Common Structural Rules for Bulk Carriers and Oil Tankers

Rule Change Notice 1 to 01 JAN 2017 version

Notes: (1) These Rule Changes enter into force on 1st July 2018.

COMMON STRUCTURAL RULES FOR BULK CARRIERS AND OIL TANKERS

RULE CHANGE NOTICE 1

This document contains amendments within the following Parts and Chapters of the Common Structural Rules for Bulk Carriers and Oil Tankers, 1 January 2017. The amendments are effective on 1st July 2018.

The technical background document containing explanation for the amendments in this document can be found in "Technical Background for Rule Change Notice 1 to 01 JAN 2017 version".

Contents

PART 1 GENERAL RULE REQUIREMENTS

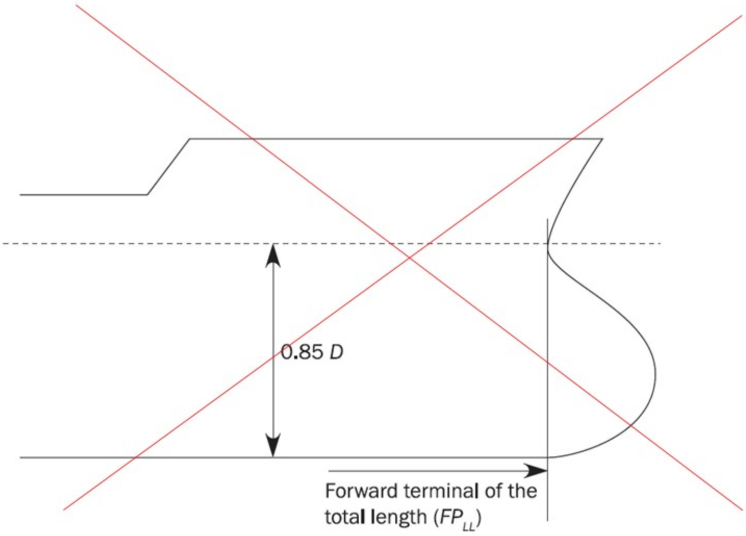
CHAPTER 1
RULE GENERAL PRINCIPLE

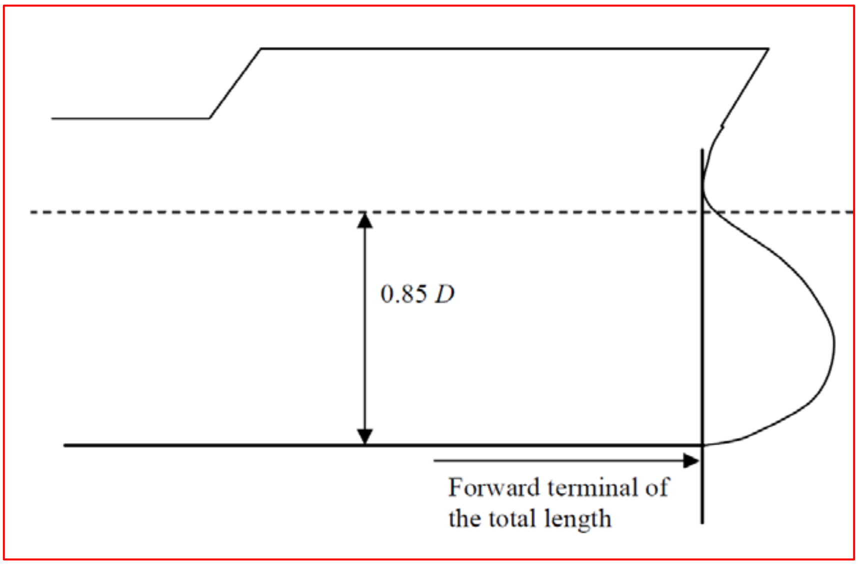
SECTION 4 SYMBOLS AND DEFINITIONS

3 DEFINITIONS

3.1 Principal Particulars

3.1.2 ***L_{LL}*, freeboard length**





3.1.5 Draughts

T, the draught in m, is the summer load line draught for the ship in operation, measured from the moulded baseline at midship. Note this may be less than the maximum permissible summer load waterline draught.

T_{SC} is the scantling draught, in m, at which the strength requirements for the scantlings of the ship are met and represents the full load condition. The scantling draught T_{SC} is to be not less than that corresponding to the assigned freeboard. The draught of ships to which timber freeboards are assigned corresponds to the loading condition of timber, and the requirements of the Society are to be applied to this draught.

T_{BAL} is the minimum design normal ballast draught amidships, in m, at which the strength requirements for the scantlings of the ship are met. This normal ballast draught is the minimum draught of ballast conditions including ballast water exchange operation, if any, for any ballast conditions in the loading manual including both departure and arrival conditions.

T_{BAL-H} is the minimum design heavy ballast draught, in m, at which the strength requirements for the scantlings of the ship are met. This heavy ballast draught is to be considered for ships having heavy ballast condition.

3.8 Glossary

3.8.1 Definition of terms

Table 7: Definition of terms

(partial update to Table 7 as follows)

Terms	Definition
….	….
Duct keel	A keel built of plates in box form ~~extending the length of the cargo tank~~. It is used to house ballast and other piping leading forward which otherwise would have to run through the cargo tanks and/or ballast tanks.
….	….
Propeller post	The forward post of stern frame, which is bored for propeller shaft.
….	….
Rudder post	After post of stern frame to which the rudder is hung (also called stern post).
Stern	The after end of the vessel.
Stern frame	~~The heavy strength member in single or triple screw ships, combining the rudder post~~ The heavy strength members attached to the after end of a hull to form the ship's stern. It includes rudder post, propeller post, and aperture for the propeller.
….	….

(*part of table shown only)*

CHAPTER 2
GENERAL ARRANGEMENT DESIGN

SECTION 2 SUBDIVISION ARRANGEMENT

1 WATERTIGHT BULKHEAD ARRANGEMENT

1.1 Number and disposition of watertight bulkheads

1.1.1

All ships are to have at least the following transverse watertight bulkheads:

a) One collision bulkhead.

b) One aft peak bulkhead.

c) ~~One bulkhead at each end of the machinery space.~~ One bulkhead forward of the machinery space, and one bulkhead at the aft end of the machinery space which may be the aft peak bulkhead.

SECTION 4 ACCESS ARRANGEMENT

2 CARGO AREA AND FORWARD SPACES

2.1 General

2.1.1 Means of access ~~Ship structure access manual~~

~~Ship structures subject to overall and close-up inspection and thickness measurements are to be provided with means of access which are to be described in a "Ship Structure Access Manual". Reference is made to SOLAS, Ch II-1, Reg 3-6.~~

Each space is to be provided with means of access as regulated in SOLAS, Ch II-1, Reg 3-6. This requirement applies to:

- Oil tankers.
- Bulk carriers having a length of 150 m or above, irrespective of their gross tonnage.

CHAPTER 3
STRUCTURAL DESIGN PRINCIPLES

SECTION 2 NET SCANTLING APPROACH

SYMBOLS

…

d_f : Distance in mm, for the extension of flange for L2 profiles, see Figure 3.

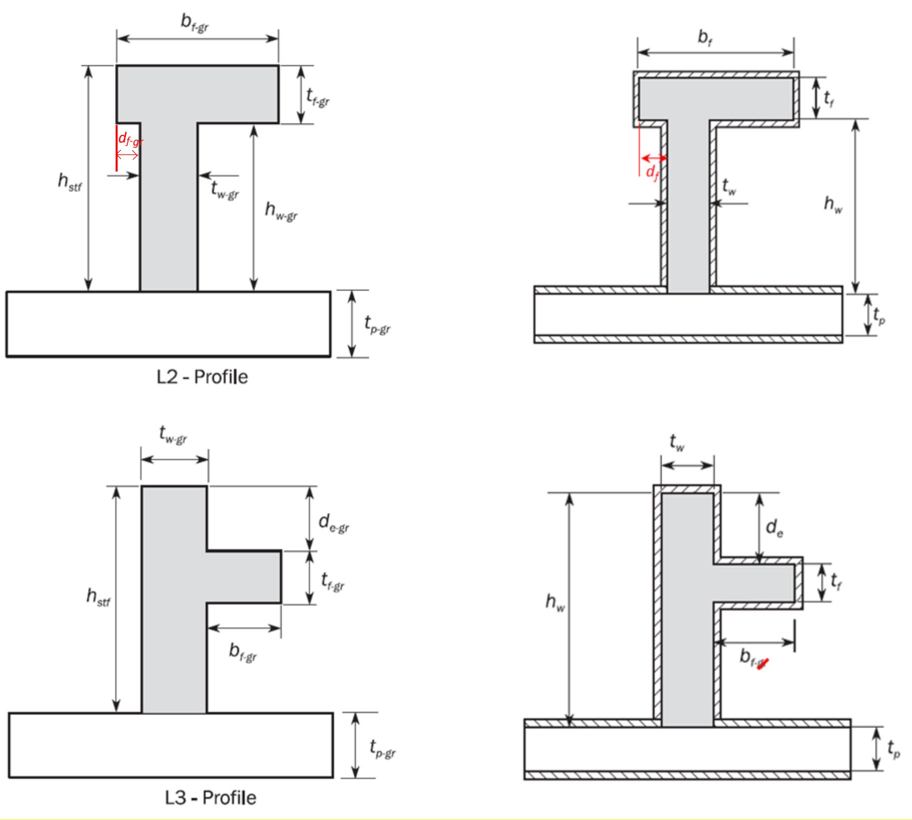
…

1 GENERAL

1.3 Scantling compliance

1.3.2

Figure 3: Net sectional properties of local supporting members (continued)



SECTION 6 STRUCTURAL DETAIL PRINCIPLES

10 BULKHEAD STRUCTURE

10.4 Corrugated bulkheads

10.4.10 Upper stool

The upper stool, when fitted, is to have a height:

- Not less than two ~~Between two and three~~ times the corrugation depth, for bulk carriers.
- At least one corrugation depth, for oil tankers.

Rectangular stools are to have a height in general equal to twice the depth of corrugations, measured from the deck level and at the hatch side girder or at the inner hull as applicable. Brackets or deep webs are to be fitted to connect the upper stool to the deck transverse or hatch end beams.

The upper stool of a transverse bulkhead is to be properly supported by deck girders or deep brackets between the adjacent hatch end beams. The width of the upper stool bottom plate is generally to be the same as that of the lower stool top plate. The stool top of non-rectangular stools of bulk carriers is to have a width not less than twice the depth of corrugations. The ends of stool side ordinary stiffeners when fitted in a vertical plane, are to be attached to brackets at the upper and lower end of the stool.

The stool is to be fitted with diaphragms in line with and effectively attached to longitudinal deck girders extending to the hatch end coaming girders or transverse deck primary supporting members. Scallops in the brackets and diaphragms in way of the connection to the stool bottom plate are to be avoided.

SECTION 7 STRUCTURAL IDEALISATION

SYMBOLS

…

t_w : Net web thickness, in mm. For bulb profiles, see [1.4.1].

b_f : Breadth of flange, in mm, see Ch 3, Sec 2, Figure 2. For bulb profiles, see [1.4.1] ~~Table 1 and Table 2~~.

…

1 STRUCTURAL IDEALISATION OF STIFFENERS AND PRIMARY SUPPORTING MEMBERS

1.4.3 Effective shear depth of stiffeners

The effective shear depth of stiffeners, d_{shr}, in mm, is to be taken as:

$$\cancel{d_{shr} = (h_{stf} + t_p)\sin\varphi_w}$$

$$d_{shr} = (h_{stf} - 0.5t_{c-stf} + t_p + 0.5t_{c-pl})\sin\varphi_w$$

where:

h_{stf} : Height of stiffener, in mm, as defined in Ch 3, Sec 2, Figure 2.

t_p : Net thickness of the stiffener attached plating, in mm, as defined in Ch 3, Sec 2, Figure 2.

t_{c_stf} : Corrosion addition, in mm, of considered stiffener as given in Ch 3, Sec 3.

t_{c_pl} : Corrosion addition, in mm, of attached plate of the stiffener considered as given in Ch 3, Sec 3.

φ_w : Angle, in deg, as defined in Figure 14. φ_w is to be taken as 90 degrees if the angle is greater than or equal to 75 degrees.

1.4.4 Elastic net section modulus and net moment of inertia of stiffeners

The elastic net section modulus, Z, in cm^3 and the net moment of inertia, I, in cm^4 of stiffeners, ~~in cm^3,~~ is to be taken as:

$$Z = Z_{stf}\sin\varphi_w$$

$$I = I_{st}\sin^2\varphi_w$$

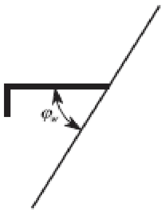
where:

Z_{stf} : Net section modulus of the stiffener, in cm^3, considered perpendicular to its attached plate, i.e. with φ_w = 90 deg.

I_{st} : Net moment of inertia of the stiffener, in cm^4, considered perpendicular to its attached plate, i.e. with φ_w = 90 deg.

φ_w : Angle, in deg, as defined in Figure 14. φ_w is to be taken as 90 degrees if the angle is greater than or equal to 75 degrees.

Figure 14 : Angle between stiffener web and attached plating



1.4.6 Effective net plastic section modulus of stiffeners

…

h_w : Depth of stiffener web, in mm, taken equal to:

- For T, L (rolled and built-up) profiles and flat bar, as defined in Ch 3, Sec 2, Figure 2.
- For L2 and L3 profiles as defined in Ch 3, Sec 2, Figure 3.
- For bulb profiles, to be taken as defined ~~for equivalent angle~~ in ~~Ch 3, Sec 2,~~ [1.4.1] ~~Figure 3 13~~.

γ : Coefficient equal to:

$$\gamma = \frac{1 + \sqrt{3 + 12\beta}}{4}$$

β : Coefficient equal to:

- $\beta = \frac{t_w^2\, f_b\, \ell_{shr}^2}{80 b_f^2\, t_f\, h_{f-ctr}} 10^6 + \frac{t_w}{2 b_f}$ for L profiles without a mid-span tripping bracket,

but not to be taken greater than 0.5.

- $\beta = 0.5$ for other cases.

A_f : Net cross sectional area of flange, in mm^2:

- $A_f = 0$ for flat bar stiffeners.
- $A_f = b_f\, t_f$ for other stiffeners.

$b_{f\text{-}ctr}$: Distance from mid thickness of stiffener web to the centre of the flange area:

- $b_{f\text{-}ctr} = 0.5\,(b_f - t_{w\cancel{\text{-}gr}})$ for rolled angle profiles and bulb profiles.
- $b_{f\text{-}ctr} = 0$ for T profiles.
- ~~For bulb profiles as given in Table 1 and Table 2.~~

$h_{f\text{-}ctr}$: Height of stiffener measured to the mid thickness of the flange

- $h_{f\text{-}ctr} = h_{\cancel{stf}w} \cancel{=} + 0.5\, t_f$ for profiles with flange of rectangular shape except for L3 profiles and for bulb profiles.
- $h_{f\text{-}ctr} = h_{\cancel{stf}w} - d_e - 0.5\, t_f$ for L3 profiles as defined in Ch 3, Sec 2, Figure ~~2~~3.
- ~~For bulb profiles as given in Table 1 and Table 2.~~

d_e : Distance from upper edge of web to the top of the flange, in mm, for L3 profiles, see Ch 3, Sec 2, Figure ~~2~~3.

f_b : Coefficient taken equal to:

- $f_b = 0.8$ for flanges continuous through the primary supporting member, with end bracket(s).
- $f_b = 0.7$ for flanges sniped at the primary supporting member or terminated at the support without aligned structure on the other side of the support, and with end bracket(s).
- $f_b = 1.0$ for other stiffeners.

t_f : Net flange thickness, in mm.

- $t_f = 0$ for flat bar stiffeners.
- For bulb profiles t_f is ~~as given in Table 1 and Table 2~~ defined in [1.4.1].

Table 1 : Characteristic flange data for HP bulb profiles, see Figure 15

h_{stf} (mm)	d_w (mm)	$b_{f\text{-}gr}$ (mm)	$t_{f\text{-}gr}$ (mm)	$b_{f\text{-}ctr}$ (mm)	$h_{f\text{-}ctr}$ (mm)
200	171	40	14.4	10.9	188
220	188	44	16.2	12.1	206
240	205	49	17.7	13.3	225
260	221	53	19.5	14.5	244
280	238	57	21.3	15.8	263
300	255	62	22.8	16.9	281
320	271	65	25.0	18.1	300
340	288	70	26.4	19.3	318
370	313	77	28.8	21.1	346
400	338	83	31.5	22.9	374
430	363	90	33.9	24.7	402

Note 1: Characteristic flange data converted to net scantlings are given as:

$b_f = b_{f\text{-}gr} + 2\ t_w$

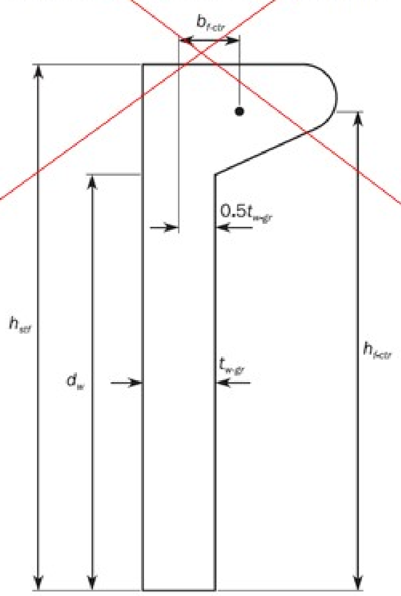
$t_f = t_{f\text{-}gr} - t_c$

$t_w = t_{w\text{-}gr} - t_c$

~~Table 2 : Characteristic flange data for JIS bulb profiles, see Figure 15~~

h_{stf} (mm)	d_w (mm)	b_{f-gr} (mm)	t_{f-gr} (mm)	b_{f-ctr} (mm)	h_{f-ctr} (mm)
180	156	34	11.9	9.0	170
200	172	39	13.7	10.4	188
230	198	45	15.2	11.7	217
250	215	49	17.1	12.9	235
Note 1: Characteristic flange data converted to net scantlings are given as: $b_f = b_{f-gr} + 2\,t_w$; $t_f = t_{f-gr} - t_c$; $t_w = t_{w-gr} - t_c$					

~~Figure 15 : Characteristic data for bulb profiles~~



2 PLATES

2.2 Load calculation point

2.2.1 Yielding

Table 4 : LCP coordinates for yielding

LCP coordinates	General (1)		Horizontal plating		Vertical transverse structure and transverse stool plating	
	Longitudinal framing (Figure 19)	Transverse framing (Figure 20)	Longitudinal framing	Transverse framing	Horizontal framing (Figure 21)	Vertical framing (Figure 22)
x coordinate	Mid-length of the EPP		Mid-length of the EPP		Corresponding to *y* and *z* values	
y coordinate	Corresponding to x and z coordinates		Outboard *y* value of the EPP		Outboard *y* value of the EPP, taken at *z* level (2)	
z coordinate	Lower edge of the EPP	The greater of lower edge of the EPP or lower edge of the strake	Corresponding to x and *y* values		Lower edge of the EPP	The greater of lower edge of the EPP or lower edge of the strake

(1) All structures other than horizontal platings or vertical transverse structures.

(2): For transom plate, the y coordinate of the load calculation point is to be taken corresponding to y value at side shell at z level of the load calculation point, for the external dynamic pressure calculation.

3 STIFFENERS

3.2 Load calculation points

3.2.1 LCP for Pressure

The load calculation point for the pressure is located at:

- Middle of the full length, l, of the considered stiffener.
- The intersection point between the stiffener and its attached plate.

For stiffeners located on transom plate, the y coordinate of the load calculation point is to be taken corresponding to y value at side shell at z level of the load calculation point, for the external dynamic pressure calculation.

4 PRIMARY SUPPORTING MEMBERS

4.1 Load calculation point

4.1.1

The load calculation point is located at the middle of the full length, ~~S~~ ℓ, at the attachment point of the primary supporting member with its attached plate. However, for primary supporting members in the cargo hold region the requirements in Pt 2, Ch 1, Sec 4, [4], as applicable, for bulk carriers and Pt 2, Ch 2, Sec 3, [1] for oil tankers are to be followed.

For primary supporting members located on transom plate, the y coordinate of the load calculation point is to be taken corresponding to y value at side shell at z level of load calculation point for the external dynamic pressure calculation.

CHAPTER 4
LOADS

SECTION 4 HULL GIRDER LOADS

2 VERTICAL STILL WATER HULL GIRDER LOADS

2.2 Vertical still water bending moment

2.2.4 Permissible vertical still water bending moment in flooded condition at sea

The permissible vertical still water bending moments in flooded condition Msw-f at any longitudinal position are to envelop:

- The most severe still water bending moments, in hogging and sagging conditions, respectively, for the intact and flooded seagoing loading conditions defined in Ch 4, Sec 8. Loading conditions encountered during ballast water exchange need not to be considered for the flooded condition.
- The most severe still water bending moments for the intact and flooded seagoing loading conditions defined in the loading manual.
- The permissible still water bending moment defined in [2.2.2] increased by 10%.

2.3 Vertical still water shear force

2.3.5 Permissible still water shear force in flooded condition at sea

The permissible vertical still water shear forces, Qsw-f for oil tankers and bulk carriers, in flooded condition at any longitudinal position are to envelop:

- The most severe still water shear forces, positive or negative, for the flooded seagoing loading conditions defined in Ch 4, Sec 8 after shear force correction in case of bulk carrier. Loading conditions encountered during ballast water exchange need not be considered for the flooded condition.
- The most severe still water shear forces for the flooded seagoing loading conditions defined in the loading manual after shear force correction in case of bulk carrier.
- The permissible still water shear force is defined in [2.3.3].

SECTION 5 EXTERNAL LOADS

SYMBOLS

…

$P_{W.WL}$: Wave pressure at the waterline, kN/m^2, for the considered dynamic load case.

$P_{W.WL} = P_W$ for $y = B_x/2$ and $z = T_{LC}$

…

z_{SD} : Z coordinate, in m, of the midpoint of stiffener span, or of the middle of the plate field.

3 EXTERNAL IMPACT PRESSURES FOR THE BOW AREA

3.2 Bottom slamming pressure

3.2.1

T_{F-e} : Design slamming draught at the FP to be provided by the Designer. TF-e is not to be greater than the minimum draught at the FP indicated in the loading manual for all seagoing conditions where any of the ballast tanks within the bottom slamming region are empty. This includes all loading conditions with tanks inside the bottom slamming region that use the 'sequential' ballast water exchange method, if relevant.

T_{F-f} : Design slamming draught at the FP to be provided by the Designer. TF-f is not to be greater than the minimum draught at the FP indicated in the loading manual for all seagoing conditions where all ballast tanks within the bottom slamming region are full. This includes all loading conditions with tanks inside the bottom slamming region that use the 'flow-through' ballast water exchange method, if relevant.

3.2.2 Loading manual information

The loading guidance information is to clearly state the design slamming draughts and the ballast water exchange method used for each ballast tank, if any.

4 EXTERNAL PRESSURES ON SUPERSTRUCTURES AND DECKHOUSES

4.3 Sides of superstructures

4.3.1

The design pressure for the external sides of superstructures, P_{Sl}, in kN/m^2, is to be taken as:

~~where:~~

$$\cancel{P_{sl} = 2.1 C_w c_f (C_B + 0.7) \frac{20}{10 + z - T_{LC}}}$$

$$P_{sl} = 2.1 C_w c_f (C_B + 0.7) \frac{20}{10 + z_{SD} - T_{SC}}$$

where:

c_F : Distribution factor according to Table 32.

4.4 End bulkheads of superstructures and deckhouse walls

4.4.1

The external pressure for the aft and forward external bulkheads of superstructures and deckhouse walls, in kN/m^2, is to be taken as:

$$\cancel{P_A = f_n f_c [f_b f_d - (z - T_{SC})]}$$

$$P_A = f_n f_c [f_b f_d - (z_{SD} - T_{SC})]$$

…

SECTION 6 INTERNAL LOADS

SYMBOLS

…….

ρ_{ST} : Density of steel, in t/m^3, to be taken as ~~7.8~~ 7.85.

…….

P_{PV} : ~~Setting of~~ Design vapour pressure ~~relief valve~~, in kN/m^2, ~~if fitted,~~ but not less than 25 kN/m^2.

7 DESIGN PRESSURE FOR TANK TESTING

7.1 Definition

7.1.1

Table 13 : Design testing load height z_{ST}

Compartment	z_{ST}
Double bottom tanks (1)	The greater of the following: $z_{ST} = z_{top} + h_{air}$ $z_{ST} = z_{bd}$
Hopper side tanks, topside tanks, double side tanks, fore and aft peaks used as tank, cofferdams	The greater of the following: $z_{ST} = z_{top} + h_{air}$ $z_{ST} = z_{top} + 2.4$
Tank bulkheads, deep tanks, fuel oil bunkers	The greater of the following: $z_{ST} = z_{top} + h_{air}$ $z_{ST} = z_{top} + 2.4$ $z_{ST} = z_{top} + 0.1\ P_{PV}$
Ballast hold	$z_{ST} = z_h + 0.9$
Chain locker (if aft of collision bulkhead)	$z_{ST} = \cancel{z_{top}}\ Z_c$
Independent tanks	The greater of the following: $z_{ST} = z_{top} + h_{air}$ $z_{ST} = z_{top} + 0.9$
Ballast ducts	Testing load height corresponding to ballast pump maximum pressure

where:

z_{bd} : Z coordinate, in m, of the bulkhead deck.

z_h : Z coordinate, in m, of the top of hatch coaming.

(1) For double bottom tanks connected with hopper side tanks, topside tanks or double side tanks, z_{ST} corresponding to "Hopper side tanks, topside tanks, double side tanks, fore and aft peaks used as tank, cofferdams" is applicable.

Z_c : Z coordinate , in m, of the top of the chain pipe.

SECTION 8 LOADING CONDITIONS

2 COMMON DESIGN LOADING CONDITIONS

2.3 Seagoing conditions

2.3.1

The following seagoing loading conditions are to be included, as a minimum, in the loading manual:

a) Homogeneous cargo loading condition including a condition at the scantling draught. Homogeneous loading conditions are to not include filling of ballast tanks in departure conditions.

b) Ballast condition where the ballast tanks may be full, partially full or empty. Where ballast tanks are partially full, the conditions in [2.2.1] are to be complied with. All cargo tanks/holds are to be empty including cargo tanks/holds suitable for the carriage of water ballast at sea. The propeller is to be fully immersed. The trim is to be by the stern and is not to exceed 0.015 LLL.

c) Conditions covering ballast water exchange procedures, if any, with the calculations of intermediate conditions just before and just after ballasting and/or deballasting any ballast tank.

4 BULK CARRIER

4.1 Specific design loading condition

4.1.1 Seagoing conditions

The following seagoing loading conditions are to be included, as a minimum, in the loading manual:
a) Cargo loading conditions as defined in [4.1.2] to [4.1.4].
b) Heavy ballast condition where the ballast tanks may be full, partially full or empty. Where ballast tanks are partially full, the conditions in [2.2.1] are to be complied with. The propeller immersion/D_p is to be at least 60%. The trim is to be by the stern and is not to exceed 0.015 L_{LL}. The moulded forward draught is not to be taken less than the smaller of 0.03 ~~L~~L_{LL} or 8 m.

4.2 Design load combinations for direct strength analysis

4.2.1 Applicable general loading patterns

The following loading patterns are to be applied:

a) Any cargo hold carrying M_{Full} with fuel oil tanks in way of the cargo hold, if any, being 100% full and ballast water tanks in the double bottom in way of the cargo hold being empty, at scantling draught.

b) Any cargo hold carrying minimum 50% of M_H, with all double bottom tanks in way of the cargo hold being empty, at scantling draught.

c) Any cargo hold taken empty, with all double bottom tanks in way of the cargo hold being empty, at the deepest ballast draught. Where a topside and double bottom tank are permanently connected as a common tank, the following conditions are to be considered:
   - The topside and double bottom tank empty,
   - The topside and double bottom tank full.

5 STANDARD LOADING CONDITIONS FOR FATIGUE ASSESSMENT

5.1 Oil tanker

5.1.1

The standard loading conditions to be applied to oil tankers for fatigue assessment as required in Ch 9, Sec 1, [6.2], are defined in Table 22 to Table 24. Where fuel oil tanks, other oil tanks or fresh water tanks are arranged in way of the cargo hold region, the filling level of them are to be taken as full for direct strength analysis according to Ch 7 and Ch 9, Sec 5. For simplified stress analysis according to Ch 9, Sec 4, the filling level of them are to be taken as half height, measured from z_{top} to the lowest point of tank.

5.2 Bulk carrier

5.2.1

The standard loading conditions to be applied to bulk carriers for fatigue assessment as required in Ch 9, Sec1, [6.3] are defined in Table 25, to Table 31 according to their additional service feature notations and the location of the assessed details. Where fuel oil tanks, other oil tanks or fresh water tanks are arranged in way of the cargo hold region, the filling level of them are to be taken as full for direct strength analysis according to Ch 7 and Ch 9, Sec 5. For simplified stress analysis according to Ch 9, Sec 4, the filling level of them are to be taken as half height, measured from z_{top} to the lowest point of tank.

CHAPTER 5
HULL GIRDER STRENGTH

APPENDIX 2 HULL GIRDER ULTIMATE CAPACITY

2 INCREMENTAL-ITERATIVE METHOD

2.3 Load-end shortening curves

2.3.1 Stiffened plate element and stiffener element

Stiffened plate element and stiffener element composing the hull girder transverse sections may collapse following one of the modes of failure specified in Table 1.

- Where the plate members are stiffened by non-continuous longitudinal stiffeners, the stress of the element is to be obtained in accordance with [2.3.3] to [2.3.8], taking into account the non-continuous longitudinal stiffener. In calculating the total forces for checking the hull girder ultimate strength, the area of non-continuous longitudinal stiffener is to be assumed as zero.

- Where the opening is provided in the stiffened plate element, the considered area of the stiffened plate element is to be obtained by deducting the opening area from the plating in calculating the total forces for checking the hull girder ultimate strength. The consideration of the opening is in accordance with the requirement in Ch 5, Sec 1, [1.2.9] to [1.2.13].

- For stiffened plate element, the effective width of plate for the load shortening portion of the stress-strain curve is to be taken as full plate width, i.e. to the intersection of other plate or longitudinal stiffener – neither from the end of the hard corner element nor from the attached plating of stiffener element, if any. In calculating the total forces for checking the hull girder ultimate strength, the area of the stiffened plate element is to be taken between the hard corner element and the stiffener element or between the hard corner elements, as applicable.

CHAPTER 6
HULL LOCAL SCANTLINGS

SECTION 2 LOAD APPLICATION

1 LOAD COMBINATION

1.2 Lateral pressures

1.2.2 Lateral pressure in flooded conditions

Watertight boundaries of compartments not intended to carry liquids, excluding ~~hull envelope~~ shell envelope, are to be subjected to lateral pressure in flooded conditions.

2 DESIGN LOAD SETS

2.1.3 Design load sets for plating, stiffeners and PSM

Design load sets for plating, stiffeners and primary supporting members are given in Table 1.

In addition, the design load sets for primary supporting members of bulk carriers with length L less than 150m and of oil tankers within the cargo hold region are given respectively in Pt 2, Ch 1, Sec 4, [4.2] and in Pt 2, Ch 2, Sec 3, [1.2].

Table 1 : Design load sets

Item	Design load set	Load component	Draught	Design load	Loading condition
Compartments not carrying liquids	FD-1 (6)	P_{in}	T_{SC}	S + D	Flooded condition
	FD-2 (6)	P_{in}	-	S	Flooded condition
(6) FD-1 and FD-2 are not applicable to external shell and corrugations of transverse vertically corrugated bulkhead separating cargo holds. Requirement in flooded conditions of transverse corrugated bulkhead are given in Pt 2, Ch 1, Sec 3, [3]. FD-1 and FD-2 are to be considered for strength deck whenever applicable.					

(*part of table shown only*)

SECTION 4 PLATING

SYMBOLS

For symbols not defined in this section, refer to Ch 1, Sec 4.

α_p : Correction factor for the panel aspect ratio to be taken as follow but not to be taken greater than 1.0.

$$\alpha_p = 1.2 - \frac{b}{2.1a}$$

a : Length of plate panel, in mm, as defined in Ch 3, Sec 7, [2.2.2].

b : Breadth of plate panel, in mm, as defined in Ch 3, Sec 7, [2.2.2].

P : Design pressure for the considered design load set, see Ch 6, Sec 2, [2], calculated at the load calculation point defined in Ch 3, Sec 7, [2.2], in kN/m2.

σ_{hg} : Hull girder bending stress, in N/mm2, as defined in Ch 6, Sec 2, [1.1], calculated at the load calculation point as defined in Ch 3, Sec 7, [2.2].

χ : Coefficient taken equal to:

- In intact condition:
  - $\chi = 0.70$ for inner bottom or bilge hopper tank plating in cargo holds of bulk carriers,
  - $\chi = 1.00$ for other cases.
- In flooded condition:
  - $\chi = 1.00$ for collision bulkheads for acceptance criteria set AC-S,
  - $\chi = 0.95$ for collision bulkheads for acceptance criteria set AC-SD,
  - $\chi = 1.15$ for other watertight boundaries of compartments.

2 SPECIAL REQUIREMENTS

2.6 Supporting structure in way of corrugated bulkheads

2.6.3 Upper stool

a) The net thickness of the stool bottom plate is not to be less than that required for the attached corrugated bulkhead and is to be of at least the same material yield strength as the attached corrugation. The extension of the top plate beyond the corrugation is not to be less than the as-built flange thickness of the corrugation.

b) The net thickness of the lower portion of stool side plating is not to be less than the greater of the following, ~~80% of the upper part of the bulkhead plating as required by [1.2] and Pt 2, Ch 1, Sec 3, [3.1], as applicable, whichever is the greater, where the same material is used. If material of different yield strength is used, the required thickness is to be adjusted by the ratio of the two material factors k as defined in Ch 3, Sec 1, [2.2.1].~~

- The net thickness obtained from [1.1],
- 80% of the net thickness of the upper part of the bulkhead plating as required by
  - [1.2],
  - Pt 2, Ch 1, Sec 3, [3.1], or Pt 2, Ch 2, Sec 3, [2.2.1] as applicable,

  where the same material is used.

If materials of different yield strength are used, the required thickness is to be adjusted by the ratio of the two material factors k as defined in Ch 3, Sec 1, [2.2.1].

SECTION 5 STIFFENERS

SYMBOLS

For symbols not defined in this section, refer to Ch 1, Sec 4.

d_{shr} : Effective shear depth, in mm, as defined in Ch 3, Sec 7, [1.4.3].

ℓ_{bdg} : Effective bending span, in m, as defined in Ch 3, Sec 7, [1.1.2].

ℓ_{shr} : Effective shear span, in m, as defined in Ch 3, Sec 7, [1.1.3].

P : Design pressure for the design load set being defined in Ch 6, Sec 2 and calculated at the load calculation point defined in Ch 3, Sec 7, [3.2], in kN/m^2.

χ : Coefficient taken equal to:

- In intact condition:
  - $\chi = 0.90$ for stiffeners attached to inner bottom or bilge ~~and~~ hopper tank plating in cargo holds of bulk carriers,
  - $\chi = 1.00$ for other cases.
- In flooded condition: χ as defined in Ch 6, Sec 4 for flooded condition.

1 STIFFENERS SUBJECT TO LATERAL PRESSURE

1.1 Yielding check

1.1.2 Section modulus

The minimum net section modulus, *Z* in cm3, is not to be taken less than the greatest value calculated for all applicable design load sets as defined in Ch 6, Sec 2, [2.1.3], given by:

$$Z = \frac{|P|\, s\, \ell_{bdg}^{2}}{f_{bdg}\, \chi\, C_s\, R_{eH}}$$

with $\chi\ C_s$ not to be taken greater than 1.0.

1.1.3 Group of stiffeners

Scantlings of stiffeners based on requirements in [1.1.1] and [1.1.2] may be decided based on the concept of grouping designated sequentially placed stiffeners of equal scantlings on a single stiffened panel between primary supporting members. The scantling of the group is to be taken as the greater of the following:

• The average of the required scantling of all stiffeners within a group.

• 90% of the maximum scantling required for any one stiffener within the group.

SECTION 6 PRIMARY SUPPORTING MEMBERS AND PILLARS

SYMBOLS

P : Design pressure for the design load set being considered as defined in Ch 6, Sec 2 and calculated at the load calculation point as defined in Ch 3, Sec 7, [4.1.1], in kN/m^2.

ℓ_{bdg} : Effective bending span, as defined in Ch 3, Sec 7, [1.1.6], in m.

ℓ_{shr} : Effective shear span, as defined in Ch 3, Sec 7, [1.1.7], in m.

χ : Coefficient taken equal to:

- In intact condition:
  - $\chi = 0.90$ for primary supporting members attached to inner bottom or bilge ~~and~~ hopper tank plating in cargo holds of bulk carriers,
  - $\chi = 1.00$ for other cases.
- In flooded condition: χ as defined in Ch 6, Sec 4 for flooded condition.

CHAPTER 7
DIRECT STRENGTH ANALYSIS

SECTION 2 CARGO HOLD STRUCTURAL STRENGTH ANALYSIS

4 LOAD APPLICATION

4.4 Procedure to adjust hull girder shear forces and bending moments

4.4.9 Procedure to adjust vertical and horizontal bending moments outside midship cargo hold region

To reach the vertical hull girder target values at each frame and transverse bulkhead position, as defined in [4.3.2], the vertical bending moment adjustments, m_{vi}, are to be applied at web frames and transverse bulkhead positions of the finite element model, as shown in Figure 19. The vertical bending moment adjustment at each longitudinal location, i, is to be calculated as follows:

$$\cancel{f(i) = -M_{v-targ}(i) + M_{V-FEM}(i) + M_{lineload}(i) + M_{Y-aft} \cdot \left(2 \cdot \frac{x_i - x_{aft}}{x_{fore} - x_{aft}} - 1\right)}$$

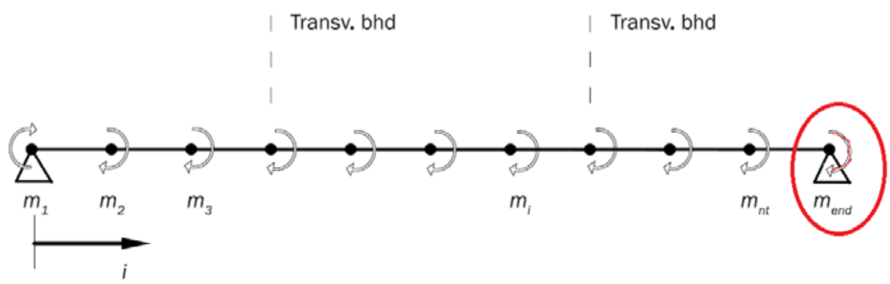
$$\underline{f(i) = M_{v-targ}(i) - M_{V-FEM}(i) - M_{lineload}(i) - M_{Y-aft} \cdot \left(2 \cdot \frac{x_i - x_{aft}}{x_{fore} - x_{aft}} - 1\right)}$$

$$m_{vi} = \frac{f(i) + f(i+1)}{2} - \sum_{j=0}^{i-1} m_{vj}$$

$$m_{v\_end} = -\sum_{j=0}^{n_t} m_{vj}$$

...

Figure 19 : Adjustments of bending moments outside midship cargo hold region.



m_{Ni} can be substituted to m_{vi} in this figure and mi is the positive ~~torsion~~ in FE coordinate system

bending moment

SECTION 3 LOCAL STRUCTURAL STRENGTH ANALYSIS

2 LOCAL AREAS TO BE ASSESSED BY FINE MESH ANALYSIS

2.1 List of mandatory structural details

2.1.5 Connections between deck and double bottom longitudinal stiffeners and adjoining structures of transverse bulkhead

Fine mesh analysis is to be carried out for the connections of deck and double bottom longitudinal stiffeners and adjoining structures of transverse bulkhead, either plane or corrugated bulkhead. The adjoining structures of transverse bulkhead include the structural members in way of the bulkhead, the partial deck girders and partial double bottom girders, if any.

For example, the following structural members are to be assessed, some of them being shown in Figure 3:

- At least one pair of connections between inner and outer bottom longitudinal stiffeners and adjoining structures of transverse bulkhead.
- At least one pair of connections between inner and outer bottom longitudinal stiffeners and adjoining structures of adjacent floor to the transverse bulkhead.
- At least one connection between deck longitudinal stiffener (fitted above or below deck) and adjoining vertical structure of transverse oil tight bulkhead.
- Connection between deck longitudinal partial girder on top of transverse oil tight bulkheads when fitted and adjoining vertical structure of transverse oil tight bulkhead.
- Connection between bottom longitudinal partial girder in way of transverse oil tight bulkheads when fitted and adjoining vertical structure of transverse oil tight bulkhead.

The selection of the connections between longitudinal and vertical stiffeners to be analyzed is to be based on the maximum relative deflection between supports, i.e. between floor and transverse bulkhead or between deck transverse and transverse bulkhead. Where there is a significant variation in end connection arrangement between stiffeners or scantlings, analyses of additional connections may be required by the Society.

Outside the midship cargo hold region, the scantlings of the connections as given above are not to be less than the required scantlings obtained for the midship cargo hold region unless an equivalent strength is demonstrated by fine mesh analysis.

CHAPTER 8
BUCKLING

SECTION 2 SLENDERNESS REQUIREMENTS

3 STIFFENERS

3.1 Proportions of stiffeners

3.1.1 Net thickness of all stiffener types

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Figure 1 : Stiffener scantling parameters

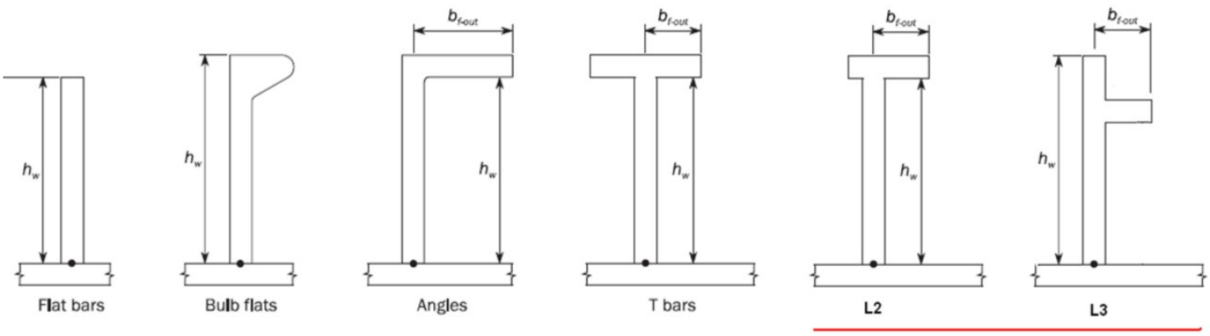


Table 1 : Slenderness coefficients

Type of Stiffener	C_w	C_f
Angle, L2 and L3 bars	75	12
T-bars	75	12
Bulb bars	45	-
Flat bars	22	-

5 BRACKETS

5.3 Edge reinforcement

5.3.1 Edge reinforcement of bracket edges

The depth of stiffener web, h_w in mm, of edge stiffeners in way of bracket edges is not to be less than:

$h_w = C\, l_b/1000 \sqrt{\frac{R_{eH}}{235}}$ or 50, whichever is greater

where:

C : Slenderness coefficient taken as:

C = 75 for end brackets.

C = 50 for tripping brackets.

R_{eH} : Specified minimum yield stress of the stiffener material, in N/mm^2.

SECTION 5 BUCKLING CAPACITY

SYMBOLS

…

d_e : Distance from upper edge of web to the top of the flange, in mm, as defined in Ch 3, Sec 2, Figure 3.

e_f : Distance from attached plating to centre of flange, in mm, as shown in Figure 1 to be taken as:

$e_f = h_w$ for flat bar profile.

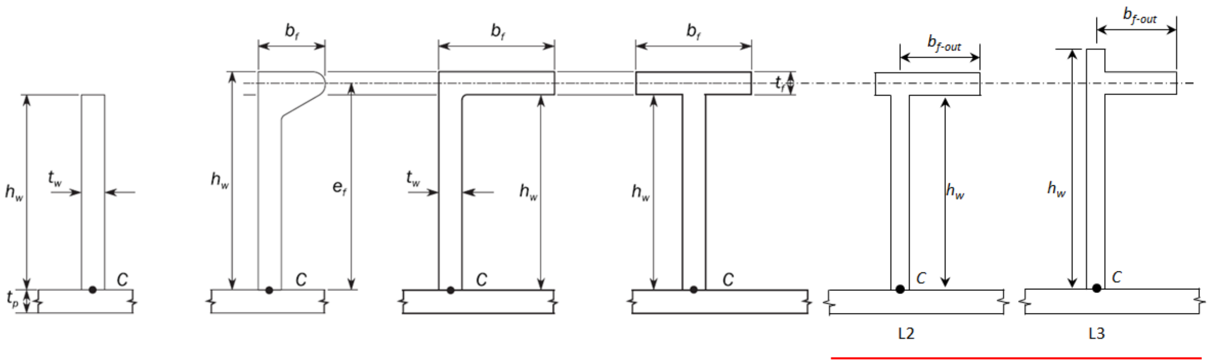
$e_f = h_w - 0.5\ t_f$ for bulb profile.

$e_f = h_w + 0.5\ t_f$ for angle, L2 and Tee profiles.

$e_f = h_w - d_e - 0.5\ t_f$ for L3 profile.

…

Figure 1: Stiffener cross sections



2 BUCKLING CAPACITY OF PLATES AND STIFFENERS

2.2 Plate capacity

2.2.4 Correction factor F_{long}

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Table 2 : Correction factor F_{long}

Structural element types			F_{long}	c
Unstiffened Panel			1.0	N/A
Stiffened Panel	Stiffener not fixed at both ends		1.0	N/A
	Stiffener fixed at both ends	Flat bar (1)	$F_{long} = c + 1$ for $\frac{t_w}{t_p} > 1$	0.10
		Bulb profile		0.30
		Angle ~~profile~~, L2 and L3 profiles		0.40
		T profile	$F_{long} = c\left(\frac{t_w}{t_p}\right)^3 + 1$ for $\frac{t_w}{t_p} \le 1$	0.30
		Girder of high rigidity (e.g. bottom transverse)	1.4	N/A
		U type profile fitted on hatch cover (2)	• Plate on which the U type profile is fitted • For $b_2 < b_1$: $F_{long} = 1$ • For $b_2 \ge b_1$: $F_{long} = \left(1.55 - 0.55\frac{b_1}{b_2}\right)\left[1 + c\left(\frac{t_w}{t_p}\right)^3\right]$ • Other plate of the U type profile: $F_{long} = 1$	0.2

(1) t_w is the net web thickness, in mm, without the correction defined in [2.3.2].
(2) b_1 and b_2 are defined in Pt 2, Ch 1, Sec 5, Figure 1.

2.3 Stiffeners

2.3.4 Ultimate buckling capacity

....

M_1 : Bending moment, in Nmm, due to the lateral load P:

$M_1 = C_i \frac{|P|sl^2}{24\times10^3}$ for continuous stiffener

$M_1 = C_i \frac{|P|sl^2}{8\times10^3}$ for sniped stiffener

$M_1 = C_i \frac{|P|sl^2}{14.2\times10^3}$ for stiffener sniped at one end and continuous at the other end

τ : Applied shear stress, in N/mm2.

- For FE analysis, τ is the reference shear stress as defined in Ch 8, Sec 4, [2.4.2] in the attached plating.
- For prescriptive assessment, τ is the shear stress at the attached plate calculated according to Ch 8, sec 3, [2.2.1] at the following load calculation point: ~~of the stiffener attached plating, as defined in ch 3, sec 7, [2].~~
  - o At the middle of the full span, l, of the considered stiffener
  - o At the intersection point between the stiffener and its attached plate.
- For grillage beam analysis, τ = 0 in the attached buckling panel.

w_0 : Assumed imperfection, in mm, to be taken as:

$w_0 = l/1000$ in general.

$w_0 = -w_{na}$ for stiffeners sniped at ~~both~~ one or both ends considering stiffener induced failure (SI).

$w_0 = w_{na}$ for stiffeners sniped at one or both ends considering plate induced failure (PI).

w_1 : Deformation of stiffener, in mm, at mid-point of stiffener span due to lateral load P. In case of uniformly distributed load, w1 is to be taken as:

$w_1 = C_i \frac{|P|sl^4}{384\times10^7 EI}$ in general

$w_1 = C_i \frac{5|P|sl^4}{384\times10^7 EI}$ for stiffeners sniped at both ends

$w_1 = C_i \frac{2|P|sl^4}{384\times10^7 EI}$ for stiffeners sniped at one end and continuous at the other end.

....

y_w : Distance, in mm, from centroid of stiffener cross section to the free edge of stiffener flange, to be taken as:

$y_w = \frac{t_w}{2}$ for flat bar.

$y_w = b_f - \frac{h_w t_w^2 + t_f b_f^2}{2A_s}$ for angle and bulb profiles.

$y_w = b_{f-out} + 0.5t_w - \frac{h_w t_w^2 + t_f(b_f^2 - 2b_f d_f)}{2A_s}$ for L2 profile

$y_w = b_{f-out} + 0.5t_w - \frac{(h_w - t_f)t_w^2 + t_f(b_f + t_w)^2}{2A_s}$ for L3 profile

$y_w = \frac{b_f}{2}$ for T profile.

....

Table 5 : Moments of Inertia

	Flat bars (1)	Bulb, angle ~~and T profiles~~, L2, L3 and T profiles
I_P	$\dfrac{h_w^3\, t_w}{3\times10^4}$	$\left(\dfrac{A_w\,(e_f-0.5t_f)^2}{3}+A_f\,e_f^2\right)\,10^{-4}$
I_T	$\dfrac{h_w\,t_w^3}{3\times10^4}\left(1-0.63\,\dfrac{t_w}{h_w}\right)$	$\dfrac{(e_f-0.5t_f)\,t_w^3}{3\times10^4}\left(1-0.63\,\dfrac{t_w}{e_f-0.5t_f}\right)+\dfrac{b_f\,t_f^3}{3\cdot10^4}\left(1-0.63\,\dfrac{t_f}{b_f}\right)$
I_ω	$\dfrac{h_w^3\,t_w^3}{36\times10^6}$	$\dfrac{A_f\,e_f^2\,b_f^2}{12\times10^6}\left(\dfrac{A_f+2.6A_w}{A_f+A_w}\right)$ for bulb, ~~and~~ angle ~~profiles.~~, L2 and L3 profiles $\dfrac{b_f^3\,t_f\,e_f^2}{12\times10^6}$ for T profiles.
(1)	t_w is the net web thickness, in mm. t_{w_red} as defined in [2.3.2] is not to be used in this table.	

CHAPTER 9
FATIGUE

SECTION 2 STRUCTURAL DETAILS TO BE ASSESSED

2 FINITE ELEMENT ANALYSIS

2.1 Structural details to be assessed

2.1.3 Details to be checked by screening fatigue assessment

The structural details listed in Table 2 for which FE fine mesh models have been analysed according to yielding requirements given in Ch 7, Sec 3 are to be assessed using the screening fatigue procedure as given in Ch 9, Sec 5, [6] or to be assessed by very fine mesh analysis according to Ch 9, Sec 5, [1] to Ch 9, Sec 5, [4].

Table 2 : Structural details for screening fatigue assessment

No	Critical detail	Applicability	
		Oil tanker	Bulk carrier
1	Bracket toe of transverse web frame	Applicable (1)	N/A
2	Toe of horizontal stringer	Applicable (1)	N/A
3	Lower hopper knuckle connection in EA hold (2) and in FA hold (2) not assigned as a ballast hold	N/A	Applicable (1)
4	Connections of transverse bulkhead lower stool to inner bottom in EA hold (2) and in FA hold (2) where the ballast hold is not assigned to the ship	N/A	Applicable (1)

(1) For details assessed by fine mesh analysis according to Ch 7, Sec 3~~, [2.1] and Ch 7, Sec 3, [3.3.2]~~ [3.2].

(2) Cargo hold located closest to the Midship

Table 3 : Structural details to be assessed by very fine mesh analysis if not designed in accordance with detail design standard

No	Critical detail	Corresponding detail design standard	Applicability	
			Oil tanker	Bulk carrier
1	Radiused upper hopper knuckle connection (intersection of knuckled inner side plate, side girder and transverse web) at the most critical frame location. (1)	Ch 9, Sec 6, [4]	One cargo tank (4)	Ballast hold of double side bulk carrier
2	Corrugations of ~~transverse~~ bulkheads to lower stool or inner bottom plating connection. (2) (3)	Ch 9, Sec 6, [6] and Ch 9, Sec 6, [7]	One cargo tank (4)	Ballast hold
3	Corrugations of transverse bulkheads to upper stool. (2) (3)	Ch 9, Sec 6, [6]	N/A	Ballast hold
4	Cruciform heel connections between side stringers in double side and transverse bulkhead horizontal stringers, for the stringer closest to the mid depth and for the uppermost one.	Ch 9, Sec 6, [5]	One cargo tank (4)	N/A
5	Lower and upper side frame bracket toes at the most critical frame position. (1)	Ch 9, Sec 6, [8]	N/A	FA hold (4), EA hold (4) and ballast hold of single skin bulk carrier
6	Cut out for longitudinal stiffeners in web-frame without web stiffener connection.	Ch 9, Sec 6, [2.1]	One cargo tank (4)	FA hold (4), EA hold (4) and ballast hold
7	Scallops in way of block joints on strength deck close to mid hold (and down to 0.1D from deck corner).	Ch 9, Sec 6, [3]	One cargo tank (4)	FA hold (4), EA hold (4) and ballast hold

(1) The most critical frame position is generally, but not necessarily, located closest to the mid length of the hold. Where a swash bulkhead is fitted, this is generally located closest to the mid length between the swash bulkhead and the oil-tight bulkhead.
(2) Stool connections at each end of the hold are to be checked unless these are symmetrical about mid-hold.
(3) ~~Position at the mid breadth location of the largest hold in the considered transverse section.~~
(4) Cargo hold located closest to the midship.

(3) Position at the mid breath or length location of the largest hold in the considered transverse or longitudinal section.

Table 8 : Hot spots for corrugated ~~transverse~~ bulkhead to lower stool connection

Hot spot location	Procedure for calculation of hot spot stress
Hot spots 1 and 3: Corrugation web above shedder plate Hot spot 4: Corrugation web below shedder plate Hot spot 5, 7 and 8: Corrugation flange Hot spot 6: Gusset plate Hot spot 9: Lower stool plate to stool top plate Hot spot 10: Corrugation corner to stool top plate Hot Spot 11: Gusset plate in way of corrugation corner	Ch 9, Sec 5, [3.1], type 'a'
Hot spot 2: Corrugation web below shedder plate	Ch 9, Sec 5, [4.3]

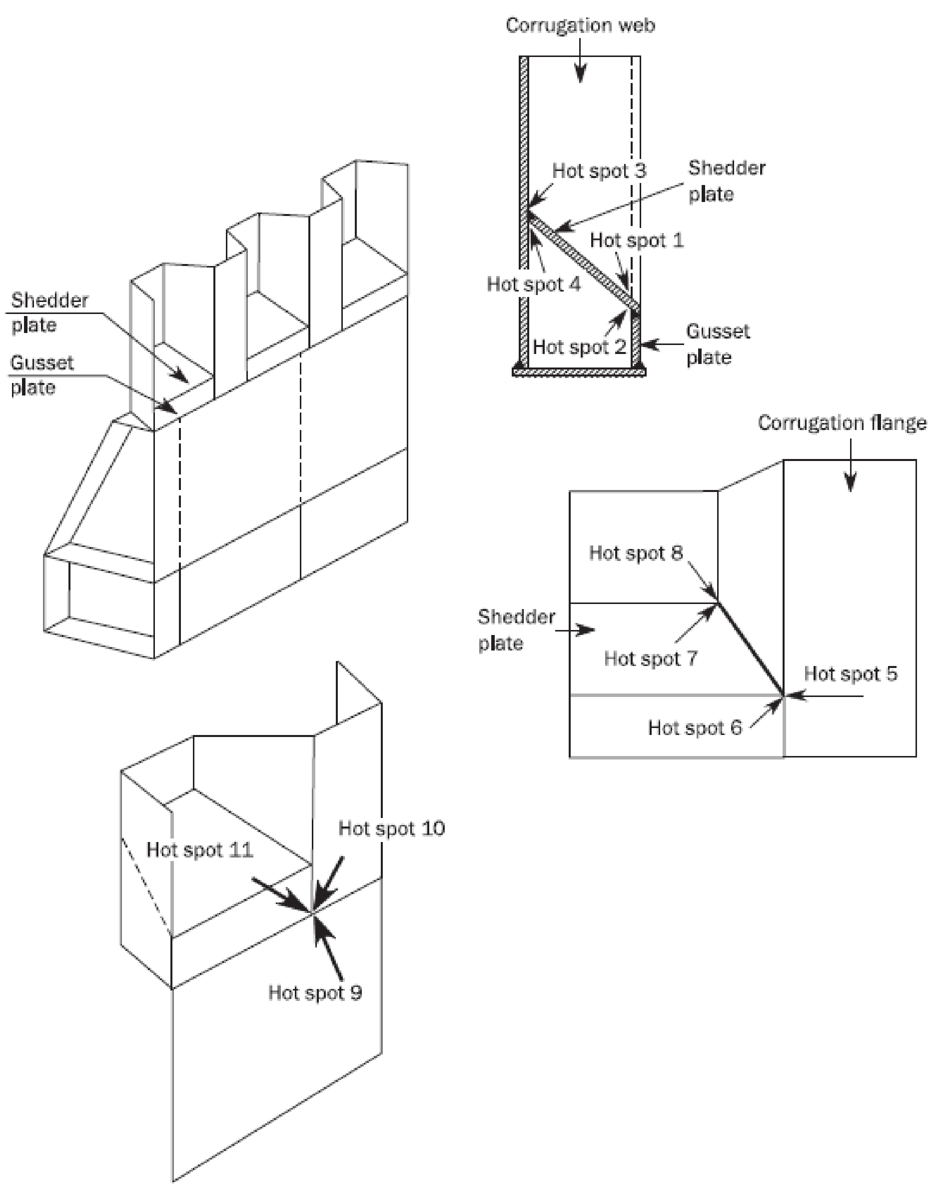


Table 9 : Hot spots for corrugated ~~transverse~~ bulkhead to lower stool - Intersecting shedder plates and single sided shedder plate

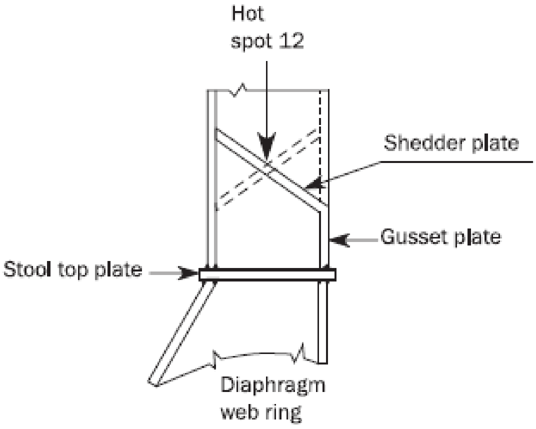
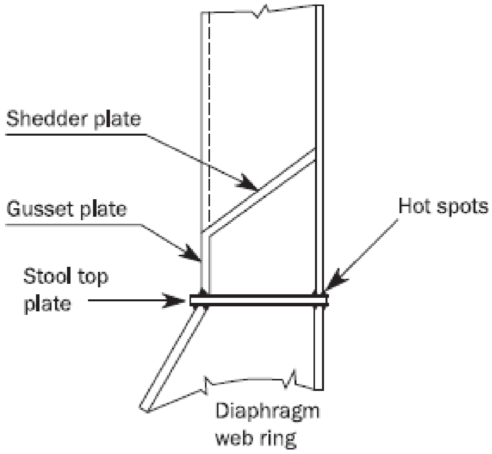
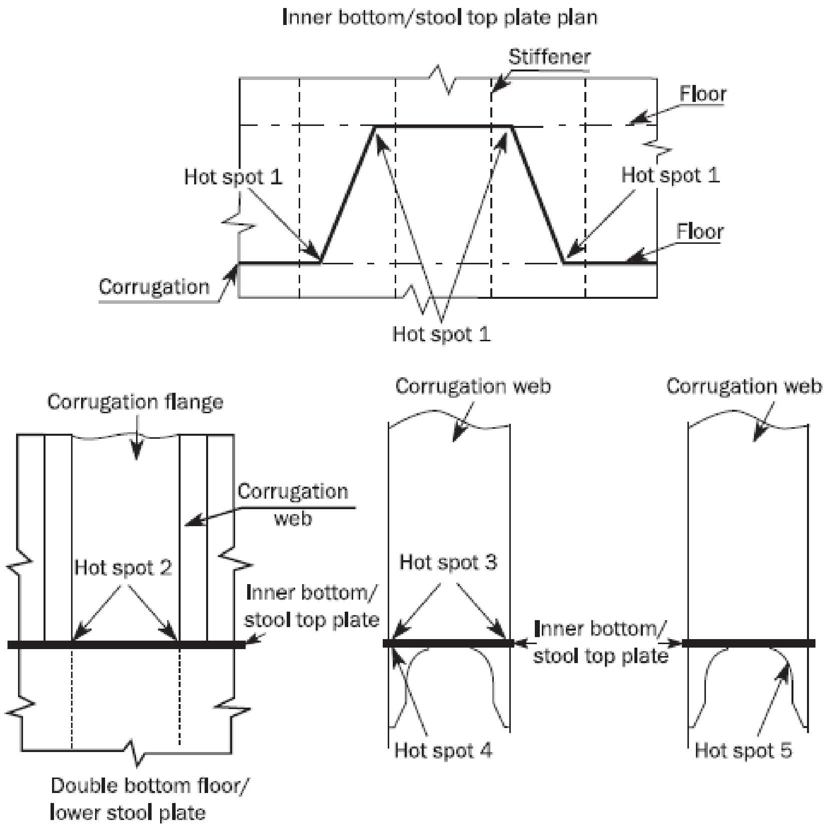
Hot spot location	Procedure for calculation of hot spot stress
Intersecting shedder plates	
Hot spot 12: Intersection of shedder plates	Ch 9, Sec 5, [3.1], type ‘a‘
	
Single sided shedder plate	
Welded connection of web and flange of corrugation to lower stool top For details of hot spots see Table 10, hot spots 1-3 If supported brackets are fitted, see Table 10 for hot spots 4	Ch 9, Sec 5, [3.1], type ‘a‘
	

Table 10 : Hot spots for corrugated ~~transverse~~ bulkhead to lower stool or inner bottom plating connection

Hot spot location	Procedure for calculation of hot spot stress
Hot spot 1: Inner bottom/lower stool top Hot spot 2: Corner of corrugation flange in way of inner bottom/lower stool top Hot spot 3: Corner of corrugation web in way of inner bottom/lower stool top Hot spot 4: Inner bottom/lower stool top in way of brackets supporting corrugation web	Ch 9, Sec 5, [3.1], type '*a*'
Hot spot 5: Edge of supporting brackets	Ch 9, Sec 5, [3.2].



SECTION 3 FATIGUE EVALUATION

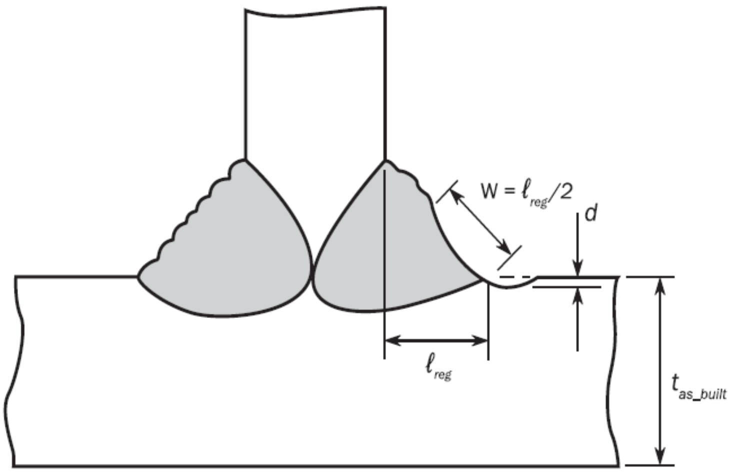
6 WELD IMPROVEMENT METHODS

6.2 Weld toe burr grinding

6.2.1

The weld may be machined using a burr grinding tool to produce a favourable shape to reduce stress concentrations and remove defects at the weld toe, see Figure 5. In order to eliminate defects, such as intrusions, undercuts and cold laps, the material in way of the weld toe is to be removed. The depth of grinding shall be at least 0.5mm below the bottom of any visible undercut. The total depth of the burr grinding is not to be greater than the lesser of 2 mm and of 7% the local gross thickness of the machined plate. Any undercut not complying with this requirement is to be repaired by an approved method.

Figure 6 : Extent of weld toe burr grinding to remove inter-bead toes on weld face

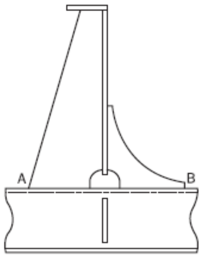
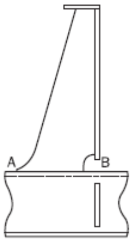
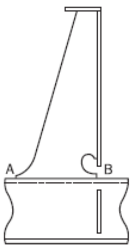
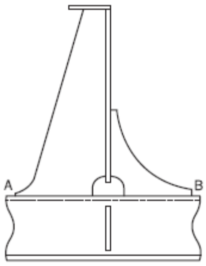
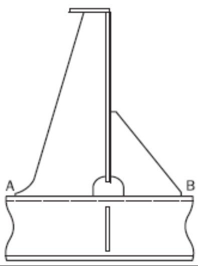


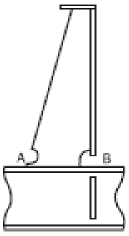
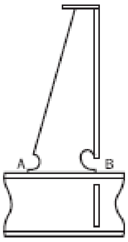
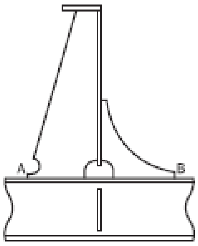
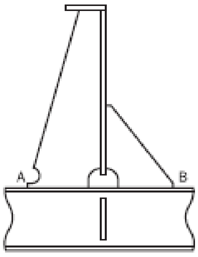
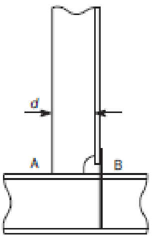
l_{leg} : Weld leg length.
w : Width of groove.
d : ~~Depth of grinding to be 0.5 mm ≤ d ≤ 1 mm.~~ Depth of grinding.

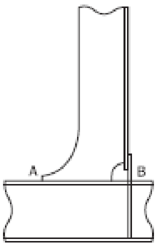
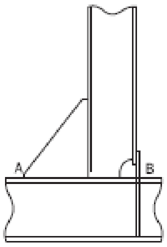
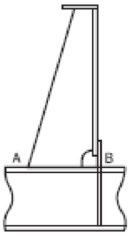
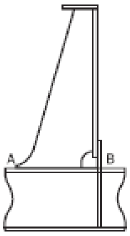
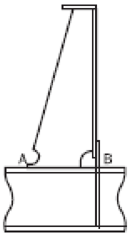
SECTION 4 SIMPLIFIED STRESS ANALYSIS

5 STRESS CONCENTRATION FACTORS

Table 4: Stress concentration factors

ID	Connection type [2][3]	Point 'A'		Point 'B'	
		K_a	K_b	K_a	K_b
16		1.52	1.67	1.28	1.34
17		~~1.34~~ 1.28	1.34	1.52	1.67
18		~~1.34~~ 1.28	1.34	1.34	1.34
19		~~1.34~~ 1.28	1.34	1.28	1.34
20		~~1.34~~ 1.28	1.34	1.52	1.67

ID	Connection type (2) (3)	Point 'A'		Point 'B'	
		K_a	K_b	K_a	K_b
21		~~1.34~~ 1.28	1.34	1.52	1.67
22		~~1.34~~ 1.28	1.34	1.34	1.34
23		~~1.34~~ 1.28	1.34	1.28	1.34
24		~~1.34~~ 1.28	1.34	1.52	1.67
25 (1)		1.28 for $d \le 150$ 1.36 for $150 < d \le 250$ 1.45 for $d > 250$	1.40 for $d \le 150$ 1.50 for $150 < d \le 250$ 1.60 for $d > 250$	1.14 for $d \le 150$ 1.24 for $150 < d \le 250$ 1.34 for $d > 250$	1.25 for $d \le 150$ 1.36 for $150 < d \le 250$ 1.47 for $d > 250$

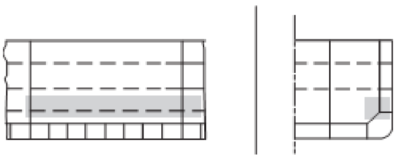
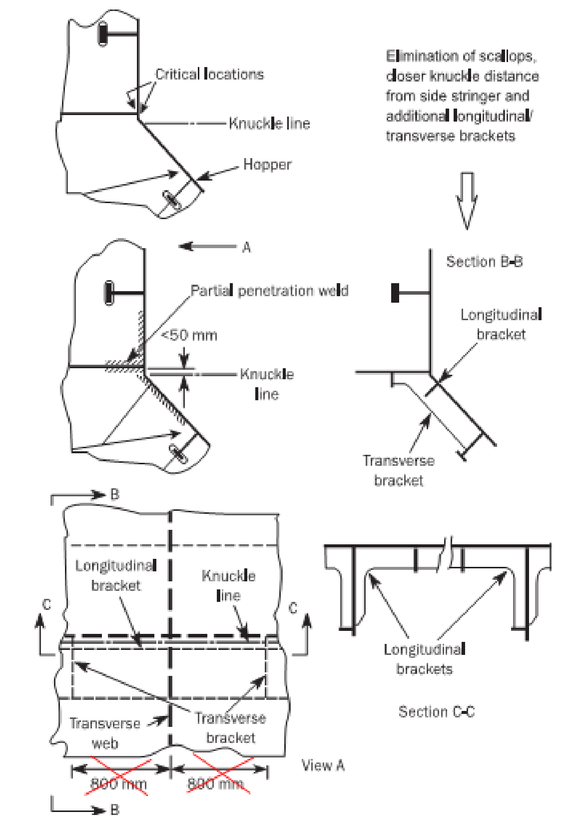
ID	Connection type [2][3]	Point 'A'		Point 'B'	
		K_a	K_b	K_a	K_b
26		1.28	1.34	1.34	1.47
27		1.52	1.67	1.34	1.47
28		1.52	1.67	1.34	1.47
29		~~1.34~~ 1.28	1.34	1.34	1.47
30		~~1.34~~ 1.28	1.34	1.34	1.47

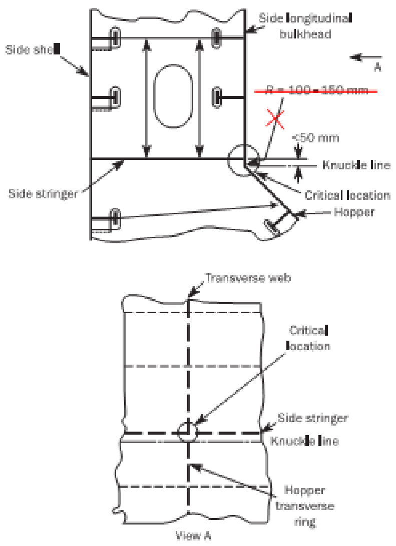
SECTION 6 DETAIL DESIGN STANDARD

4 HOPPER KNUCKLE CONNECTION

4.1 Design standard C to H

Table 8 : Design standard H – upper hopper knuckle connection detail, radiused type, oil tankers and double side bulk carrier

<table>
<tr><td colspan="2">Connections of transverse webs in double side tanks to hopper tanks
Hopper corner connections employing radiused knuckle between side longitudinal bulkhead and hopper sloping plating</td></tr>
<tr><td>Critical areas</td><td>Design standard H</td></tr>
<tr><td></td><td rowspan="3">

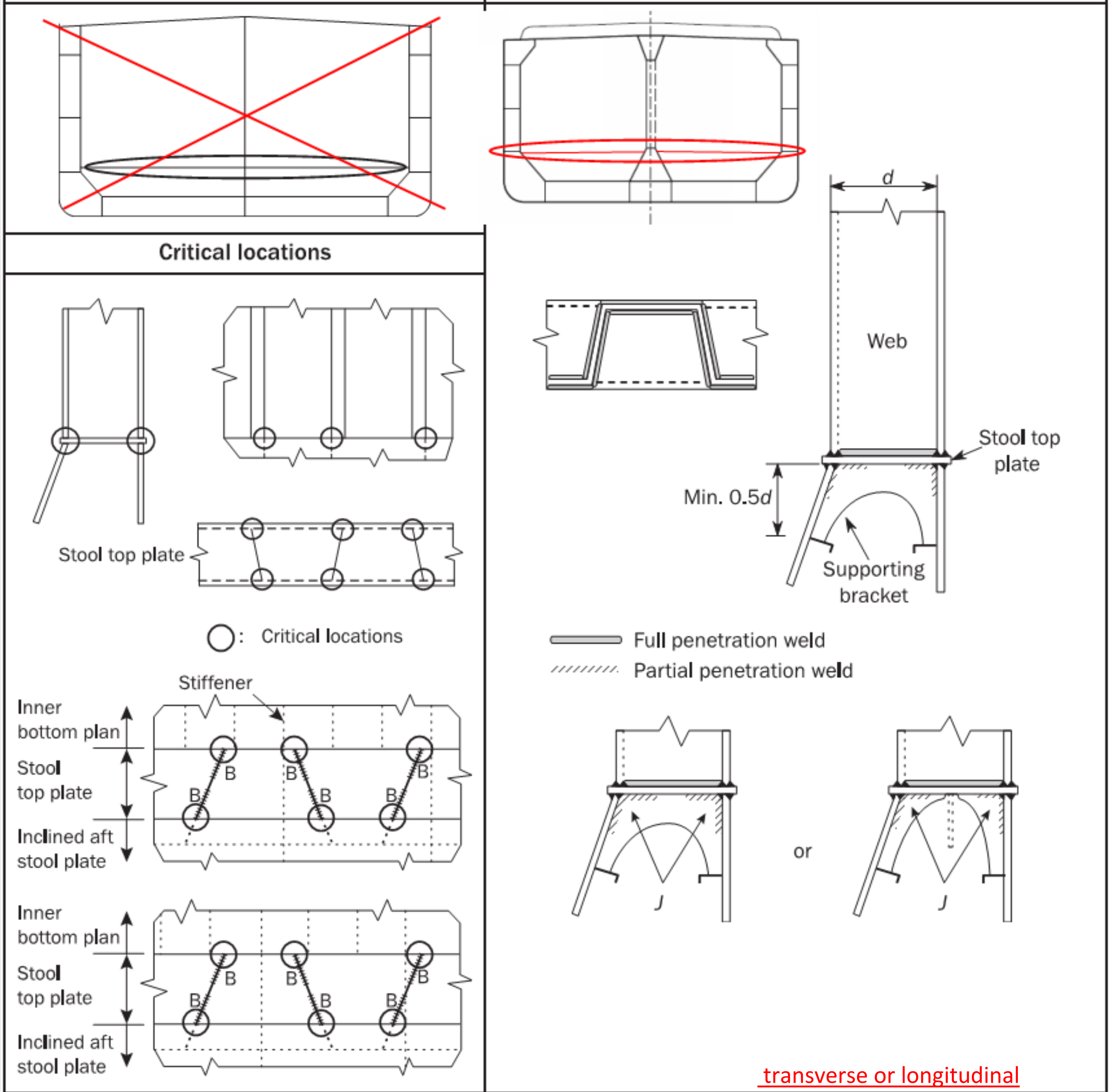
Note 1: Distance from side stringer to centre of knuckle is to be as small as practicable, but is not to exceed 50 mm.
Note 2: The knuckle radius is not to be less than 4.5 $t_{as-built}$ or 100 mm, whichever is the greater, where $t_{as-built}$ is the as-built thickness of the knuckle part, according to Ch 12 Sec 1 [3] & [4]
Note 3: Additional transverse brackets offset at a suitable distance on either side of transverse floor/hopper connection.
Note 4: Additional longitudinal bracket on the side of sloping plate.
Note 5: Longitudinal and/or transverse brackets may be omitted if it can be demonstrated that the girder provides sufficient support at the knuckle line, i.e. that fatigue requirements according to Ch 9, Sec 5 and local strength analysis requirements according to Ch 7, Sec 3 are fulfilled.</td></tr>
<tr><td>Critical locations</td></tr>
<tr><td>
</td></tr>
<tr><td>Critical location</td><td>Side stringer connections to side longitudinal bulkhead in way of transverse webs. Double side tank transverse web and hopper transverse web connections to side longitudinal bulkhead and to side stringers in way of hopper corners.</td></tr>
<tr><td colspan="2">[RCN1 to 01 JAN 2014]</td></tr>
</table>

6 BULKHEAD CONNECTION TO LOWER AND UPPER STOOL

6.1 Design standard J, K and L

Table 11 : Design standard K – transverse or longitudinal corrugated bulkhead connection detail, oil tanker

Connections of ~~transverse~~ bulkhead with lower stool - oil tanker	
Critical areas	transverse or longitudinal Design standard K



Critical location	Connections of lower stool top plate to corrugated ~~transverse~~ bulkheads.
Detail design standard	The use of scallops is to be avoided on diaphragms/web at lower stool top plates. Supporting brackets are to be fitted in line with corrugation web as required in Ch 6, Sec 4, [2.6.2]. Scallop is not permitted in the supporting bracket.
Building tolerances	Ensure alignment between lower stool side plates and corrugation faces according to IACS Recommendation No. 47.

CHAPTER 10
OTHER STRUCTURES

SECTION 1 FORE PART

3 STRUCTURE SUBJECTED TO IMPACT LOADS

3.3 BOW IMPACT

3.3.6 Primary supporting members

…

g) The net web thickness of each primary supporting member, tw, in mm including decks/bulkheads in way of the side shell is not to be less than:

$$t_w = \frac{P_{FB}\, b_{BI}}{\sin\varphi_w\, \cancel{\sigma_{crb}}\ \underline{\sigma_{cr}}}$$

where

ϕ_w : Angle, in deg, between the primary supporting member web and the shell plate, see Figure 5.

~~σ_{crb}~~ σ_{cr}: Critical buckling stress in compression of the web of the primary supporting member or deck/bulkhead panel in way of the applied load given by Ch 8, Sec 5, ~~[3.1.1]~~ [2.2.3], in N/mm2. In the calculation, both σ_x and σ_y given in Ch 8, Sec 5, [2.2.3] are to be considered and UP-B is to be applied.

4 ADDITIONAL SCANTLING REQUIREMENTS

4.1 Plate stem

4.1.2 Breasthooks and diaphragm plating

The net thickness of breasthooks/diaphragm plates in way of bow impact strengthening area defined in [3.3.1], *tw*, in mm, is not to be less than:

$$t_w = \frac{s}{70}\sqrt{\frac{R_{eH}}{235}}$$

Where:

s : Spacing of stiffeners on the web, as defined in Ch 1, Sec 4, Table 5, in mm. Where no stiffeners are fitted, *s* is to be taken as the depth of the web.

SECTION 3 AFT PART

2 AFT PEAK

2.2 Stiffening of floors and girders in aft peak

2.2.1

Stiffeners on the floors and girders in aft peak ballast or fresh water tanks above propeller are to be designed in accordance with [2.2.2] and [2.2.3]. This applies for stiffeners located in an area extending longitudinally between the forward edge of the rudder and the after end of the propeller boss and transversely within the diameter of the propeller.

2.2.~~1~~2

The height of stiffeners, h_{stf}, in mm, on the floors and girders are not to be less than:

$h_{stf} = 80\ \ell_{stf}$ for flat bar stiffeners.

$h_{stf} = 70\ \ell_{stf}$ for bulb profiles and flanged stiffeners.

where:

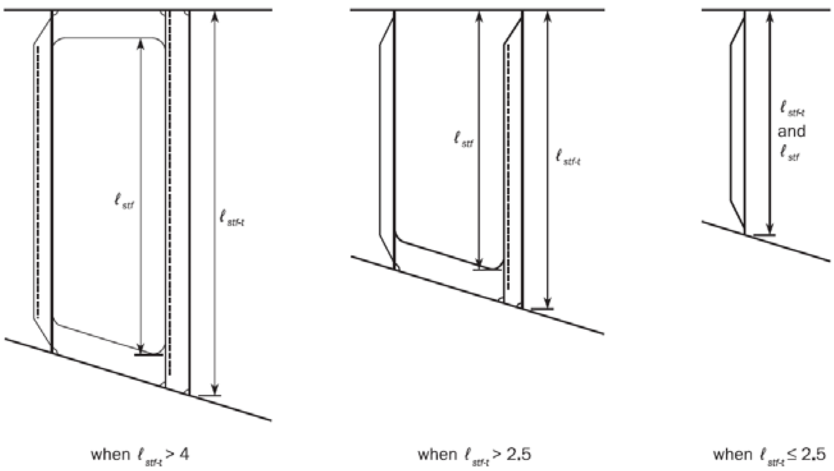
ℓ_{stf} : Length of stiffener, in m, as shown in Figure 1. Length need not be taken greater than 5 m.

2.2.~~2~~3

~~Stiffeners on the floors and girders in aft peak ballast or fresh water tanks above propeller are to be arranged with brackets. This apply for stiffeners located in an area extending longitudinally between the forward edge of the rudder and the after end of the propeller boss and transversely within the diameter of the propeller.~~ End brackets are to be provided as follows:

- Brackets are to be fitted at the lower and upper ends when $l_{stf\text{-}t}$ exceeds 4 m.
- Brackets are to be fitted at the lower end when $l_{stf\text{-}t}$ exceeds 2.5 m.

Figure 1 : Stiffening of floors and girders in the aft peak tank



3 STERN FRAMES

3.3 Connections

3.3.1 Connections with hull structure

Stern frames are to be effectively attached to the aft structure and the required scantling for the lower part of ~~the stern frame~~ the propeller post is to be extended from the ~~forward~~ aft end of propeller post, at the centerline of the propeller shaft, to a length not less than 1500 + 6 L_2 mm, in order to provide an effective connection with keel. However, the stern frame need not extend beyond the aft peak bulkhead.

4 SPECIAL SCANTLING REQUIREMENTS FOR SHELL STRUCTURES

4.1 Shell plating

4.1.2 Heavy shell plates

Heavy shell plates are to be fitted locally in way of the heavy plate floors as required by [2.1.1].The net thickness of heavy shell plates is not to be less than the value given in [4.1.1]. Outboard of the heavy floors, the heavy shell plates may be reduced in thickness in as gradual a manner as practicable. Where the horn plating is radiused into the shell plating, the radius at the shell connection, r in mm, is not to be less than:

$r = 150 + 0.8 L_2$

SECTION 4 TANKS SUBJECT TO SLOSHING

2 SCANTLING REQUIREMENTS

2.2 Stiffeners

2.2.1

The net section modulus, Z in cm^3, of stiffeners subjected to sloshing pressures is not to be less than:

$$Z = \frac{P_{Slh} S \ell_{bdg}^{\ 2}}{f_{bdg} C_s R_{eH}}$$

where:

f_{bdg} : Bending moment factor:

f_{bdg} = 12 for stiffeners fixed against rotation at each end. This is generally to be applied for scantlings of all continuous stiffeners.

f_{bdg} = 8 for stiffeners with one or both ends not fixed against rotation. This is generally to be applied to discontinuous stiffeners.

C_s : Permissible bending stress coefficient to be taken as: ~~defined in Table 2.~~

- For members subject to hull girder stress: coefficient to be taken as defined in Table 2.
- $C_s = C_{s\text{-}max}$ for other cases.

P_{slh} : The greater of $P_{slh\text{-}ing}$, $P_{slh\text{-}t}$ or $P_{slh\text{-}min}$ as specified in [1.3].

$C_{s\text{-}max}$: Coefficient as defined in Table 3.

CHAPTER 11
SUPERSTRUCTURE, DECKHOUSES AND HULL OUTFITTING

SECTION 3 EQUIPMENT

1 GENERAL

1.1 Application

1.1.3

The Equipment Number (*EN*) formula for anchoring equipment is based on an assumed maximum current speed of 2.5 m/s, maximum wind speed of 25 m/s and a minimum scope of chain cable ~~between~~ of 6 ~~and 10~~, the scope being the ratio between the length of chain paid out and the water depth. For ships with length greater than 135 m, alternatively the required anchoring equipment can be considered applicable to a maximum current speed of 1.54 m/s, a maximum wind speed of 11 m/s and waves with maximum significant height of 2 m.
It is assumed that under normal circumstances a ship ~~will~~ uses only one bow anchor and chain cable at a time.

2 EQUIPMENT NUMBER CALCULATION

2.1 Requirements

2.1.1

Anchors and chains are to be in accordance with Table 1 and the quantity, mass and sizes of these are to be determined by the equipment number (EN), given by:

$$EN = \Delta^{2/3} + 2\,B\,h + 0.1\,A$$

where:

h : Effective height, in m, from the summer load waterline to the top of the uppermost house, to be obtained in accordance with the following formula:
$h = h_{FB} + \Sigma hn$

When calculating h, sheer and trim are to be disregarded. For the lowest tier h is to be measured at centreline from the upper deck or from a notional deck line where there is local discontinuity in the upper deck, as shown in Figure 1.

h_{FB} : Freeboard amidships from the summer load waterline to the upper deck, in m.

hn : Height, in m, at the centreline of superstructure or of deckhouse tier 'n' having a breadth greater than $B/4$. Where a house having a breadth greater than $B/4$ is above a house with a breadth of $B/4$ or less, the upper house is to be included and the lower ignored ~~(see in Figure 1)~~.
A : Side projected ~~A~~area, in m^2, ~~in profile view,~~ of the parts of the hull, superstructures and houses above the summer load waterline which are within the length L and also have a breadth greater than $B/4$.
Fixed screens or bulwarks 1.5 m or more in height are to be regarded as parts of houses when determining h and A. In particular, the hatched area shown in Figure 2 is to be included.
The height of hatch coamings and that of any deck cargo, such as containers, may be disregarded when determining h and A.

Figure 1: Measurement of heights

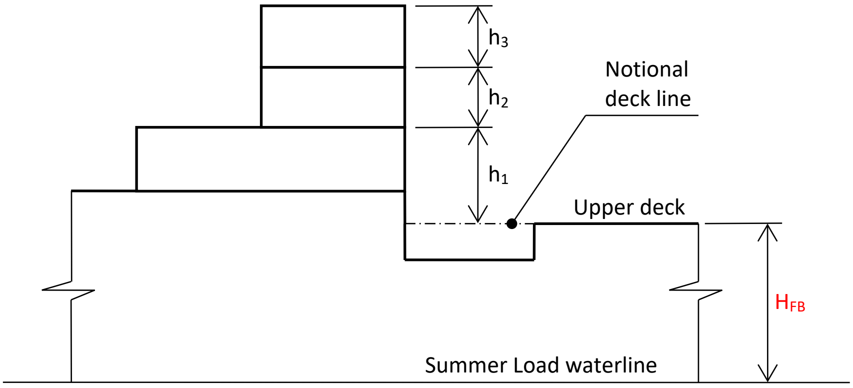
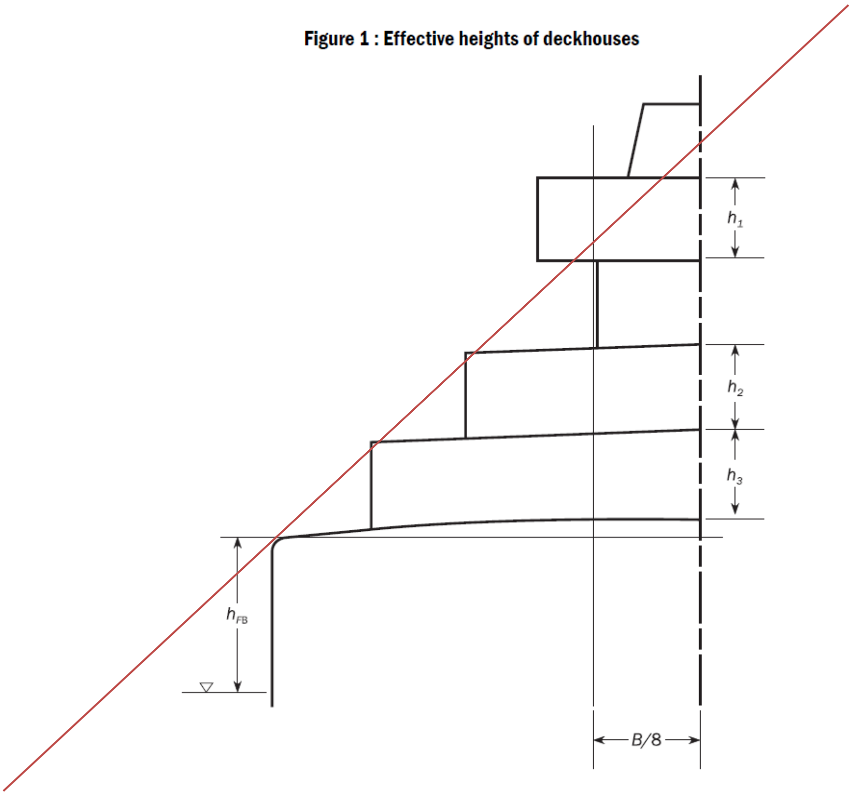


Figure 1 : Effective heights of deckhouses



3 ANCHORING EQUIPMENT

3.1 General

3.1.1 General

Two bower anchors are to be connected to chain cable and stowed in position ready for use. ~~A third anchor is recommended to be provided as a spare bower anchor and is listed for guidance only; it is not required as a condition of classification.~~

3.1.2 Design

~~Anchors are to be of an approved design. The design of anchor heads is to be such as to minimise stress concentrations. In particular, the radii, on all parts of cast anchor heads are to be as large as possible, especially where there is considerable change of section.~~

~~If the anchor design is different from standard or approved anchor types, drawing of the anchor, including material specification, is to be submitted for approval.~~

The anchors are to be of an approved type and satisfy the testing conditions as per the Society's requirements.

~~3.1.3 Testing~~

~~All anchors and chain cables are to be tested at establishments and on machines recognised by the Society,under the supervision of surveyors or other representatives of the Society and in accordance with the relevant requirements for materials of the Society.~~

~~Test certificates showing particulars of weights of anchors, or size and weight of cable and of the test loads applied are to be available. These certificates are to be examined by the surveyor when the anchors and cables are placed onboard the ship.~~

3.3 High ~~and Super High~~ Holding Power Anchors

3.3.1 General

Where agreed by the owner, consideration will be given to the use of special types of anchors. High Holding Power (HHP) ~~and Super High Holding Power (SHHP) anchors~~, i.e. anchors for which a holding power higher at least twice ~~than~~ that of ordinary anchors has been proved according to the applicable requirements of the Society's Rules for Materials, do not require prior adjustment or special placement on the sea bottom.

3.3.2 HHP ~~or SHHP~~ anchor mass

Where HHP ~~or SHHP~~ anchors are used as bower anchors, the mass of each anchor is to be not less than 75% ~~or 50%, respectively,~~ of ~~that~~ the mass required for ordinary stockless anchors in Table 1.
~~The mass of SHHP anchors is to be, in general, less than or equal to 1500 kg.~~

~~3.3.4 Testing~~

~~An anchor for which approval is sought as a high holding power (HHP) anchor, is to be tested at sea to show that it has a holding power of twice that approved for a standard stockless anchor of the same mass.~~

~~If approval is sought for a range of sizes, tests are to be carried out for at least two anchor sizes. The mass of the maximum size approved is not to be more than 10 times the mass of the largest size tested.~~

~~Each test is to comprise a comparison between at least two anchors: one ordinary stockless bower anchor and one HHP anchor~~

~~The tests are generally to be carried out by means of a tug. The pull is to be measured by a dynamometer or determined from recently verified data of the tug's bollard pull as a function of propeller rpm.~~

~~During the test, the length of the chain cable on each anchor is to be sufficient to obtain an approximately horizontal pull on the anchor. Generally, a horizontal distance between anchor and tug equal to 10 times the water depth will be sufficient.~~

~~For SHHP, the tests are to be conducted on at least three different types of bottom, which may be soft mud or silt, sand or gravel, and hard clay or similarly compacted material.~~

3.5 Chain lockers and stowed anchors

3.5.2 ~~Application~~ Securing of the inboard ends of chain cables

3.5.3 Securing of stowed anchors

Anchor lashings are to be designed to resist a load at least corresponding to twice the anchor mass plus 10 m of cable without exceeding 40% of the yield strength of the lashing material.

3.9 Towlines and mooring line

3.9.1 General

Mooring lines and towlines are not required as a condition of Classification. ~~The hawsers and towlines listed in Table 2 are intended as a guide. Where the tabular breaking strength is greater than 490kN, the breaking strength and the number of individual hawsers given in Table 2 may be modified, provided that their product is not less than that of the breaking strength and the number of hawsers given in Table 2.~~

The designer is to provide the following information:

- Towing line:
  - Length, in m,
  - Breaking strength, in kN.
- Mooring lines:
  - Number
  - Length of each, in m,
  - Breaking strength, in kN.

Side projected area including that of deck cargoes as given by the loading manual is to be taken into account for selection of towing/mooring lines.

~~**Table 2 : Towline and hawsers**~~

~~Equipment Number~~		~~Towline wire or rope~~		~~Hawsers~~		
~~Greater than~~	~~Equal to or less than~~	~~Length, in m~~	~~Breaking strenght, in kN~~	~~Number~~	~~Length of each, in m~~	~~Breaking strenght, in kN~~
~~150~~	~~175~~	~~180~~	~~98.0~~	~~3~~	~~120~~	~~54.0~~
~~175~~	~~205~~	~~180~~	~~112.0~~	~~3~~	~~120~~	~~59.0~~
~~205~~	~~240~~	~~180~~	~~129.0~~	~~4~~	~~120~~	~~64.0~~
~~240~~	~~280~~	~~180~~	~~150.0~~	~~4~~	~~120~~	~~69.0~~
~~280~~	~~320~~	~~180~~	~~174.0~~	~~4~~	~~140~~	~~74.0~~
~~320~~	~~360~~	~~180~~	~~207.0~~	~~4~~	~~140~~	~~78.0~~
~~360~~	~~400~~	~~180~~	~~224.0~~	~~4~~	~~140~~	~~88.0~~
~~400~~	~~450~~	~~180~~	~~250.0~~	~~4~~	~~140~~	~~98.0~~
~~450~~	~~500~~	~~180~~	~~277.0~~	~~4~~	~~140~~	~~108.0~~
~~500~~	~~550~~	~~190~~	~~306.0~~	~~4~~	~~160~~	~~123.0~~
~~550~~	~~600~~	~~190~~	~~338.0~~	~~4~~	~~160~~	~~132.0~~
~~600~~	~~660~~	~~190~~	~~371.0~~	~~4~~	~~160~~	~~147.0~~
~~660~~	~~720~~	~~190~~	~~406.0~~	~~4~~	~~160~~	~~157.0~~
~~720~~	~~780~~	~~190~~	~~441.0~~	~~4~~	~~170~~	~~172.0~~
~~780~~	~~840~~	~~190~~	~~480.0~~	~~4~~	~~170~~	~~186.0~~
~~840~~	~~910~~	~~190~~	~~518.0~~	~~4~~	~~170~~	~~201.0~~
~~910~~	~~980~~	~~190~~	~~559.0~~	~~4~~	~~170~~	~~216.0~~
~~980~~	~~1060~~	~~200~~	~~603.0~~	~~4~~	~~180~~	~~230.0~~
~~1060~~	~~1140~~	~~200~~	~~647.0~~	~~4~~	~~180~~	~~250.0~~
~~1140~~	~~1220~~	~~200~~	~~691.0~~	~~4~~	~~180~~	~~270.0~~
~~1220~~	~~1300~~	~~200~~	~~738.0~~	~~4~~	~~180~~	~~284.0~~
~~1300~~	~~1390~~	~~200~~	~~786.0~~	~~4~~	~~180~~	~~309.0~~

~~1390~~	~~1480~~	~~200~~	~~836.0~~	~~4~~	~~180~~	~~324.0~~
~~1480~~	~~1570~~	~~220~~	~~888.0~~	~~5~~	~~190~~	~~324.0~~
~~1570~~	~~1670~~	~~220~~	~~941.0~~	~~5~~	~~190~~	~~333.0~~
~~1670~~	~~1790~~	~~220~~	~~1024.0~~	~~5~~	~~190~~	~~353.0~~
~~1790~~	~~1930~~	~~220~~	~~1109.0~~	~~5~~	~~190~~	~~378.0~~
~~1930~~	~~2080~~	~~220~~	~~1168.0~~	~~5~~	~~190~~	~~402.0~~
~~2080~~	~~2230~~	~~240~~	~~1259.0~~	~~5~~	~~200~~	~~422.0~~
~~2230~~	~~2380~~	~~240~~	~~1356.0~~	~~5~~	~~200~~	~~451.0~~
~~2380~~	~~2530~~	~~240~~	~~1453.0~~	~~5~~	~~200~~	~~480.0~~
~~2530~~	~~2700~~	~~260~~	~~1471.0~~	~~6~~	~~200~~	~~480.0~~
~~2700~~	~~2870~~	~~260~~	~~1471.0~~	~~6~~	~~200~~	~~490.0~~
~~2870~~	~~3040~~	~~260~~	~~1471.0~~	~~6~~	~~200~~	~~500.0~~
~~3040~~	~~3210~~	~~280~~	~~1471.0~~	~~6~~	~~200~~	~~520.0~~
~~3210~~	~~3400~~	~~280~~	~~1471.0~~	~~6~~	~~200~~	~~554.0~~
~~3400~~	~~3600~~	~~280~~	~~1471.0~~	~~6~~	~~200~~	~~588.0~~
~~3600~~	~~3800~~	~~300~~	~~1471.0~~	~~6~~	~~200~~	~~618.0~~
~~3800~~	~~4000~~	~~300~~	~~1471.0~~	~~6~~	~~200~~	~~647.0~~
~~4000~~	~~4200~~	~~300~~	~~1471.0~~	~~7~~	~~200~~	~~647.0~~
~~4200~~	~~4400~~	~~300~~	~~1471.0~~	~~7~~	~~200~~	~~657.0~~
~~4400~~	~~4600~~	~~300~~	~~1471.0~~	~~7~~	~~200~~	~~667.0~~
~~4600~~	~~4800~~	~~300~~	~~1471.0~~	~~7~~	~~200~~	~~677.0~~
~~4800~~	~~5000~~	~~300~~	~~1471.0~~	~~7~~	~~200~~	~~686.0~~
~~5000~~	~~5200~~	~~300~~	~~1471.0~~	~~8~~	~~200~~	~~686.0~~
~~5200~~	~~5500~~	~~300~~	~~1471.0~~	~~8~~	~~200~~	~~696.0~~
~~5500~~	~~5800~~	~~300~~	~~1471.0~~	~~8~~	~~200~~	~~706.0~~
~~5800~~	~~6100~~	~~300~~	~~1471.0~~	~~8~~	~~200~~	~~706.0~~
~~6100~~	~~6500~~	~~300~~	~~1471.0~~	~~9~~	~~200~~	~~716.0~~
~~6500~~	~~6900~~	~~300~~	~~1471.0~~	~~9~~	~~200~~	~~726.0~~
~~6900~~	~~7400~~	~~300~~	~~1471.0~~	~~10~~	~~200~~	~~726.0~~
~~7400~~	~~7900~~	~~300~~	~~1471.0~~	~~11~~	~~200~~	~~726.0~~
~~7900~~	~~8400~~	~~300~~	~~1471.0~~	~~11~~	~~200~~	~~735.0~~
~~8400~~	~~8900~~	~~300~~	~~1471.0~~	~~12~~	~~200~~	~~735.0~~
~~8900~~	~~9400~~	~~300~~	~~1471.0~~	~~13~~	~~200~~	~~735.0~~
~~9400~~	~~10000~~	~~300~~	~~1471.0~~	~~14~~	~~200~~	~~735.0~~
~~10000~~	~~10700~~	~~–~~	~~–~~	~~15~~	~~200~~	~~735.0~~
~~10700~~	~~11500~~	~~–~~	~~–~~	~~16~~	~~200~~	~~735.0~~
~~11500~~	~~12400~~	~~–~~	~~–~~	~~17~~	~~200~~	~~735.0~~
~~12400~~	~~13400~~	~~–~~	~~–~~	~~18~~	~~200~~	~~735.0~~
~~13400~~	~~14600~~	~~–~~	~~–~~	~~19~~	~~200~~	~~735.0~~
~~14600~~	~~16000~~	~~–~~	~~–~~	~~21~~	~~200~~	~~735.0~~
~~[RCN1 to 01 JAN 2014]~~						

SECTION 4 SUPPORTING STRUCTURE FOR DECK EQUIPMENT AND FITTINGS

2 ANCHORING WINDLASS AND CHAIN STOPPER

2.1 General

2.1.4

These requirements are to be assessed based on ~~gross~~ net scantlings.

2.1.5

The following load cases are to be examined for the anchoring operation, as appropriate:
a) Windlass where chain stoppers~~ is provided~~ are fitted but not attached to the windlass: 45% of BS.
b) Windlass where no chain stoppers~~ is not provided~~ is fitted or the chain stopper is attached to the windlass: 80% of BS.
c) Chain stopper: 80% of BS.
where:
BS : Minimum breaking strength of the chain cable.

2.1.12

The stresses resulting from anchoring design loads induced in the supporting structure are not to be greater than the following permissible values:

• Normal stress, 1.00 *ReH*
• Shear stress, ~~0.58~~0.6 *ReH*

2.1.15

The stresses resulting from green sea design loads induced in the supporting structure are not to be greater than the following permissible values:

• Normal stress, 1.00 *ReH*
• Shear stress, ~~0.58~~0.6 ReH.

3 MOORING WINCHES

3.1.6 Corrosion model

These requirements are to be assessed based on ~~gross~~ net scantlings.

3.1.7

Each of the following load cases are to be examined for design loads due to mooring operation:

a) Mooring winch at maximum pull: 100% of the Rated Pull.

b) Mooring winch with brake effective: 100% of the Holding Load.

c) Line strength: 125% of the breaking strength of the mooring line~~ (hawser) according to Ch 11, Sec 3, Table 2 for the ship's corresponding equipment number.~~ provided by the designer (refer to Sec 3, [3.9]).

Rated pull and holding load are defined in [3.1.3] and [3.1.4]. The design load is to be applied through the mooring line according to the arrangement shown on the mooring arrangement plan.

5 BOLLARDS AND BITTS, FAIRLEADS, STAND ROLLERS, CHOCKS AND CAPSTANS

5.1 General

5.1.1

~~Shipboard fittings (bollards and bitts, fairleads, stand rollers and chocks) and capstans used for mooring and towing operations are to be fitted to the deck or bulwark structures.~~
Article 5 provides requirements applicable to the design and construction of shipboard fittings and supporting structures used for the normal towing at bow, side and stern and mooring operations as well as the strength of supporting structures of winches and capstans.

Normal towing means towing operations necessary for manoeuvring in ports and sheltered waters associated with the normal operations of the ship.

Where a ship is equipped with shipboard fittings intended to be used for other towing services, the strength of these fittings and their supporting structures are to comply with the requirements of this Article.

5.1.2

~~Where fairleads are fitted in bulwarks, the thickness of bulwarks may need to be increased. See Ch 11, Sec 2, [2.2].~~
Article 5 is not applicable to design and construction of shipboard fittings and supporting structures used for special towing services defined as:

a) Escort towing: Towing service, in particular, for laden oil tankers required in specific estuaries. Its main purpose is to control the ship in case of failures of the propulsion or steering system. It should be refered to local escort requirements and guidance given by,e.g., the Oil Companies International Marine Forum (OCIMF)

b) Canal transit towing: Towing service for ships transiting, e.g. the Panama Canal. It should be refereed to local canal transit requirements.

c) Emergency towing for oil tankers: Towing service to assist tankers in case of emergency. For the emergency towing arrangements, ships subject to SOLAS regulation II-1/3-4 Paragraph 1 are to comply with that regulation and resolution MSC.35(63) as may be amended.

5.1.3

~~The structural arrangement is to provide continuity of strength.~~
~~The structural arrangement of the ship's structure in way of the shipboard fittings and their seats and in way of capstans is to be such that abrupt changes of shape or section are to be avoided in order to minimise stress concentrations. Sharp corners and notches are to be avoided, especially in highly stressed areas.~~
Where fairleads are fitted in bulwarks, the thickness of bulwarks may need to be increased. See Ch 11, Sec 2, [2.2].

5.1.4

The supporting structure is to be dimensioned to ensure that for the loads specified in ~~[5.1.6] to [5.1.8]~~ [5.2.1] and [5.3.1], the stresses do not exceed the permissible values given in [5.~~1.9~~5].
The capability of the structure to resist buckling failure is to be assured according to Ch 8.

5.1.5

These requirements are to be assessed based on net scantlings.

~~5.1.6~~

~~Design loads for the supporting structure for shipboard fittings are to be according to:~~
~~a) In the case of normal towing in harbour or manoeuvring operations, 125% of the maximum towline load as indicated on the towing and mooring arrangement plan.~~
~~b) In the case of towing service other than that experienced in harbour or manoeuvring operations, such as escort service, the nominal breaking strength of towline.~~

~~c) In the case of mooring operations, 125% of the nominal breaking strength of the mooring line (hawser) according to Ch 11, Sec 3, Table 2 for the ship's corresponding equipment number.~~

~~**5.1.7**~~

~~The design load for the supporting structure for capstans is to taken as 125% of the maximum hauling in force.~~

~~**5.1.8**~~

~~The assessment of the structure is to consider lines of action of the applied design load, taking into account the particular arrangements proposed; however, the total load applied for towing and mooring scenarios described in [5.1.6] need not be more than twice the design load on the mooring line or towline. The acting point for the force on the shipboard fittings is to be taken as the attachment point of the mooring line or towline, or at a change in its direction.~~

~~**5.1.9**~~

~~For the design load specified in [5.1.6] to [5.1.8], the stresses induced in the supporting structure and welds are not to exceed the following permissible values:~~
~~• Normal stress, 1.00 ReH.~~
~~• Shear stress, 0.60 ReH.~~

~~**5.1.10**~~

~~The following requirements on Safe Working Load apply for a single post basis (i.e. no more than one turn of one cable).~~
~~a) The SWL used for normal towing operations, e.g. harbour/manoeuvring is not to exceed 80% of the design load per [5.1.6] item (a); and the SWL used for other towing operations, e.g. escort is not to exceed the design load per [5.1.6] item (b). For deck fittings used for both normal and other towing operations, the greater of the design loads of [5.1.6] item (a) and [5.1.6] item (b) is to be used.~~
~~b) The SWL for mooring operations is not to exceed 80% of the design load per [5.1.6] item (c).~~
~~c) The SWL of each deck fitting is to be marked (by weld bead or equivalent) on the deck fittings used for towing and/or mooring.~~
~~d) The towing and mooring arrangements plan mentioned in [5.1.11] is to define the method of use of towing lines and/or mooring lines.~~

~~**5.1.11**~~

~~The SWL for the intended use for each deck fitting is to be stated in the towing and mooring arrangements plan available onboard for consistency for the guidance of the Master. For each deck fitting, the following is to be included:~~
~~a) Location on the ship.~~
~~b) Fitting type.~~
~~c) SWL.~~
~~d) Purpose (mooring/harbour towing/escort towing).~~
~~e) Manner of applying towing or mooring line load including limiting fleet angles.~~
~~This information is to be incorporated into the pilot card in order to provide the pilot with proper information on~~
~~harbour/escorting operations.~~

5.2 Towing

5.2.1 Towing design loads

The minimum design load applied to supporting structures for shipboard fittings is not to be less than the following values:

a) For normal towing operations, 125% of the intended maximum towing load (static bollard pull) as indicated on the towing and mooring arrangements plan,

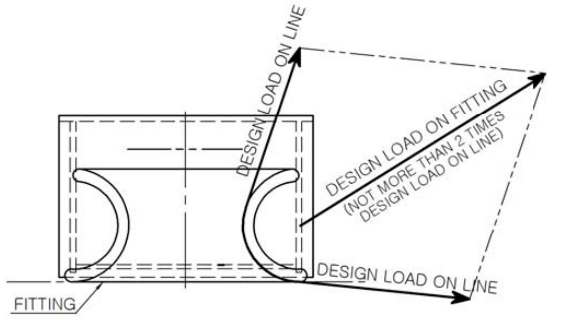
b) For other towing service, the minimum breaking strength of the tow line provided by the designer (refer to Sec 3, [3.9]),

c) For fittings intended to be used for, both, normal and other towing operations, the greater of the design loads according to a) and b).

When a safe towing load, TOW, greater than the value determined according to [5.2.4] is provided by the designer, the design load is to be increased in accordance with the appropriate TOW/design load relationship given in [5.2.1] and [5.2.4].

The design load is to be applied to fittings in all directions that may occur by taking into account the arrangement shown on the towing and mooring arrangements plan. Where the towing line takes a turn at a fitting the total design load applied to the fitting is equal to the resultant of the design loads acting on the line (see Figure 4). However, the design load applied to the fitting needs not to be greater than twice the design load of the line.

Figure 4: Design load on fitting



5.2.2 Shipboard fittings

Shipboard fittings may be selected from an industry standard accepted by the Society and at least based on the following loads.

a) For normal towing operations, the intended maximum towing load (static bollard pull) as indicated on the towing and mooring arrangements plan,

b) For other towing service, the minimum breaking strength of the tow line provided by the designer (refer to Sec 3, [3.9]),

c) For fittings intended to be used for, both, normal and other towing operations, the greater of the loads according to a) and b).

Towing bitts (double bollards) may be chosen for the towing line attached with eye splice if the industry standard distinguishes between different methods to attach the line, i.e. figure-of-eight or eye splice attachment.

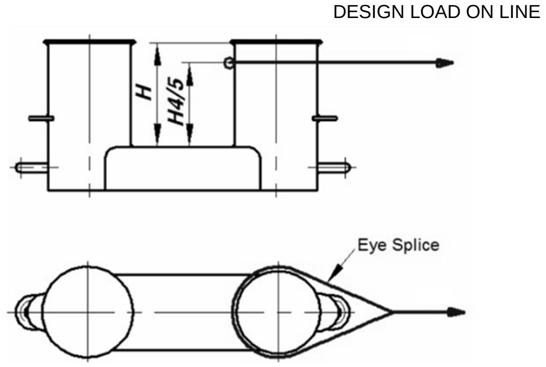
When the shipboard fitting is not selected from an accepted industry standard, the strength of the fitting and of its attachment to the ship is to be in accordance with the requirements of this Article.

Towing bitts (double bollards) are required to resist the loads caused by the towing line attached with eye splice.

5.2.3 Towing force acting point

The acting point of the towing force on shipboard fittings is to be taken at the attachment point of a towing line or at a change in its direction. For bollards and bitts the attachment point of the towing line is to be taken not less than 4/5 of the tube height above the base (see Figure 5).

Figure 5: Attachment point of the towing line



5.2.4 Safe Towing Load (TOW)

The Safe Towing Load (TOW), in t, is the load limit for towing purpose.

The following requirements for Safe Towing Load (TOW) apply for the use with no more than one line. If not otherwise chosen, for towing bitts (double bollards) TOW is the load limit for a towing line attached with eye-splice.

a) TOW used for normal towing operations is not to exceed 80% of the design load given in [5.2.1] a).

b) TOW used for other towing operations is not to exceed 80% of the design load given in [5.2.1] b).

c) For fittings used for both normal and other towing operations, the greater of the safe towing loads in a) and b) above is to be used.

d) For fittings intended to be used for, both, towing and mooring, [5.3] applies to mooring.

TOW of each shipboard fitting is to be marked by weld bead or equivalent, on the deck fittings used for towing.

For fittings intended to be used for, both, towing and mooring, SWL, in t, according to [5.3.4] is to be marked in addition to TOW.

5.3 Mooring

5.3.1 Mooring design loads

The minimum design load applied to supporting structures for shipboard fittings is not to be less than 115% of the minimum breaking strength of the mooring line provided by the designer (refer to Sec 3, [3.9])

The minimum design load applied to supporting structures for winches is not to be less than 125% of the intended maximum brake holding load, where the maximum brake holding load is to be assumed not less than 80% of the minimum breaking strength of the mooring line provided by the designer (refer to Sec 3, [3.9]).

The minimum design load for the supporting structure for capstans is to taken as 125% of the maximum hauling in force.

When a safe working load SWL greater than the value determined according to [5.3.4] is provided by the designer, the design load is to be multiplied by the ratio SWL/design load, where the design load is given above as appropriate.

The design load is to be applied to fittings in all directions that may occur by taking into account the arrangement shown on the towing and mooring arrangements plan. Where the mooring line takes a turn at a fitting the total design load applied to the fitting is equal to the resultant of the design loads acting on the line (See Figure 4). However, the design load applied to the fitting needs not to be greater than twice the design load on the line.

5.3.2 Shipboard fittings

Shipboard fittings may be selected from an industry standard accepted by the Society and at least based on the minimum breaking strength of the mooring line provided by the designer (refer to Sec 3, [3.9]).

Mooring bitts (double bollards) are to be chosen for the mooring line attached in figure-of-eight fashion if the industry standard distinguishes between different methods to attach the line, i.e. figure-of-eight or eye splice attachment.

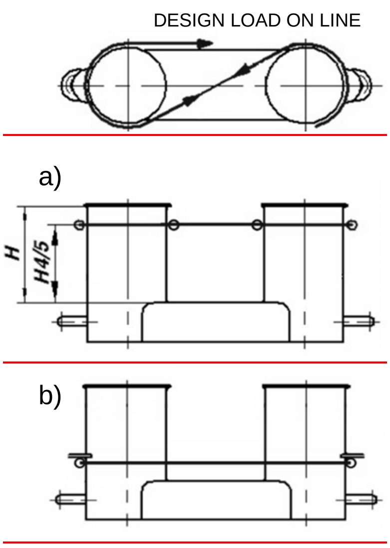
When the shipboard fitting is not selected from an accepted industry standard, the strength of the fitting and of its attachment to the ship is to be in accordance with this Article.

Mooring bitts (double bollards) are required to resist the loads caused by the mooring line attached in figure-of-eight fashion.

5.3.3 Mooring force acting point

The acting point of the mooring force on shipboard fittings is to be taken at the attachment point of a mooring line or at a change in its direction. For bollards and bitts the attachment point of the mooring line is to be taken not less than 4/5 of the tube height above the base (See Figure 6 a). However, if fins are fitted to the bollard tubes to keep the mooring line as low as possible, the attachment point of the mooring line may be taken at the location of the fins (See Figure 6 b).

Figure 6: Attachment point of the mooring line



5.3.4 Safe Working Load (SWL)

The Safe Working Load (SWL), in t, is the load limit for mooring purpose.

The following requirements on Safe Working Load apply for the use with no more than one mooring line.

Unless a greater SWL is provided by the designer, the SWL is not to exceed the minimum breaking strength of the mooring line provided by the designer (refer to Sec 3, [3.9]).

The SWL of each deck fitting is to be marked (by weld bead or equivalent) on the deck fittings used for mooring.

For fittings intended to be used for, both, mooring and towing, TOW, in t, according to [5.2.4] is to be marked in addition to SWL.

5.4 Supporting structure

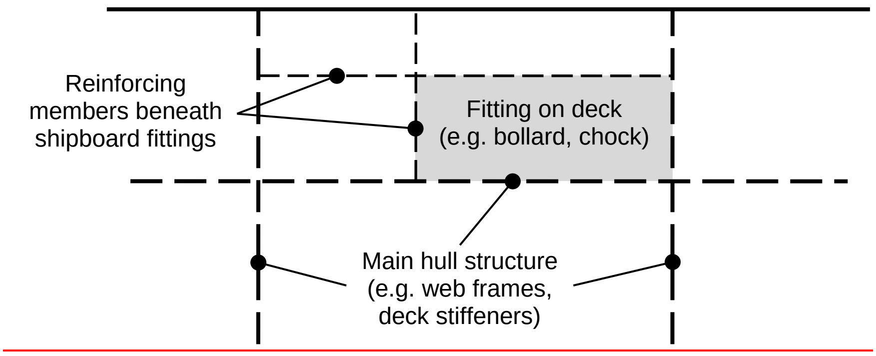
5.4.1

Shipboard fittings for towing and mooring, winches and capstans for mooring are to be located on stiffeners and/or girders, which are part of the deck construction so as to facilitate efficient distribution of the towing or mooring loads. Other arrangements may be accepted (for chocks in bulwarks, etc.) provided the strength is confirmed adequate for the intended service.

5.4.2

The reinforced structural members beneath shipboard fittings are to be effectively arranged for any variation of direction (horizontally and vertically) of the towing/mooring forces acting upon the shipboard fittings (see Figure 7).

Figure 7: Sample arrangement



5.4.3

Shipboard fittings (bollards and bitts, fairleads, stand rollers and chocks) and capstans used for mooring and/or towing operations are to be fitted to the deck or bulwark structures.

5.4.4

The structural arrangement is to provide continuity of strength. Proper alignment of fittings and supporting structure is to be ensured.

The structural arrangement of the ship's structure in way of the shipboard fittings and their seats and in way of capstans is to be such that abrupt changes of shape or section are to be avoided in order to minimise stress concentrations. Sharp corners and notches are to be avoided, especially in highly stressed areas.

5.5 Acceptance criteria

5.5.1

For the design load specified in [5.2.1] and [5.3.1], the stresses induced in the shipboard fittings, the supporting structure and welds are not to exceed the following permissible values defined in [5.5.3] and [5.5.4], as applicable:

5.5.2

The strength assessment of the shipboard fittings can be performed by means of either beam theory or grillage analysis, or by finite element analysis.

At the discretion of the Society, load tests of the fittings may be accepted as alternative to strength assessment by above mentioned analysis.

5.5.3

For strength assessment with beam theory or grillage analysis, the permissible stresses to be considered are the following:

- Normal stress: 1.00 ReH.
- Shear stress: 0.60 ReH.

Normal stress is the sum of bending stress and axial stress with the corresponding shearing stress acting perpendicular to the normal stress. No stress concentration factors are taken into account.

5.5.4

For strength assessment with finite element analysis, the von Mises equivalent stress to be considered is not to exceed *ReH*.

For strength calculations by means of finite elements, the geometry is to be modelled as realistically as possible. The ratio of element length to width is not to exceed 3. Girders are to be modelled using shell or plane stress elements. Symmetric girder flanges may be modelled by beam or truss elements. The element height of girder webs must not exceed one-third of the web height. In way of small openings in girder webs the web thickness is to be reduced to a mean thickness over the web height. Large openings are to be modelled. Stiffeners may be modelled by using shell, plane stress, or beam elements. Stresses are to be read from the centre of the individual element. For shell elements the stresses are to be evaluated at the mid plane of the element.

5.6 Corrosion addition of the fittings

5.6.1

The corrosion addition, *tc*, of the fittings is not be less than the following values:

a) For pedestals and foundations on deck which are not part of a fitting according to an accepted industry standard, 2.0 mm.

b) For shipboard fittings not selected from an accepted Industry standard, 2.0 mm.

5.6.2

In addition to the corrosion addition the wear allowance, *tw*, for shipboard fittings not selected from an accepted Industry standard is not to be less than 1.0 mm, added to surfaces which are intended to regularly contact the line.

5.7 Towing and mooring arrangements plan

5.7.1

The SWL and TOW for the intended use for each deck fitting is to be stated in the towing and mooring arrangements plan available onboard for the guidance of the Master.

It is to be noted that TOW is the load limit for towing purpose and SWL that for mooring purpose.

For each deck fitting, the following is to be included on the arrangement plan:

a) Location on the ship,

b) Fitting type,

c) SWL and or TOW,

d) Purpose (mooring, harbour towing, other towing),

e) Manner of applying towing or mooring line load including limiting fleet angles.

Item c) with respect to items d) and e), is subject to approval by the Society.

5.7.2

The information provided on the plan is to include:

f) The arrangement of mooring lines showing number of lines (N),

g) The minimum breaking strength of each mooring line (MBL),

h) The acceptable environmental conditions:

- 30 second mean wind speed from any direction
- Maximum current speed acting on bow or stern (±10°).

This information is to be incorporated into the pilot card in order to provide the pilot with proper information on harbor and other towing operations.

5.7.3

The towing and mooring arrangements plan is to define the method of use of towing lines and/or mooring lines.

CHAPTER 12
CONSTRUCTION

SECTION 3 DESIGN OF WELDED JOINTS

2 TEE OR CROSS JOINT

2.4 Partial ~~and~~ or full penetration of welds

2.4.4 Extent of full or partial penetration welding

The extent of full or partial penetration welding in each particular location listed in [2.4.5] and [2.4.6] is to be approved by the Society. However, the minimum extent of full/partial penetration welding from the reference point (i.e. intersection point of structural members, end of bracket toe, etc.) is not to be taken less than 300 mm, unless otherwise specifically stated.

2.4.5 Locations required for full penetration welding

Full penetration welds are to be used in the following locations and elsewhere as required by the rules, see Figure 3:

a) Floors to hopper/inner bottom plating in way of radiused hopper knuckle.

b) Radiused hatch coaming plate at corners to deck.

c) Connection of vertical corrugated bulkhead to the lower hopper plate and to the inner bottom plate within the cargo hold region, when the vertical corrugated bulkhead is arranged without a lower stool.

d) Connection of structural elements in the double bottom in line with corrugated bulkhead flanges to the inner bottom plate, when the vertical corrugated bulkhead is arranged without a lower stool.

e) Connection of vertical corrugated bulkhead to the lower hopper plate, and connection of structural elements in the lower hopper area in line with corrugated bulkhead flanges to the lower hopper plate, where connections are clear of lower stools.

f~~d~~) Connection of vertical corrugated bulkhead to top plating of lower stool.

g) Corrugated bulkhead lower stool side plating to lower stool top plate.

h) Corrugated bulkhead lower stool side plating to inner bottom.

i) Connection of structural elements in double bottom to the inner bottom plate in holds intended for the carriage of liquid at sea with a distance of ~~150~~300 mm from the side plating of the lower stool, see Figure 3.

j~~e~~) Edge reinforcement or pipe penetration both to strength deck, sheer strake and bottom plating within 0.6 *L* amidships, when the dimensions of the opening exceeds 300 mm.

k~~f~~) Abutting plate panels with as-built thickness less than or equal to 12 mm, forming outer shell boundaries below the scantling draught, including but not limited to: sea chests, rudder trunks, and portions of transom. For as-built thickness greater than 12 mm, partial penetration in accordance with [2.4.2].

l~~g~~) Crane pedestals and associated bracketing and support structure.

mh) For toe connections of longitudinal hatch coaming end bracket to the deck plating, full penetration weld for a distance of 0.15 *Hc* from toe of side coaming termination bracket is required, where *Hc* is the hatch coaming height.

ni) Rudder horns and shaft brackets to shell structure.

oj) Thick flanges of long transverse web frames to side web frames. Thick flanges of long longitudinal girder to bulkhead web frames.

2.4.6 Locations required for ~~full or~~ partial penetration welding

Partial penetration welding as defined in [2.4.2], is to be used in the following locations (see examples in Figure 3). ~~Additional locations may be required based on other criteria, such as fatigue assessment as given in Ch 9 (see Figure 3):~~

Partial penetration welding as defined in [2.4.2], is to be used in the following locations:

a) Connection of hopper sloping plate to longitudinal bulkhead (inner hull).

b) Longitudinal/transverse bulkhead primary supporting member end connections to the double bottom.

~~c) Corrugated bulkhead lower stool side plating to lower stool top plate.~~

~~d) Corrugated bulkhead lower stool side plating to inner bottom.~~

ce) Corrugated bulkhead lower stool supporting floors to inner bottom.

df) Corrugated bulkhead gusset and shedder plates.

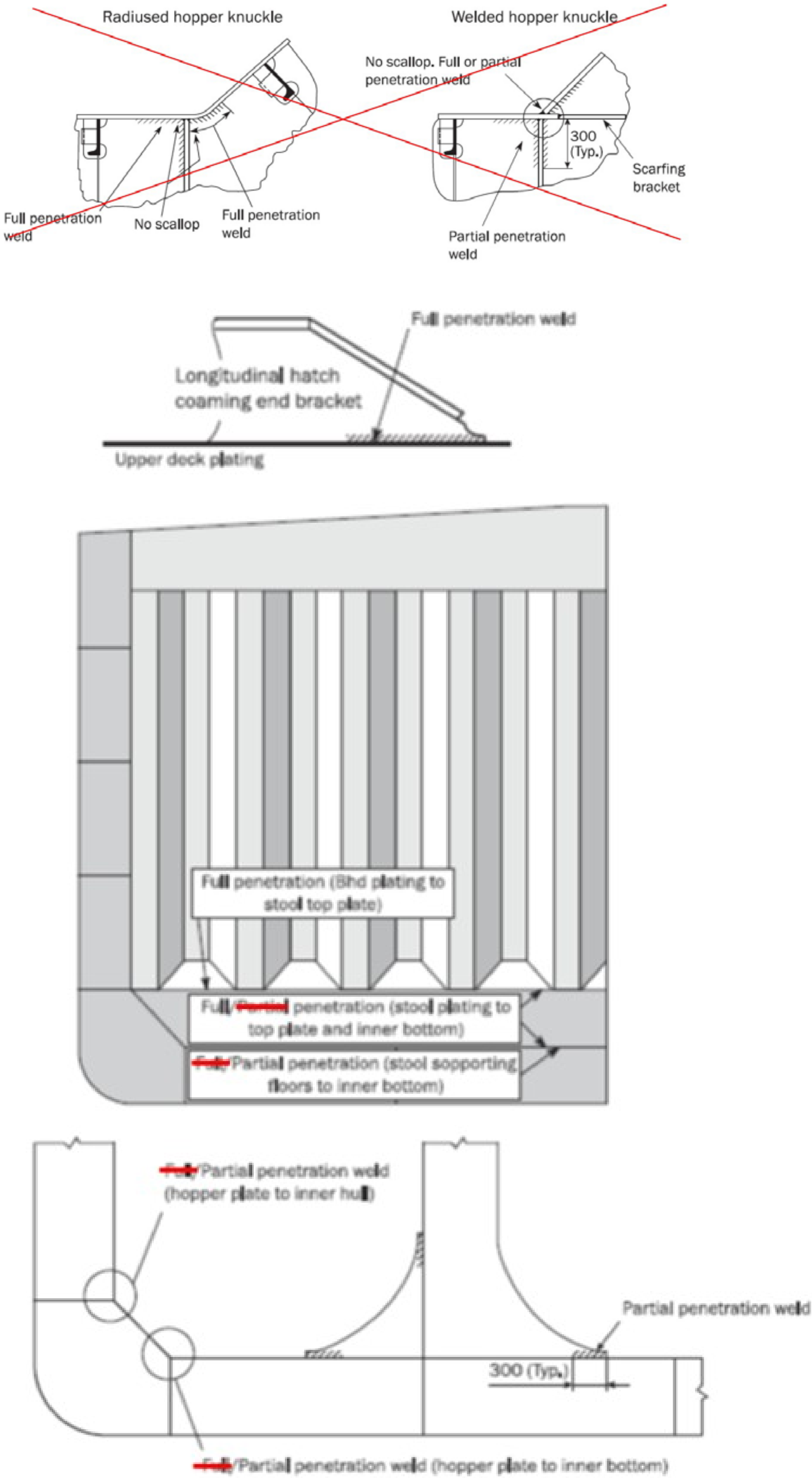
eg) Lower 15% of the length of built-up corrugation of vertical corrugated bulkheads.

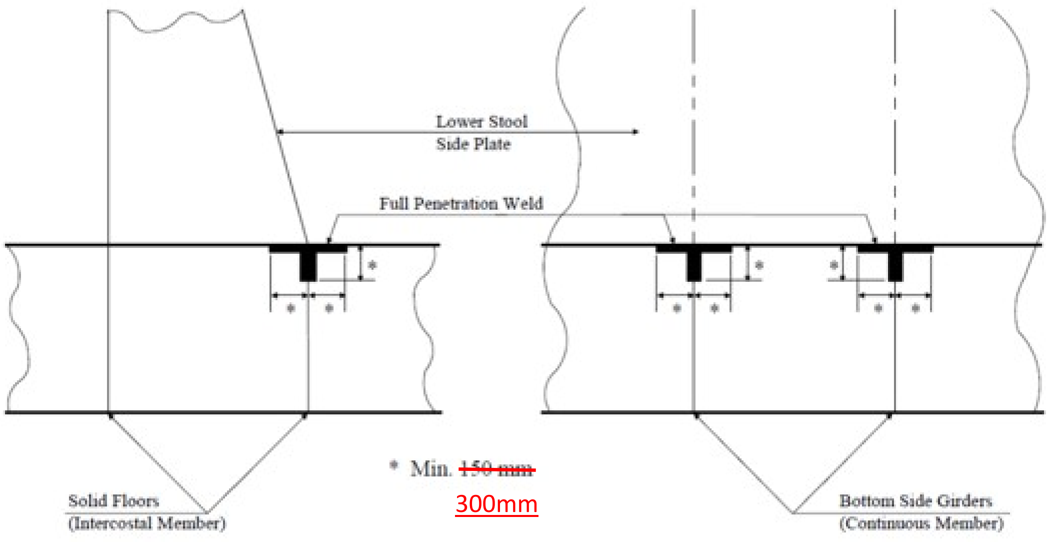
fh) Structural elements in double bottom below bulkhead primary supporting members and stool plates, except in way of 2.4.5i).

gi) Lower hopper plate to inner bottom.

hj) Horizontal stringers on bulkheads in way of their bracket toe and the heel.

Figure 3 : High stress areas welding (examples)





2.5 Weld size criteria

2.5.2

The leg length, ℓ_{leg} in mm, of continuous, lapped or intermittent fillet welds is not to be taken less than the greater of the following values:

$$\ell_{leg} = f_1 f_2 t_{as-built}$$

$$\ell_{leg} = f_{yd} f_{weld} f_2 f_3 t_{as-built} + t_{gap}$$

ℓ_{leg} as given in Table 1.

where:

f_1 : Coefficient depending on welding type:

f_1=0.30 for double continuous welding.

f_1=0.38 for intermittent welding.

f_2 : Coefficient depending on the edge preparation:

f_2=1.0 for ~~double continuous welding~~ welds without bevelling.

f_2=0.7 for ~~partial penetration~~ welds with one/both side bevelling and $f = t_{as-built}/3$.

f_{yd} : Coefficient not to be taken less than the following:

$$f_{yd} = \left(\frac{1}{K}\right)^{0.5}\left(\frac{235}{R_{eH\_weld}}\right)^{0.75}$$

$$f_{yd} = 0.71$$

R_{eH_weld} : Specified minimum yield stress for the weld deposit in N/mm^2, not to be less than:

: R_{eH_weld} = 305 N/mm^2 for welding of normal strength steel with R_{eH} = 235N/mm^2.

: ReH_weld = 375 N/mm² for welding of higher strength steels with ReH from 265 to 355 N/mm².

: ReH_weld = 400 N/mm² for welding of higher strength steel with ReH = 390 N/mm².

f_{weld} : Weld factor dependent on the type of the structural member, see Table 2, Table 3 and Table 4.

k : Material factor of the abutting member.

f_3 : Correction factor for the type of weld:

f_3=1.0 for double continuous weld.

$f_3 = s_{ctr}/\ell_{weld}$

s_{ctr} : Distance between successive fillet welds, in mm.¨

Table 4 : Weld factors for primary supporting members

Hull structural member	Connection			f_{weld}
	Of	To Within end 15% of shear span and extending to end of member		
Primary supporting member	Web plate	Shell plating, deck plating, inner bottom plating, bulkhead	~~Within 15% of shear span at ends~~	0.48
			Elsewhere	0.38
		Face plate	In tanks/holds Members located within 0.125L from fore peak	0.38
			Elsewhere if cross section area of face plate exceeds 65 cm²	0.38
			Elsewhere	0.24
	End connections		In way of boundaries of ballast and cargo tanks	0.48
			Elsewhere	0.38

5 CONNECTION DETAILS

5.1 Bilge keels

5.1.1

The ground bar is to be connected to the shell with a continuous fillet weld, and the bilge keel to the ground bar with a continuous fillet weld in accordance with Table 5.

Table 5 : Connections of bilge keels

Structural items being joined	Leg length of weld, in mm	
	At ends (1)	Elsewhere
Ground bar to the shell	0.62 t_{1as_built}	0.48 t_{1as_built}
Bilge keel web to ground bar	0.48 t_{2as_built}	0.30 t_{2as_built}

$t_{1as\text{-}built}$: As-built thickness of ground bar, in mm.

$t_{2as\text{-}built}$: As-built thickness of web of bilge keel, in mm.

(1) : Zone “b” in Fig. 19 and Fig. 20 in Pt 1 Ch 3 Sec 6 for definition of “ends”

CHAPTER 13
SHIP IN OPERATION-RENEWAL CRITERIA

SECTION 1 PRINCIPLES AND SURVEY REQUIREMENTS

1 PRINCIPLES

1.3 Requirements for documentation

1.3.2 Hull girder sectional properties

The Midship section plan to be supplied onboard the ship is to include the minimum required hull girder sectional properties, as defined in Ch 5, Sec 1, for the ~~typical~~ representative transverse sections of all cargo holds.

PART 2 SHIP TYPES

CHAPTER 1
BULK CARRIERS

SECTION 3 HULL LOCAL SCANTLINGS

1 CARGO HOLD SIDE FRAMES OF SINGLE SIDE BULK CARRIERS

1.4 Provided support at upper and lower connections of side frames

1.4.2 Net connection area of brackets

The net connection area~~, A_i, in cm^2,~~ of the lower or upper connecting bracket to the ~~i-th~~ supporting longitudinal stiffener is ~~not to be taken less than~~ to comply with the following formula:

$$\cancel{A_i = 0.4\frac{z_i s k_{bkt}}{l_1^2 k_{lg,i}}10^{-3}}$$

$$\sum_i A_i d_i R_{eH,bkt-i} \geq 0.02\alpha_T P s l_{SF}^2 10^{-3}$$

where:

~~Z_i : Net section modulus, in cm3, of the i-th longitudinal stiffener on the side or hopper/topside tank supporting the lower/upper end connecting bracket of the side frame, as applicable.~~

~~l_1 : As defined in [1.4.1].~~

~~k_{bkt} : Material factor for the bracket.~~

~~$k_{lg,i}$: Material factor for the i-th longitudinal stiffener.~~

A_i : The offered net connection area of the bracket connecting with the i-th longitudinal stiffener, in cm^2.

d_i, α_T : As defined in [1.4.1].

$R_{eH,bkt-i}$: The specified minimum yield stress of the bracket connecting with the i-th longitudinal stiffener, in N/mm^2,

s : The space of the side frame, in mm.

4 ALLOWABLE HOLD LOADING FOR BC-A & BC-B SHIPS IN FLOODED CONDITIONS

4.1 Evaluation of double bottom capacity and allowable hold loading

4.1.4 Allowable hold loading

ρ_{ST} : Density of steel, in t/m^3, to be taken as ~~7.8~~ 7.85.

SECTION 5 CARGO HATCH COVERS

7 WEATERTIGHTNESS, CLOSING ARRANGEMENT, SECURING DEVICES AND STOPPERS

7.2 Gaskets

7.2.1

The weight of hatch covers and any cargo stowed thereon, together with inertia forces generated by ship motions, are to be transmitted to the ship's structure ~~through steel to steel contact~~.

~~This may be achieved by providing continuous skirt plates on the hatch covers or by means of defined bearing pads.~~