plate
Reinforcement strip
Corrugation flange
One side full penetration weld
Lower stool shelf plate
Reinforcement strip
Lower stool side plating
Reinforcement strips with shedder plate
Weld of reinforcement strip to shelf plate
Upper end to be suitably tapered
Lower end to be tapered above shelf plate within line of gusset
Gusset plate
Lower shelf plate
Reinforcement strip
Shedder plate
Gusset plate
Lower stool side plating
Reinforcement strips with shedder and gusset plates

Notes to Figure 4.6.12 on reinforcement:

1. Square or trapezoidal corrugations are to be reinforced with plate strips fitted to each corrugation flange sufficient to meet the requirements of 6.4.
2. The number of strips fitted to each corrugation flange is to be sufficient to meet the requirements of 6.4.
3. The shedder plate may be fitted in one piece or prefabricated with a welded knuckle (gusset plate).
4. Gusset plates, where fitted, are to be welded to the shelf plate in line with the flange of the corrugation, to reduce the stress concentrations at the corrugation corners. Ensure good alignment between gusset plate, corrugation flange and lower stool sloping plate. Use deep penetration welding at all connections. Ensure start and stop of welding is as far away as practically possible from corners of corrugation.
5. Shedder plates are to be attached by one side full penetration welds onto backing bars.
6. Shedder and gusset plates are to have a thickness equal to or greater than the original bulkhead thickness. Gusset plate is to have a minimum height (on the vertical part) equal to half of the width of the corrugation flange. Shedders and gussets are to be same material as flange material.

ANNEX B **to subsection 6.4:**

Guidance to Assess Capability of Carriage of High-Density Cargoes on Existing Bulk carriers according to the Strength of Transverse Bulkhead between Cargo Holds Nos.1 and 2.



NOTES:

(1) ρc typical of cargoes to be carried; in any case a value of 3.0 t/m³, corresponding to ore cargo, is to be considered.

(2) In deciding the reinforcement needed, consideration will be given to the effects of restricting the cargo distribution (homogeneous loading condition or reduction in the ship deadweight).

SECTION 7 Hatch covers

7.1 Evaluation of Scantlings of Hatch Covers and Hatch Coamings of Cargo Holds of Bulk Carriers, Ore Carriers and Combination Carriers (IACS UR S21 Rev.5)

7.1.1 Application and definitions

These requirements apply to all bulk carriers, ore carriers and combination carriers, as defined in Part 1, Chapter 2, SECTION 6, 6.6), and are for all cargo hatch covers and hatch forward and side coamings on exposed decks in position 1, as defined in ILLC.

Present subsection applies to ships contracted for construction on or after 1 January 2004.

The strength requirements are applicable to hatch covers and hatch coamings of stiffened plate construction. The secondary stiffeners and primary supporting members of the hatch covers are to be continuous over the breadth and length of the hatch covers, as far as practical. When this is impractical, sniped end connections are not to be used and appropriate arrangements are to be adopted to ensure sufficient load carrying capacity.

The spacing of primary supporting members parallel to the direction of secondary stiffeners is not to exceed 1/3 of the span of primary supporting members. The secondary stiffeners of the hatch coamings are to be continuous over the breadth and length of the hatch coamings.

These requirements are in addition to the requirements of the ILLC. The net minimum scantlings of hatch covers are to fulfil the strength criteria given in:

- 7.1.3.3, for plating,
- 7.1.3.4, for secondary stiffeners,
- 7.1.3.5 for primary supporting members,

the critical buckling stress check in 7.1.3.6 and the rigidity criteria given in 7.1.3.7, adopting the load model given in 7.1.2.

The net minimum scantlings of hatch coamings are to fulfil the strength criteria given in:

- 7.1.4.2, for plating,
- 7.1.4.3, for secondary stiffeners,
- 7.1.4.4, for coaming stays,

adopting the load model given in 7.1.4.1.

The net thicknesses, t_{net}, are the member thicknesses necessary to obtain the minimum net scantlings required by 7.1.3 and 7.1.4.

The required gross thicknesses are obtained by adding the corrosion additions, t_s, given in 7.1.6, to t_{net}.

Material for the hatch covers and coamings is to be steel according to the requirements for ship's hull.

7.1.2 Hatch cover load model

The pressure p, in kN/m², on the hatch covers panels is given by:

- For ships of 100 m in length and above

$$p = 34{,}3 + \frac{p_{fp} - 34{,}3}{0{,}25} \cdot \left(0{,}25 - \frac{x}{L}\right) \geq 34{,}3$$, for hatch ways located at the freeboard deck

where:

p_{FP}	=	pressure at the forward perpendicular
	=	$49{,}1 + (L - 100) \cdot a$
a	=	0,0726 for type B freeboard ships
	=	0,356 for ships with reduced freeboard

L = Freeboard length as defined in Regulation 3 of Annex I to the 1966 Load Line Convention as modified by the Protocol of 1988, to be taken not greater than 340 m, m,
x = distance of the mid length of the hatch cover under examination from the forward end of L, m,

Where a position 1 hatchway is located at least one superstructure standard height higher than the freeboard deck, the pressure p may be 34.3kN/m².

– For ships less than 100 m in length

$$p = 15{,}8 + \frac{L}{3} \cdot \left(1 - \frac{5}{3} \cdot \frac{x}{L}\right) - 3{,}6 \cdot \frac{x}{L} \geq 0{,}195 \cdot L + 14{,}9$$

for hatch ways located at the freeboard deck

Where two or more panels are connected by hinges, each individual panel is to be considered separately.

7.1.3 Hatch cover strength criteria

7.1.3.1 Allowable stress checks

The normal and shear stresses σ and τ in the hatch cover structures are not to exceed the allowable values, σ_a and σ_a given by:

$$\sigma_a = 0{,}8 \cdot \sigma_F, \qquad N/mm^2$$

$$\tau_a = 0{,}46 \cdot \sigma_F, \qquad N/mm^2$$

where:

σ_F = the minimum upper yield stress of the material, N/mm².

The normal stress in compression of the attached flange of primary supporting members is not to exceed 0,8 times the critical buckling stress of the structure according to the buckling check as given in 7.1.3.6.

The stresses in hatch covers that are designed as a grillage of longitudinal and transverse primary supporting members are to be determined by a grillage or a Finite Element analysis.

When a beam or a grillage analysis is used, the secondary stiffeners are not to be included in the attached flange area of the primary members.

When calculating the stresses σ and τ, the net scantlings are to be used.

7.1.3.2 Effective cross-sectional area of panel flanges for primary supporting members

The effective flange area A_f 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:

$$A_f = \sum_{nf} (10 \cdot b_{ef} \cdot t), \qquad cm^2$$

where:

nf = 2, if attached plate flange extends on both sides of girder web
= 1, if attached plate flange extends on one side of girder web only
t = net thickness of considered attached plate, mm
b_{ef} = effective breadth of attached plate flange on each side of girder web, m
= b_p, but not to be taken greater than $0{,}165 \cdot \ell$
b_p = half distance between the considered primary supporting member and the adjacent one, m

ℓ = span of primary supporting members, m

7.1.3.3 Local net plate thickness

The local net plate thickness t of the hatch cover top plating is not to be less than:

$$t = F_p \cdot 15{,}8 \cdot s \cdot \sqrt{\frac{p}{0{,}95 \cdot \sigma_F}}, \quad \text{mm}$$

but to be not less than 1% of the spacing of the stiffener or 6 mm if that be greater.

where:

F_p = factor for combined membrane and bending response
= 1,50 in general
= $1{,}90 \cdot \sigma/\sigma_a$, for $\sigma/\sigma_a \geq 0{,}8$, for the attached plate flange of primary supporting members
s = stiffener spacing, m
p = pressure as defined in 7.1.2, kN/m^2
σ = as defined in 7.1.3.5
σ_a = as defined in 7.1.3.1.

7.1.3.4 Net scantlings of secondary stiffeners

The required minimum section modulus, Z, of secondary stiffeners of the hatch cover top plate, based on stiffener net member thickness, are given by:

$$Z = \frac{1000 \cdot \ell^2 \cdot s \cdot p}{12 \cdot \sigma_a}, \quad \text{cm}$$

where:

ℓ = secondary stiffener span, in m, to be taken as the spacing, in m, of primary supporting members or the distance between a primary supporting member 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 ⅔ of the minimum brackets arm length, but not greater than 10% of the gross span, for each bracket
s = secondary stiffener spacing, m
p = pressure as defined in 7.1.2, kN/m^2
σ_α = as defined in 7.1.3.1.

The net section modulus of the secondary stiffeners is to be determined based on an attached plate width assumed equal to the stiffener spacing.

7.1.3.5 Net scantlings of primary supporting members

The section modulus and web thickness of primary supporting members, based on member net thickness, are to 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, defined in 7.1.3.1.

The breadth of the primary supporting member flange is to be not 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 is not to exceed 15 times the flange thickness.

7.1.3.6 Critical buckling stress check

7.1.3.6.1 Hatch cover plating

The compressive stress σ in the hatch cover plate panels, induced by the bending of primary supporting members parallel to the direction of secondary stiffeners, is not to exceed 0,8 times the critical buckling stress σ_{C1}, to be evaluated as defined below:

$\sigma_{C1} = \sigma_{E1}$ when $\sigma_{E1} \leq \sigma_F/2$

$= \sigma_F \cdot \left(1 - \frac{\sigma_F}{4 \cdot \sigma_{E1}}\right)$ when $\sigma_{E1} > \sigma_E/2$

Where:

σ_F = minimum upper yield stress of the material, N/mm²

σ_{e1} = $3{,}6 \cdot E \cdot \left(\frac{t}{1000 \cdot s}\right)^2$

E = modulus of elasticity, N/mm²

= $2{,}06 \cdot 10^5$ for steel

t = net thickness of plate panel, mm

s = spacing of secondary stiffeners, m

The mean compressive stress σ in each of the hatch cover plate panels, induced by the bending of primary supporting members perpendicular to the direction of secondary stiffeners, is not to exceed 0,8 times the critical buckling stress σ_{C2}, to be evaluated as defined below:

$\sigma_{c2} = \sigma_{E2}$ when $\sigma_{E2} \leq \sigma_F/2$

$= \sigma_F \cdot \left(1 - \frac{\sigma_F}{4 \cdot \sigma_{E2}}\right)$ when $\sigma_{E2} > \sigma_F/2$

Where:

σ_F = minimum upper yield stress of the material, N/mm²,

σ_{E2} = $0{,}9 \cdot m \cdot E \cdot \left(\frac{t}{1000 \cdot S_s}\right)^2$

m = $c \cdot \left[1 + \left(\frac{S_s}{\ell_s}\right)^2\right]^2 \cdot \frac{2{,}1}{\Psi + 1{,}1}$

E = modulus of elasticity, N/mm²

= $2{,}06 \cdot 10^5$ for steel

t = net thickness of plate panel, mm,

S_s = length of the shorter side of the plate panel, m,

ℓ_s = length of the longer side of the plate panel, m,

Ψ = ratio between smallest and largest compressive stress

c = 1,30 when plating is stiffened by primary supporting members

= 1,21 when plating is stiffened by secondary stiffeners of angle or T type

= 1,10 when plating is stiffened by secondary stiffeners of bulb type

= 1,05 when plating is stiffened by flat bar

The biaxial compressive stress in the hatch cover panels, when calculated by means of FEM shell element model, is to be in accordance with the Society's rule as deemed equivalent to the above criteria.

7.1.3.6.2 Hatch cover secondary stiffeners

The compressive stress σ in the top flange of secondary stiffeners, induced by the bending of primary supporting members parallel to the direction of secondary stiffeners, is not to exceed 0,8 times the critical buckling stress σ_{CS}, to be evaluated as defined below:

$\sigma_{CS} = \sigma_{ES}$ when $\sigma_{ES} \leq \sigma_F/2$

$= \sigma_{F.} \left(1 - \frac{\sigma_F}{4 \cdot \sigma_{ES}}\right)$ when $\sigma_{ES} > \sigma_F/2$

where:

σ_F = minimum upper yield stress of the material, N/mm²,

σ_{ES} = ideal elastic buckling stress of the secondary stiffener, N/mm²,

= minimum between σ_{E3} and σ_{E4}

σ_{E3} = $\dfrac{0{,}001 \cdot E \cdot I_a}{A \cdot l^2}$

E = modulus of elasticity, N/mm²

= $2{,}06 \cdot 10^5$ for steel

I_a = moment of inertia of the secondary stiffener, including a top flange equal to the spacing of secondary stiffeners, cm⁴

A = cross-sectional area of the secondary stiffener, including a top flange equal to the spacing of secondary stiffeners, cm²

ℓ = span of the secondary stiffener, m,

σ_{E4} = $\dfrac{\pi^2 \cdot E \cdot I_w}{10^4 \cdot I_p \cdot l^2} \cdot \left(m^2 + \dfrac{K}{m^2}\right) + 0{,}385 \cdot E \cdot \dfrac{I_t}{I_p}$

K = $\dfrac{C \cdot l^4}{\pi^4 \cdot E \cdot I_w} \cdot 10^6$

m = number of half waves, given by the following table:

	0 < K < 4	4 < K < 36	36 < K < 144	$(m-1)^2 \cdot m^2 < K \le m^2 \cdot (m+1)^2$
m	1	2	3	m

I_w = sectorial moment of inertia of the secondary stiffener about its connection with the plating, cm6,

= $\frac{h_w^3 \cdot t_w^3}{36} \cdot 10^{-6}$ for flat bar secondary stiffeners

= $\frac{t_f \cdot b_f^3 \cdot h_w^2}{12} \cdot 10^{-6}$ for "Tee" secondary stiffeners

= $\frac{b_f^3 \cdot h_w^2}{12 \cdot (b_f + h_w)^2} \cdot [t_f \cdot (b_f^2 + 2 \cdot b_f \cdot h_w + 4 \cdot h_w^2) + 3 \cdot t_w \cdot b_f \cdot h_w] \cdot 10^{-6}$, for angles and bulb secondary stiffeners

I_p = polar moment of inertia of the secondary stiffener about its connection with the plating, cm⁴ ,

= $\frac{h_w^3 \cdot t_w}{3} \cdot 10^{-4}$ for flat bar secondary stiffeners

= $\left(\frac{h_w^3 \cdot t_w}{3} + h_w^2 \cdot b_f \cdot t_f\right) \cdot 10^{-4}$ for flanged secondary stiffeners

I_t = St. Venant's moment of inertia of the secondary stiffener without top flange, cm4,

= $\frac{h_w \cdot t_w^3}{3} \cdot 10^{-4}$ for flat bar secondary stiffeners

= $\frac{1}{3} \cdot \left[h_w \cdot t_w^3 + b_f \cdot t_f^3 \cdot \left(1 - 0{,}63 \cdot \frac{t_f}{b_f}\right)\right] \cdot 10^{-4}$, for flanged secondary stiffeners

h_w = height of the secondary stiffener, mm,

t_w = net thickness of the secondary stiffener, mm,

b_f = width of the secondary stiffener bottom flange, mm,

t_f = net thickness of the secondary stiffener bottom flange, mm,

s = spacing of secondary stiffeners, m,

C = spring stiffness exerted by the hatch cover top plating

= $\dfrac{k_p \cdot E \cdot t_p^3}{3 \cdot s \cdot \left(1 + \dfrac{1{,}33 \cdot k_p \cdot h_w \cdot t_p^3}{1000 \cdot s \cdot t_w^3}\right)} \cdot 10^{-3}$

k_p = $1-\eta_p$ to be taken not less than zero;
for flanged secondary stiffeners, k_p need not be taken less than 0,1

η_p = $\dfrac{\sigma}{\sigma_{E1}}$

σ = as defined in 7.1.3.5

σ_{E1} = as defined in 7.1.3.6.1
t_p = net thickness of the hatch cover plate panel, mm

For flat bar secondary stiffeners and buckling stiffeners, the ratio h/t_W is to be not greater than $15 \cdot k^{0,5}$,

Where:

h = Height of the stiffener,
t_w = net thickness of the stiffener,
k = $235/\sigma_F$
σ_F = minimum upper yield stress of the material, N/mm².

7.1.3.6.3 Web panels of hatch cover primary supporting members

This check is to be carried out for the web panels of primary supporting members, formed by web stiffeners or by the crossing with other primary supporting members, the face plate (or the bottom cover plate) or the attached top cover plate.

The shear stress τ in the hatch cover primary supporting members web panels is not to exceed 0,8 times the critical buckling stress τ_C, to be evaluated as defined below:

$\tau_c = \tau_E$ when $\tau_E \le \tau_F/2$

$= \tau_F \cdot \left(1 - \frac{\tau_F}{4 \cdot \tau_E}\right)$ when $\tau_E > \tau_F/2$

Where:

σ_F = minimum upper yield stress of the material, N/mm²,
τ_F = $\frac{\sigma_F}{\sqrt{3}}$
τ_E = $0{,}9 \cdot k_\tau \cdot E \cdot \left(\frac{t_{pr,n}}{1000 \cdot d}\right)^2$
E = modulus of elasticity, N/mm²
= $2{,}06 \cdot 10^5$ for steel
$t_{pr,n}$ = net thickness of primary supporting member, mm,
k_t = $5{,}35 + \frac{4{,}0}{\left(\frac{a}{d}\right)^2}$
a greater dimension of web panel of primary supporting member, m
d smaller dimension of web panel of primary supporting member, m.

For primary supporting members parallel to the direction of secondary stiffeners, the actual dimensions of the panels are to 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 is to be taken for the determination of the stress τ_C. In such a case, the average shear stress τ between the values calculated at the ends of this panel is to be considered.

7.1.3.7 Deflection limit and connections between hatch cover panels

Load bearing connections between the hatch cover panels are to be fitted with the purpose of restricting the relative vertical displacements. The vertical deflection of primary supporting members is to be not more than $0{,}0056 \cdot \ell$, where ℓ is the greatest span of primary supporting members.

7.1.4 Hatch coamings and local details

7.1.4.1 Load model

The pressure p_{coam} on the No. 1 forward transverse hatch coaming is given by:

p_{coam} = 220, kN/m², when a forecastle is fitted in accordance with 8.1

= 290, kN/m², in the other cases

The pressure p_{coam} on the other coamings is given by:

p_{coam} = 220, kN/m²

7.1.4.2 Local net plate thickness

The local net plate thickness t of the hatch coaming plating is given by:

$$t = 14{,}9 \cdot s \cdot \sqrt{\frac{p_{coam}}{\sigma_{a,coam}} \cdot s_{coam}}, \qquad mm$$

where:

s = secondary stiffener spacing, m
p_{coam} = pressure as defined in 7.1.4.1, kN/m²,
S_{coam} = safety factor to be taken equal to 1,15
σ_{coam} = $0{,}95 \cdot \sigma_F$

The local net plate thickness is to be not less than 9,5 mm.

7.1.4.3 Net scantlings of longitudinal and transverse secondary stiffeners

The required section modulus Z of the longitudinal or transverse secondary stiffeners of the hatch coamings, based on net member thickness, is given by:

$$Z = \frac{1000 \cdot S_{coam} \cdot \ell^2 \cdot s \cdot p_{coam}}{m \cdot c \cdot \sigma_{a,coam}}, \qquad cm^3$$

where:

m = 16, in general
= 12, for the end spans of stiffeners sniped at the coaming corners
S_{coam} = safety factor to be taken equal to 1,15
ℓ = span of secondary stiffeners, m,
s = spacing of secondary stiffeners, m,
p_{coam} = pressure as defined in 7.1.4.1, kN/m²,
c_p = ratio of the plastic section modulus to the elastic section modulus of the secondary stiffeners with an attached plate breadth equal to 40·t, where t is the plate net thickness, mm,
= 1,16 in the absence of more precise evaluation
$\sigma_{a,coam}$ = $0{,}95 \cdot \sigma_F$

7.1.4.4 Net scantlings of coaming stays

The required minimum section modulus, Z, and web thickness, t_w, of coaming stays designed as beams with flange connected to the deck or sniped and fitted with a bracket (see Figure 4.7.1 and Figure 4.7.2) at their connection with the deck, based on member net thickness, are given by:

$$Z = \frac{1000 \cdot H_C^2 \cdot s \cdot p_{coam}}{2 \cdot \sigma_{coam}}$$

$$t_w = \frac{1000 \cdot H_c \cdot s \cdot p_{coam}}{h \cdot \tau_{a,coam}}$$

where:

H_C = stay height, m
s = stay spacing, m
h = stay depth at the connection with the deck, mm
p_{coam} = pressure as defined in 7.1.4.1, kN/m²
$\sigma_{a,coam}$ = $0{,}95 \cdot \sigma_F$
$\tau_{a,coam}$ = $0{,}5 \cdot \sigma_F$

For calculating the section modulus of coaming stays, their face plate area is to be taken into account only when it is welded with full penetration welds to the deck plating and adequate underdeck structure is fitted to support the stresses transmitted by it.

For other designs of coaming stays, such as, for examples, those shown in Figure 4.7.3 and Figure 4.7.4, the stress levels in 7.1.3.1 apply and are to be checked at the highest stressed locations.

7.1.4.5 Local details

The design of local details is to comply with the Society requirement for the purpose of transferring the pressures on the hatch covers to the hatch coamings and, through them, to the deck structures below. Hatch coamings and supporting structures are to be adequately stiffened to accommodate the loading from hatch covers, in longitudinal, transverse and vertical directions.

Underdeck structures are to be checked against the load transmitted by the stays, adopting the same allowable stresses specified in 7.1.4.4.

Unless otherwise stated, weld connections and materials are to be dimensioned and selected in accordance with the Society requirements.

Double continuous welding is to be adopted for the connections of stay webs with deck plating and the weld throat is to be not less than $0{,}44 \cdot t_W$, where t_W is the gross thickness of the stay web.

Toes of stay webs are to be connected to the deck plating with deep penetration double bevel welds extending over a distance not less than 15% of the stay width.

7.1.5 Closing arrangements

7.1.5.1 Securing devices

The strength of securing devices is to comply with the following requirements:

Panel hatch covers are to be secured by appropriate devices (bolts, wedges or similar) suitably spaced alongside the coamings and between cover elements.

Arrangement and spacing are to be determined with due attention to the effectiveness for weather-tightness, depending upon the type and the 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 is not to be less than:

$$A = 1{,}4 \cdot a/f, \qquad cm^2$$

where:

a = spacing of securing devices, not being taken less than 2m, m
f = $(\sigma_Y/235)^e$
σ_Y = specified minimum upper yield stress of the steel used for fabrication, not to be taken

greater than 70% of the ultimate tensile strength, N/mm².

e = 0,75 for $\sigma_Y > 235$
= 1,00 for $\sigma_Y \leq 235$

Rods or bolts are to have a net diameter not less than 19 mm for hatchways exceeding 5m² in area.

Between cover and coaming and at cross-joints, a packing line pressure sufficient to obtain weathertightness is to be maintained by the securing devices.

For packing line pressures exceeding 5 N/mm, the cross-section area is to be increased in direct proportion. The packing line pressure is to be specified.

The cover edge stiffness is to be sufficient to maintain adequate sealing pressure between securing devices. The moment of inertia I, of edge elements is not to be less than:

$$I = 6 \cdot p \cdot a^4, \quad cm^4$$

where:

p = packing line pressure, minimum 5 N/mm, N/mm.

a = spacing of securing devices, m.

Securing devices are to be of reliable construction and securely attached to the hatchway coamings, decks or covers. Individual securing devices on each cover are to have approximately the same stiffness characteristics.

Where rod cleats are fitted, resilient washers or cushions are to be incorporated. Where hydraulic cleating is adopted, a positive means is to be provided to ensure that it remains mechanically locked in the closed position in the event of failure of the hydraulic system.

7.1.5.2 Stoppers

Hatch covers are to be effectively secured, by means of stoppers, against the transverse forces arising from a pressure of 175 kN/m².

With the exclusion of No.1 hatch cover, hatch covers are to be effectively secured, by means of stoppers, against the longitudinal forces acting on the forward end arising from a pressure of 175 kN/m².

No. 1 hatch cover is to be effectively secured, by means of stoppers, against the longitudinal forces acting on the forward end arising from a pressure of 230 kN/m². This pressure may be reduced to 175 kN/m² when a forecastle is fitted in accordance with 8.1.

The equivalent stress:

(i) in stoppers and their supporting structures, and
(ii) calculated in the throat of the stopper welds

is not to exceed the allowable value of $0,8 \cdot \sigma_Y$.

7.1.5.3 Materials and welding

Stoppers or securing devices are to be manufactured of materials, including welding electrodes, meeting the relevant Society's requirements.

7.1.6 Corrosion addition and steel renewal

7.1.6.1 Hatch covers

For all the structure (plating and secondary stiffeners) of single skin hatch covers, the corrosion addition t_s is to be 2,0 mm.

For double skin hatch covers, the corrosion addition is to be:

- 2,0 mm for the top and bottom plating
- 1,5 mm for the internal structures.

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} + 0,5 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 is to be maintained in GOOD condition, as defined in Part 1, Chapter 3, SECTION 1, 1.2.14.

For the internal structure of double skin hatch covers, thickness gauging is required when plating renewal is to be carried out or when this is deemed necessary, at the discretion of the Society 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}.

7.1.6.2 Hatch coamings

For the structure of hatch coamings and coaming stays, the corrosion addition t_s is to be 1,5 mm. Steel renewal is required where the gauged thickness is less than t_{net}+0,5 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 is to be maintained in GOOD condition, as defined in Part 1, Chapter 3, SECTION 1, 1.2.14.

Figure 4.7.1:

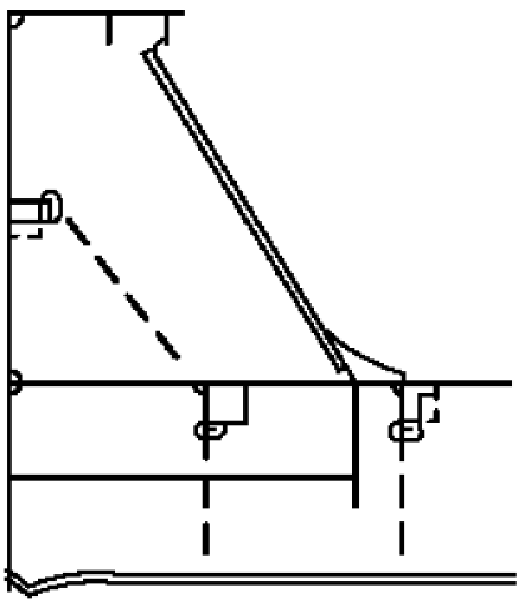


Figure 4.7.2:

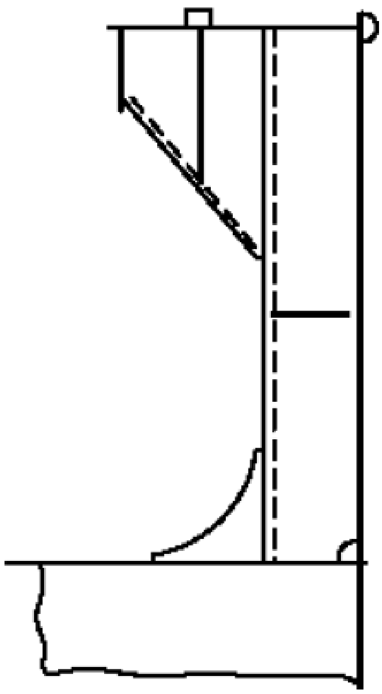


Figure 4.7.3:

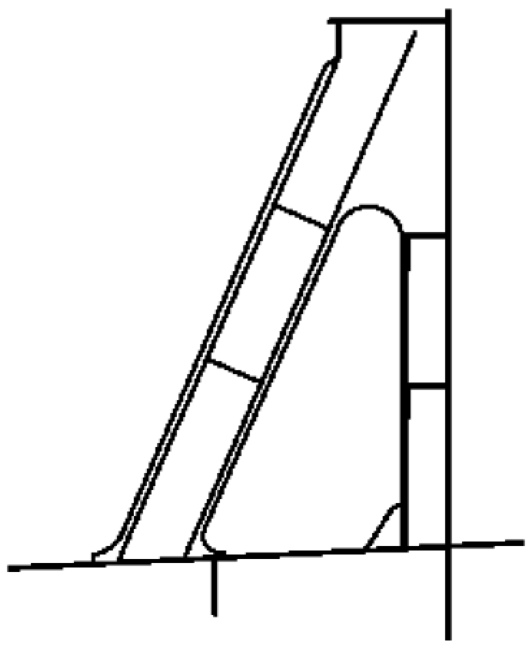
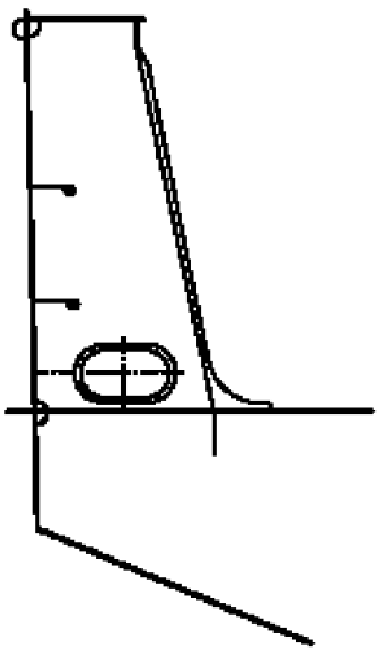


Figure 4.7.4:



7.2 Cargo Hatch Cover Securing Arrangements for Bulk Carriers not Built-in accordance with 7.1 (IACS UR S30 Corr. 1)

7.2.1 Application and Implementation

(i) These requirements apply to all bulk carriers, as defined in Part 1, Chapter 2, SECTION 6, 6.6.2.(ii), which were not built-in accordance with 7.1 and are for steel hatch cover securing devices and stoppers for cargo hold hatchways No.1 and No. 2 which are wholly or partially within 0,25.L of the fore perpendicular, except pontoon type hatch cover.

(ii) All bulk carriers not built-in accordance with 7.1 are to comply with the requirements of this subsection in accordance with the following schedule:

(a) For ships which will be 15 years of age or more on 1 January 2004 by the due date of the first intermediate or special survey after that date;

(b) For ships which will be 10 years of age or more on 1 January 2004 by the due date of the first special survey after that date;

(c) For ships which will be less than 10 years of age on 1 January 2004 by the date on which the ship reaches 10 years of age.

(iii) Completion prior to 1 January 2004 of an intermediate or special survey with a due date after 1 January 2004 cannot be used to postpone compliance. However, completion prior to 1 January 2004 of an intermediate survey the window for which straddles 1 January 2004 can be accepted.

7.2.2 Securing Devices

The strength of securing devices is to comply with the following requirements:

(i) Panel hatch covers are to be secured by appropriate devices (bolts, wedges or similar) suitably spaced alongside the coamings and between cover elements.

Arrangement and spacing are to be determined with due attention to the effectiveness for weather-tightness, depending upon the type and the size of the hatch cover, as well as on the stiffness of the cover edges between the securing devices.

(ii) The net sectional area of each securing device is not to be less than:

$$A = 1{,}4 \cdot a/f, \ \ cm^2$$

where:

a = spacing between securing devices not to be taken less than 2 m

f = $(\sigma_Y/235)^e$

σ_Y = specified minimum upper yield stress of the steel used for fabrication, not to be taken greater than 70% of the ultimate tensile strength, N/mm².

e = 0,75 for $\sigma_Y > 235$

= 1,0 for $\sigma_Y \leq 235$

Rods or bolts are to have a net diameter not less than 19 mm for hatchways exceeding 5m² in area.

(iii) Between cover and coaming and at cross-joints, a packing line pressure sufficient to obtain weathertightness is to be maintained by the securing devices.

For packing line pressures exceeding 5 N/mm, the cross-section area is to be increased in direct proportion. The packing line pressure is to be specified.

(iv) The cover edge stiffness is to be sufficient to maintain adequate sealing pressure between securing devices. The moment of inertia, I, of edge elements is not to be less than:

$$I = 6 \cdot p \cdot a^4, \quad cm^4$$

where:

p = packing line pressure minimum 5 N/mm, N/mm,

a = spacing of securing devices, m.

(v) Securing devices are to be of reliable construction and securely attached to the hatchway coamings, decks or covers. Individual securing devices on each cover are to have approximately the same stiffness characteristics.

(vi) Where rod cleats are fitted, resilient washers or cushions are to be incorporated.

(vii) Where hydraulic cleating is adopted, a positive means is to be provided to ensure that it remains mechanically locked in the closed position in the event of failure of the hydraulic system.

7.2.3 Stoppers

(i) No.1 and 2 hatch covers are to be effectively secured, by means of stoppers, against the transverse forces arising from a pressure of 175 kN/m².

(ii) No.2 hatch covers are to be effectively secured, by means of stoppers, against the longitudinal forces acting on the forward end arising from a pressure of 175 kN/m².

(iii) No.1 hatch cover is to be effectively secured, by means of stoppers, against the longitudinal forces acting on the forward end arising from a pressure of 230 kN/m².

This pressure may be reduced to 175 kN/m² if a forecastle is fitted.

(iv) The equivalent stress:

– in stoppers and their supporting structures, and
– calculated in the throat of the stopper welds is not to exceed the allowable value of $0,8 \cdot \sigma_Y$.

7.2.4 Materials and Welding

(i) Where stoppers or securing devices are fitted to comply with this subsection, they are to be manufactured of materials, including welding electrodes, meeting the Society's relevant requirements.

SECTION 8 Additional requirements

8.1 Requirements for the Fitting of a Forecastle for Bulk Carriers, Ore Carriers and Combination Carriers (IACS UR S28 Rev.3)

8.1.1 Application and definitions

These requirements apply to all bulk carriers, ore carriers and combination carriers, as defined in Part 1, Chapter 2, SECTION 6, 6.6, which are contracted for construction on or after 1 January 2004.

Such ships are to be fitted with an enclosed forecastle on the freeboard deck.

The required dimensions of the forecastle are defined in 8.1.2.

The structural arrangements and scantlings of the forecastle are to comply with the relevant Society's requirements.

8.1.2 Dimensions

The forecastle is to be located on the freeboard deck with its aft bulkhead fitted in way or aft of the forward bulkhead of the foremost hold, as shown in Figure 4.8.1.

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 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.

The forecastle height H_F above the main deck is to be not less than:

– the standard height of a superstructure as specified in the International Convention on Load Line 1966 and its Protocol of 1988, or
– H_C + 0,5 m, where H_C is the height of the forward transverse hatch coaming of cargo hold No.1,

whichever is the greater.

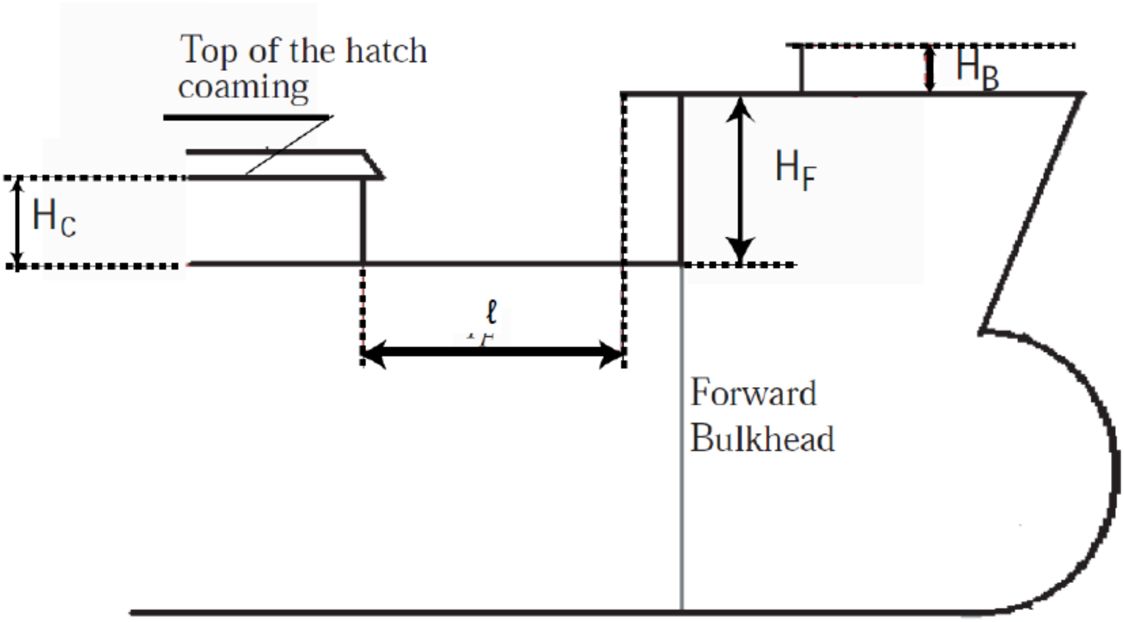
All points of the aft edge of the forecastle deck are to be located at a distance l_F:

$$l_F \leq 5 \cdot \sqrt{H_F - H_C}$$

from the hatch coaming plate in order to apply the reduced loading to the No.1 forward transverse hatch coaming and No.1 hatch cover in applying 7.1.4.1 and 7.1.5.2, respectively, of 7.1.

A breakwater is not to be fitted on the forecastle deck with the purpose of protecting the hatch coaming or hatch covers. If fitted for other purposes, it is to be located such that its upper edge at centre line is not less than H_B / tan20° forward of the aft edge of the forecastle deck, where H_B is the height of the breakwater above the forecastle (see Figure 4.8.1).

Figure 4.8.1:



CHAPTER 5 Container Ships

CONTENTS

SECTION 1 General

1.1 Classification

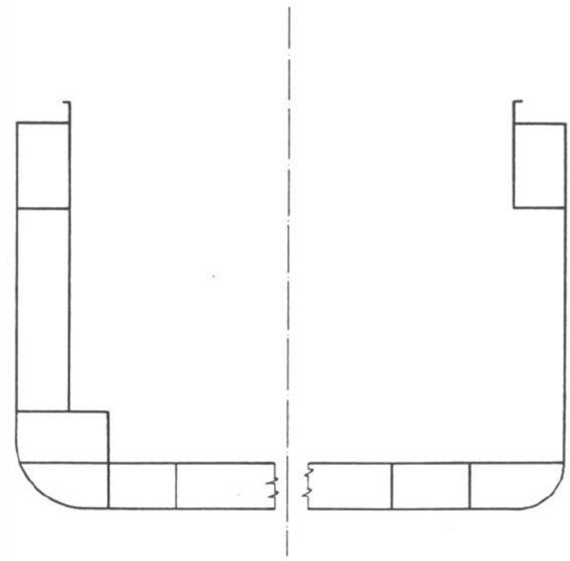
1.1.1 The requirements of this Chapter apply to ships intend to carry standard freight containers for general cargo at pre-determined positions on board, in holds, and on weather deck.

1.1.2 Unless otherwise mentioned in this Chapter, the requirements of Part 3 are applicable.

1.1.3 Ships exclusively intended for the carriage of containers and arranged with cell guides in holds and built-in accordance with relevant requirements, specified in this Chapter, may be given the Class notation **CONTAINERSHIP**.

1.1.4 The basic structural configuration of a container ship includes a double bottom and a double skin side construction, or alternatively a single skin side construction, with an efficient torsion box girder or equivalent structure at the top sides, as shown in Figure 5.1.1.

Figure 5.1.1:



1.2 Information required

1.2.1 Information is to be submitted on the load data on which the design approval of supporting structures and securing arrangements is to be based. The following plans are to be submitted for approval:

(a) A container stowage plan including specification of the size, maximum mass and strength standard of the containers to be transported.
(b) A container securing plan showing arrangements of lashings with data regarding type (wire rope, chain, rod etc.), fittings, materials, and minimum breaking strength.
(c) Drawings of supporting structures including cell guide and adjoining hull structures, container sockets and other supports with necessary local strengthenings of the hull structures.
(d) Calculations of maximum forces and stresses in container supports and adjoining hull structures, cell guides and lashings.

SECTION 2 Longitudinal strength

2.1 General

2.1.1 Longitudinal strength calculations are to be made in accordance with the requirements of Part 3, Chapter 2. These are to cover the range of load ballast conditions proposed for the ship.

2.2 Hull section modulus

2.2.1 The minimum hull section modulus of a container ship is to be calculated according to Part 3, Chapter 2. In addition, attention is to be given to the following requirements:

(a) Where outboard continuous hatch coamings are arranged, 80 per cent of their sectional area may be included in the calculations of the actual hull section modulus.
(b) Where a continuous longitudinal underdeck girder, or girders, are arranged to support the inboard hatch coamings, 50 per cent of their sectional area may be included in the calculations of the actual hull section modulus. If the girder is fitted in conjunction with a longitudinal centreline bulkhead, 80 per cent of the sectional area may be included.
(c) The maximum permissible bending stresses of the hull girder are to be as those given in Part 3, Chapter 2.

SECTION 3 Bottom structure

3.1 General

3.1.1 The scantlings of the bottom structure are to be determined in accordance with the requirements of Part 3, Chapter 3.

3.1.2 Additionally the double bottom is to be longitudinally framed and plate floors are to be fitted at a maximum spacing of 3.8 m. The plate floors are to have a minimum thickness of:

$$t = 6 + 0{,}03 \cdot L, \qquad mm$$

3.2 Container supports

3.2.1 Side girders are to be arranged under container corner seatings and for double bottoms with a depth greater than 1,6 m, additional longitudinal stiffening is to be introduced to ensure the stability of the side girders, against buckling.

SECTION 4 Deck structure

4.1 General

4.1.1 The upper deck is to be longitudinally framed throughout the region of container holds, and the midship scantlings should generally extend over the region of the container holds.

4.1.2 Decks are to be efficiently scarfed into the machinery space, and the fore and aft end structure.

4.2 Deck plating and stiffening

4.2.1 The scantlings (plate thickness, stiffeners' section modulus) of the upper and second deck are to comply with the requirements of Part 3, Chapter 5, Section 2 and Chapter 7, Section 1.

4.2.2 The scantlings of the lower deck have also to comply with the above requirements, but the thickness may be required to be increased in cases when the deck acts as a primary support for the side shell stiffening.

4.2.3 Cross deck strips at the strength deck forming the top of a transverse bulkhead are to have thickness not less than the greater of the following:
$t = 0{,}012 \cdot s1, \quad mm$
$t = 0{,}00083 \cdot s_1 \cdot \sqrt{L + 2{,}5}\,, \quad mm$
$t = 10 + 0{,}01 \cdot L \text{ or } 12, \; mm$, whichever is the lesser.

where:
s_1 = Stiffener spacing, mm.
L = Length of ship, m.

Where the difference between the thickness of plating inside and outside the line of main hatches exceeds 12 mm, a transitional plate of thickness equivalent to the mean of the adjacent plate thickness is to be fitted.

4.2.4 Cross deck strips at lower decks are to have a thickness not less than the greater of the following:

1) $t = 0{,}012 \cdot s1, \; mm$, for second deck
$t = 0{,}0095 \cdot s1, \; mm$, for other decks
2) $t = 6{,}5 \; mm$

where:
s_1 = Spacing as defined in 4.2.3.

The thickness should generally not exceed 12 mm in second decks and 8,5 mm in other decks.

4.2.5 Longitudinal underdeck girders are to be fitted at deck level to support the hatch coamings. The arrangement may consist of one girder on the centreline or one girder port and one to starboard in the breadth of the hatchway; the girders may take the form of open sections or closed box sections.

4.3 Hatchways

4.3.1 Hatchway covers in position 1 and 2 loaded with containers are to comply with the requirements of Part 3, Chapter 15.

4.3.2 Hatch coamings are also to comply with the previous requirements and to have a minimum thickness equal to the greater of the following:
1) $t = 0{,}008 \cdot H, mm$
2) $t = 11, mm$

where:
H = Height of the coaming, mm.

SECTION 5 Lashing and stowing arrangements

5.1 General

5.1.1 Containers may be stowed longitudinally or transversely and are to be effectively supported by the ship structure.

5.1.2 Containers are also to be prevented from sliding, lifting or tilting by a system of fixed supports or detachable lashing equipment.

5.2 Cell guides

5.2.1 Cell guide structures in holds or on weather decks may be welded to the hull structure or arranged to be detachable (screwed on).

5.2.2 The vertical guide rails should consist of equal angles of thickness not less than 12,5 mm and which are preferably to be connected by web plates at the levels of the container corners. They also are to be supported by a system of cross ties or longitudinal ties transferring the longitudinal and transverse forces to the hull structure.

5.2.3 The total clearance between containers and cell guides is not to exceed 25 mm in transverse and 40 mm in the longitudinal direction.

5.3 Lashings and other removable equipment

5.3.1 On weather decks a combination of stacking cones, locking cones or twist cones and lashing is to be implemented. For one or two tiers of containers locking cones are sufficient. When more tiers are required, lashings have to be provided in addition. All containers not secured by lashings are to have lock stackers.

5.3.2 For containers stowed on blocks several tiers upon inner bottom, adequate support below each bottom container corner is to be provided.

5.3.3 Lateral shoring may be obtained by fixed shoring elements supported at the ship's side, decks or transverse bulkheads and lashings. At each level of horizontal supports bridge stackers are to be fitted between each stack of containers.

5.4 Design loads

5.4.1 The scantlings of all container substructures are to be determined on the basis of the permissible gross weights of the containers as per ISO STANDARDS recommendations unless binding stowage plans contain gross weights which differ from the above gross weights.

5.5 Permissible stresses

5.5.1 The stresses in substructures for containers as well as for cell guide systems and lashing devices in the double bottom, in the deck and in the hatch covers of cargo decks are not to exceed the following values:

(a) Maximum bending stress $\sigma = 165$ N/mm²

(b) Maximum shear stress $\tau = 115$ N/mm²

CHAPTER 6 Ferries and Roll on – Roll off Ships

CONTENTS

SECTION 1 General

1.1 Application

1.1.1 This Chapter applies to roll on-roll off cargo ships and ferries which are defined as follows:

(a) A roll on-roll off cargo ship is a ship specially designed and constructed for the carriage of vehicles and cargo in pallet form or in containers, and loaded by wheeled vehicles.

(b) A ferry is a ship specially designed and constructed for the carriage of passengers and vehicles on a regular scheduled service of short duration.

1.1.2 Unless otherwise specified in this Chapter, the requirements of Part 3 are applicable.

1.2 Structural configuration

1.2.1 The basic structural configuration provided for these ships is a multi-deck hull including a double bottom and in some cases wing tanks up to the lower deck.

1.2.2 Longitudinal framing is generally to be adopted at the strength deck and at the bottom.

1.3 Information required

1.3.1 Apart from the plans and information requirements specified in Part 3, Chapter 1, Section 2 the following details are to be submitted for approval:

(a) The intended service areas required for ships designed to operate within specified geographical limits.

(b) Stern or bow ramp arrangements.

(c) Bow, side and stern door arrangements.

(d) Movable decks, if fitted, including stowing arrangements for portable components.

SECTION 2 Longitudinal strength

2.1 General

2.1.1 Longitudinal strength calculations are to be made in accordance with the requirements of Part 3, Chapter 2.

SECTION 3 Bottom structure

3.1 General

3.1.1 Scantlings of the double bottom structure are in general to be obtained in accordance with Part 3, Chapter 3.

3.2 Pillar reinforcements

3.2.1 In ships where the deck centreline supports are widely spaced, transmission of the pillar loads to the double bottom structure will be specially considered, and additional reinforcements may be required if high shear and bending stresses are induced by the concentrated loads. These reinforcements should take the form of additional floors and fore and aft girders, and have to be determined by direct calculations.

3.3 Centre girder

3.3.1 In ferries with a specified operating area service the thickness of double bottom centre girder may be reduced by 10%, and the thickness of the double bottom side girders and floors may be reduced by 5% from the required values for conventional ships (see Part 3, Chapter 3). However, in no case should it be less than 6 mm.

SECTION 4 Car decks

4.1 General

4.1.1 Permanent car decks are normally to be built as grillage systems of girders and stiffeners integrated to the hull structure with deck plating welded to the supporting strength members.

4.1.2 They also are to be designed on the basis of the maximum loading to which they may be subjected in service and where applicable, the hatch covers are to be similarly designed.

4.2 Design loads

4.2.1 Details of the deck loading resulting from the proposed stowage and operation of vehicles are to be supplied by the Shipbuilder. These details are to include the wheel load, the axle and wheel spacing, the wheel size and tyre print dimensions of the vehicles. These loads are to be based on the most severe conditions of stowed vehicles.

4.2.2 For plating and stiffeners of car decks the local load due to direct wheel loads from vehicles is to be obtained from the following formula:

$$p = \frac{Q \cdot g}{n}, \qquad \text{kN}$$

where:

Q = Total load per axle, tonnes.
g = Gravitational acceleration (=9,81 m/sec^2).
n = Number of wheels per axle.

4.3 Plating

4.3.1 The deck plate thickness is not to be less than:

$$t = C \cdot \sqrt{P} + t_k, \qquad \text{mm}$$

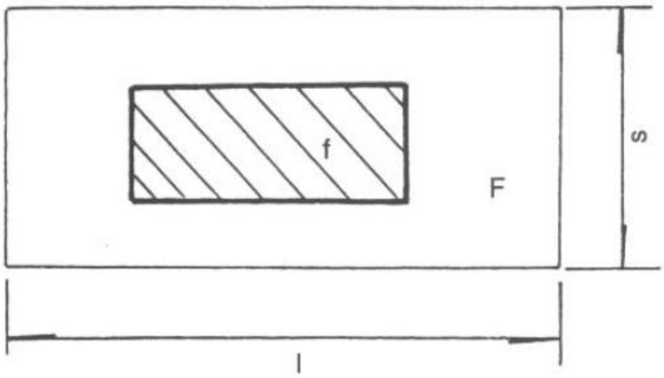
where:

P = Local load as defined in 4.2.2.
t_k = Corrosion allowance, mm, to be taken not less than 1,5 mm.
C = $2 - \sqrt{(f/F) \cdot [K_1 - K_2 \cdot (f/F)]}$, for $0{,}0 < f/F < 0{,}3$
= $C_{0,3} - 0{,}5(f/F)$, for $0{,}3 < f/F$

f = Tyre print area, see Figure 6.4.1.
F = Area of plate panel, see Figure 6.4.1.
K_1 = $3.5 + 4/3 \cdot (a - 1)$
K_2 = $4.5 + 2 \cdot (a - 1)$
a = Plate panel aspect ratio l/s.
$C_{0,3}$ = Coefficient corresponding to f/F = 0,3.

In no case should t be less than 5 mm.

Figure 6.4.1



4.4 Stiffening

4.4.1 The section modulus of deck beams or longitudinals is to be not less than that required for a weather or cargo deck, as appropriate, nor less than that required to satisfy the most severe arrangement of print wheel loads on the stiffener in association with a bending stress of 100 N/mm² assuming 100% fixity.

4.5 Movable decks

4.5.1 Movable decks are generally to be constructed as pontoons comprising a web structure with top decking. They are to be efficiently supported and hinges, pillars, or other means are to be designed on the basis of the imposed loads. Plans showing the proposed arrangements and scantlings as well as details of the deck loading are to be submitted for approval.

4.5.2 The deck plate thickness for steel decks is to be as required by 4.3.1 and the section modulus of webs and deck stiffeners is to be at least equal to:

$$SM = 25{,}9 \cdot R \cdot I \cdot (1 - K),\ cm^3 \text{, for } K<0{,}5$$
$$= 14{,}1 \cdot R \cdot I,\ cm^3 \text{, for } K \geq 0{,}5$$

where:
R = Maximum axle load, tonnes.
L = Unsupported span of stiffeners, m.
K = The ratio (wheel spacing)/(beam span).

4.5.3 The structure of movable decks may be alternatively designed on the basis of a direct calculation using a grillage idealization. Proposals about this method are to be submitted for consideration.

4.6 Drainage of car decks

4.6.1 Vehicle decks within superstructures are to have a suitable number of drainage openings on each side of the ship.

4.6.2 The area and disposition of drainage openings should be in accordance with Part 5, Chapter 9, 13.1.5.

4.6.3 If the drainage openings are lower than the ship's summer draught waterline when the ship has a list of 5 , the outlets are to be led to a suitable space in accordance with Part 5, Chapter 9, 3.2.5.

SECTION 5 Bow and Stern Doors

5.1 Bow doors and inner doors (IACS UR S8 Rev.4)

5.1.1 General

5.1.1.1 Application

(a) These requirements are for the arrangement, strength and securing of bow doors and inner doors leading to a complete or long forward enclosed superstructures, or to a long non-enclosed superstructure, where fitted to attain minimum bow height equivalence.
The requirements apply to all ro-ro passenger ships and ro-ro cargo ships engaged on international voyages and also to ro-ro passenger ships and ro-ro cargo ships engaged only in domestic (non-international) voyages, except where specifically indicated otherwise herein.
The requirements are not applicable to high speed, light displacement craft as defined in the IMO Code of Safety for High-Speed Craft.
(b) Two types of bow door are provided for:
- **Visor doors** opened by rotating upwards and outwards about a horizontal axis through two or more hinges located near the top of the door and connected to the primary structure of the door by longitudinally arranged lifting arms,
- **Side-opening doors** opened either by rotating outwards about a vertical axis through two or more hinges located near the outboard edges or by horizontal translation by means of linking arms arranged with pivoted attachments to the door and the ship. It is anticipated that side-opening bow doors are arranged in pairs.

Other types of bow door will be specially considered in association with the applicable requirements of these rules.

5.1.1.2 Arrangement

(a) Bow doors are to be situated above the freeboard deck. A watertight recess in the freeboard deck located forward of the collision bulkhead and above the deepest waterline fitted for arrangement of ramps or other related mechanical devices may be regarded as a part of the freeboard deck for the purpose of this requirement.
(b) An inner door is to be fitted. The inner door is to be part of the collision bulkhead. The inner door needs not be fitted directly above the bulkhead below, provided it is located within the limits specified for the position of the collision bulkhead, refer to regulation II-1/12 of the SOLAS Convention, as appropriate to the type of ship. A vehicle ramp may be arranged for this purpose, provided its position complies with regulation II-1/12 of the SOLAS Convention, as appropriate to the type of ship. If this is not possible a separate inner weathertight door is to be installed, as far as practicable within the limits specified for the position of the collision bulkhead.
(c) Bow doors are to be so fitted as to ensure tightness consistent with operational conditions and to give effective protection to inner doors. Inner doors forming part of the collision bulkhead are to be weathertight over the full height of the cargo space and arranged with fixed sealing supports on the aft side of the doors.
(d) Bow doors and inner doors are to be arranged so as to preclude the possibility of the bow door causing structural damage to the inner door or to the collision bulkhead in the case of damage to or detachment of the bow door. If this is not possible, a separate inner weathertight door is to be installed, as indicated in 5.1.1.2(b).
(e) The requirements for inner doors are based on the assumption that vehicle is effectively lashed and secured against movement in stowed position.

5.1.1.3 Definitions

- Securing device: a device used to keep the door closed by preventing it from rotating about its hinges.
- Supporting device: a device used to transmit external or internal loads from the door to a securing device and from the securing device to the ship's structure, or a device other than a securing device, such as a hinge, stopper or other fixed device, that transmits loads from the door to the ship's structure.
- Locking device: a device that locks a securing device in the closed position
- Ro-ro passenger ship: a passenger ship with ro-ro spaces or special category spaces.
- Ro-ro spaces: are spaces not normally sub-divided 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.
- Special category spaces: are those enclosed vehicle spaces above or below the bulkhead deck, into and from which vehicles can be driven and to which passengers 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 10m.

5.1.2 Strength Criteria

5.1.2.1 Primary structure and Securing and Supporting devices

(a) Scantlings of the primary members, securing and supporting devices of bow doors and inner doors are to be determined to withstand the design loads defined in 5.1.3, using the following permissible stresses:

shear stress: $\tau = \frac{80}{k}, \quad N/mm^2$

bending stress: $\sigma = \frac{120}{k}, \quad N/mm^2$

equivalent stress: $\sigma_c = \sqrt{\sigma^2 + 3\tau^2} = \frac{150}{k}, \quad N/mm^2$

where k is the material factor as given in Part 3, Chapter 2, SECTION 3, but is not to be taken less than 0,72 unless a direct fatigue analysis is carried out.

(b) The buckling strength of primary members is to be verified as being adequate.

(c) For steel-to-steel bearings in securing and supporting devices, the nominal bearing pressure calculated by dividing the design force by the projected bearing area is not to exceed $0{,}8 \cdot \sigma_f$, where σ_f is the yield stress of the bearing material. For other bearing materials, the permissible bearing pressure is to be determined according to the manufacturer's specification.

(d) The arrangement of securing and supporting devices is to be such that threaded bolts do not carry support forces. The maximum tension in way of threads of bolts not carrying support forces is not to exceed:

$$\frac{125}{k}, \quad N/mm^2$$

5.1.3 Design loads

5.1.3.1 Bow doors

(a) The design external pressure, in kN/m² to be considered for the scantlings of primary members, securing and supporting devices of bow doors is not to be less than the pressure normally used by the Society nor than:

$$P_e = 2{,}75 \cdot \lambda \cdot C_H \cdot (0{,}22 + 0{,}15 \cdot \tan\alpha) \cdot (0{,}4 \cdot V \cdot \sin\beta + 0{,}6 \cdot L^{0,5})^2$$

where:

V	=	contractual ship's speed, knots,	
L	=	ship's length, but need not be taken greater than 200 meters, m,	
λ	=	coefficient depending on the area where the ship is intended to be operated:	
	=	1 for seagoing ships,	
	=	0,8 for ships operated in coastal waters,	
	=	0,5 for ships operated in sheltered waters NOTE: Coastal waters and sheltered waters are defined according to the practice of the Society. As an example, coastal waters may be defined as areas, where significant wave heights do not exceed 4m for more than three hours a year and sheltered waters as areas, where significant wave heights do not exceed 2m for more than three hours a year.	
C_H	=	$0{,}0125 \cdot L$	for L<80m
	=	1	for L≥80m
α	=	flare angle at the point to be considered, defined as the angle between a vertical line and the tangent to the side shell plating, measured in a vertical plane normal to the horizontal tangent to the shell plating,	
β	=	entry angle at the point to be considered, defined as the angle between a longitudinal line parallel to the centreline and the tangent to the shell plating in a horizontal plane.	

(b) The design external forces, in kN, considered for the scantlings of securing and supporting devices of bow doors are not to be less than:

$$F_x = P_e \cdot A_x$$

$$F_y = P_e \cdot A_y$$

$$F_z = P_e \cdot A_z$$

where:

A_x = area, in m², of the transverse vertical projection of the 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° 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 is to be excluded.

A_y = area, in m², of the longitudinal vertical projection of the 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° 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.

A_z = area, in m² of the horizontal projection of the door 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 the lesser, Where the flare angle of the bulwark is at least 15° 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.

h = height, in m, of the door between the levels of the bottom of the door and the upper deck or between the bottom of the door and the top of the door, whichever is the lesser,

l = length, in m, of the door at a height h/2 above the bottom of the door,

W = breadth, in m, of the door at a height h/2 above the bottom of the door,
P_e = external pressure, in kN/m² as given in 5.1.3.1(a) with angles α and β defined as follows:
α = flare angle measured at the point on the bow door, l/2 aft of the stem line on the plane h/2 above the bottom of the door, as shown in Figure 6.5.1,
β = entry angle measured at the same point as α.

For bow doors, including bulwark, of unusual form or proportions, e.g. ships with a rounded nose and large stem angles, the areas and angles used for determination of the design values of external forces may require to be specially considered.

(c) For visor doors the closing moment M_y under external loads, in kNm, is to be taken as:

$$M_y = F_x \cdot a + 10 \cdot W \cdot c - F_z \cdot b$$

where:

W = mass of the visor door, t,

a = vertical distance, from visor pivot to the centroid of the transverse vertical projected area of the visor door, as shown in Figure 6.5.2, m,

b = horizontal distance, from visor pivot to the centroid of the horizontal projected area of the visor door, as shown in Figure 6.5.2, m,

c = horizontal distance, from visor pivot to the centre of gravity of visor mass, as shown in Figure 6.5.2, m.

(d) Moreover, the lifting arms of a visor door and its supports are to be dimensioned for the static and dynamic forces applied during the lifting and lowering operations, and a minimum wind pressure of 1,5kN/m² is to be taken into account.

5.1.3.2 Inner doors

(a) The design external pressure p_e, kN/m², considered for the scantlings of primary members, securing and supporting devices and surrounding structure of inner doors is to be taken as the greater of the following:

$$p_e = 0{,}45 \cdot L, \text{ and}$$

$$\text{hydrostatic pressure } p_h = 10 \cdot h$$

where:

h = the distance from the load point to the top of the cargo space, m,

L = the ship's length, as defined in 5.1.3.1(a).

(b) The design internal pressure p_i, kN/m², considered for the scantlings of securing devices of inner doors is not to be less than:

$$p_i = 25$$

5.1.4 Scantlings of bow doors

5.1.4.1 General

(a) The strength of bow doors is to be commensurate with that of the surrounding structure.
(b) Bow doors are to be adequately stiffened and means are to be provided to prevent lateral or vertical movement of the doors when closed. For visor doors adequate strength for the opening

and closing operations is to be provided in the connections of the lifting arms to the door structure and to the ship structure.

5.1.4.2 Plating and secondary stiffeners

(a) The thickness of the bow door plating is not to be less than that required for the side shell plating, using bow door stiffener spacing, but in no case less than the minimum required thickness of fore end shell plating.
(b) The section modulus of horizontal or vertical stiffeners is not to be less than that required for end framing. Consideration is to be given, where necessary, to differences in fixity between ship's frames and bow doors stiffeners.
(c) The stiffener webs are to have a net sectional area not less than:

$$A = \frac{Qk}{10}, \qquad cm^2$$

where:

Q = shear force in the stiffener calculated by using uniformly distributed external pressure p_e as given in 5.1.3.1(a), kN.

5.1.4.3 Primary structure

(a) The bow door secondary stiffeners are to be supported by primary members constituting the main stiffening of the door.
(b) The primary members of the bow door and the hull structure in way are to have sufficient stiffness to ensure integrity of the boundary support of the door.
(c) Scantlings of the primary members are generally to be supported by direct strength calculations in association with the external pressure given in 5.1.3.1(a) and permissible stresses given in 5.1.2.1(a). Normally, formulae for simple beam theory may be applied to determine the bending stress. Members are to be considered to have simply supported end connections.

5.1.5 Scantlings of inner doors

5.1.5.1 General

(a) Scantlings of the primary members are generally to be supported by direct strength calculations in association with the external pressure given in 5.1.3.2(a) and permissible stresses given in 5.1.2.1(a). Normally, formulae for simple beam theory may be applied.
(b) Where inner doors also serve as a vehicle ramps, the scantlings are not to be less than those required for vehicle decks.
(c) The distribution of the forces acting on the securing and supporting devices is generally to be supported by direct calculations taking into account the flexibility of the structure and the actual position and stiffness of the supports.

5.1.6 Securing and supporting of bow doors

5.1.6.1 General

(a) Bow doors are to be fitted with adequate means of securing and supporting so as to be commensurate with the strength and stiffness of the surrounding structure. The hull supporting structure in way of the bow doors is to be suitable for the same design loads and design stresses as the securing and supporting devices. Where packing is required, the packing material is to be of a comparatively soft type, and the supporting forces are to be carried by the steel structure only.

Other types of packing may be considered. Maximum design clearance between securing and supporting devices is not generally to exceed 3 mm.
A means is to be provided for mechanically fixing the door in the open position.

(b) Only the active supporting and securing devices having an effective stiffness in the relevant direction are to be included and considered to calculate the reaction forces acting on the devices. Small and/or flexible devices such as cleats intended to provide load compression of the packing material are not generally to be included in the calculations called for in 5.1.6.2(e). The number of securing and supporting devices is generally to be the minimum practical whilst taking into account the requirements for redundant provision given in 5.1.6.2(f) and 5.1.6.2(g) and the available space for adequate support in the hull structure.

(c) For opening outwards visor doors, the pivot arrangement is generally to be such that the visor is self-closing under external loads, that is $M_y > 0$. Moreover, the closing moment M_y as given in 5.1.3.1(c) is to be not less than:

$$M_{yo} = 10 \cdot W_c + 0{,}1 \cdot (a^2 + b^2)^{0{,}5}(F_x^2 + F_Z^2)^{0{,}5}$$

5.1.6.2 Scantlings

(a) Securing and supporting devices are to be adequately designed so that they can withstand the reaction forces within the permissible stresses given in 5.1.2.1(a).

(b) For visor doors the reaction forces applied on the effective securing and supporting devices assuming the door as a rigid body are determined for the following combination of external loads acting simultaneously together with the self-weight of the door:

(i) case 1 F_x and F_z

(ii) case 2 0,7·F_y acting on each side separately together with 0,7·F_x and 0,7·F_z

where:

F_x, F_y, and F_z are determined as indicated in 5.1.3.1(b) and applied at the centroid of projected areas.

(c) For side-opening doors the reaction forces applied on the effective securing and supporting devices assuming the door as a rigid body are determined for the following combination of external loads acting simultaneously together with the self-weight of the door:

(i) case 1 F_x, F_y and F_z acting on both doors

(ii) case 2 0,7·F_x and 0,7·F_z acting on both doors and 0,7·F_y acting on each door separately,

where:

F_x, F_y and F_z are determined as indicated in 5.1.3.1(b) and applied at the centroid of projected areas.

(d) The support forces as determined according to 5.1.6.2(b)(i) and 5.1.6.2(c)(i) shall generally give rise to a zero moment about the transverse axis through the centroid of the area A_x. For visor doors, longitudinal reaction forces of pin and/or wedge supports at the door base contributing to this moment are not to be of the forward direction.

(e) The distribution of the reaction forces acting on the securing and supporting devices may require to be supported by direct calculations taking into account the flexibility of the hull structure and the actual position and stiffness of the supports.

(f) The arrangement of securing and supporting devices in way of these securing devices is to be designed with redundancy so that in the event of failure of any single securing or supporting device the remaining devices are capable to withstand the reaction forces without exceeding by more than 20% the permissible stresses as given in 5.1.2.1.

(g) For visor doors, two securing devices are to be provided at the lower part of the door, each capable of providing the full reaction force required to prevent opening of the door within the permissible stresses given in 5.1.2.1(a). The opening moment M_o, in kN·m, to be balanced by this reaction force, is not to be taken less than:

$$M_o = 10 \cdot W \cdot d + 5 \cdot A_x \cdot a$$

where:

d = vertical distance from the hinge axis to the centre of gravity of the door, as shown in Figure 6.5.2, m

a = as defined in 5.1.3.1(c).

(h) For visor doors, the securing and supporting devices excluding the hinges should be capable of resisting the vertical design force (Fz -10·W) within the permissible stresses given in 5.1.2.1(a), kN.
(i) All load transmitting elements in the design load path, from door through securing and supporting devices into the ship structure, including welded connections, are to be to the same strength standard as required for the securing and supporting devices. These elements include pins, supporting brackets and back-up brackets.
(j) For side-opening doors, thrust bearing has to be provided in way of girder ends at the closing of the two leaves to prevent one leaf to shift towards the other one under effect of unsymmetrical pressure (see example of Figure 6.5.3). Each part of the thrust bearing has to be kept secured on the other part by means of securing devices. Any other arrangement serving the same purpose may be proposed.

5.1.7 Securing and locking arrangement

5.1.7.1 Systems for operation

(a) Securing devices are to be simple to operate and easily accessible.

Securing devices are to be equipped with mechanical locking arrangement (self-locking or separate arrangement), or to be of the gravity type. The opening and closing systems as well as securing and locking devices are to be interlocked in such a way that they can only operate in the proper sequence.

(b) Bow doors and inner doors giving access to vehicle decks are to be provided with an arrangement for remote control, from a position above the freeboard deck, of:
– the closing and opening of the doors, and
– associated securing and locking devices for every door.

Indication of the open/closed position of every door and every securing and locking device is to be provided at the remote-control stations. The operating panels for operation of doors are to be inaccessible to unauthorized persons. A notice plate, giving instructions to the effect that all securing devices are to be closed and locked before leaving harbour, is to be placed at each operating panel and is to be supplemented by warning indicator lights.

(c) Where hydraulic securing devices are applied, the system is to be mechanically lockable in closed position. This means that, in the event of loss of the hydraulic fluid, the securing devices remain locked.
The hydraulic system for securing and locking devices is to be isolated from other hydraulic circuits, when in closed position.

5.1.7.2 Systems for indication/monitoring

(a) Separate indicator lights and audible alarms are to be provided on the navigation bridge and on the operating panel to show that the bow door and inner door are closed and that their securing and locking devices are properly positioned.

The indication panel is to be provided with a lamp test function. It shall not be possible to turn off the indicator light.

(b) The indicator system is to be designed on the fail-safe principle and is to show by visual alarms if the door is not fully closed and not fully locked and by audible alarms if securing devices become open or locking devices become unsecured. The power supply for the indicator system for operating and closing doors is to be independent of the power supply for operating and closing the doors and is to be provided with a back-up power supply from the emergency source of power or other secure power supply e.g. UPS. The sensors of the indicator system are to be protected from water, ice formation and mechanical damages.

NOTE:

The indicator system is considered designed on the fail - safe principal when:

1. The indication panel is provided with:
   - a power failure alarm
   - an earth failure alarm
   - a lamp test
   - separate indication for door closed, door locked, door not closed and door not locked.
2. Limit switches electrically closed when the door is closed (when more limit switches are provided, they may be connected in series).
3. Limit switches electrically closed when securing arrangements are in place (when more limit switches are provided, they may be connected in series).
4. Two electrical circuits (also in one multicore cable), one for the indication of door closed / not closed and the other for door locked / not locked.
5. In case of dislocation of limit switches, indication to show: not closed / not locked / securing arrangement not in place - as appropriate.

(c) The indication panel on the navigation bridge is to be equipped with a mode selection function "harbour / sea voyage", so arranged that audible alarm is given on the navigation bridge if the vessel leaves harbour with the bow door or inner door not closed or with any of the securing devices not in the correct position.

(d) A water leakage detection system with audible alarm and television surveillance is to be arranged to provide an indication to the navigation bridge and to the engine control room of leakage through the inner door.

NOTE:

The indicator system is considered designed on the fail - safe principal when:

1. The indication panel is provided with:
   - a power failure alarm
   - an earth failure alarm
   - a lamp test
   - separate indication for door closed, door locked, door not closed and door not locked.
2. Limit switches electrically closed when the door is closed (when more limit switches are provided, they may be connected in series).
3. Limit switches electrically closed when securing arrangements are in place (when more limit switches are provided, they may be connected in series).
4. Two electrical circuits (also in one multicore cable), one for the indication of door closed / not closed and the other for door locked / not locked.
5. In case of dislocation of limit switches, indication to show: not closed / not locked / securing arrangement not in place - as appropriate.

(e) Between the bow door and the inner door a television surveillance system is to be fitted with a monitor on the navigation bridge and in the engine control room. The system is to monitor the position of the doors and a sufficient number of their securing devices. Special consideration is to be given for the lighting and contrasting colour of objects under surveillance.

NOTE:

The indicator system is considered designed on the fail - safe principal when:

1. The indication panel is provided with:
   - a power failure alarm
   - an earth failure alarm
   - a lamp test
   - separate indication for door closed, door locked, door not closed and door not locked.
2. Limit switches electrically closed when the door is closed (when more limit switches are provided, they may be connected in series).
3. Limit switches electrically closed when securing arrangements are in place (when more limit switches are provided, they may be connected in series).
4. Two electrical circuits (also in one multicore cable), one for the indication of door closed / not closed and the other for door locked / not locked.
5. In case of dislocation of limit switches, indication to show: not closed / not locked / securing arrangement not in place - as appropriate.

(f) A drainage system is to be arranged in the area between bow door and ramp, or where no ramp is fitted, between the bow door and inner door. The system is to be equipped with an audible alarm function to the navigation bridge being set off when the water levels in these areas exceed 0,5m or the height water level alarm, whichever is lesser.

NOTE:

The indicator system is considered designed on the fail - safe principal when:

1. The indication panel is provided with:
   - a power failure alarm
   - an earth failure alarm
   - a lamp test
   - separate indication for door closed, door locked, door not closed and door not locked.
2. Limit switches electrically closed when the door is closed (when more limit switches are provided, they may be connected in series).
3. Limit switches electrically closed when securing arrangements are in place (when more limit switches are provided, they may be connected in series).
4. Two electrical circuits (also in one multicore cable), one for the indication of door closed / not closed and the other for door locked / not locked.
5. In case of dislocation of limit switches, indication to show: not closed / not locked / securing arrangement not in place - as appropriate.

(g) For ro-ro passenger ships on international voyages, the special category spaces and ro-ro spaces are to be continuously patrolled or monitored by effective means, such as television surveillance, so that any movement of vehicles in adverse weather conditions or unauthorized access by passengers thereto, can be detected whilst the ship is underway.

5.1.8 Operating and Maintenance Manual

5.1.8.1 An Operating and Maintenance Manual for the bow door and inner door is to be provided on board and is to contain necessary information on:

– main particulars and design drawings,
  - special safety precautions
  - details of vessel, class, statutory certificates
  - equipment and design loading (for ramps)

  - key plan of equipment (doors and ramps)
  - manufacturer's recommended testing for equipment
  - description of equipment
    - bow doors
    - inner bow doors
    - bow ramp/doors
    - side doors
    - stern doors
    - central power pack
    - bridge panel
    - engine control room panel
- service conditions,
  - limiting heel and trim of ship for loading/unloading
  - limiting heel and trim for door operations
  - doors/ramps operating instructions
  - doors/ramps emergency operating instructions
- maintenance
  - schedule and extent of maintenance
  - trouble shooting and acceptable clearances
  - manufacturer's maintenance procedures
- register of inspections, including inspection of locking, securing and supporting devices, and repairs and renewals

This Manual is to be submitted for approval that the above-mentioned items are contained in the OMM and that the maintenance part includes the necessary information with regard to inspections, trouble-shooting and acceptance / rejection criteria.

NOTE: It is recommended that recorded inspections of the door supporting and securing devices be carried out by the ship's staff at monthly intervals or following incidents that could result in damage, including heavy weather or contact in the region of the shell doors. Any damages recorded during such inspections are to be reported to the Society.

5.1.8.2 Documented operating procedures for closing and securing the bow door and inner door are to be kept on board and posted at appropriate place.

Figure 6.5.1: Definition of α and β

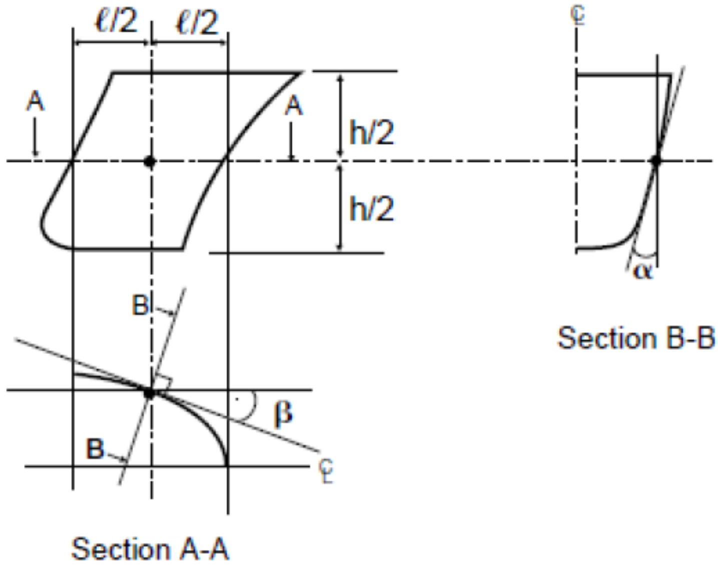


Figure 6.5.2: Bow Door of Visor Type

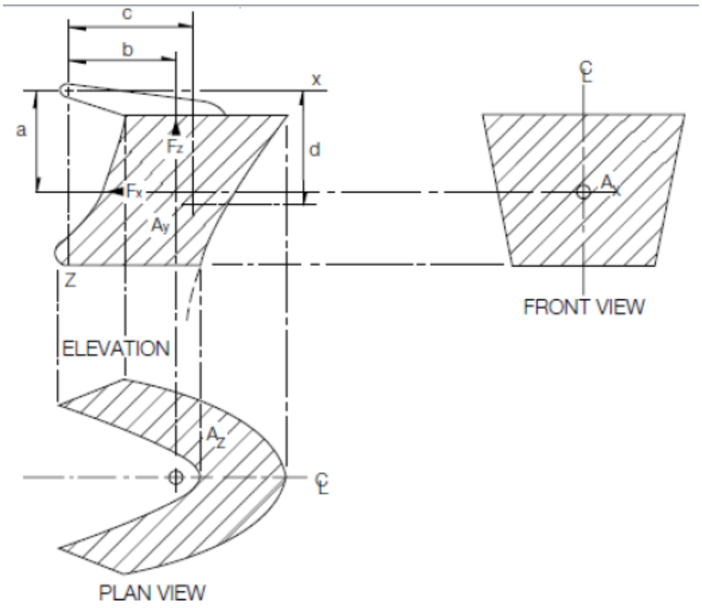
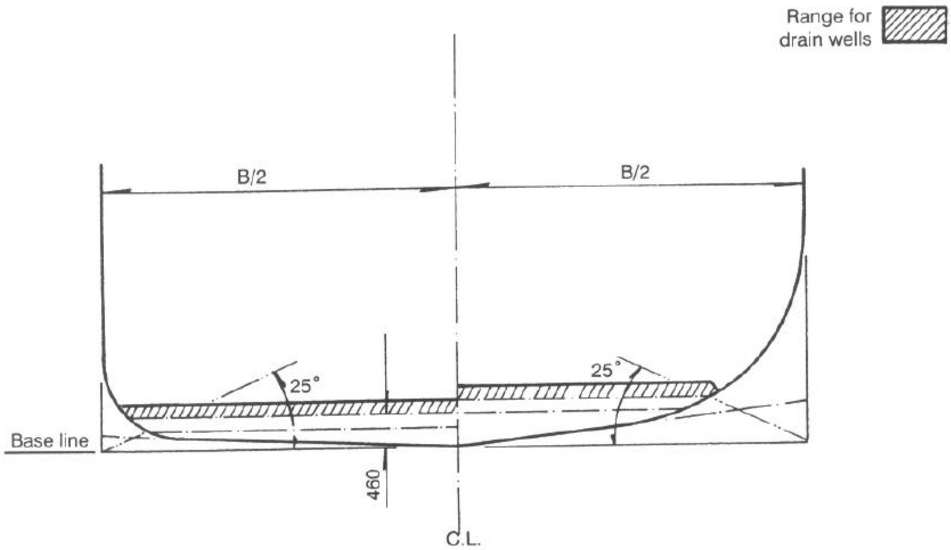


Figure 6.5.3: Thrust Bearing



5.2 Side Shell Doors and Stern Doors (IACS UR S9 Rev.6)

5.2.1 General

5.2.1.1 Application

(e) These requirements are for the arrangement, strength and securing of side shell doors, abaft the collision bulkhead, and of stern doors leading to enclosed spaces.
The requirements apply to all ro-ro passenger ships and ro-ro cargo ships engaged on international voyages and also to ro-ro passenger ships and ro-ro cargo ships engaged only in domestic (non-international) voyages, except where specifically indicated otherwise herein. The requirements are not applicable to high speed, light displacement craft as defined in the IMO Code of Safety for High-Speed Craft.

5.2.1.2 Arrangement

(a) Stern doors for passenger vessels are to be situated above the freeboard deck. Stern doors for Ro-Ro cargo ships and side shell doors may be either below or above the freeboard deck.
(b) Side shell doors and stern doors are to be so fitted as to ensure tightness and structural integrity commensurate with their location and the surrounding structure.
(c) Where the sill of any side shell door is below the uppermost load line, the arrangement is to be specially considered (see IACS Interpretation LL 21).
(d) Doors should preferably open outwards.

5.2.1.3 Definitions

- Securing device: a device used to keep the door closed by preventing it from rotating about its hinges or about pivoted attachments to the ship.
- Supporting device: a device used to transmit external or internal loads from the door to a securing device and from the securing device to the ship's structure, or a device other than a securing device, such as a hinge, stopper or other fixed device, that transmits loads from the door to the ship's structure.
- Locking device: a device that locks a securing device in the closed position.
- Ro-ro passenger ship: a passenger ship with ro-ro spaces or special category spaces.
- Ro-ro spaces: are spaces not normally sub-divided in any way and 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.
- Special category spaces: are those enclosed vehicle spaces above or below the bulkhead deck, into and from which vehicles can be driven and to which passengers 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 10m.

5.2.2 Strength Criteria

5.2.2.1 Primary structure and Securing and Supporting devices

(a) Scantlings of the primary members, securing and supporting devices of side shell doors and stern doors are to be determined to withstand the design loads defined in 5.2.3, using the following permissible stresses:

shear stress: $\tau = \frac{80}{k}, \quad N/mm^2$

bending stress: $\sigma = \frac{120}{k}, \quad N/mm^2$

equivalent stress: $\sigma_c = \sqrt{\sigma^2 + 3\tau^2} = \frac{150}{k}, \quad N/mm^2$

where k is the material factor as given in Part 3, Chapter 2, SECTION 3, but is not to be taken less than 0,72 unless a direct fatigue analysis with regard to relevant modes of failures is carried out.

(b) The buckling strength of primary members is to be verified as being adequate.
(c) For steel-to-steel bearings in securing and supporting devices, the nominal bearing pressure calculated by dividing the design force by the projected bearing area is not to exceed 0,8·σF, where σ_F is the yield stress of the bearing material. For other bearing materials, the permissible bearing pressure is to be determined according to the manufacturer's specification.

(d) The arrangement of securing and supporting devices is to be such that threaded bolts do not carry support forces. The maximum tension in way of threads of bolts not carrying support forces is not to exceed 125/k N/mm^2, with k defined in 5.2.2.1(a).

5.2.3 Design loads

5.2.3.1 The design forces, in kN, considered for the scantlings of primary members, securing and supporting devices of side shell doors and stern doors are to be not less than:

(i) Design forces for securing or supporting devices of doors opening inwards:

- external force: $F_e = A \cdot p_e + F_p$
- internal force: $F_i = F_o + 10 \cdot W$

(ii) Design forces for securing or supporting devices of doors opening outwards:

- external force: $F_e = A \cdot p_e$
- internal force: $F_i = F_o + 10 \cdot W + F_p$

(iii) Design forces for primary members:

- external force: $F_e = A \cdot p_e$
- internal force: $F_i = F_o + 10 \cdot W$ whichever is the greater,

where:

A = area of the door opening, m^2,

W = mass of the door, t,

F_p = total packing force, kN. Packing line pressure is normally not to be taken less than 5 N/mm,

F_o = the greater of F_c and 5 A, kN,

F_c = accidental force due to loose of cargo etc., to be uniformly distributed over the area A and not to be taken less than 300 kN. For small doors such as bunker doors and pilot doors, the value of Fc may be appropriately reduced. However, the value of Fc may be taken as zero, provided an additional structure such as an inner ramp is fitted, which is capable of protecting the door from accidental forces due to loose cargoes.

p_e = external design pressure determined at the centre of gravity of the door opening and not taken less than:

$10 \cdot (T - Z_G) + 25, \quad \text{for } Z_G < T, \quad kN/m^2$

$25, \quad \text{for } Z_G \geq T, \quad \frac{kN}{m^2}$

Moreover, for stern doors of ships fitted with bow doors, p_e is not to be taken less than:

$$P_e = 0{,}6 \cdot \lambda \cdot C_H \cdot (0{,}8 + 0{,}6 \cdot L^{0{,}5})^2$$

λ = coefficient depending on the area where the ship is intended to be operated:
= 1 for sea going ships,
= 0,8 for ships operated in coastal waters,
= 0,5 for ships operated in sheltered waters.

NOTE: Coastal waters and sheltered waters are defined according to the practice of the Society. As an example, coastal waters may be defined as areas where significant wave heights do not exceed 4m for more than three hours a year and sheltered waters as areas where significant wave heights do not exceed 2m for more than three hours a year.

C_H = 0,0125·L for L < 80m
= 1 for L ≥ 80m

L = ship's length, but need not be taken greater than 200 m
T = draught at the highest subdivision load line, m,
Z_G = height of the centre of area of the door above the baseline, m.

5.2.4 Scantlings of side shell doors and stern doors

5.2.4.1 General

(a) The strength of side shell doors and stern doors is to be commensurate with that of the surrounding structure.
(b) Side shell doors and stern doors are to be adequately stiffened and means are to be provided to prevent any lateral or vertical movement of the doors when closed. Adequate strength is to be provided in the connections of the lifting/manoeuvering arms and hinges to the door structure and to the ship's structure.
(c) Where doors also serve as vehicle ramps, the design of the hinges should take into account the ship angle of trim and heel, which may result in uneven loading on the hinges.
(d) Shell door openings are to have well-rounded corners and adequate compensation is to be arranged with web frames at sides and stringers or equivalent above and below.

5.2.4.2 Plating and secondary stiffeners

(a) The thickness of the door plating is not to be less than the required thickness for the side shell plating, using the door stiffener spacing, but in no case less than the minimum required thickness of shell plating.
Where doors serve as vehicle ramps, the plating thickness is to be not less than required for vehicle decks.
(b) The section modulus of horizontal or vertical stiffeners is not to be less than that required for side framing. Consideration is to be given, where necessary, to differences in fixity between ship's frames and door stiffeners.
Where doors serve as vehicle ramps, the stiffener scantlings are not to be less than required for vehicle decks.

5.2.4.3 Primary Structure

(a) The secondary stiffeners are to be supported by primary members constituting the main stiffening of the door.
(b) The primary members and the hull structure in way are to have sufficient stiffness to ensure structural integrity of the boundary of the door.
(c) Scantlings of the primary members are generally to be supported by direct strength calculations in association with the design forces given in 5.2.3 and permissible stresses given in 5.2.2.1(a). Normally, formulae for simple beam theory may be applied to determine the bending stresses. Members are to be considered to have simply supported end connections.

5.2.5 Securing and Supporting of Doors

5.2.5.1 General

(a) Side shell doors and stern doors are to be fitted with adequate means of securing and supporting so as to be commensurate with the strength and stiffness of the surrounding structure. The hull supporting structure in way of the doors is to be suitable for the same design loads and design stresses as the securing and supporting devices.
Where packing is required, the packing material is to be of a comparatively soft type, and the supporting forces are to be carried by the steel structure only. Other types of packing may be considered.

Maximum design clearance between securing and supporting devices is not generally to exceed 3mm.
A means is to be provided for mechanically fixing the door in the open position.

(b) Only the active supporting and securing devices having an effective stiffness in the relevant direction are to be included and considered to calculate the reaction forces acting on the devices. Small and/or flexible devices such as cleats intended to provide local compression of the packing material are not generally to be included in the calculations called for in 5.2.5.2(b). The number of securing and supporting devices are generally to be the minimum practical whilst taking into account the requirement for redundant provision given in 5.2.5.2(c) and the available space for adequate support in the hull structure.

5.2.5.2 Scantlings

(a) Securing and supporting devices are to be adequately designed so that they can withstand the reaction forces within the permissible stresses given in 5.2.2.1(a).
(b) The distribution of the reaction forces acting on the securing devices and supporting devices may require to be supported by direct calculations taking into account the flexibility of the hull structure and the actual position of the supports.
(c) The arrangement of securing devices and supporting devices in way of these securing devices is to be designed with redundancy so that in the event of failure of any single securing or supporting device the remaining devices are capable to withstand the reaction forces without exceeding by more than 20% the permissible stresses as given in 5.2.2.1(a).
(d) All load transmitting elements in the design load path, from the door through securing and supporting devices into the ship's structure, including welded connections, are to be to the same strength standard as required for the securing and supporting devices. These elements include pins, support brackets and back-up brackets.

5.2.6 Securing and Locking Arrangement

5.2.6.1 Systems for operation

(a) Securing devices are to be simple to operate and easily accessible. Securing devices are to be equipped with mechanical locking arrangement (self-locking or separate arrangement), or are to be of the gravity type. The opening and closing systems as well as securing and locking devices are to be interlocked in such a way that they can only operate in the proper sequence.
(b) Doors which are located partly or totally below the freeboard deck with a clear opening area greater than $6m^2$ are to be provided with an arrangement for remote control, from a position above the freeboard deck, of:
- the closing and opening of the doors,
- associated securing and locking devices.

For doors, which are required to be equipped with a remote-control arrangement, indication of the open/closed position of the door and the securing and locking device is to be provided at the remote-control stations. The operating panels for operation of doors are to be inaccessible to unauthorized persons. A notice plate, giving instructions to the effect that all securing devices are to be closed and locked before leaving harbour, is to be placed at each operating panel and is to be supplemented by warning indicator lights.

(c) Where hydraulic securing devices are applied, the system is to be mechanically lockable in closed position. This means that, in the event of loss of the hydraulic fluid, the securing devices remain locked. The hydraulic system for securing and locking devices is to be isolated from other hydraulic circuits, when closed position.

5.2.6.2 Systems for indication/monitoring

(a) The following requirements apply to doors in the boundary of special category spaces or ro-ro spaces, as defined in 5.2.1.3, through which such spaces may be flooded. For cargo ships, where no part of the door is below the uppermost waterline and the area of the door opening is not greater than $6m^2$, then the requirements of this section need not be applied.

(b) Separate indicator lights and audible alarms are to be provided on the navigation bridge and on each operating panel to indicate that the doors are closed and that their securing and locking devices are properly positioned.
The indication panel is to be provided with a lamp test function. It shall not be possible to turn off the indicator light.

(c) The indicator system is to be designed on the fail-safe principle and is to show by visual alarms if the door is not fully closed and not fully locked and by audible alarms if securing devices become open or locking devices become unsecured. The power supply for the indicator system is to be independent of the power supply for operating and closing the doors and is to be provided with a backup power supply from the emergency source of power or secure power supply e.g. UPS.

NOTE: see 5.1.7.2(b) for fail safe principal design.

The sensors of the indicator system are to be protected from water, ice formation and mechanical damages.

(d) The indication panel on the navigation bridge is to be equipped with a mode selection function "harbour/sea voyage", so arranged that audible alarm is given on the navigation bridge if the vessel leaves harbour with any side shell or stern doors not closed or with any of the securing devices not in the correct position.

(e) For passenger ships, a water leakage detection system with audible alarm and television surveillance is to be arranged to provide an indication to the navigation bridge and to the engine control room of any leakage through the doors.
For cargo ships, a water leakage detection system with audible alarm is to be arranged to provide an indication to the navigation bridge.

(f) For ro-ro passenger ships, on international voyages, the special category spaces and ro-ro spaces are to 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.

5.2.7 Operating and Maintenance Manual

5.2.7.1 An Operating and Maintenance Manual for the side shell doors and stern doors is to be provided on board and is to contain necessary information on:

- main particulars and design drawings,
  - special safety precautions
  - details of vessel
  - equipment and design loading (for ramps)
  - key plan of equipment (doors and ramps)
  - manufacturer's recommended testing for equipment
  - description of equipment for
    - bow doors
    - inner bow doors
    - bow ramp/doors
    - side doors
    - stern doors
    - central power pack
    - bridge panel
    - engine control room panel

– service conditions,
  - limiting heel and trim of ship for loading/unloading
  - limiting heel and trim for door operations
  - doors/ramps operating instructions
  - doors/ramps emergency operating instructions
– maintenance
  - schedule and extent of maintenance
  - trouble shooting and acceptable clearances
  - manufacturer's maintenance procedures
– register of inspections, including inspection of locking, securing and supporting devices, and repairs and renewals

This Manual is to be submitted for approval that the above-mentioned items are contained in the OMM and that the maintenance part includes the necessary information with regard to inspections, trouble-shooting and acceptance / rejection criteria.

NOTE: It is recommended that recorded inspections of the door supporting and securing devices be carried out by the ship's staff at monthly intervals or following incidents that could result in damage, including heavy weather or contact in the region of the shell doors. Any damages recorded during such inspections are to be reported to the Society.

5.2.7.2 Documented operating procedures for closing and securing side shell and stern doors are to be kept on board and posted at the appropriate places.

Explanatory Note:

The external pressure applied on stern doors is derived from the formula considered in 5.1 for bow doors, assuming:

α = 0°
β = 90°
V = 2 knots

5.3 Side Shell Doors and Stern Doors - Retrospective application of 5.2, as amended 1996, to existing ro-ro passenger ships (IACS UR S15 Rev. 1)

5.3.1 The structural condition of side shell doors and stern doors, especially the primary structure, the securing and supporting arrangements and the hull structure alongside and above the doors, are to be specially examined and any defects rectified.

5.3.2 The following measures are to be complied with by all existing Ro-Ro passenger ships that:
– have not been assigned any navigational restrictions, or
– are engaged in international voyages, or
– have been assigned the class notation **EU-A**

no later than completion of the first annual survey commenced after 1 September 2003:

(a) The structural arrangement of securing devices and supporting devices of inwards opening doors in way of these securing devices and, where applicable, of the surrounding hull structure is to be reassessed in accordance with the applicable requirements of 5.2.5 and modified accordingly.

(b) The securing and locking arrangements for side shell doors and stern doors which may lead to the flooding of a special category space or ro-ro cargo space as defined in the SOLAS Convention and in 5.2.1.3, are to comply with the following requirements:

– Separate indicator lights and audible alarms are to be provided on the navigation bridge and on each operating panel to indicate that the doors are closed and that their securing and locking devices are properly positioned. The indication panel is to be provided with a lamp test function. It shall not be possible to turn off the indicator light.

- The indication panel on the navigation bridge is to be equipped with a mode selection function "harbour/sea voyage", so arranged that audible alarm is given if the vessel leaves harbour with side shell or stern doors not closed or with any of the securing devices not in the correct position.
- A water leakage detection system with audible alarm and television surveillance is to be arranged to provide an indication to the navigation bridge and to the engine control room of any leakage through the doors.

5.3.3 Documented operating procedures for closing and securing side shell and stern doors are to be kept on board and posted at the appropriate places.

5.3.4 The degree of compliance of ro-ro passenger ships other than those mentioned in 5.3.2 with the requirements stated in 5.3.2, will be decided on a case-by-case basis and after taking into account their operational area and the imposed restrictions.

5.4 Bow Doors and Inner Doors - Retrospective Application of 5.1, as amended 1995, to existing Ro-Ro Passenger Ships (IACS UR S16 Cor.1)

5.4.1 The structural condition of bow doors and inner doors, especially the primary structure, securing and supporting arrangements and the hull structure alongside and above the doors, are be specially examined and any defects rectified.

5.4.2 The requirements of 5.1.8 concerning operating procedures of the bow door and inner door are be complied with.

5.4.2 The following measures are to be applied to all existing ro-ro passenger ships that:

- have not been assigned any navigational restrictions, or
- are engaged in international voyages, or
- have been assigned the class notation **EU-A**

no later than the completion of the first annual survey commenced after 1 September 2003:

(a) The location and arrangement of inner doors are to comply with the applicable requirements the SOLAS Convention and with 5.1.1.2(d).

(b) Ships with visor door are to comply with 5.1.6.2(g) requiring redundant provision of securing devices preventing the upward opening of the bow door. In addition, where the visor door is not self-closing under external loads (i.e. the closing moment M_y calculated in accordance with 5.1.3.1(c) is less than zero) then the opening moment M_o is not to be taken less than $-M_y$. If drainage arrangements in the space between the inner and bow doors are not fitted, the value M_o is to be specially considered.
Where available space above the tank top does not enable the full application of 5.1.6.2(g), equivalent measures are to be taken to ensure that the door has positive means for being closed during seagoing operation.

(c) Ships with visor door are to comply with 5.1.6.2(h) requiring securing and supporting devices excluding hinges to be capable of bearing the vertical design force (Fz - 10W) without exceeding the permissible stresses given in 5.1.2.1(a).

(d) For side-opening doors, the structural arrangements for supporting vertical loads, including securing devices, supporting devices and, where applicable, hull structure above the door, are to be re-assessed in accordance with the applicable requirements of 5.1.6 and modified accordingly.

(e) The securing and locking arrangements for bow doors and inner doors which may lead to the flooding of a special category space or ro-ro space as defined in the 5.1.1.3 are to comply with applicable requirements of the SOLAS Convention, and with the following requirements as well:

- Separate indicator lights and audible alarms are to be provided on the navigation bridge and on each panel to indicate that the doors are closed and that their securing and locking devices are properly positioned.
- The indication panel is to be provided with a lamp test function. It is not to be possible to turn off the indicator light.
- The indication panel on the navigation bridge is to be equipped with a mode selection function "harbour/sea voyage", so arranged that audible alarm is given if the vessel leaves harbour with the bow doors or inner doors not closed or with any of the securing devices not in the correct position.
- A water leakage detection system with audible alarm and television surveillance are to be arranged to provide an indication to the navigation bridge and to the engine control station of any leakage through the doors.

5.4.4 The degree of compliance of ro-ro passenger ships other than those mentioned in 5.4.3 with the requirements stated in 5.4.3, will be decided on a case-by-case basis and after taking into account their operational area and the imposed restrictions.

SECTION 6 Open type ferries

6.1 Application

6.1.1 This Chapter applies to open type ferries defined as follows:

An open type ferry is a ship with single deck hull for the carriage of vehicles, an engine room and passenger accommodation aft, a single or double bottom and a bow ramp door. The anchor equipment is situated aft.

6.1.2 For ships considered in this Section the ratio L/D is to be not less than 16 and the ratio B/D to be less than 3.

6.1.3 Unless otherwise mentioned in this Section, the requirements of SECTION 1 to SECTION 5 are applicable.

6.2 Structural configuration

6.2.1 The basic structural configuration provide in this Section is a single deck hull, subdivided by transverse and longitudinal bulkheads.

6.2.2 Gangways are to be provided from both sides of the car deck on the top of the side walls. The height of the side walls is to be not less than 0,70 m and the clear breadth of the gangways not less than 0,90 m. In way of web frames supporting the superstructure, a 10% reduction of the useful breadth of the gangways may be accepted.

6.2.3 A weathertight inner door is to be provided behind the bow ramp door. The inner door should be opened forward. The height of the inner door is to be not less than 1,20 m.

6.2.4 The bottom and the car deck are to frame longitudinally in the car deck region. However, consideration will be given to alternative proposals.

6.3 Longitudinal strength

6.3.1 The section modulus of the midship section to the car deck and to the keel is not to be less than:

$$SM_o = 1{,}44 \cdot F \cdot D \cdot B, \quad cm^3$$

where:

F $188 \cdot L - 3500$

L,B,D = As defined in Part 3, Chapter 1, 3.2.

6.3.2

(a) The calculation of the midship section modulus is to be carried out in accordance with Part 3, Chapter 2.

(b) Side gangways rigid connected with the car deck may be considered as forming part of the car deck and may therefore be included in the section modulus calculation.

6.4 Single bottom structure

6.4.1 A longitudinally framed single bottom is formed by bottom transverses, associated with continuous bottom girders and longitudinals.

6.4.2 Bottom transverses shall be fitted not more than 3,2 m apart.

6.4.3 Bottom girders shall be fitted not more than 2,5 m apart.

6.4.4 The depth measured at the middle of the span l of the bottom transverses and girders is to be not less than twice the depth of the slot for the bottom longitudinals.

6.4.5 The thickness of bottom transverses and girders is to be not less than that obtained from the following formula:

$$t = L/35 + 6{,}5, \quad mm$$

where:

L = Length of ship, m.

6.4.6 The section modulus of bottom transverses, girders and longitudinals, in association with the plating to which it is attached, is to be not less than that given in the following formula:

$$SM = C \cdot h \cdot s \cdot l^2, \quad cm^3$$

where:

s = Spacing of bottom transverses, girders or longitudinals, m.

h = Depth of the ship D for bottom transverses and girders, m. For bottom longitudinals h is the vertical distance from the middle of the span l to a point located 1,2 m above the car deck at side amidships, m.

l = Unsupported span of bottom transverses, girders or longitudinals, m.

C = 8,41 for bottom transverses,
= 9,50 for bottom girders,
= 10,32 for bottom longitudinals.

6.5 Side stiffening amidships

6.5.1 The section modulus of vertical webs, vertical frames or side longitudinals, in association with the effective plating to which it is attached, is to be not less than that given in the following formula:

$$SM = C \cdot h \cdot s \cdot l^2, \qquad cm^3$$

where:

s	=	Spacing of vertical webs and vertical frames or side longitudinals, m.
h	=	Vertical distance from the middle of l for vertical webs and frames or from the side longitudinals, to a point located 1,2 m above the car deck at side amidships, m.
l	=	Length between supporting points, m.
C	=	7,36 for vertical webs,
	=	7,85 for vertical frames,
	=	7,50 for side longitudinals

6.6 Hull envelope plating

6.6.1 The thickness of the hull envelope plating amidships is to be such as to comply with the hull section modulus requirements of 6.3 and the scantling requirements of Part 3, Chapter 6.

6.7 Car deck

6.7.1 The construction of the car deck is to comply with the requirements of SECTION 4.

6.8 Bow door

6.8.1 The construction of the bow door is to comply with the requirements of SECTION 5.

CHAPTER 7 Passenger Ships

CONTENTS

SECTION 1 General

1.1 Application

1.1.1 The requirements of this chapter are intended to apply to all ships carrying more than twelve (12)passengers (passenger ships) on international voyages. Passenger ships operating within the territory waters of a state, should be specially considered after taking into account the size, the trading and the relevant governmental regulations in force at the time of application for classification.

1.1.2 Passenger ships, which due to their overall design are only suitable for trade in defined waterways may in no case be assigned an extended navigation notation to the character Classification, even if the strength of the hull is sufficient for a wider range of service. In this case, this may be expressed in the Certificate by adding the note:
"The strength of the hull structural elements complies with the navigation notation...".

1.2 Information required

1.2.1 In addition to the information specified in Part 3, Chapter 1, Section 2, the following documents are to be submitted for approval or consideration, if already approved by the Administration or other recognized Classification Society:

- Proof of floatability in damaged condition according to SOLAS requirements.
- Plans showing the arrangement of openings in the watertight bulkheads, in the shell plating and in the bulkhead and weather decks and plans showing the closing appliances for such openings.
- A damage control and safety plan containing all data essential for maintaining the survival capability.
- The floodable length curves plan.

SECTION 2 Longitudinal strength

2.1 General

2.1.1 Longitudinal strength calculations are generally to be made in accordance with the requirements of Part 3, Chapter 2. Sufficient effective side shell plating area is to be provided to transmit the shear and vertical forces to the strength deck.

2.1.2 Where the ship sides are arranged with rows of windows which significantly reduce the shear strength, the strength deck may be defined as a lower deck than that according to the definition given for the main Class. The hull structural strength is otherwise to be as required for the main class assuming design loads for passenger spaces as for accommodation deck or weather deck, whichever is applicable.

2.2 Permissible stresses

2.2.1 If the strength deck and the bottom structure are longitudinally framed the nominal permissible bending stress may be increased by 10 per cent.

SECTION 3 Bottom structure

3.1 General

3.1.1 The bottom structure calculations are generally to be made in accordance with Part 3, Chapter 3.

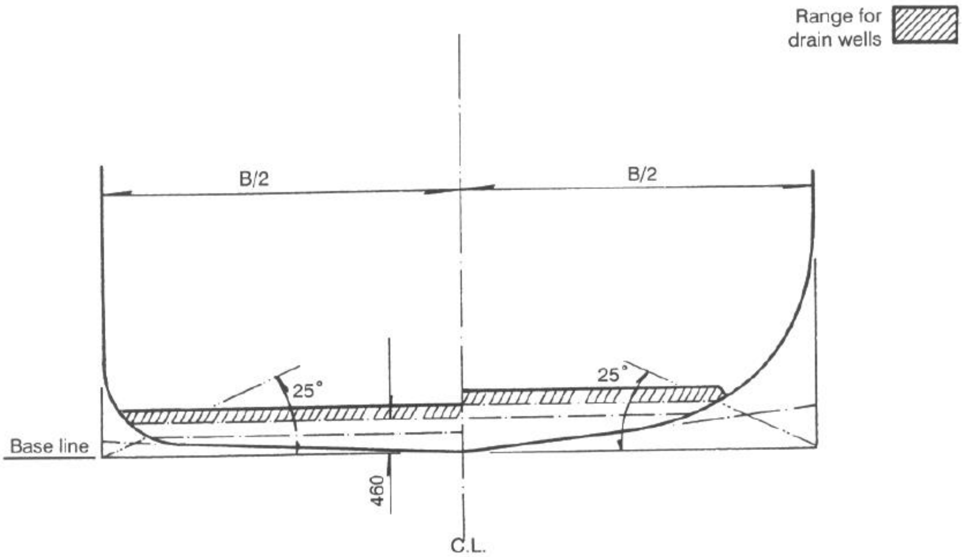
3.2 Double Bottom

3.2.1 A double bottom is to be fitted extending from the forepeak bulkhead to the afterpeak bulkhead, as far as practicable and compatible with the design and proper operation of the ship, (see also SOLAS 1983).

3.2.2 The double bottom need not be fitted in way of deep tanks provided that the efficiency of the watertight subdivision is not impaired by such an arrangement.

3.2.3 In order to protect the ship's bottom up to the turn of bilge, the intersecting line of the outer edge of the margin plate with the shell plating is to be above the horizontal plane passing through the point of intersection with the frame line amidships of a transverse diagonal line inclined 25 to the base line and cutting it at B/2 from the centreline of the ship, (see Figure 7.3.1).

Figure 7.3.1:



3.2.4 The bottoms of the drain wells are to be situated at a distance at least equal to 460 mm above the base line, (see Figure 7.3.1).

SECTION 4 Bulkheads

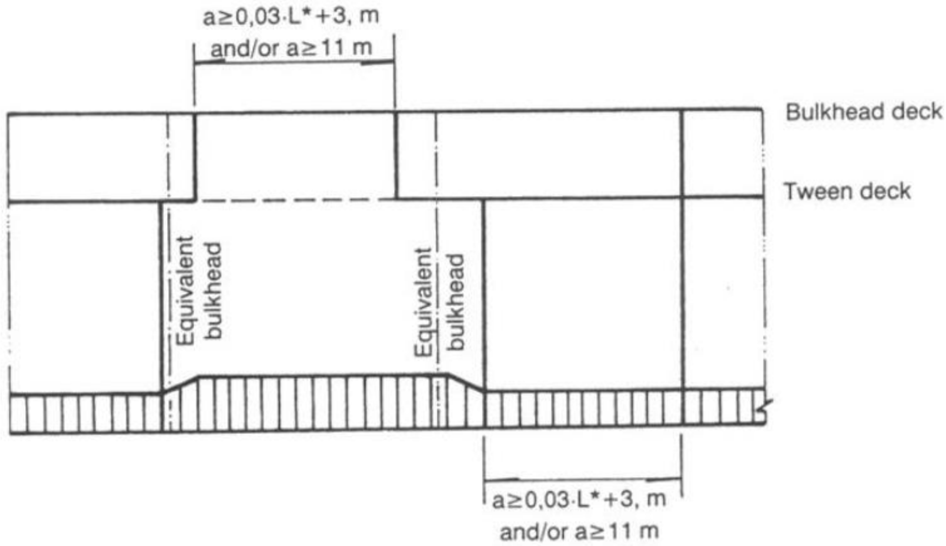
4.1 Bulkhead spacing

4.1.1 The subdivision of the ship by means of transverse and longitudinal bulkheads is governed by the requirements of flooding calculations. The minimum spacing of transverse watertight bulkheads is to be, (see Figure 7.4.1):

$$a = 0{,}03 \cdot L* + 3, \qquad m$$

where:
L* = Length between perpendiculars at deepest load waterline, m.

Figure 7.4.1:



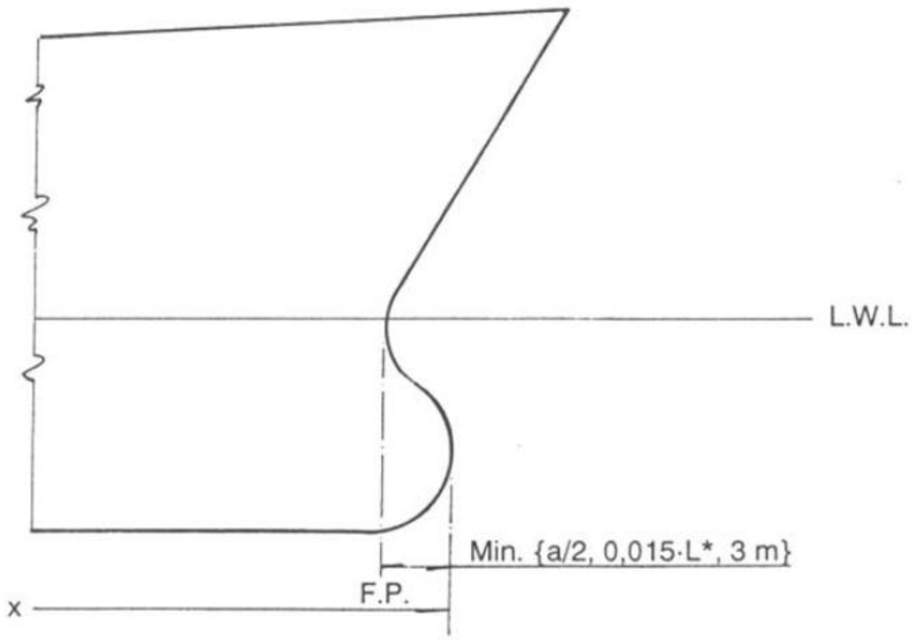
4.1.2 The collision bulkhead is to be situated at a distance x from the forward perpendicular given by:

$$0{,}05L^{*}, \mathrm{m} \le x \le 0{,}005L^{*} + 3, \quad \mathrm{m}$$

where:
L* = Length between perpendiculars at deepest load waterline, m.

4.1.3 In ships having any part of the underwater body extending forward of the forward perpendicular, for example a bulbous bow, the required distance specified in 4.1.2 may be measured from a reference point located in the least of the following:
(1) $a/2$, (see Figure 7.4.2).
(2) $0{,}015L*$.
(3) 3 m.

Figure 7.4.2:



4.2 Bulkhead openings

4.2.1 The number of openings in the watertight bulkheads is to be reduced to the minimum compatible with the design and proper operation of the ship.

4.2.2 No doors, manholes, or other access openings are permitted in the collision bulkhead below the margin line and in watertight transverse bulkheads separating one cargo hold from the other or from a bunker.

4.3 Bulkhead doors

4.3.1 The number of watertight bulkhead doors is to be reduced to the minimum compatible with the design and proper operating of the ship.

4.3.2 The type and location of the watertight bulkhead doors as well as their controls are to comply with Regulation II-1/15 of the 1983 SOLAS Amendments.

4.3.3 Before being fitted, the watertight bulkhead doors, together with their frames, are to be tested by a head of water corresponding to the bulkhead deck height. After having been fitted, the doors are to be hose or soap tested for tightness and to be subjected to an operational test.

4.4 Bulkhead deck

4.4.1 All openings in the bulkhead deck are to be capable of being weathertight closed unless protected by weathertight superstructures.

4.4.2 In case of deck immersion due to heeling in a damaged condition, to limit the spreading of water over large areas of the bulkhead deck, partial watertight wing bulkheads are to be fitted above or in the immediate vicinity of the main subdivision bulkheads.

SECTION 5 Openings in shell plating

5.1 Number of openings

5.1.1 The number of the openings in the shell plating is to be reduced to the minimum compatible with the design and proper operation of the ship.

5.2 Sidescuttles

5.2.1 The arrangement, position and type of sidescuttles and associated deadlights are to be in accordance with the requirements of Regulation II-117 of the 1983 SOLAS Amendments and with Regulation 23 of ILLC 1966.

5.3 Doors

5.3.1 Doors in the shell plating below the bulkhead deck are to be provided with watertight closures. Their lowest point is not to be located below the deepest load waterline.

5.4 Inboard openings

5.4.1 The inboard openings of ash, rubbish shoots etc., are to be fitted with efficient covers. If the inboard openings are situated below the margin line, these covers are to be watertight and additionally, automatic non-return valves are to be fitted in the shoots above the deepest load line. Equivalent arrangements may be approved.

SECTION 6 Cross flooding arrangements

6.1 General

6.1.1 Where the damage stability calculation requires the installation of cross flooding arrangements in order to avoid unacceptably high unsymmetrical flooding, these should work automatically as far as possible.

6.1.2 Non-automatic controls for cross flooding fittings are to be capable of being operated at least from the bulkhead deck.

6.1.3 Particular attention is to be paid to the effects of the cross-flooding arrangements upon the stability in intermediate stages of flooding.

6.1.4 When determining the bulkhead scantlings of tanks extending up to the bulkhead deck, connected by cross-flooding arrangements, the increase in pressure head at the immersed side that may occur at maximum heel in the damaged condition must be taken into account.

CHAPTER 8 Offshore Supply Vessels

CONTENTS

SECTION 1 General

1.1 Application

1.1.1 This Chapter applies to ships which are specially designed for the service of offshore units and intended to have the service notation **OFFSHORE SUPPLY VESSEL**.

1.1.2 Unless otherwise mentioned in this Chapter, the requirements of Part 3 are applicable.

1.1.3 For offshore supply vessels the relevant requirements of the IMO Resolution A.534 (Xlll) apply with regard to intact stability and damaged stability.

SECTION 2 Longitudinal strength

2.1 General

2.1.1 Longitudinal strength calculations are to be made in accordance with the requirements of Part 3, Chapter 2.

SECTION 3 Hull envelope plating

3.1 Side shell plating

3.1.1 The thickness of the side shell plating including the bilge strake is to be in accordance with the requirements of Part 3, Chapter 6, but in no case is to be less than 9 mm.

3.1.2 Where the stern area is subjected to loads due to heavy cargo, sufficient strengthening is to be provided.

3.1.3 In exposed areas efficient fenders are to be fitted with adequate support behind them.

3.2 Deck plating

3.2.1 The thickness of the weather deck is to be in accordance with the requirements of Part 3, Chapter 7, but in no case is to be less than 8 mm. Additional local increases in scantlings may be required where specialized cargoes are likely to induce concentrated loads.

3.2.2 Stowracks are to be fitted on deck, for deck cargoes, and are to be effectively attached to the deck.

3.2.3 Small hatches, valve controls, ventilators, air pipes etc. are to be located in protected positions in order to avoid damage by cargo and to minimize the possibility of flooding of other spaces.

SECTION 4 Framing

4.1 Transverse framing system

4.1.1 The section modulus of the main and tweendeck frames is to be increased by 25 per cent above the values required by Part 3, Chapter 4.

SECTION 5 Superstructures and deckhouses

5.1 Scantlings

5.1.1 The thickness of the side and end bulkhead plating of superstructures and deckhouses is to be increased by 1 mm above the thickness required by Part 3, Chapter 14, Sections 2 and 3.

5.1.2 The section modulus of stiffeners is to be increased by 5 per cent above the values required by Part 3, Chapter 14, Sections 3 and 4.

SECTION 6 Access to spaces

6.1 Access to machinery spaces

6.1.1 Access to machinery spaces should, if possible, be arranged within the forecastle. Any access to the machinery space from the exposed cargo deck is to be provided with two weathertight closures.

6.1.2 Machinery space ventilators are to be located as high as is practicable above the deck and are to be fitted with spark arresters.

6.2 Access to spaces below the exposed cargo deck

6.2.1 Access to spaces below the exposed cargo deck shall preferably be from a position within or above the superstructure deck.

CHAPTER 9 Tugs

CONTENTS

SECTION 1 General

1.1 Application

1.1.1 This Chapter applies to ships which are specially designed for towing operations and intended to have the service notation **TUG**.

1.1.2 Unless otherwise mentioned in this Chapter, the requirements of Part 3 are applicable.

1.1.3 The draught T used for the determination of scantlings is to be not less than 0.85 D.

1.2 Information required

1.2.1 In addition to the information specified in Part 3, Chapter 1, Section 2 the following plans are to be submitted for approval:
(a) Towing hook.
(b) Slip arrangement.

SECTION 2 Longitudinal strength

2.1 General

2.1.1 Longitudinal strength calculations are to be made in accordance with the requirements of Part 3, Chapter 2.

SECTION 3 Bottom structure

3.1 General

3.1.1 The bottom structure is to be in accordance with the requirements of Part 3, Chapter 3.

3.1.2 The requirements for strengthening of the bottom structure forward detailed in Part 3, Chapter 3, Section 3, do not apply to tugs.

SECTION 4 Machinery casings

4.1 Exposed casings

4.1.1 The height of exposed machinery room casings is not to be less than 900 mm above the upper surface of the deck and are to be made watertight.

4.1.2 Stiffeners to exposed casings are to be connected to the deck or carried through.

4.2 Emergency exit

4.2.1 In the machinery room an emergency exit is to be provided, which can be used at extreme angles of heel and should be positioned as high as possible above the waterline and on or near the vessel's centreline.

4.2.2 The cover of the emergency exit, which is to have a weathertight closure, is to be capable of being opened easily from outside and inside. The axis of the cover is to run in the athwartship direction.

4.2.3 The coaming height is to be at least 600 mm above the upper surface of the deck.

SECTION 5 Towing arrangement

5.1 Towing hook

5.1.1 The towing hook is to be fitted as low as practicable in order to minimize heeling moments arising in normal working conditions.

5.1.2 The towing hook has to be fitted with a reliable slip arrangement which facilitates towline release, regardless of the angle of heel.

5.1.3 The slip arrangement should be operable from the bridge, as well as in the vicinity of the hook itself.

5.1.4 The towing arrangement should be tested to the Surveyor’s satisfaction.

5.1.5 The breaking strength of the towing hook should generally be 50 per cent in excess of that of the towline.

SECTION 6 Fenders

6.1 General

6.1.1 A strong fender is to be provided to the ship’s side at deck level extending all fore and aft.

SECTION 7 Equipment

7.1 Towlines

7.1.1 Towlines need not comply with the requirements of Part 3, Chapter 17, Section 5, but should be adequate for the tug’s maximum bollard pull, with an appropriate factor of safety which is not to be taken less than 2.

CHAPTER 10 Barges and Pontoons

CONTENTS

SECTION 1 General

1.1 Application

1.1.1 This Chapter applies to manned or unmanned non-self-propelled ships defined as follows:
(a) Barges for the carriage of dry cargoes in cargo holds.
(b) Barges for the carriage of liquid cargoes in bulk.
(c) Pontoons designed for the carriage of cargo on deck.

1.1.2 For barges carrying dry cargoes and for pontoons, unless otherwise mentioned in this Chapter, the requirements of Part 3 are applicable.

1.1.3 For barges carrying liquid cargoes, unless otherwise mentioned in this Chapter, the requirements of Part 4, Chapter 1 are applicable.

1.2 Definitions

1.2.1 For ships with swim ends, the length L may be measured to the outside surface of the rake plating at the summer load waterline.

1.2.2 Where swim ends are fitted both fore and aft, or where a swim end is arranged aft but no rudder is fitted, then L need not exceed 97 per cent of the extreme length on the summer load waterline.

SECTION 2 Longitudinal strength

2.1 General

2.1.1 Longitudinal strength calculations are to be made in accordance with the requirements of Part 3, Chapter 2, but the midship section modulus may be 5% less than required according to Part 3, Chapter 2.

2.1.2 The scantlings of the primary longitudinal members (strength deck, shell plating, deck longitudinals, bottom and side longitudinals) may be 5% less than required in Part 3 or Part 4, Chapter 1, whichever is applicable.

2.1.3 Longitudinal strength calculations for the condition "Barge, fully loaded, at crane" are required, where barges are intended to be lifted on board ship by means of cranes. For this condition, the following stresses are permissible:
Bending stress $\sigma_b = 150,\ \mathrm{N/mm^2}$
Shear stress $\tau = 100,\ \mathrm{N/mm^2}$

SECTION 3 Hull envelope plating

3.1 Swim end plating

3.1.1 The bottom shell plating thickness is to be maintained up to the summer load waterline for the rake plating. Above this point, the thickness may be tapered to that of the side shell requirements from a point not less than 1 m above the load waterline.

SECTION 4 Bulkheads

4.1 Collision bulkhead

4.1.1 For barges and pontoons, the position of the collision bulkhead is to be determined according to Part 3, Chapter 8, Section 1, 1.1.4.

4.1.2 Where in barges and pontoons the form and construction of their ends is identical, so that there is no determined fore or aft of the ship, a collision bulkhead is to be fitted at each end.

4.2 Hold watertight bulkheads

4.2.1 A watertight bulkhead is to be fitted at the aft of the hold area. Other watertight bulkheads are to be fitted as necessary to provide transverse strength and watertight subdivision.

SECTION 5 Towing arrangements

5.1 General

5.1.1 All barges and pontoons are to be fitted with adequate arrangements for towing. In general, such arrangements shall consist of not less than two sets of bollards, each of which shall be suitable for accepting a towline with a working load equal to the breaking strength of the towline required by Part 3, Chapter 17, Section 5.

SECTION 6 Equipment

6.1 Manned Barges and pontoons

6.1.1 For manned barges and pontoons the required equipment should be in accordance with Part 3, Chapter 17.

6.1.2 Where more than two anchors are required, the spare anchor may be used as a stern anchor.

6.2 Unmanned barges and pontoons

6.2.1 For unmanned barges and pontoons the number of anchors may be reduced to one and the length of the chain cable to 50 per cent of the length required by Part 3, Chapter 17.

CHAPTER 11 Floating Cranes

CONTENTS

SECTION 1 General

1.1 Application

1.1.1 This Chapter applies to vessels intended to have the service notation FLOATING CRANE and are specially designed to operate in a harbour or sheltered water environment where there is no significant movement of the vessel due to wave action and the sea state is not worse than that described for Beaufort No. 2.

1.1.2 Unless otherwise mentioned in this Chapter, the requirements of Part 3 are applicable, taking into account necessary strengthening for supporting the crane during operation and in stowed condition at sea.

1.2 Definitions

1.2.1 For vessels with swim ends, the length L may be measured to the outside surface of the rake plating at the summer load waterline.

1.2.2 Where swim ends are fitted both fore and aft, or where a swim end is arranged aft but no rudder is fitted, then L need not exceed 97 per cent of the extreme length on the summer load waterline.

1.3 Information required

1.3.1 In addition to the information specified in Part 3, Chapter 1, the following documents are to be submitted for approval:

(a) Supporting structures and strengthening of hull in way of supports.
(b) Electrical installations for the crane.
(c) Intact and damage stability calculations.

SECTION 2 Longitudinal strength

2.1 General

2.1.1 Longitudinal strength calculations are to be carried out in accordance with the requirements of Part 3, Chapter 2.

SECTION 3 Hull envelope plating

3.1 Bottom shell plating

3.1.1 The minimum thickness of the bottom plating is to be increased by 30 per cent above the minimum thickness required in Part 3, Chapter 6.

3.1.2 Where swim ends are fitted the bottom shell plating is to be maintained up to the summer load waterline for the rake plating. Above this point, the thickness may be tapered to that of the side shell requirements from a point not less than 1 m above the load waterline.

3.2 Side shell plating

3.2.1 The minimum thickness of the side shell plating is to be increased by 10 per cent against the minimum thickness required in Part 3, Chapter 6.

3.3 Deck plating

3.3.1 The minimum thickness of the deck plating is to be increased by 10 per cent against the minimum thickness required in Part 3, Chapter 7.

SECTION 4 Crane system

4.1 General

4.1.1 The forces and loads acting on the crane structure are to be determined in accordance with the operating and environmental conditions for which the crane is to be certified and must be clearly specified together with the speeds of all crane movements, braking times, lifting capacities, ranges, etc.

4.1.2 A recognized national standard will be considered as an alternative basis for approval of cranes provided the Society is satisfied that the criteria are at least equivalent to the design criteria specified in this Section.

4.2 Design loads

4.2.1 The crane structure has to be examined for the operation condition, taking into account the following forces and loads:
(a) Dead loads.
(b) Lifting loads.
(c) Dynamic forces due to hoisting.
(d) Slewing forces.
(e) Forces due to vessel motions.
(f) Wind forces.
(g) Loads on access ways and platforms.

4.2.2 The crane structure and any stowed arrangements are to be examined for the stowage condition, taking into account the following forces:
(a) Forces due to vessel motions.
(b) Wind forces.

4.3 Static loads

4.3.1 The dead load F_d is the self-weight of any component of the lifting appliance which is not included in the lifting load.

4.3.2 The lifting load F_L is the maximum static load which the appliance is certified to lift, together with the static weight of any component of the crane structure which is directly connected to, and undergoes the same motion as, the dead load during the lifting operation.

4.4 Dynamic forces due to hoisting

4.4.1 The dynamic forces due to hoisting F_H are those imposed on the structure by shock and accelerating the lifting load F_L from rest to a steady hoisting speed.

4.4.2 The dynamic forces due to hoisting are to be obtained from the following formula:

$$F_H = F_L \cdot C_H, \quad N$$

where:

F_L = Lifting load, N.
C_H = Hoisting factor
= $1 + 0{,}3 \cdot V_H$
V_H = Hoisting speed, m/s, but need be taken as not greater than 1.0 m/s.

4.5 Slewing forces

4.5.1 The inertia forces acting on the lifting load and crane structure resulting from slewing the crane are to be considered.

4.5.2 The slewing acceleration is to be supplied by the manufacturer. Where this is not available the acceleration at the jib head of the crane, with the crane jib at maximum radius, is to be taken as 0,6 m/s^2.

4.6 Forces due to vessel motions

4.6.1 Floating cranes are to be designed to operate safely and efficiently in a harbour or sheltered water environment at an angle of heel of 5° and an angle of trim of 2° occurring simultaneously.

4.6.2 Special consideration will be given where it is intended to operate a floating crane at an angle of heel differing from 5° or an angle of trim differing from 2°.

4.6.3 The forces due to vessel motions are to be determined in accordance with Table 11.4.1.

Table 11.4.1: Forces due to vessel motions

MOTION		Component of force, N		
		Normal to deck	Parallel to deck	
			Transverse	Longitudinal
Static	Roll	$w \cdot \cos\varphi$	$w \cdot \sin\varphi$	-
	Pitch	$w \cdot \cos\psi$	-	$w \cdot \sin\psi$
	Combined	$0{,}91 \cdot w$	$0{,}40 \cdot w$	$0{,}10 \cdot w$
Dynamic	Roll	$\pm 0{,}07 \cdot w \cdot \frac{\phi}{T_R^2} \cdot y$	$\pm 0{,}07 \cdot w \cdot \frac{\phi}{T_R^2} \cdot Z_R$	-
	Pitch	$\pm 0{,}07 \cdot w \cdot \frac{\psi}{T_p^2} \cdot x$	-	$\pm 0{,}07 \cdot w \cdot \frac{\psi}{T_p^2} \cdot z_\rho$
	Heave -Roll	$\pm 0{,}05 \cdot w \cdot \frac{L}{T_H^2} \cdot \cos\phi$	$\pm 0{,}05 \cdot w \cdot \frac{L}{T_H^2} \cdot \sin\phi$	-
	-Pitch	$\pm 0{,}05 \cdot w \cdot \frac{L}{T_H^2} \cdot \cos\psi$	-	$\pm 0{,}05 \cdot w \cdot \frac{L}{T_H^2} \cdot \sin\psi$

w = Weight of crane or its component part, N.
L = Vessel's length, as defined in 1.2, m.
T_R = Roll period, s.
T_P = Pitch period, s.
T_H = Heave period, s.
x = Longitudinal distance parallel to the deck from centre of pitching motion, taken to be at longitudinal centre of floatation to the centre of gravity of the crane system, m.
y = Transverse distance parallel to deck from centreline of the vessel to the centre of gravity of crane system, m.
z_R = Distance normal to deck from centre of rolling motion, taken to be at the vertical centre

of gravity of the vessel to the vertical centre of gravity of the crane system, m.
z_p = Distance normal to deck from centre of pitching motion to the centre of gravity of the crane system, m
φ and ψ are in degrees.

4.6.4 The following combination of static and dynamic forces are to be considered:

(a) Rolling motion only: static roll + dynamic roll + dynamic heave at roll angle φ .
(b) Pitching motion only: static pitch + dynamic pitch + dynamic heave at pitch angle ψ .
(c) Combined motion: static combined + 0,8 (dynamic roll + dynamic pitch).
In each case the component of force due to wind is to be included where applicable.

4.6.5 In the stowed condition the crane structure and any stowed arrangements are to be designed to withstand forces resulting from the following two design combinations:

(a)
- Acceleration normal to deck of ± 1,0 g.
- Acceleration parallel to deck in fore and aft direction of ± 0,5 g.
- Static heel of 30°.
- Wind of 63 m/s acting in fore and aft direction.

(b)
- Acceleration normal to deck of 1,0 g.
- Acceleration parallel to deck in transverse direction of 0,5 g.
- Static heel of 30°.
- Wind of 63 m/s acting in a transverse direction.

4.7 Wind forces

4.7.1 The wind pressure acting on the crane structure is given by the formula:

$$p = 0{,}613\, v^2 , \qquad N/m^2$$

where:
v = Wind speed, m/s.

The wind speed for the “in service” condition is to be taken as 20 m/s and for the stowed condition as 63 m/s.

4.7.2 Where it is anticipated, that wind speeds in excess of those defined in 4.7.1 may occur, then these higher wind speeds are to be considered.

4.7.3 The wind force acting on the suspended load is to be taken as 300 N per tonne of lifting load, but where a floating crane is to be designed to lift loads of a specific shape and size, the wind force may be calculated for the appropriate dimensions and configuration.

4.7.4 The wind force on the crane structure or individual members of the structure is to be calculated from the following expression:

$$F_W = A \cdot p \cdot C_f, \qquad N$$

where:
A = Solid area projected on to a plane perpendicular to the wind direction, m².
p = Wind pressure (see 4.7.1), N/m².
Cf = Force coefficient in the direction of wind.

= 1,6 for individual members (rolled sections, rectangles, hollow sections, flat plates).
= 1,1 for machinery houses, etc. (rectangular clad structures on ground or solid base).

4.7.5 For latticed tower structures, the wind force based on the solid area of the windward fare (see 4.7.4) is to be multiplied by the coefficient C_{f1} = 2,6.

4.8 Platform and access-way loading

4.8.1 Platforms and access-ways are to designed to carry a uniformly distributed load over the full platform area of 5000 N/m² and a concentrated load of 3000 N on any individual member.

4.9 Load cases

4.9.1 The crane design is to be considered with respect to loads resulting from the following conditions:
(a) Load case 1: crane operating without wind.
(b) Load case 2: crane operating with wind.
(c) Load case 3: crane in stowed condition.

4.9.2 Load case 1

For the condition of the crane operating without wind the design is to be considered with respect to a combination of static loads (see 4.3) and horizontal forces defined in 4.4 to 4.6, as given by the following formula:

$$F_1 = 1{,}05 \cdot (F_D + F_{D1} + F_H + F_{L1} + C_H + F_{S1}), \qquad N$$

where:

F_D = Dead load, N.
F_{D1} = Horizontal component of dead load due to heel and trim, N.
F_H = Dynamic force due to hoisting (see 4.4.2), N.
F_{L1} = Horizontal component of live load due to heel and trim (see 4.6), N.
C_H = Hoisting factor, as specified in 4.4.2.
F_{S1} = Horizontal load due to slewing acceleration (see 4.5), N.

4.9.3 Load case 2

For the condition of the crane operating with wind the design is to be considered with respect to a combination of static loads (see 4.3) and horizontal forces defined in 4.4 to 4.7, as given by the following formula:

$$F_2 = F_1 + F_W, \qquad N$$

where:
F_1 = Load as defined in 4.9.2.
F_W = Wind force (see 4.7), N.

4.9.4 Load case 3

The crane is to be considered in its stowed condition when subjected to forces resulting from accelerations due to the vessel motions and static inclination together with wind forces appropriate to the stowed condition. The effects of anchorages, locks and lashings, etc. are to be taken into consideration.

CHAPTER 12 Oil Recovery Ships

CONTENTS

SECTION 1 General

1.1 Classification

1.1.1 The requirements in this Section apply to vessels intended for occasionally handling, storage and transportation of oil with flash point below 60 C, recovered from a spill of oil, in emergency situations.

1.1.2 Vessels built and equipped in compliance with the following requirements may be given the class notation **OIL RECOVERY SHIP**.

1.1.3 In case of ships engaged in oil recovery operations and which either:

– operate in certain, strictly defined sea areas, or,
– are of novel design, or,
– are of limited operational capabilities,

special consideration may be given and a corresponding class notation to be assigned.

1.2 Scope

1.2.1 The following matters are covered by the classification:

– safety against fire and explosion during handling, storage and transportation of oil recovered from a spill on sea,
– supporting structures for equipment applied during oil recovery operations,
– stability and floatability,
– available power for supply to equipment used during oil recovery operations.

1.3 Assumption

1.3.1 The classification of the vessel is based on the assumption that the operation of the vessel during oil recovery operation will be in accordance with the approved operation manual, see 5.1.

1.4 Documentation

1.4.1 General arrangement plan(s) showing the following particulars is to be submitted for approval:

– gas-dangerous zones and spaces
– location of equipment for reception and handling of oil such as pumps, skimmer, winches, etc.
– tanks intended for storage of recovered oil with accesses
– oil tank venting arrangement
– doors, hatches, ventilation openings and any other openings to gas-dangerous spaces and adjacent safe spaces
– ventilation arrangement for gas-dangerous spaces and adjacent safe spaces
– exhaust outlets from machinery
– fire extinguishing equipment and structural fire protection, see however 1.4.3
– electrical equipment in gas-dangerous areas with specification of explosion protected equipment, together with certificates.

1.4.2 The following plans and particulars are to be submitted for approval:

– diagrammatic plan of piping system for handling of oil
– plan showing supporting structures and fastening arrangements for equipment applied during oil recovery operations. Reaction forces to be stated.
– diagrammatic plan of power supply system for equipment used during oil recovery operations
– single line diagram for intrinsically safe circuits
– electric power balance for oil recovery operations, if applicable
– specification of gas-measuring instrument
– stability and floatability calculation of the vessel in the operating mode, however, see 1.4.3

(c) operation manual.

1.4.3 In the case that fire extinguishing equipment and structural fire protection and/or stability and floatability have been approved by a National administration applying requirements which may be considered equivalent to those of the class, such approval, satisfactorily documented, may be accepted as evidence of compliance with the class requirements.

1.5 Testing

1.5.1 Upon completion, the procedure for transfer to oil recovery operation of the vessel is to be demonstrated and such operation is to be simulated to verify that the vessel will be able to operate as intended.

SECTION 2 Basic requirements

2.1 General

2.1.1 The vessel is to be provided with:

- a suitable working deck for use in oil recovery operation,
- storage tanks for recovered oil,
- pumping and piping arrangement for transfer and discharge of recovered oil.

2.1.2 The vessel is to have adequate stability and floatability in all relevant operational conditions. The stability and floatability properties will be considered in each particular case.

2.1.3 The visibility from the manoeuvering station is to be such that the Master can easily monitor oil recovery operations both on deck and in the water.

2.1.4 The oil tanks and the deck area, from where the operation is performed, are to be as far away from the accommodation as possible.

2.1.5 Exhaust outlets from machinery are to be located as high as practicable above the deck and are to be fitted with spark arresters.

2.2 Fire protection and extinction

2.2.1 Exterior boundaries of superstructures and deckhouses enclosing accommodation and including any overhanging decks which support accommodation are to be insulated to “A-60” standard for the whole of the portions which face the gas dangerous zones and for 3 m aft or forward of these, whichever is relevant. Alternatively, a permanently installed water-spraying system in compliance with 2.2.3 may be accepted. Aluminium bulkheads will not be accepted in these boundaries.

2.2.2 Portholes or windows in the area specified in 2.2.1 are to be fitted with permanently installed inside deadlights of steel having a thickness equal to the steel in the bulkhead.

2.2.3 If impractical to fit deadlights, navigating bridge windows and other windows in the area specified in 2.2.1 are to be protected by a sprinkler system having a capacity of at least 10 litres/min/m^2. The system is to be fully activated by opening of one valve on the bridge.

2.2.4 For protection of the working deck area two dry powder fire extinguishers, each with a capacity of at least 50 kg, are to be provided. In addition, a foam applicator is to be provided. The quantity of foam concentrate is to be at least 0,4 litres/m² working deck area, minimum 200 litres. The foam expansion ratio is generally not to exceed 12 to 1. The fire extinguishers are to be placed near the deck area where the equipment for handling of recovered oil is located, and are to be fitted with hoses of adequate length.

2.3 Tank arrangement

2.3.1 Tanks within the accommodation and/or engine room area of the vessel are in general not to be used for storage of recovered oil.

2.3.2 Tanks intended for storage of recovered oil are normally to be separated from the engine room and accommodation by means of cofferdams, tanks for other purposes (fuel oil, ballast etc.) or dry compartments other than accommodation. For easy access to all parts, the cofferdams are to have a minimum width of 600 mm.

2.3.3 Where cofferdams are impractical to arrange, tanks adjacent to the engine room may be accepted for storage of recovered oil provided that tank bulkhead is:

- accessible for inspection
- carried continuously through abutting plate panels, except that full penetration welding may be used at the top of the tank
- pressure tested at every periodical survey.

2.3.4 Upon special consideration double bottom tanks in the engine room area may be used for storage of recovered oil. The arrangement of pipes and openings between tanks is to be such that static pressure on the double bottom tank top is prevented. Level alarms are to be fitted.

2.3.5 A tank arrangement requiring removable manhole covers is to be avoided. Open manholes between a maximum of 3 tanks may be accepted, provided the manhole covers are removable from ballast or fresh water tanks.

2.3.6 All openings to the tanks (sounding pipes, hatches for placing of portable pumps and hoses) for recovered oil are to be located on open deck.

2.3.7 Tanks for recovered oil are to have suitable access from open deck for cleaning and gas-freeing. Long tanks are to have access in both ends.

2.3.8 Tanks exceeding a breadth of 0,56 B or a length of 0,1 L or 12 m whichever is the greater are normally to be provided with wash bulkheads or similar arrangement to reduce liquid sloshing in partially filled tanks.

2.3.9 The height of tanks for recovered oil is not to be less than 1,5 m. Internal obstructions in tanks for recovered oil are to be provided with adequate openings to allow a full flow of oil. The area of one single opening is for that purpose not to be less than twice the sectional area of the discharge pipe. The openings are to be arranged that the tanks can be effectively drained.

2.3.10 Any coating in tanks for recovered oil is to be of an oil and dispersion resistant type.

2.4 Support of heavy components

2.4.1 The strength of the supporting structures for equipment applied during oil recovery operations can be based on the assumption that the oil recovery operations will take place in moderate sea conditions.

2.4.2 For cranes intended for use during oil recovery operations, dynamic loads due to the vessel's motions are to be taken into account. In general, the cranes and their supporting structures are to have scantlings based on at least twice the working load of the crane.

SECTION 3 Gas-dangerous and Safe Areas

3.1 Definitions

3.1.1 The following spaces are to be considered as gas dangerous spaces during oil recovery operations:

- tanks for storage of recovered oil,
- enclosed or semi-enclosed spaces in which pipe flanges, valves, hoses, pumps and/or other equipment for handling of recovered oil are located.

3.1.2 The following spaces are to be considered as gas dangerous if the requirements to ventilation given in 4.2.4 are not complied with:

- cofferdams and spaces adjacent to tanks intended for storage of recovered oil,
- enclosed or semi-enclosed spaces having access or opening into other gas-dangerous areas,
- any enclosed space outside the recovered oil tank area through which piping which may contain recovered oil passes or terminates.

3.1.3 Gas-dangerous zones are:

- zones on the open deck or semi-enclosed spaces on the deck within a distance of 3 m from oil skimmer equipment, hoses and valves used for recovered oil handling, openings and air pipes from tanks for recovered oil and openings and ventilation outlets from gas-dangerous spaces
- the open over tanks intended for storage of recovered oil and 3 m forward and aft of this area on the open deck up to height of 2,4 m above the deck.

3.1.4 Safe areas are areas which are not defined as gas-dangerous in the above.

3.2 Access and other openings

3.2.1 There are normally not to be access doors or other openings between a safe room and gas-dangerous area. Access doors may, however, be accepted between such spaces on the following conditions:

- the safe room is to have ventilation overpressure in relation to the gas-dangerous area
- the doors are normally to be self-closing and arranged to swing into the safer space so that they are kept closed by the overpressure
- signboards are to be fitted warning that the doors are to be kept closed during oil recovery operations.

SECTION 4 Arrangement and equipment

4.1 General

4.1.1 The vessel is to be arranged and equipped so as to minimize the time needed to make it operational. This implies that systems and equipment for handling of recovered oil as far as practicable are to be permanently installed.

4.1.2 Systems and arrangements are to be such that procedures for and practical execution of filling, venting, discharge, sounding, etc. will be simple to perform.

4.1.3 All electrical and mechanical equipment for use in gas-dangerous areas during oil recovery operations is to be certified for operation in gas contaminated atmosphere.

4.2 Ventilation system

4.2.1 There are to be independent ventilation for gas-dangerous and safe spaces.

4.2.2 Safe spaces adjacent to gas-dangerous areas are normally to have mechanical ventilation with overpressure relative to gas-dangerous areas. The inlet air is to be taken from a safe area on open deck located as far as practicable from possible gas sources. Also the outlet air is normally to be led to a safe area on open deck. Location of the outlet in an open deck gas-dangerous zone may, however, be considered, depending upon the arrangement in each case.

4.2.3 Gas-dangerous spaces are normally to have mechanical ventilation of extraction type, giving at least 8 changes of air per hour. The inlet air is to be taken from a safe area on open deck.

4.2.4 Spaces which normally would be regarded as gas-dangerous spaces according to 3.1.2. above may be accepted as safe on the condition that the following special requirements to ventilation in addition to those given in 4.2.2 above are complied with:

– the ventilation capacity is to be at least 20 changes of air per hour
– the arrangement of ventilation inlet and outlet openings in the room is to be such that the entire rooms are efficiently ventilated, taking special consideration to locations where gas may be released or accumulated.

4.3 Tank venting system

4.3.1 Ventilation outlets from the tanks are to be led to open deck.

The outlets are to have a minimum height of 2,4 m above deck and be located at a minimum horizontal distance of 5 m away from openings to accommodation and other gas-safe spaces, ventilation intakes for accommodation and engine room and non-certified safe electrical equipment.

4.3.2 Portable ventilation outlet pipes intended for use during oil spill recovery operations only, may be accepted.

4.3.3 The venting arrangement is in general to comply with the requirements given for the main class.

4.4 Arrangement of piping systems

4.4.1 The system for pumping and transfer of recovered oil is to be located outside engine room and accommodation.

4.4.2 The transfer system is to be arranged such that simultaneous filling and discharge will be possible.

4.4.3 For coupling of portable skimming equipment one or maximum two filling connections with branch pipes to all tanks for recovered oil are to be arranged on deck.

4.4.4 The filling line is to be provided with means for injection of emulsion-breaking chemicals. The arrangement is to be so as to facilitate efficient mixing with recovered oil, e.g. by injection to the suction side of a pump. For tanks provided with heating coils the requirements may be dispensed with.

4.4.5 Where permanently installed oil recovery piping is incompatible with the normal cargo system, suitable blanking arrangements are to be provided.

4.4.6 Parts of existing piping and pumping systems may be used if found to satisfy the general safety principles. Such arrangements will be evaluated in each case.

4.4.7 The internal diameter of sounding pipes from tanks for recovered oil is to be less than 50 mm. The sounding pipes are to be located on open deck.

4.4.8 For all piping connections other than mentioned above, blanking-off before oil is loaded into the tanks is to be possible. The blanking device is to be fitted to the nearest detachable pipe connection at the tank.

4.5 Power supply and electrical equipment

4.5.1 The following equipment will be accepted in gas-dangerous areas:
- flameproof, pressurized, increased safety or intrinsically safe equipment
- cables complying with the requirements of Part 6, Chapter 6, Section 1, 1.1.

4.5.2 Means for disconnection of electrical supply to non-certified electrical equipment in gas-dangerous spaces is to be arranged. Signboards are to be fitted at the respective switches. Electrical cables led through these spaces and electrical equipment in the machinery spaces are exempted.

4.5.3 Non-certified safe electrical equipment located in gas-dangerous zones on open deck are to be disconnected during oil recovery operation.

4.5.4 The arrangement of power supply to non- permanent oil skimming and pumping equipment is as far as practicable to be permanently installed. For circuits with higher rating, the outlet is to be arranged from a connection box, provided with a door which is interlocked with a switch. The supply from the main switchboard to the connection box or socket-outlet is to be permanently installed, and provided with separate switchgear with short-circuit and overcurrent protection in each insulated phase.

4.5.5 Non-permanent oil skimming and pumping equipment and independent power-packages are to be certified as safe for operation in gas-contaminated atmosphere.

4.5.6 The socket-outlet and connection boxes mentioned in 4.5.4 are to be located at easily accessible places and in such a way that flexible cables are not carried through doors or accommodation spaces.

4.6 Miscellaneous requirements

4.6.1 A portable hydrocarbon gas-measuring instrument of approved type is to be provided on board.

4.6.2 The deck area where handling of hoses and equipment for recovered oil takes place is to be provided with adequate lighting.

4.6.3 A low sea suction is to be arranged for cooling water pumps for machinery.

4.6.4 Exhaust pipes or any other pipes with surface temperature exceeding 220 C are not to pass through gas-dangerous spaces.

4.6.5 Signboards are to be fixed by screws, rivets or equal.

SECTION 5 Operational Instructions

5.1 General

5.1.1 The vessel is to have an approved operation manual onboard. The manual is to give information regarding the safe use of the vessel during oil recovery operations and is to have references to enclosed drawings.

5.1.2 The operation manual is in general to give information regarding the following:

(a) Arrangement and equipment
- tank arrangement
- transfer system
- gas measuring instrument
- various equipment

(b) Mobilization
- checking of all equipment taken onboard to ascertain that it is certified for use in gas-contaminated atmospheres
- mounting and fastening of non-permanent equipment
- blanking-off of pipes
- assembling of air pipes
- disconnection of electrical power supply
- closing of openings between safe and gas-dangerous areas
- start of additional ventilation equipment
- change-over to low suction for cooling water pumps
- fitting of signboards regarding the use of open flame, non-certified electrical equipment etc.

(c) Operation
- guidelines regarding safe distance from an oil spill source. If gases are traced on open deck, the vessel is to be withdrawn immediately.
- gas measurements during operation (on open deck and in spaces where gas might accumulate)
- actions to be taken if gases are traced in enclosed spaces (cleaning, ventilation, emptying of adjacent tanks, etc)
- precautions against overfilling of tanks
- discharging

(d) Cleaning and gas-freeing of tanks and pipes

(e) Stability in all relevant operational conditions.

CHAPTER 13 Fire Fighting Ships

CONTENTS

SECTION 1 General

1.1 Classification

1.1.1 The requirements included in this Chapter apply, in addition to those applicable requirements of other Parts, to vessels which are intended to fight fire.

1.1.2 Vessels built in compliance with these requirements will be assigned by the Society a class notation consisting of the following notations:

(a) The type notation "**FIRE FIGHTING SHIP**" which is assigned in order to declare that the ship is provided with fire-fighting and fire protection equipment in compliance with these Rules.

(b) The category notation "**I**", "**II**" or "**III**" which signifies that the ship is provided with the equipment specified in Table 13.3.1 depending on her category.

(c) The "**SP**" notation which signifies that a self-protection system in compliance with SECTION 4 is provided.

1.1.3 In case of ships engaged in fire-fighting operations and which either,

- operate in certain strictly defined sea areas, or,
- are of novel design, or,
- are of limited operational capabilities, or,
- have to comply with special requirements imposed by the National Authority with whom the ship is registered and/or by the Administration within whose territorial jurisdiction the ship is intended to operate,

special consideration may be given and a corresponding class notation to be assigned upon agreement with the involved parts.

1.1.4 The Classification of the vessel is based on the following assumptions:

- the vessel has been operated in accordance with the approved Operational Manual,
- the crew engaged in fire-fighting operations has been properly trained.

1.2 Documentation

1.2.1 In addition to the documentation required for the main class, the following plans and particulars are to be submitted:

- A general arrangement plan showing the disposition of all fire-fighting equipment.
- A general arrangement plan showing the disposition of fire divisions and their class.
- Stability calculations.
- Plans showing the layout and capacity of the water spraying system.
- Plans of any other fire-fighting systems provided.
- Construction plan of the fire doors.
- A plan of the seating arrangements for the water monitors.
- Details of major items of fire-fighting equipment.
- Detailed plans of the fire divisions
- Particulars of the means of keeping the ship in position during fire-fighting operations.
- A plan showing the fire pumps, the fire water main, the hydrants, hoses and hose nozzles and the monitors and their delivery capabilities.
- Details of the fireman's outfits provided.
- The Operation Manual

1.3 Testing

1.3.1 After the completion of the installation of the fire-fighting systems and the corresponding equipment, appropriate tests, should be carried out in order to ensure that the vessel is able to operate as intended.

1.3.2 During the testing, the angle of list should be measured when various combinations of water monitors are in operation.

SECTION 2 Basic requirements

2.1 Structural design

2.1.1 The hull structure of the ship should be strengthened so that the vessel to be capable to withstand the forces which are expected to be imposed during the fire-fighting operations by the fire extinguishing systems.

2.1.2 The structural design of the ship should be based on the most adverse operational conditions.

2.1.3 All sea-suctions of the fire pumps should be located as low as practicable.

2.1.4 The compartment in which the driving units of the fire-fighting pumps are located should be considered as "machinery space".

2.1.5 In ships which are not provided with a water spray system all portlights and windows are to be provided with efficient deadlights or external sheet shutters except in the wheel house.

2.2 Manoeuvrability

2.2.1 The ship should be provided with the necessary arrangements which will give to the ship adequate manoeuvrability during fire-fighting operations under the most unfavourable expected conditions.

2.2.2 The most unfavourable manoeuvrability requirements for calm water operation should not require more than 80% of the available propulsion force in any direction.

2.3 Stability

2.3.1 The effect of the monitors, when they are operating at their maximum output in all possible directions of use, should be taken into account in the stability calculations.

2.3.2 The ship should comply with the corresponding stability and draught requirements imposed by the National Authority.

2.4 Lights

2.4.1 At least two horizontally and vertically adjustable searchlights should be provided for operations in darkness.

2.4.2 The lights should provide a level of illumination of 50 lux within an area of not less than 10 m diameter, at a distance of 250 m, in clear atmospheric conditions.

2.5 Operation Manual

2.5.1 The Operational Manual which should be always kept onboard should include the following information:

- Detailed description of all fire-fighting and self-protection systems and equipment.
- Detailed and Clear instructions for the operation, maintenance and testing of all fire-fighting and self-protection systems and equipment.
- Instructions for operation of the vessel during fire-fighting, including bunkering operations while the ship is operating on station.

SECTION 3 Fire-extinguishing systems

3.1 Water monitor system

3.1.1 Requirements concerning the minimum number of monitors, their discharge rate, the length and the height of the produced jet above the sea level are given in Table 13.3.1.

3.1.2 The monitors and their seating arrangement are to be of robust construction and of appropriate strength for all modes and conditions of operation.

3.1.3 The horizontal angular movement of the monitors is to be at least ± 90° from the centre line of the vessel.

3.1.4 The monitors are to be arranged so that the required length and height of jet can be achieved when all monitors are operating simultaneously along the centre line of the vessel. Means should be provided for preventing impact of the jets on the ship's structure.

3.1.5 Two of the monitors should be provided with jet dispersion arrangements.

3.1.6 All monitors should be remotely controllable from a protected position providing a good view of the monitors and the operating area.

3.2 Pumps and piping systems

3.2.1 The applicable requirements for pumping and piping systems covered by the main class are to be complied with.

3.2.2 The required number of pumps and the minimum total pump capacities are specified in Table 13.3.1.

3.2.3 The pumps and their piping system which are intended for fire-fighting and self-protection are not to be available for other services and they should be provided with independent sea inlets.

3.2.4 Where the pumps are used for self-protection, the piping is to be independent of that supplying the monitors.

3.2.5 Sea-valves with nominal diameter greater than 450 mm are to be power actuated and manually operable as well.

3.2.6 Arrangements should be provided for the prevention of starting of the fire-fighting pumps when the water inlet valves are closed.

3.2.7 The design maximum water velocity in the suction lines should normally not exceed 2 m/s.

3.2.8 Piping from seawater inlets to water monitors should be protected against corrosion internally. External protection is required for all piping exposed to the weather.

Table 13.3.1: Fire-extinguishing equipment

Category	**I**	**II**		**III**
Monitors				
Number (min.)	2	3	4	4
Minimum discharge rate per monitor (m^3/h)	1200	2400	1800	2400
Length of jet (1) (m)	120	150		150
Height of jet (2) (m)	50	80		90
Minimum fuel oil capacity (h)	24	96		96
Pumps and Piping Systems				
Minimum total pump capacity (m^3/h)	2400	7200		9600
Number of pumps	1-2	2-4		2-4
Number of hose connections each side of ship	4	8		8
Fireman's Outfits				
Number of fireman's outfits	4	8		8

NOTES:
1. Length is considered to be the horizontal distance from the mean impact area to the nearest point of the vessel.
2. Height is considered to be the vertical distance from the sea level to the mean impact area measured at a horizontal distance at least 70 m from nearest point of the vessel.

3.3 Hose connections and hose stations

3.3.1 The required number of hose connections for each ship category is given in Table 13.3.1.

3.3.2 Hose stations should be provided for at least half the number of the hose connections. Each hose station should be provided with 2 x 15 m hose and a nozzle capable of producing a jet or a spray and simultaneously a jet and a spray.

3.4 Fireman's Outfits

3.4.1 The required number of fireman's outfits is given in Table 13.3.1 for each ship category.

3.4.2 A fireman's outfit shall consist of:
- Protective clothing of material to protect the skin from heat radiating from the fire and from burns and scalding by steam. The outer surface is to be water-resistant.
- Boots and gloves of rubber or other electrically non-conducting material.
- A rigid helmet providing effective protection against impact.
- An electric safety lamp (hand lantern) of an approved type with a minimum operating period of 3 hours.
- An axe with an insulated handle.
- A self-contained breathing apparatus which is to be capable of functioning for a period of at least 30 minutes and having a capacity of at least 1200 lt of free air. Spare, fully charged air bottles are to be provided at the rate of at least one set per required apparatus.

For each breathing apparatus a fireproof life-line of sufficient length and strength is to be provided capable of being attached by means of a snaphook to the harness of the apparatus or to a separate belt in order to prevent the breathing apparatus becoming detached when the life-line is operated.

3.4.3 The fireman's outfits should be placed in a separate fire station the entrance of which should be clearly marked.

3.4.4 A suitable air compressor for recharging the bottles of the breathing apparatus of the fireman's outfit should be provided. The capacity of the compressor should be at least 70 lt/min.

SECTION 4 Self-protection

4.1 General

4.1.1 Vessels which have been assigned the special notation "**SP**" should be protected by a permanent water spraying system in accordance with the requirements of this section.

4.2 Fixed water-spraying system

4.2.1 The system should be designed so that to protect all outside vertical parts of hull, superstructures and deckhouses including foundations for water monitors and other equipment.

4.2.2 Pipelines and nozzles should be protected against damage during the fire-fighting operations.

4.2.3 The capacity of the water spraying system should not be less than 10 $lt/(min \cdot m^2)$ for all areas under protection. In case of protected areas which are internally insulated to a A-60 standard the required capacity should not be less than 5 $lt/(min \cdot m^2)$.

4.2.4 The system should be divided into sections in order to be possible to stop the operation of the system in areas which are not exposed to heat.

4.2.5 The pumps of the fire-fighting system may also be used to the spraying system provided that their capacity is properly increased by the capacity required by the latter. In this case a shut-off valve should be fitted in a proper position between the main piping of the two systems.

4.2.6 Sufficient freeing ports and deck scuppers should be provided so that to ensure efficient drainage of accumulated water under all conditions and modes of operation.