08-392

RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

Part CSR-T Common Structural Rules for Double Hull Oil Tankers

Rules for the Survey and Construction of Steel Ships
Part CSR-T 2008 AMENDMENT NO.1

Rule No.36 29th May 2008
Resolved by Technical Committee on 1st February / 31st March 2008
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Rule No.36 29th May 2008
AMENDMENT TO THE RULES FOR THE SURVEY AND CONSTRUCTION OF STEEL SHIPS

"Rules for the survey and construction of steel ships" has been partly amended as follows:

Part CSR-T Common Structural Rules for Double Hull Oil Tankers

Amendment 1-1

Section 2 Rule Principles

2. General Assumptions

2.1 General

2.1.2 Classification Societies

Table 2.2.1 has been amended as follows.

Table 2.2.1 IACS Unified Requirements Applicable to Oil Tankers

Number	Title
A1	*Equipment*
A2	*Shipboard fittings and supporting hull structures associated with towing and mooring on conventional vessels*
S1	*Requirements for Loading Conditions, Loading Manuals and Loading Instruments*
S2	*Definitions of ship's length L and block coefficient* C_b
S3	*Strength of end bulkheads of superstructures and deckhouses*
S4	*Criteria for use of high tensile steel with yield points of 315 N/mm*^{2} *and 355N/mm*^{2} *(with respect to longitudinal strength)*
S5	*Calculation of midship section moduli for conventional ship for ship's scantlings*
S6	*Use of steel grades for various hull members – ships of 90m in length and above*
S7	*Minimum longitudinal strength Standards*
S11	*Longitudinal strength Standard*
S13	*Strength of bottom forward in oil tankers*
S14	*Testing procedures of Watertight Compartments*
S26	*Strength and securing of Small Hatches on the Exposed Fore Deck*
S27	*Strength Requirements for Fore Deck Fittings and Arrangements*

5. Application of Principles

5.4 Load-capacity Based Requirements

5.4.1 General

Paragraph 5.4.1.1 has been amended as follows.

5.4.1.1 In general, the Working Stress Design (WSD) method is applied in the requirements, except for the hull girder ultimate strength criteria where the ~~p~~Partial safety ~~f~~Factor (PF) method is applied. The partial safety factor format is applied for this highly critical failure mode to better account for uncertainties related to static loads, dynamic loads and capacity formulations.

5.6 Application of Rule Requirements

5.6.3 Design verification - hull girder ultimate strength

Paragraph 5.6.3.1 has been amended as follows.

5.6.3.1 The requirements for the ultimate strength of the hull girder are based on a ~~p~~Partial safety ~~f~~Factor (PF) method, see **4.5**. A safety factor is assigned to each of the basic variables, the still water bending moment, wave bending moment and ultimate capacity. The safety factors were determined using a structural reliability assessment approach, the long term load history distribution of the wave bending moment was derived using ship motion analysis techniques suitable for determining extreme wave bending moments.

Section 3 RULE APPLICATION

2. Documentation, Plans and Data Requirements

2.2 Submission of Plans and Supporting Calculations

2.2.3 Plans to be supplied onboard the ship

Sub-paragraph 2.2.3.1(h) has been added as follows.

2.2.3.1 One copy of the following plans indicating the new-building and renewal thickness for each structural item:

(a) main scantling plans as given in **2.2.2.1(a)**
(b) one copy of the final approved loading manual, see **2.1.1**
(c) one copy of the final loading instrument test conditions, see **Section 8/1.1.3**
(d) detailed construction plans as given in **2.2.2.1(c)**
(e) welding
(f) details of the extent and location of higher tensile steel together with details of the specification and mechanical properties, and any recommendations for welding, working and treatment of these steels
(g) details and information on use of special materials, such as aluminium alloy, used in the hull construction.
(h) towing and mooring arrangements plan, see **Section 11/3.1.6.16**

5. Calculation and Evaluation of Scantling Requirements

5.1 Determination of Scantling Requirements for Plates

5.1.3 Determination of scantlings of elementary plate panels for hull girder strength

Sub-paragraph 5.1.3.4(c) has been amended as follows.

5.1.3.4 The required scantling of a plate strake is to be taken as the greatest value required for each EPP within that strake as given by:

(a) an EPP positioned entirely within the strake boundaries, e.g. EPP2 in **Fig. 3.5.2**
(b) an EPP with a strake boundary weld seam bisecting it predominantly in the direction of the long edge of the EPP, e.g. EPP 1, 3, 4 and 6 in **Fig. 3.5.2**
(c) an EPP with a strake boundary weld seam bisecting it predominantly in the direction of the short edge of the EPP within more than half the EPP breadth, ~~sepp~~ s_{epp}, from the edge, e.g. EPP 1 and 2 in **Fig. 3.5.3(a)**.

5.3 Calculation and Evaluation of Scantling Requirements for Primary Support Members

5.3.3 Bending requirements of primary support members

Paragraph 5.3.3.4 has been amended as follows.

5.3.3.4 Where it is impracticable to fit a primary support member with the required web depth, then it is permissible to fit a member with reduced depth provided that the fitted member has equivalent moment of inertia or deflection to the required member. The required equivalent moment of inertia is to be based on an equivalent section given by the effective width of plating at mid span with required plate thickness, web of required depth and thickness and face plate of sufficient width and thickness to satisfy the required mild steel section modulus. All other rule requirements, such as minimum thicknesses, ~~(s/t)~~ slenderness ratio, section modulus and shear area, are to be satisfied for the member of reduced depth. The equivalent moment of inertia may be also demonstrated by an equivalent member having the same deflection as the required member.

Section 4 BASIC INFORMATION

1. Definitions

1.1 Principal Particulars

1.1.5 Draughts

Paragraph 1.1.5.2 has been amended as follows.

1.1.5.2 T_{bal}, is the minimum design ballast draught, in metres, at which the strength requirements for the scantlings of the ship are met. The minimum design ballast draught is not to be greater than the minimum ~~ballast~~ draught of ballast conditions including ballast water exchange operation, measured from the moulded base line at amidships, for any ballast loading condition in the loading manual including both departure and arrival conditions.

Paragraph 1.1.5.3 has been amended as follows.

1.1.5.3 $T_{bal\text{-}n}$, the normal ballast draught in metres, is the draught at departure given for the normal ballast condition in the loading manual, measured from the moulded base line at amidships, see **Section 8/1.1.2.3**. The normal ballast condition is the ballast condition in compliance with condition specified in **Section 8/1.1.2.2(a)**.

Paragraph 1.1.5.4 has been amended as follows.

1.1.5.4 T_{full}, the full load design draught in metres, is the draught at departure given for the homogeneous full load condition in the loading manual, measured from the moulded base line at amidships, see **Section 8/1.1.2.3**. ~~This draught is also known as the full load design draught.~~

1.1.9 Block coefficient

Paragraph 1.1.9.1 has been amended as follows.

1.1.9.1 C_b, the block coefficient at the scantling draught, is defined as:

$$C_b = \frac{\nabla}{L B_{WL} T_{sc}}$$

Where:

∇	: moulded displacement volume at the scantling draught, in m^3
L	: rule length, as defined in **1.1.1.1**
B_{WL}	: moulded breadth measured amidships, in m, at the scantling draught waterline
T_{sc}	: scantling draught, as defined in **1.1.5.5**

Paragraph 1.1.9.2 has been added as follows.

1.1.9.2 C_{b-LC}, the block coefficient at considered loading condition, is defined as:

$$C_{b-LC} = \frac{\nabla_{LC}}{L B_{WL} T_{LC}}$$

Where:

∇_{LC}	: moulded displacement volume at the T_{LC}, in m^3
L	: rule length, as defined in **1.1.1.1**
B_{WL}	: moulded breadth measured amidships, in *m*, at the T_{LC}
T_{LC}	: draught at amidships, in *m*, in the loading condition being considered.

In table 4.1.1, the definition of "Gusset" has been amended as follows.

Gusset	A ~~triangular~~ plate, usually fitted to distribute forces at a strength connection between two structural members

In table 4.1.1, the definition of "Hopper plating" has been amended as follows.

Hopper plating	Plating running the length of a compartment sloping between the inner bottom ~~tank top~~ and vertical portion of inner hull longitudinal bulkhead ~~side shell~~

2. Structural Idealisation

2.2 Definition of Spacing and Supported Breadth

2.2.2 Spacing and supporting load breadth of primary support members

Paragraph 2.2.2.2 has been amended as follows.

2.2.2.2 Unless specifically defined elsewhere in the Rules, the loading breadth supported by a girder is defined as half the sum of the primary support member spacing on each side, see **Fig. 4.2.9**.

2.2.3 Effective spacing of curved plating

Paragraph 2.2.3.1 has been amended as follows.

2.2.3.1 For curved plating the stiffener spacing or the primary support member spacing, *s* or *S*, is to be measured on the mean chord between members.

2.4 Geometrical Properties of Local Support Members

2.4.3 Effective plastic section modulus and shear area of stiffeners

Paragraph 2.4.3.2 has been amended as follows.

2.4.3.2 The effective net plastic section modulus, Z_{pl-net}, of local support members is to be taken as:

$$Z_{pl-net} = \frac{f_w \, d_w{}^2 \, t_{w-net} \sin\varphi_w}{2000} + \frac{(2\gamma - 1) A_{f-net} \left(h_{f-ctr} \sin\varphi_w - b_{f-ctr} \cos\varphi_w\right)}{1000} \quad (cm^3)$$

Where:

f_w : web shear stress factor
= 0.75 for flanged profile cross-sections with n = 1 or 2
= 1.0 for flanged profile cross-sections with n = 0 and for flat bar stiffeners

n : number of moment effective end supports of each member ~~Each member may have~~ = 0, 1 or 2 ~~moment effective end supports. A moment~~
effective end support may be considered where:
(a) the stiffener is continuous at the support
(b) the stiffener passes through the support plate while it is connected at it's termination point by a carling (or equivalent) to adjacent stiffeners ~~beams~~
(c) the stiffener is attached to a abutting stiffener ~~beam~~ effective in bending (not a buckling stiffener) or bracket. The bracket is assumed to be bending effective when it is attached to another stiffener ~~beam~~ (not a buckling stiffener).

d_w : depth of stiffener web, in *mm*
= h_{stf} - t_{f-net}~~grs~~ for T, L (rolled and built up) and L2 profiles
= h_{stf} for flat bar and L3 profiles
to be taken as given in **Table 4.2.3** and **Table 4.2.4** for bulb profiles

h_{stf} : stiffener height, in *mm*, see **Fig. 4.2.12**

γ = $0.25\left(1+\sqrt{3+12\beta}\right)$

β = 0.5 for all cases, except L profiles without a mid span tripping bracket

$$= \frac{10^6 t^2{}_{w-net} \, f_b \, l_f^2}{80 \, b_f^2 \, t_{f-net} \, h_{f-ctr}} + \frac{t_{w-net}}{2 b_f}$$

but not to be taken greater than 0.5 for L (rolled and built-up) profiles without a mid span tripping bracket

A_{f-net} : net cross-sectional area of flange, in mm^2
= $b_f \, t_{f-net}$ in general
= 0 for flat bar stiffeners

b_f : breadth of flange, in *mm*, see **Fig. 4.2.12**. For bulb profiles, see **Table 4.2.3** and **Table 4.2.4**

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

$= 0.5\left(b_f - t_{w-grs}\right)$ for rolled angle profiles

$= 0$ for T profiles

as given in **Table 4.2.3** and **Table 4.2.4** for bulb profiles

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

$= h_{stf} - 0.5\ t_{f\text{-}net}$~~grs~~ for profiles with flange of rectangular shape except for L3 profiles

$= h_{stf} - d_{edge} - 0.5\ t_{f\text{-}net}$~~grs~~ for L3 profiles

as given in **Table 4.2.3** and **4.2.4** for bulb profiles

d_{edge} : distance from upper edge of web to the top of the flange, in *mm*. For L3 profiles,see **Fig. 4.2.12**

f_b =1.0 in general

=0.8 for continuous flanges with end bracket(s). A continuous flange is defined as a flange that is not sniped and continuous through the primary support member

=0.7 for non-continuous flanges with end bracket(s). A non-continuous flange is defined as a flange that is sniped at the primary support member or terminated at the support without aligned structure on the other side of the support

l_f : length of stiffener flange between supporting webs, in *m*, but reduced by the arm length of end bracket(s) for stiffeners with end bracket(s) fitted

$t_{f\text{-}net}$: net flange thickness, in *mm*

= 0 for flat bar stiffeners given in **Table 4.2.3** and **Table 4.2.4** for bulb profiles

$t_{w\text{-}net}$: net web thickness, in *mm*

φ_w : angle between the stiffener web and the plate flange, see **Fig. 4.2.14**, in *degrees*. φ_w is to be taken as 90 *degrees* if the angle is greater than or equal to 75 *degrees*

2.5 Geometrical Properties of Primary Support Members

2.5.1 Effective shear area of primary support members

Paragraph 2.5.1.2 has been amended as follows.

2.5.1.2 For single and double skin primary support members, the effective net shear~~web~~ area, A_{shr}~~w~~$_{-net50}$, is to be taken as:

A_{shr}~~w~~$_{-net50} = 0.01\ h_n\ t_{w-net50}$ (cm^2)

Where:

h_n : for a single skin primary support member, see **Fig. 4.2.16**, the effective web height, in *mm*, is to be taken as the lesser of

(a) h_w

(b) $h_{n3} + h_{n4}$

(c) $h_{n1} + h_{n2} + h_{n4}$

: for a double skin primary support member, the same principle is to be adopted in determining the effective web height.

h_w : web height of primary support member, in *mm*

$h_{n1}, h_{n2}, h_{n3}, h_{n4}$: as shown in **Fig. 4.2.16**

$t_{w-net50}$: net web thickness

$= t_{w-grs} - 0.5\, t_{corr}$ (*mm*)

t_{w-grs} : gross web thickness, in *mm*

t_{corr} : corrosion addition, as given in **Section 6/3.2**, in *mm*

The title of Fig. 4.2.16 has been amended as follows.

Fig. 4.2.16 Effective Shear~~Web~~ Area in way of Openings

Paragraph 2.5.1.4 has been amended as follows.

2.5.1.4 Where a girder flange of a single skin primary support member is not parallel to the axis of the attached plating, the effective net shear~~web~~ area, $A_{\underline{shr}\cancel{w}-net50}$, is to be taken as:

$$A_{\underline{shr}\cancel{w}-net50} = 0.01\, h_n\, t_{w-net50} + 1.3\, A_{f-net50} \sin 2\theta \sin\theta \qquad (cm^2)$$

Where:

$A_{f-net50}$: net flange/face plate area

$= 0.01\, b_f\, t_{f-net50}$ (cm^2)

b_f : breadth of flange or face plate, in *mm*

$t_{f-net50}$: net flange thickness

$= t_{f-grs} - 0.5 t_{corr}$ (*mm*)

t_{f-grs} : gross flange thickness, in *mm*

t_{corr} : corrosion addition, as given in **Section 6/3.2**, in *mm*

θ : angle of slope of continuous flange, see **Fig. 4.2.17**

$t_{w-net50}$: net web thickness, as defined in **2.5.1.2**, in *mm*

h_n : effective web height, as defined in **Fig. 4.2.16**, in *mm*

The title of Fig. 4.2.17 has been amended as follows.

Fig. 4.2.17 Effective Shear~~Web~~ Area in way of Brackets

2.6 Geometrical Properties of the Hull Girder Cross-Section

2.6.4 Effective vertical hull girder shear area

Paragraph 2.6.4.5 has been amended as follows.

2.6.4.5 The equivalent net corrugation thickness, $t_{cg\text{-}net50}$, is only applicable for the calculation of the effective area, $A_{eff\text{-}net50}$, and shear force distribution factor, f_i as defined in **Section 8/1.3.2.2**.

3. Structure Design Details

3.3 Termination of Primary Support Members

3.3.2 End connection

Paragraph 3.3.2.2 has been amended as follows.

3.3.2.2 The ends of bBrackets are generally to be soft-toedradiused or well-rounded at their toes. The free edges of the brackets are to be stiffened. Scantlings and details are given in **3.3.3**.

3.3.3 Brackets

Paragraph 3.3.3.1 has been amended as follows.

3.3.3.1 In general, the arm lengths of brackets connecting primary support members are not to be less than the web depth of the member, and need not be taken as greater than 1.5 times the web depth. ~~The two arms of a bracket are to be of approximately equal lengths~~. The thickness of the bracket is, in general, not to be less than that of the girder web plate.

Paragraph 3.3.3.2 has been amended as follows.

3.3.3.2 For a ring system where the end bracket is integral with the webs of the members and the face plate is carried continuously along the edges of the members and the bracket, the full area of the largest face plate is to be maintained close to the mid point of the bracket and gradually tapered to the smaller face plates. Butts in face plates are to be kept well clear of the bracket toes~~radius ends~~.

3.4 Intersections of Continuous Local Support Members and Primary Support Members

3.4.3 Connection between primary support members and intersecting stiffeners (local support members)

Paragraph 3.4.3.3 has been amended as follows.

3.4.3.3 The load, W_1, transmitted through the shear connection is to be taken as follows.~~:~~
If the web stiffener is connected to the intersecting stiffener:

$$W_1 = W\left(\alpha_a + \frac{A_{1-net}}{4 f_c A_{w-net} + A_{1-net}}\right) \qquad (kN)$$

If the web stiffener is not connected to the intersecting stiffener:

$W_1 = W$ ~~if the web stiffener is not connected to the intersecting stiffener~~

Where:

W : the total load, in kN, as defined in **3.4.3.2**

α_a : panel aspect ratio, not to be taken greater than 0.25

$$= \frac{s}{1000\, S}$$

S : primary support member spacing, in m

s : stiffener spacing, in mm

A_{1-net} : effective net shear area of the connection, to be taken as the sum of the components of the connection

$$A_{1d-net} + A_{1c-net} \qquad (cm^2)$$

in case of a slit type slot connections area, A_{1-net}, is given by:

$$A_{1-net} = 2 l_d t_{w-net} 10^{-2} \qquad (cm^2)$$

in case of a typical double lug or collar plate connection area, A_{1-net}, is given by:

$$A_{1-net} = 2 f_1 l_c t_{c-net} 10^{-2} \qquad (cm^2)$$

Paragraph 3.4.3.4 has been amended as follows.

3.4.3.4 The load, W_2, transmitted through the primary support member web stiffener is to be taken as follows.~~:~~
If the web stiffener is connected to the intersecting stiffener:

$$W_2 = W\left(1 - \alpha_a - \frac{A_{1-net}}{4 f_c A_{w-net} + A_{1-net}}\right) \qquad (kN)$$

If the web stiffener is not connected to the intersecting stiffener:

$W_2 = 0$

Where:

W : the total load, in kN, as defined in **3.4.3 2**

α_a : panel aspect ratio

$$= \frac{s}{1000\, S}$$

S : primary support member spacing, in m

s	: stiffener spacing, in *mm*
$A_{1\text{-}net}$	: effective net shear area of the connection, in cm^2, as defined in **3.4.3.3**
f_c	: collar load factor, as defined in **3.4.3.3**
$A_{w\text{-}net}$	: effective net cross-sectional area of the primary support member web stiffener , in cm^2, as defined in **3.4.3.3**

Section 6 Materials and Welding

5. Weld Design and Dimensions

5.5 Slot Welds

5.5.2 Closing plates

Paragraph 5.5.2.2 has been amended as follows.

5.5.2.2 Slots are to be well rounded and have a minimum slot length, l_{slot}, of 90*mm* and a minimum ~~maximum~~ width, w_{slot}, of twice the gross plate thickness. Slots cut in plating are to have smooth, clean and square edges and are in general to be spaced a distance, s_{slot}, not greater than 140*mm*. Slots are not to be filled with welding.

Paragraph 5.5.3 and paragraph 5.5.3.1 have been deleted.

~~**5.5.3 Rudder closing plates**~~

~~5.5.3.1 Connection of rudder side plating to vertical and horizontal webs, where internal access for welding is not practicable, may be by means of slot welds on to flat bars on the webs. The slots are to have a minimum slot length, l_{slot}, of 75*mm* and in general, a minimum width, w_{slot}, of twice the side plating gross thickness. The ends of the slots are to be rounded. The space between the slots, s_{slot}, is not to be greater than 150*mm* and welding is to be based on a weld factor of 0.54, in association with the fillet leg size requirements of **5.7.1.2**.~~

5.7 Determination of the Size of Welds

5.7.1 General

Paragraph 5.7.1.2 has been amended as follows.

5.7.1.2 The leg length, l_{leg}, as shown in **Fig. 6.5.8**, of continuous, lapped or intermittent fillet welds, in association with the requirements of **5.7.2** to **5.7.5**, is not to be taken as less than:

(a) $l_{leg} = f_1 t_{p-grs}$

(b) $l_{leg} = f_{yd} f_{weld} f_2 t_{p-grs} + t_{gap}$

(c) l_{leg} as given in **Table 6.5.2**

Where:

f_1 = 0.30 for double continuous welding
= 0.38 for intermittent welding

$t_{p\text{-}grs}$: the gross plate thickness, in *mm*. Is generally to be taken as that of the abutting member (member being attached). See **5.7.1.5**

f_{yd} : correction factor taking into account the yield strength of the weld deposit

$$= \left(\frac{1}{k}\right)^{0.5} \left(\frac{235}{\sigma_{weld}}\right)^{0.75}$$ but is not to be taken as less than 0.707

σ_{weld} : minimum yield stress of the weld deposit, and is not to be less than
305N/mm^2 for welding of normal strength steel
375N/mm^2 for welding of higher strength steels with yield strength of 265 to 355N/mm^2
400 N/mm^2 for welding of higher strength steel with yield strength of 390N/mm^2

See **5.9.4** for additional requirements that are to be applied where the weld size is determined based on a weld deposit yield strength that exceeds the specified minimum value

k : higher strength steel factor, as defined in **1.1.4**. k is to be based on the material of the abutting member

f_{weld} : weld factor depending on the type of structural member, see **5.7.2, 5.7.3 and 5.7.5** ~~**5.7.1 and 5.7.4**~~

f_2 : correction factor for the type of weld
1.0 for double continuous fillet
$\frac{s_{ctr}}{l_{weld}}$ for intermittent or chain welding

l_{weld} : the actual length of weld fillet, clear of crater, in *mm*

s_{ctr} : the distance between successive weld fillets, from centre to centre, in *mm*

t_{gap} : allowance for weld gap (lesser gaps may be permitted, see **5.9.2**)
$=2.0mm$ for $t_{p\text{-}grs} > 6.5mm$
$= 2\left(1.25 - \frac{1}{f_2}\right)(mm)$ for $t_{p\text{-}grs} \le 6.5mm$

5.7.3 Welding of primary support members

Table 6.5.4 has been amended as follows.

Table 6.5.4 Connection of Primary Support Members

Primary Support Member gross face area, in cm^2		Position (1)	Weld factor, f_{weld}			
			In tanks		In dry spaces	
Greater than	Not greater than		To face plate	To plating	To face plate	To plating
	30.0	At ends Remainder	0.20 0.12	0.26 0.20	0.20 0.12	0.20 0.15
30.0	65.0	At ends Remainder	0.20 0.12	0.38 0.26	0.20 0.12	0.20 0.15
65.0	95.0	At ends Remainder	0.42 0.30 (2)	0.59 (3) 0.42	0.20 0.15	0.30 0.20
95.0	130.0	At ends Remainder	0.42 0.30 (2)	0.59 (3) 0.42	0.30 0.20	0.42 0.30
130.0		At ends Remainder	0.59 0.42	0.59 (3) 0.42	0.42 0.30	0.59 (3) 0.42

Note

1. The weld factors 'at ends' are to be applied for 0.2 *times* the overall length of the member from each end, but at least beyond the toe of the member end brackets. On vertical webs, the increased welding may be omitted at the top, but is to extend at least 0.3 *times* overall length from the bottom.
2. Weld factor 0.38 to be used for cargo tanks.
3. Where the web plate thickness is increased locally to meet shear stress requirements, the weld size may be based on the gross web thickness clear of the increased area, but is to be not less than weld factor of 0.42 based on the increased gross thickness.
4. In regions of high stress, see **5.3.4**, **5.7.4** and **5.8**.

Table 6.5.5 has been amended as follows.

Table 6.5.5 Stiffener End Connection Welds

Connection	Weld area, A_{weld}, in cm^2	Weld Factor, f_{weld} (1)
(1) Stiffener welded direct to plating	$0.25A_{stf\text{-}grs}$ or 6.5 cm^2 whichever is the greater	0.38
(2) Bracketless connection of stiffeners, stiffener lapped to bracket or bracket lapped to stiffener:		
(a) in dry space	$1.2\sqrt{Z_{grs}}$	0.26
(b) in tank	$1.4\sqrt{Z_{grs}}$	0.38
(c) main frame to tank side bracket in 0.15L forward	as **(a)** or **(b)**	0.38
(3) Bracket welded to face of stiffener and bracket connection to plating	—	0.38

Where:

$A_{stf\text{-}grs}$ gross cross sectional area of the stiffener, in cm^2

A_{weld} weld area, in cm^2, and is calculated as total length of weld, in *cm*, *times* throat thickness, in *cm* (Where the gap exceeds 2*mm* the weld size is to be increased. See **5.7.1.6**)

Z_{grs} the gross section modulus required, in cm^3, of the stiffener on which the scantlings of the bracket are based

Note

1. For minimum weld fillet sizes, see **Table 6.5.2**.

Section 7 LOADS

2. Static Load Components

2.2 Local Static Loads

2.2.3 Static tank pressure

Paragraph 2.2.3.2 has been amended as follows.

2.2.3.2 The static tank pressure, P_{in-air}, in the case of overfilling or filling during flow through ballast water exchange, is to be taken as:

$$P_{in-air} = \rho_{sw} g z_{air} \qquad (kN/m^2)$$

Where:

z_{air} : vertical distance from top of air pipe or overflow pipe to the load point, whichever is the lesser, see **Fig. 7.2.3**, in *m*
$= z_{tk} + h_{air}$

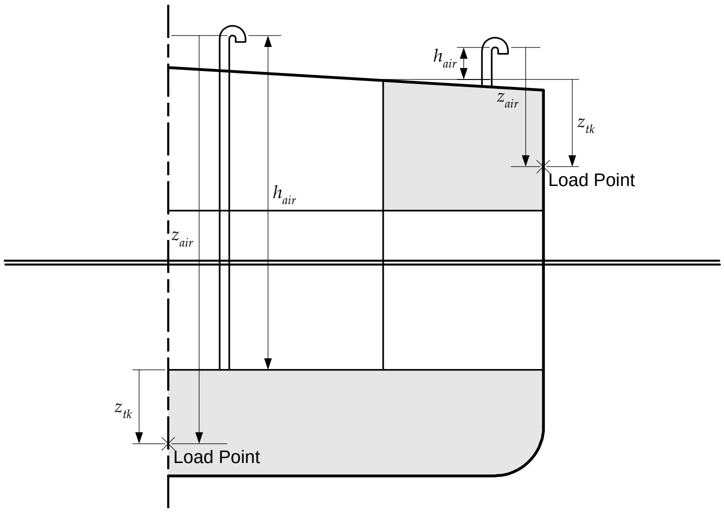
ρ_{sw} : density of sea water, 1.025 $tonnes/m^3$

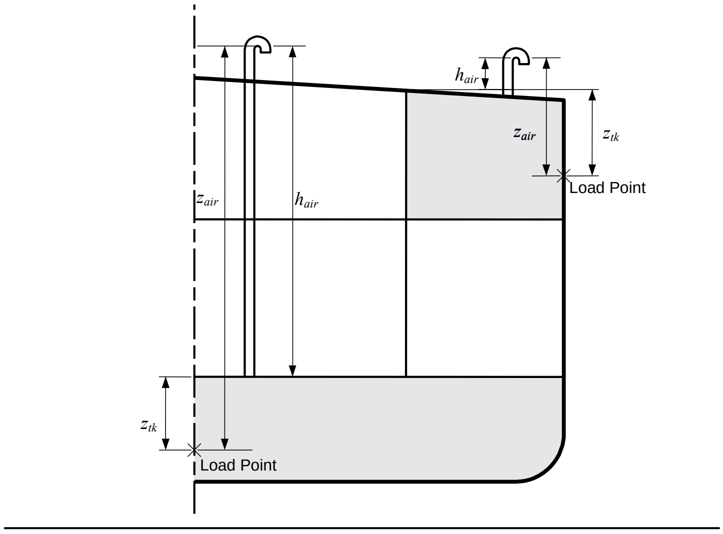
g : acceleration due to gravity, 9.81 m/s^2

h_{air} : height of air pipe or overflow pipe, in *m*, is not to be taken less than 0.76 *m* above highest point of tank, excluding small hatchways. For tanks with tank top below the weather deck the height of air-pipe or overflow pipe is not to be taken less than 0.76*m* above deck at side unless a lesser height is approved by the flag Administration ~~the tanks are arranged with overflow tank or equivalent~~. See also **Fig. 7.2.3**.

Fig.7.2.3 has been amended as follows.

Fig. 7.2.3 Pressure-Heads and Distances used for Calculation of Static Tank Pressure





3. Dynamic Load Components

3.1 General

3.1.3 Metacentric height and roll radius of gyration

3.1.3.1 The metacentric height, *GM*, and roll radius of gyration, $r_{roll\text{-}gyr}$, associated with the rule loading conditions or specified draughts are specified in **Table 7.3.1**.

Table 7.3.1 has been amended as follows.

Table 7.3.1 *GM* and $r_{roll\text{-}gyr}$

	T_{LC}	*GM*	$r_{roll\text{-}gyr}$
Loaded at deep draught	between 0.9T_{sc} and T_{sc}	0.12*B*	0.35*B*
Loaded on reduced draught	0.6T_{sc}	0.24*B*	0.40*B*
In ballast	T_{bal}	0.33*B*	0.45*B*

Where:

B	: moulded breadth, in *m*, as defined in **Section 4/1.1.3.1**
T_{LC}	: draught in the loading condition being considered, in *m*
T_{sc}	: scantling draught, in *m*, as defined in **Section 4/1.1.5.5**
T_{bal}	: minimum design ballast draught, in *m*, as defined in **Section 4/1.1.5.2**
$T_{bal\text{-}n}$	: normal ballast draught, in *m*, as defined in **Section 4/1.1.5.3**

3.3 Ship Accelerations

3.3.3 Vertical acceleration

Paragraph 3.3.3.3 has been amended as follows.

3.3.3.3 For fatigue strength:

f_{prob} is to be taken as 0.45

$$f_V = \left(\frac{C_{b-LC}}{C_b}\right)^2 \left(1.2 - \frac{L}{1000}\right)$$

Where:

C_{b-LC} : block coefficient for considered loading condition, as defined in **Section 4/1.1.9.2**

C_b : block coefficient, as defined in **Section 4/1.1.9.1**

L : rule length, in *m*, as defined in **Section 4/1.1.1.1**

4. Sloshing and Impact Loads

4.3 Bottom Slamming Loads

4.3.1 Application and limitations

Paragraph 4.3.1.1 has been amended as follows.

4.3.1.1 The slamming loads in this section apply to ships with $C_b \geq 0.7$ and bottom slamming draught $\geq$ $0.01L$ ~~$0.02L$~~ and $\leq 0.045L$.

4.4 Bow Impact Loads

4.4.1 Application and limitations

Paragraph 4.4.1.1 has been amended as follows.

4.4.1.1 The bow impact pressure applies to the side structure in the area forward of $0.1L$ aft of F.P. and between the ~~static~~ waterline at draught T_{bal} and the highest deck at side.

4.4.2 Bow impact pressure

Paragraph 4.4.2.1 has been amended as follows.

4.4.2.1 The bow impact pressure, P_{im}, is to be taken as:

$$P_{im} = 1.025 f_{im} c_{im} V_{im}^2 \sin\gamma_{wl} \qquad (kN/m^2)$$

Where:

f_{im}	0.55 at $0.1L$ aft of F.P. 0.9 at $0.0125L$ aft of F.P. 1.0 at and forward of F.P. intermediate values to be obtained by linear interpolation
V_{im}	: impact speed, in *m/s* $= 0.514 V_{fwd} \sin\alpha_{wl} + \sqrt{L}$
V_{fwd}	: forward speed, in knots $= 0.75V$ but is not to be taken as less than 10
V	: service speed, in knots, as defined in **Section 4/1.1.8.1**
$\alpha_{\omega l}$	: local waterline angle at the position considered, but is not to be taken as less than 35 *degrees*, see **Fig. 7.4.6**.
$\gamma_{\omega l}$	: local bow impact angle measured normal to the shell from the horizontal to the tangent line at the position considered but is not to be less than 50 *degrees*, see **Fig. 7.4.6**.
c_{im}	1.0 for positions between draughts T_{bal} and T_{sc} $= \sqrt{1 + \cos^2[90\frac{(h_{fb} - 2h_o)}{h_{fb}}]}$ for positions above draught T_{sc}
h_{fb}	: vertical distance from the waterline at draught T_{sc} to the highest deck at side, see **Fig. 7.4.6**, in *m*
h_o	: vertical distance from the waterline at draught T_{sc}, to the position considered, see **Fig. 7.4.6**, in *m*
L	: rule length, in *m*, as defined in **Section 4/1.1.1.1**
T_{sc}	: scantling draught, in *m*, as defined in **Section 4/1.1.5.5**
T_{bal}	: minimum design ballast draught, in *m*, for the normal ballast condition as defined in **Section 4/1.1.5.2**
WL_j	: waterline at the position considered, see **Fig. 7.4.6**

Guidance Note

Where local bow impact angle measured normal to the shell, $\gamma_{\omega l}$, is not available, this angle may be taken as:

$$\gamma_{\omega l} = \tan^{-1}\left(\frac{\tan\beta_{pl}}{\cos\alpha_{wl}}\right)$$

Where

β_{pl} local body plan angle at the position considered from the horizontal to the tangent line, but is not to be less than 35 *degrees*

Section 8 SCANTLING REQUIREMENTS

1. Longitudinal Strength

1.3 Hull Girder Shear Strength

1.3.2 Assessment of hull girder shear strength

Paragraph 1.3.2.2 has been amended as follows.

1.3.2.2 The permissible positive and negative still water shear forces for seagoing and harbour/sheltered water operations, $Q_{sw\text{-}perm\text{-}sea}$ and $Q_{sw\text{-}perm\text{-}harb}$ are to satisfy:

$$Q_{sw-perm} \le Q_{v-net50} - Q_{wv-pos} \qquad (kN)$$

for maximum permissible positive shear force

$$Q_{sw-perm} \ge -Q_{v-net50} - Q_{wv-neg} \qquad (kN)$$

for minimum permissible negative shear force

Where:

$Q_{sw\text{-}perm}$: permissible hull girder still water shear force as given in **Table 8.1.4**, in *kN*

$Q_{v\text{-}net50}$: net hull girder vertical shear strength to be taken as the minimum for all plate elements that contribute to the hull girder shear capacity

$$= \frac{\tau_{ij-perm} t_{ij-net50}}{1000 q_v} \qquad (kN)$$

$\tau_{ij\text{-}perm}$: permissible hull girder shear stress, τ_{perm}, as given in **Table 8.1.4**, in N/mm^2 , for plate *ij*

$Q_{wv\text{-}pos}$: positive vertical wave shear force, in *kN*, as defined in **Table 8.1.4**

$Q_{wv\text{-}neg}$: negative vertical wave shear force, in *kN*, as defined in **Table 8.1.4**

$t_{ij\text{-}net50}$: equivalent net thickness, t_{net50}, for plate ij, in *mm*. For longitudinal bulkheads between cargo tanks, t_{net50} is to be taken as $t_{sfc\text{-}net50}$ and $t_{str\text{-}k}$ as appropriate, see **1.3.3.1** and **1.3.4.1**

t_{net50} : net thickness of plate, in *mm*

$$= t_{grs} - 0.5 t_{corr}$$

t_{grs} : gross plate thickness, in *mm*. The gross plate thickness for corrugated bulkheads is to be taken as the minimum of $t_{w\text{-}grs}$ and $t_{f\text{-}grs}$, in *mm*

$t_{w\text{-}grs}$: gross thickness of the corrugation web, in *mm*

$t_{f\text{-}grs}$: gross thickness of the corrugation flange, in *mm*

t_{corr} : corrosion addition, in *mm*, as defined in **Section 6/3.2**

q_v : unit shear flow per *mm* for the plate being considered and based on the net scantlings. Where direct calculation of the unit shear flow is not available, the unit shear flow may be taken equal to:

$$= f_i\left(\frac{q_{1-net50}}{I_{v-net50}}\right)\cdot 10^{-9} \qquad (mm^{-1})$$

f_i : shear force distribution factor for the main longitudinal hull girder shear carrying members being considered. For standard structural configurations f_i is as defined in **Fig. 8.1.2**

$q_{1-net50}$: first moment of area, in cm^2, about the horizontal neutral axis of the effective longitudinal members between the vertical level at which the shear stress is being determined and the vertical extremity ~~of effective shear carrying members, in cm^3~~, taken at the section being considered. The first moment of area is to be based on the net thickness, t_{net50}

$I_{v-net50}$: net vertical hull girder section moment of inertia, in m^4, as defined in **Section 4/2.6.1.1**

2. Cargo Tank Region

2.1 General

2.1.6 Minimum thickness for primary support members

Table 8.2.2 has been amended as follows.

Table 8.2.2 Minimum Net Thickness for Primary Support Members in Cargo Tank Region

Scantling Location	Net Thickness (mm)
Double bottom centreline girder	$5.5+0.025L_2$
Other double bottom girders	$5.5+0.02L_2$
Double bottom floors, web plates of side transverses and stringers in double hull	$5.0+0.015L_2$
Web and flanges of vertical web frames on longitudinal bulkheads, horizontal stringers on transverse bulkhead, ~~and~~ deck transverses (above and below upper deck) and cross ties	$5.5+0.015L_2$
Where: L_2 : rule length, L, as defined in **Section 4/1.1.1.1**, but need not be taken greater than 300m	

2.2 Hull Envelope Plating

2.2.3 Bilge plating

Paragraph 2.2.3.2 has been amended as follows.

2.2.3.2 The net thickness of bilge plating, t_{net}, without longitudinal stiffening is not to be less than:

$$t_{net} = \frac{\sqrt[3]{r^2 S_t P_{ex}}}{100} \qquad (mm)$$

Where:

P_{ex} : design sea pressure for the design load set 1 calculated at the lower turn of bilge, in kN/m^2

r : effective bilge radius

$= r_0 + 0.5(a+b) \qquad (mm)$

r_0 : radius of curvature, in *mm*. See **Fig. 8.2.1**

S_t : distance between transverse stiffeners, webs or bilge brackets, in *m*

a : distance between the lower turn of bilge and the outermost bottom longitudinal, in *mm*, see **Fig. 8.2.1** and **2.3.1.2**. Where the outermost bottom longitudinal is within the curvature, this distance is to be taken as zero.

b : distance between the upper turn of bilge and the lowest side longitudinal, in *mm*, see **Fig. 8.2.1** and **2.3.1.2**. Where the lowest side longitudinal is within the curvature, this distance is to be taken as zero.

Where plate seam is located in the straight plate just below the lowest stiffener on the side shell, any increased thickness required for the bilge plating does not have to extend to the adjacent plate above the bilge provided that the plate seam is not more than *sb*/4 below the lowest side longitudinal. Similarly for flat part of adjacent bottom plating, any increased thickness for the bilge plating does not have to be applied provided that the plate seam is not more than *sa*/4 beyond the outboard bottom longitudinal. Regularly longitudinally stiffened bilge plating is to be assessed as a stiffened plate. The bilge keel is not considered as “longitudinal stiffening” for the application of this requirement.

2.5 Bulkheads

2.5.6 Corrugated bulkheads

Paragraph 2.5.6.5 has been amended as follows.

2.5.6.5 Where the corrugated bulkhead is built with flange and web plate of different thickness ~~thicknesses are different~~, then the thicker net plating thickness, t_{m-net}, is to be taken as the greatest value calculated for all applicable design load sets, as given in **Table 8.2.7**, and given by:

$$t_{m-net} = \sqrt{\frac{0.0005 b_p^2 |P|}{C_a \sigma_{yd}} - t_{n-net}^2} \qquad (mm)$$

Where:

t_{n-net} : net thickness of the thinner plating, either flange or web, in *mm*

b_p : breadth of thicker plate, either flange or web, in *mm*

P : design pressure for the design load set being considered, calculated at the load point defined in **Section 3/5.1**, in kN/m^2

C_a : permissible bending stress coefficient

= 0.75 for acceptance criteria set AC1

= 0.90 for acceptance criteria set AC2

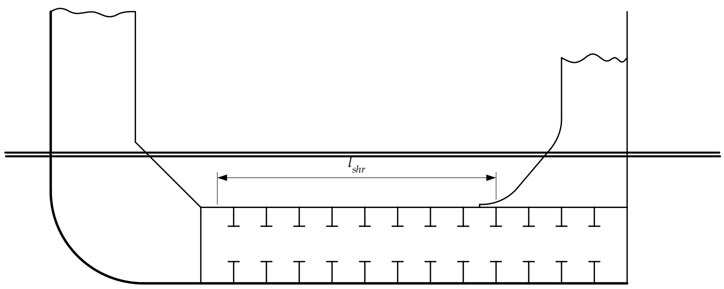
σ_{yd} : specified minimum yield stress of the material, in N/mm^2

2.6 Primary Support Members

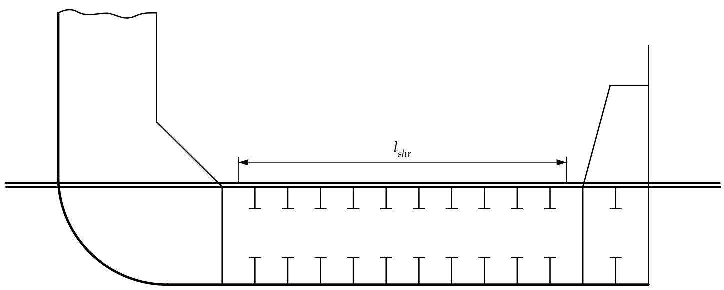
2.6.3 Floors and girders in double bottom

Fig. 8.2.6 has been amended as follows.

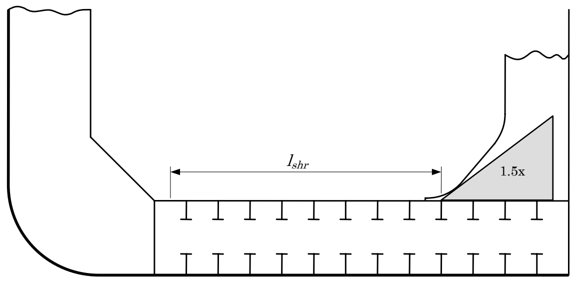
Fig. 8.2.6 Effective Shear Span of Floors



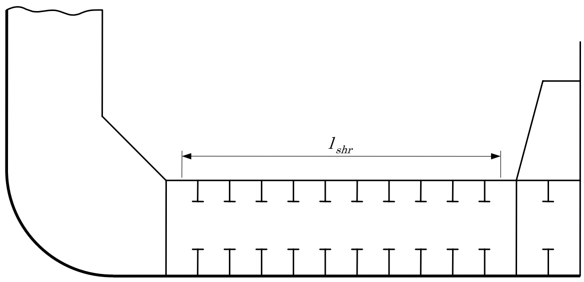
typical arrangement with hopper and end bracket



typical arrangement with hopper and stool



Typical arrangement with hopper and end bracket



Typical arrangement with hopper and stool

2.6.4 Deck transverses

Paragraph 2.6.4.1 has been amended as follows.

2.6.4.1 The web depth of deck transverses is not to be less than:

(a) 0.20 $l_{bdg\text{-}dt}$ for deck transverses in the wing cargo tanks of ships with two longitudinal bulkheads

(b) 0.13 $l_{bdg\text{-}dt}$ for deck transverses in the centre cargo tanks of ships with two longitudinal bulkheads. The web depth of deck transverses in the centre cargo tank is not to be less than 90% of that of the deck transverses in the wing cargo tank

(c) 0.10 $l_{bdg\text{-}dt}$ for the deck transverses of ships with a centreline longitudinal bulkhead.

(d) See also **2.6.1.7**

Where:

$l_{bdg\text{-}dt}$: effective bending span of the deck transverse, in *m*, see **Section 4/2.1.4** and **Fig. 8.2.7**, but is not to be taken as less than 60% of the breadth of the tank at the location being considered

Paragraph 2.6.4.3 has been amended as follows.

2.6.4.3 The net section modulus of deck transverses is not to be less than $Z_{in-net50}$ and $Z_{ex-net50}$ as given by the following. The net section modulus of the deck transverses in the wing cargo tanks is also not to be less than required for the deck transverses in the centre tanks.

$$Z_{in-net50} = \frac{1000 M_{in}}{C_{s-pr}\sigma_{yd}} \qquad (cm^3)$$

$$Z_{ex-net50} = \frac{1000 M_{ex}}{C_{s-pr}\sigma_{yd}} \qquad (cm^3)$$

Where:

M_{in} : design bending moment due to cargo pressure, in kNm, to be taken as:

(a) for deck transverses in wing cargo tanks of ships with two longitudinal bulkheads, and for deck transverses in cargo tanks of ships with a centreline longitudinal bulkhead:

~~$= 0.042\varphi P_{in-dt} S l_{bdg-dt}^2 + M_{st}$~~

$= 0.042\varphi_t P_{in-dt} S l_{bdg-dt}^2 + M_{st}$

but is not to be taken as less than M_o

(b) for deck transverses in centre cargo tank of ships with two longitudinal bulkheads:

~~$= 0.042\varphi P_{in-dt} S l_{bdg-dt}^2 + M_{vw}$~~

$= 0.042\varphi_t P_{in-dt} S l_{bdg-dt}^2 + M_{vw}$

but is not to be taken as less than M_o

M_{st} : bending moment transferred from the side transverse

$= c_{st}\beta_{st} P_{in-st} S l_{bdg-st}^2 \qquad (kNm)$

where a cross tie is fitted in a wing cargo tank and $l_{bdg-st-ct}$ is greater than $0.7 l_{bdg-st}$, then l_{bdg-st} in the above formula may be taken as $l_{bdg-st-ct}$.

M_{vw} : bending moment transferred from the vertical web frame on the longitudinal bulkhead

$= c_{vw}\beta_{vw} P_{in-vw} S l_{bdg-vw}^2 \qquad (kNm)$

where $l_{bdg-vw-ct}$ is greater than $0.7 l_{bdg-vw}$, then l_{bdg-vw} in the above formula may be taken as $l_{bdg-vw-ct}$.
for vertically corrugated bulkheads, M_{vw} is to be taken equal to bending moment in upper end of corrugation over the spacing between deck transverses

M_0 : minimum bending moment

$= 0.083 P_{in-dt} S l_{bdg-dt}^2 \qquad (kNm)$

M_{ex} : design bending moment due to green sea pressure

$= 0.067 P_{ex-dt} S l_{bdg-dt}^2 \qquad (kNm)$

P_{in-dt} : design cargo pressure for the design load set being considered, calculated at mid point of effective bending span, l_{bdg-dt}, of the deck transverse located at mid tank, in kN/m^2

P_{in-st} : corresponding design cargo pressure in wing cargo tank for the design load set being considered, calculated at the mid point of effective bending span, l_{bdg-st}, of the side transverse located at mid tank, in kN/m^2

P_{in-vw} : corresponding design cargo pressure in the centre cargo tank of ships with two longitudinal bulkheads for the design load set being considered, calculated at mid point of effective bending span, l_{bdg-vw}, of the vertical web frame on the longitudinal bulkhead located at mid tank, in kN/m^2

P_{ex-dt} : design green sea pressure for the design load set being considered, calculated at mid point of effective bending span, l_{bdg-dt}, of the deck transverse located at mid tank, in kN/m^2

<u>φ_t</u> ~~φ~~ $= 1 - 5\left(\dfrac{y_{toe}}{l_{bdg-dt}}\right)$ but is not to be taken as less than 0.6

y_{toe} : distance from the end of effective bending span, l_{bdg-dt}, to the toe of the end bracket of the deck transverse, in m

β_{st} $= 0.9\left(\dfrac{l_{bdg-st}}{l_{bdg-dt}}\right)\left(\dfrac{I_{dt}}{I_{st}}\right)$ but is not to be taken as less than 0.10 or greater than 0.65

β_{vw} $= 0.9\left(\dfrac{l_{bdg-vw}}{l_{bdg-dt}}\right)\left(\dfrac{I_{dt}}{I_{vw}}\right)$ but is not to be taken as less than 0.10 or greater than 0.50

S : primary support member spacing, in m, as defined in **Section 4/2.2.2**

l_{bdg-dt} : effective bending span of the deck transverse, in m, see **Section 4/2.1.4** and **Fig. 8.2.7**, but is not to be taken as less than 60% of the breadth of the tank <u>at the location being considered</u>

Paragraph 2.6.4.4 has been amended as follows.

2.6.4.4 The net shear area of deck transverses is not to be less than $A_{shr-in-net50}$ and $A_{shr-ex-net50}$ as given by:

$$A_{shr-in-net50} = \frac{10 Q_{in}}{C_{t-pr}\,\tau_{yd}} \qquad (cm^2)$$

$$A_{shr-ex-net50} = \frac{10 Q_{ex}}{C_{t-pr}\,\tau_{yd}} \qquad (cm^2)$$

Where:

Q_{in} : design shear force due to cargo pressure

$$= 0.65\, P_{in-dt}\, S\, l_{shr} + c_1\, D\, b_{ctr}\, S\, \rho\, g \qquad (kN)$$

Q_{ex}	: design shear force due to green sea pressure $= 0.65 P_{ex-dt} S l_{shr}$ (kN)
P_{in-dt}	: design cargo pressure for the design load set being considered, calculated at mid point of effective bending span, l_{bdg-dt}, of the deck transverse located at mid tank, in kN/m^2
P_{ex-dt}	: design green sea pressure for the design load set being considered, calculated at mid point of effective bending span, l_{bdg-dt}, of the deck transverse located at mid tank, in kN/m^2
S	: primary support member spacing, in *m*, as defined in **Section 4/2.2.2**
l_{shr}	: effective shear span, of the deck transverse, in *m*, see **Section 4/2.1.5**
l_{bdg-dt}	: effective bending span of the deck transverse, in *m*, see **Section 4/2.1.4** and **Fig. 8.2.7**, but is not to be taken as less than 60% of the breadth of the tank at the location being considered
c_1	= 0.04 in way of wing cargo tanks of ships with two longitudinal bulkheads = 0.00 in way of centre tank of ships with two longitudinal bulkheads = 0.00 for ships with a centreline longitudinal bulkhead
D	: moulded depth, in *m*, as defined in **Section 4/1.1.4**
b_{ctr}	: breadth of the centre tank, in *m*
ρ	: density of liquid in the tank, in $tonnes/m^3$, not to be taken less than 1.025, see **Section 2/3.1.8**
g	: acceleration due to gravity, 9.81 m/s^2
C_{t-pr}	: permissible shear stress coefficient for primary support member as given in **Table 8.2.10**
τ_{yd}	$= \frac{\sigma_{yd}}{\sqrt{3}}$ N/mm^2
σ_{yd}	: specified minimum yield stress of the material, in N/mm^2

2.6.7 Horizontal stringers on transverse bulkheads

Paragraph 2.6.7.1 has been amended as follows.

2.6.7.1 The web depth of horizontal stringers on transverse bulkhead is not to be less than:

(a) 0.28 l_{bdg-hs} for horizontal stringers in wing cargo tanks of ships with two longitudinal bulkheads
(b) 0.20 l_{bdg-hs} for horizontal stringers in centre tanks of ships with two longitudinal bulkheads, but the web depth of horizontal stringers in centre tank is not to be less than required depth for a horizontal stringer in wing cargo tanks
(c) 0.20 l_{bdg-hs} for horizontal stringers of ships with a centreline longitudinal bulkhead
(d) see also **2.6.1.7**.

Where:

l_{bdg-hs} : effective bending span of the horizontal stringer, in *m*, but is not to be taken as less than 50% of the breadth of the tank at the location being considered, see **Section4/2.1.4** and **Fig. 8.2.7**

Paragraph 2.6.7.2 has been amended as follows.

2.6.7.2 The net section modulus, Z_{net50}, of the horizontal stringer over the end $0.2l_{bdg-hs}$ is not to be less than:

$$Z_{net50} = \frac{1000M}{C_{s-pr}\,\sigma_{yd}} \qquad (cm^3)$$

Where:

M : design bending moment
$= c P S l_{bdg-hs}^2 \qquad (kNm)$

P : design pressure for the design load set being considered, calculated at mid point of effective bending span, l_{bdg-hs}, and at mid point of the spacing, S, of the horizontal stringer, in kN/m^2

S : sum of the half spacing (distance between stringers) on each side of the horizontal stringer under consideration, in *m*

l_{bdg-hs} : effective bending span of the horizontal stringer, in *m*, but is not to be taken as less than 50% of the breadth of the tank at the location being considered, see **Section 4/2.1.4** and **Fig. 8.2.7**

c 0.073 for horizontal stringers in cargo tanks of ships with a centreline bulkhead
0.083 for horizontal stringers in wing cargo tanks of ships with two longitudinal bulkheads
0.063 for horizontal stringers in the centre tank of ships with two longitudinal bulkheads

C_{s-pr} : permissible bending stress coefficient as given in **Table 8.2.10**

σ_{yd} : specified minimum yield stress of the material, in N/mm^2

Paragraph 2.6.7.4 has been amended as follows.

2.6.7.4 The net shear area, $A_{shr-net50}$, of the horizontal stringer over the end 0.2 l_{shr} is not to be less than:

$$A_{shr-net50} = \frac{10Q}{C_{t-pr}\,\tau_{yd}} \qquad (cm^2)$$

Where:

Q : design shear force

$= 0.5PSl_{shr}$ (kN)

P : design pressure for the design load set being considered, calculated at mid point of effective bending span, l_{bdg-hs}, and at mid point of the spacing, S, of the horizontal stringer, in kN/m^2

S : sum of the half spacing (distance between stringers), on each side of the horizontal stringer under consideration, in m

l_{shr} : effective shear span of the horizontal stringer, in m, see **Section4/2.1.5**

C_{t-pr} : permissible shear stress coefficient as given in **Table 8.2.10**

τ_{yd} $= \frac{\sigma_{yd}}{\sqrt{3}}$ (N/mm^2)

σ_{yd} : specified minimum yield stress of the material, in N/mm^2

3. Forward of the Forward Cargo Tank

3.2 Bottom Structure

3.2.6 Plate stems

Paragraph 3.2.6.2 has been amended as follows.

3.2.6.2 Between the minimum design ballast draught, T_{bal}, ~~waterline~~ at the stem and the scantling draught, T_{sc}, the plate stem net thickness, $t_{stem-net}$, is not to be less than:

$$t_{stem-net} = \frac{L_2\sqrt{\frac{235}{\sigma_{yd}}}}{12}$$

(mm), but need not be taken as greater than 21mm

Where:

L_2 : rule length, L, in m, as defined in **Section 4/1.1.1.1**, but need not be taken greater than 300m

σ_{yd} : specified minimum yield stress of the material, in N/mm^2

Above the ~~summer load~~ scantling draught ~~waterline~~ the thickness of the stem plate may be tapered to the requirements for the shell plating at the upper deck.

Below the minimum design ballast draught ~~waterline~~ the thickness of the stem plate may be tapered to the requirements for the plate keel.

3.8 Miscellaneous Structures

3.8.2 Bulbous bow

Paragraph 3.8.2.6 has been amended as follows.

3.8.2.6 The shell plating is to be increased in thickness at the forward end of the bulb and also in areas likely to be subjected to contact with anchors and chain cables during anchor handling. The increased plate thickness is to be the same as that required for plated stems given in **3.2.6**.

3.9 Scantling Requirements

3.9.3 Primary support members

Paragraph 3.9.3.3 has been amended as follows.

3.9.3.3 For primary support members subjected to lateral pressure, the effective net shear area, $A_{shr\text{-}net50}$ ~~$A_{w\text{-}net50}$~~, is to be taken as the greatest value for all applicable design load sets, as given in **Table 8.3.8**, and given by:

$$A_{shr-net50} = 10\frac{f_{shr}|P|S\,l_{shr}}{C_t\,\tau_{yd}} \qquad \sout{A_{w-net50} = 10\frac{f_{shr}|P|S\,l_{shr}}{C_t\,\tau_{yd}}} \qquad (cm^2)$$

Where:

P : design pressure for the design load set being considered, calculated at the load calculation point defined in **Section 3/5.3.2**, in kN/m^2

S : primary support member spacing, in m, as defined in **Section 4/2.2.2**

l_{shr} : effective shear span, as defined in **Section 4/2.1.5**, in m

f_{shr} : shear force factor, as given in **Table 8.3.5**

C_t : permissible shear stress coefficient for the acceptance criteria set being considered, as given in **Table 8.3.7**

τ_{yd} $= \frac{\sigma_{yd}}{\sqrt{3}}$ (N/mm^2)

σ_{yd} : specified minimum yield stress of the material, in N/mm^2

4. Machinery Space

4.3 Side Structure

4.3.3 Side shell local support members

Paragraph 4.3.3.2 has been deleted and paragraph 4.3.3.3 has been renumbered to paragraph 4.3.3.2.

~~4.3.3.2 The span of the longitudinal or vertical stiffeners is to be measured along the member.~~

~~4.3.3.3~~ 4.3.3.2 End connections of longitudinals at transverse bulkheads are to provide fixity, lateral support, and when not continuous are to be provided with soft-nosed brackets. Brackets lapped onto the longitudinals are not to be fitted.

Table 8.6.1 has been amended as follows.

Table 8.6.1 Allowable Plate Bending Stress Coefficient, C_a, for Assessment of Sloshing on Plates

The permissible bending stress coefficient for the design load set being considered is to be taken as:

$$C_a = \beta_a - \alpha_a \frac{|\sigma_{hg}|}{\sigma_{yd}}$$ but not to be taken greater than C_{a-max}

Where:

α_a, β_a, C_{a-max} permissible bending stress factors and are to be taken as follows

<table>
<tr><th>Acceptance Criteria Set</th><th colspan="2">Structural Member</th><th>β_a</th><th>α_a</th><th>C_{a-max}</th></tr>
<tr><td rowspan="3">AC1</td><td rowspan="2">Longitudinal strength members in the cargo tank region including <u>but not limited to</u>:
deck
longitudinal plane bulkhead
horizontal corrugated longitudinal bulkhead
longitudinal girders and stringers within the cargo tank region</td><td>Longitudinally stiffened plating</td><td>0.9</td><td>0.5</td><td>0.8</td></tr>
<tr><td>Transversely or vertically stiffened plating</td><td>0.9</td><td>1.0</td><td>0.8</td></tr>
<tr><td colspan="2">Other strength members including:
vertical corrugated longitudinal bulkhead
transverse plane bulkhead
transverse corrugated bulkhead
transverse stringers and web frames
plating of tank boundaries and primary support members outside the cargo tank region</td><td>0.8</td><td>0</td><td>0.8</td></tr>
</table>

σ_{hg} : hull girder bending stress for the design load set being considered and calculated at the load calculation point defined in **Section 3/5.1.2**

$$= \left(\frac{(z - z_{NA-net50})\, M_{sw-perm-sea}}{I_{v-net50}} \right) 10^{-3} \qquad (N/mm^2)$$

z : vertical coordinate of the load calculation point under consideration, in *m*

$z_{NA-net50}$: distance from the baseline to the horizontal neutral axis, as defined in **Section 4/2.6.1**, in *m*

$M_{sw-perm-sea}$: permissible hull girder hogging and sagging still water bending moment for seagoing operation at the location being considered, in *kNm*. The greatest of the sagging and hogging bending moment is to be used, see **Section 7/2.1**.

$I_{v-net50}$: net vertical hull girder moment of inertia, at the longitudinal position being considered, as defined in **Section 4/2.6.1**, in m^4

σ_{yd} : specified minimum yield stress of the material, in N/mm^2

Table 8.6.2 has been amended as follows.

Table 8.6.2 Allowable Bending Stress Coefficient, C_s, for Assessment of Sloshing on Stiffeners

The permissible bending stress coefficient for the design load set being considered is to be taken as:

$$C_s = \beta_s - \alpha_s \frac{|\sigma_{hg}|}{\sigma_{yd}}$$ but not to be taken greater than C_{s-max}

Where:

α_s, β_s, C_{s-max} : permissible bending stress factors and are to be taken as follows

Acceptance Criteria Set	Structural Member		β_s	α_s	C_{s-max}
AC1	Longitudinal strength members in the cargo tank region including but not limited to: deck stiffeners stiffeners on longitudinal bulkheads stiffeners on longitudinal girders and stringers within the cargo tank region	Longitudinal stiffeners	0.85	1.0	0.75
		Transverse or vertical stiffeners	0.7	0	0.7
	Other strength members including: stiffeners on transverse bulkheads stiffeners on transverse stringers and web frames stiffeners on tank boundaries and primary support members outside the cargo tank region		0.75	0	0.75

σ_{hg} : hull girder bending stress for the design load set being considered at the reference point defined in **Section 3/5.2.2.5**

$$= \left(\frac{(z - z_{NA-net50}) M_{sw-perm-sea}}{I_{v-net50}}\right) 10^{-3} \qquad (N/mm^2)$$

z : vertical coordinate of the reference point defined in **Section 3/5.2.2.5**, in *m*

$z_{NA-net50}$: distance from the baseline to the horizontal neutral axis, as defined in **Section 4/2.6.1**, in *m*

$M_{sw-perm-sea}$: permissible hull girder hogging and sagging still water bending moment for seagoing operation at the location being considered, in *kNm*. The greatest of the sagging and hogging bending moment is to be used, see **Section 7/2.1**.

$I_{v-net50}$: net vertical hull girder moment of inertia, at the longitudinal position being considered, as defined in **Section 4/2.6.1**, in m^4

σ_{yd} : specified minimum yield stress of the material, in N/mm^2

6.3 Bottom Slamming

6.3.7 Primary support members

Paragraph 6.3.7.2 has been amended as follows.

6.3.7.2 The net shear area, $A_{\underline{shr}\,w-net50}$, of each primary support member web at any position along its span is not to be less than:

$$A_{shr-net50} = 10\frac{Q_{slm}}{C_t \tau_{yd}} \qquad \text{~~}A_{w-net50} = 10\frac{Q_{slm}}{C_t \tau_{yd}}\text{~~} \qquad (cm^2)$$

Where:

Q_{slm} : the greatest shear force due to slamming for the position being considered, in *kN*, based on the application of a patch load, F_{slm} to the most onerous location, as determined in accordance with **6.3.7.3**

C_t : permissible shear stress coefficient
= 0.9 for acceptance criteria set AC3

τ_{yd} $= \frac{\sigma_{yd}}{\sqrt{3}}$ (N/mm^2)

σ_{yd} : specified minimum yield stress of the material, in N/mm^2

Paragraph 6.3.7.5 has been amended as follows.

6.3.7.5 The net web thickness, t_{w-net}, of primary support members adjacent to the shell is not to be less than:

$$t_{w-net} = \frac{s_w}{70}\sqrt{\frac{\sigma_{yd}}{235}} \quad ~~t_{w-net} = \frac{s}{70}\sqrt{\frac{\sigma_{yd}}{235}}~~ \quad (mm)$$

Where:

s_w : plate breadth, in *mm*, taken as the spacing between the web stiffening ~~stiffener spacing, in *mm*, as defined in **Section 4/2.2**~~

σ_{yd} : specified minimum yield stress of the material, in N/mm^2

6.4 Bow Impact

6.4.3 Design to resist bow impact loads

Paragraph 6.4.3.3 has been amended as follows.

6.4.3.3 Scantlings and arrangements at primary support members, including decks and bulkheads, are to comply with **6.4.7**. In areas of greatest bow impact load the adoption of web stiffeners arranged perpendicular to the hull envelope plating and the provision of double sided lug connections ~~is~~are, in general to be ~~fitted~~applied.

7. Application of Scantling Requirements to Other Structure

7.1 General

7.1.1 Application

Paragraph 7.1.1.1 has been amended as follows.

7.1.1.1 The requirements of this Sub-Section apply to plating, local and primary support members where the basic structural configurations or strength models assumed in **Section 8/2** to **8/5** are not appropriate. These are general purpose strength requirements to cover various load assumptions and end support conditions. These requirements are not to be used as an alternative to the requirements of **Section 8/2** to **8/5** where those sections can be applied.

7.2 Scantling Requirements

7.2.3 Primary support members

Paragraph 7.2.3.5 has been amended as follows.

7.2.3.5 For primary support members the net shear area of the web, $A_{shr\,w-net50}$, is to be taken as the greatest value for all applicable design load sets given in **Table 8.7.2**, and given by:

$$A_{shr-net50} = \frac{10 f_{shr} |P| S l_{shr}}{C_t \tau_{yd}} \qquad A_{w-net50} = \frac{10 f_{shr} |P| S l_{shr}}{C_t \tau_{yd}} \quad (cm^2)\text{, for lateral pressure loads}$$

$$A_{shr-net50} = \frac{10 f_{shr} |F|}{C_t \tau_{yd}} \qquad A_{w-net50} = \frac{10 f_{shr} |F|}{C_t \tau_{yd}} \quad (cm^2)\text{, for point loads}$$

$$A_{shr-net50} = \frac{\left|\Sigma 10 f_{shr-i} P_i l_{shr} + \Sigma 10 f_{shr-j} F_j\right|}{C_t \tau_{yd}} \qquad A_{w-net50} = \frac{\left|\Sigma 10 f_{shr-i} P_i l_{shr} + \Sigma 10 f_{shr-j} F_j\right|}{C_t \tau_{yd}}$$

(cm^2), for a combination of loads

Where:

P	: design pressure for the design load set being considered, calculated at the load calculation point defined in **Section 3/5.3.2**, in kN/m^2
S	: primary support member spacing, in m, as defined in **Section 4/2.2.2**
l_{shr}	: effective shear span, as defined in **Section 4/2.1.5**
f_{shr}	: shear force factor, as given in **Table 8.7.1**
C_t	: permissible shear stress coefficient for the design load set being considered as given in **Tables 8.2.10** or **8.3.7**, as applicable for the individual member being considered
τ_{yd}	$= \frac{\sigma_{yd}}{\sqrt{3}}$ (N/mm^2)
σ_{yd}	: specified minimum yield stress of the material, in N/mm^2
F	: point load for the design load set being considered, in kN
i	: indices for load component i
j	: indices for load component j

Section 9 DESIGN VERIFICATION

3. Fatigue Strength

3.3 Locations to Apply

3.3.1 Longitudinal structure

Paragraph 3.3.1.1 has been amended as follows.

3.3.1.1 A fatigue strength assessment is to be carried out and submitted for the end connections of longitudinal stiffeners to transverse bulkheads, including wash bulkheads and web frames within the cargo tank region, located on the bottom shell, inner bottom, side shell, inner ~~side~~ hull longitudinal bulkheads, longitudinal bulkheads and strength deck.

3.4 Fatigue Assessment Methods

3.4.1 Nominal stress approach

Sub paragraph 3.4.1.1(a) has been amended as follows.

3.4.1.1 The nominal stress approach, as described in **Appendix C/1**, is to be used for the fatigue evaluation of the following items:

(a) longitudinal stiffener end connections to the transverse bulkheads, including wash bulkheads, and web frames on the bottom, inner bottom, side shell, inner hull longitudinal bulkheads ~~side~~, longitudinal bulkheads and strength deck.

(b) scallops in way of block joints on the strength deck as described in **Appendix C/1.6**.

Section 10 BUCKLING AND ULTIMATE STRENGTH

3. Prescriptive Buckling Requirements

3.5 Other Structures

3.5.1 Struts, pillars and cross ties

Paragraph 3.5.1.5 has been amended as follows.

3.5.1.5 For cross-sections where the centroid and the shear centre do not coincide, the interaction between the torsional and column buckling mode is to be examined. The elastic torsional/column buckling stress, σ_{ETF}, with respect to axial compression is to be taken as:

$$\sigma_{ETF} = \frac{1}{2\zeta}\left[(\sigma_E + \sigma_{ET}) - \sqrt{(\sigma_E + \sigma_{ET})^2 - 4\zeta\sigma_E\sigma_{ET}}\right]$$

Where:

ζ $= 1 - \frac{(y_0^2 + z_0^2)A_{net50}}{I_{pol-net50}}$ ~~$= 1 - \frac{z_0^2 A_{net50}}{I_{pol-net50}}$~~

y_0 : position of shear centre relative to the cross-sectional centroid, in *cm*, see **Table 10.3.4**

z_0 : position of shear centre relative to the cross-sectional centroid, in *cm*, see **Table 10.3.4**

A_{net50} : net cross-sectional area, in cm^2

$I_{pol-net50}$: net polar moment of inertia about the shear centre of cross section, as defined in **3.5.1.4**

σ_{ET} : elastic torsional buckling stress, as defined in **3.5.1.4**

σ_E : elastic column compressive buckling stress, as defined in **3.5.1.3**

Table 10.3.4 has been amended as follows.

Table 10.3.4 Cross Sectional Properties

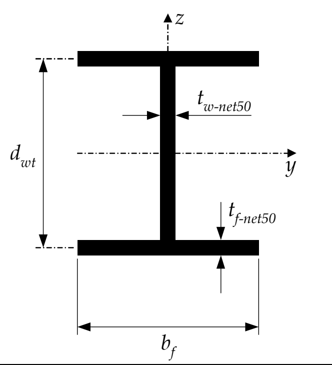
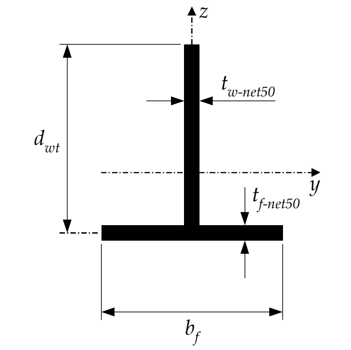
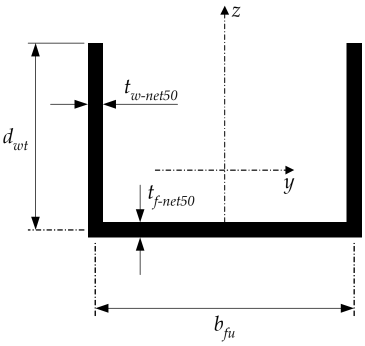
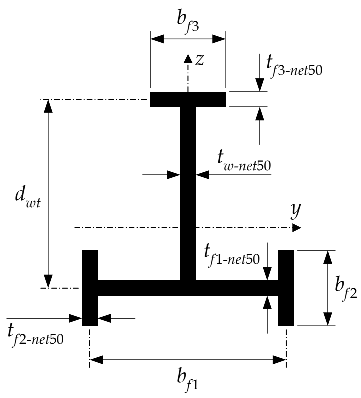
double symmetrical sections	
	$I_{sv-net50} = \frac{1}{3}\left(2b_f t_{f-net50}^3 + d_{wt} t_{w-net50}^3\right)10^{-4}$ (cm^4)
	$c_{warp} = \frac{d_{wt}^2 b_f^3 t_{f-net50}}{24} 10^{-6}$ (cm^6)

Table 10.3.4 (Continued)Cross Sectional Properties

single symmetrical sections	
	$I_{sv-net50} = \frac{1}{3}\left(b_f t_{f-net50}^3 + d_{wt} t_{w-net50}^3\right)10^{-4}$ (cm^4)
	$y_0 = 0$ cm $z_0 = -\frac{0.5 d_{wt}^2 t_{w-net50}}{d_{wt} t_{w-net50} + b_f t_{f-net50}} 10^{-1}$ (cm) $c_{warp} = \frac{b_f^3 t_{f-net50}^3 + 4 d_{wt}^3 t_{w-net50}^3}{144} 10^{-6}$ (cm^6)
	$I_{sv-net50} = \frac{1}{3}\left(b_{fu} t_{f-net50}^3 + 2 d_{wt} t_{w-net50}^3\right)10^{-4}$ (cm^4)
	$y_0 = 0$ cm $z_0 = -\frac{d_{wt}^2 t_{w-net50} 10^{-1}}{2 d_{wt} t_{w-net50} + b_f t_{f-net50}} - \frac{0.5 d_{wt}^2 t_{w-net50} 10^{-1}}{d_{wt} t_{w-net50} + b_{fu} t_{f-net50}/6}$ (cm) $c_{warp} = \frac{b_{fu}^2 d_{wt}^3 t_{w-net50}\left(3 d_{wt} t_{w-net50} + 2 b_{fu} t_{f-net50}\right)}{12\left(6 d_{wt} t_{w-net50} + b_{fu} t_{f-net50}\right)} 10^{-6}$ (cm^6)
	$I_{sv-net50} = \frac{1}{3}\left(b_{f1} t_{f1-net50}^3 + 2 b_{f2} t_{f2-net50}^3 + b_{f3} t_{f3-net50}^3 + d_{wt} t_{w-net50}^3\right)10^{-4}$ (cm^4)
	$y_0 = 0$ cm $z_o = z_s - \frac{\left(b_{f3} d_{wt} t_{f3-net50} + 0.5 d_{wt}^2 t_{w-net50}\right)10^{-1}}{d_{wt} t_{w-net50} + b_{f1} t_{f1-net50} + 2 b_{f2} t_{f2-net50} + b_{f3} t_{f3-net50}}$ (cm) $c_{warp} = I_{f1} z_s^2 + \frac{I_{f2} b_{f1}^2}{200} + I_{f3}\left(\frac{d_{wt}}{10} - z_s\right)^2$ ~~$c_{warp} = \left(I_{f1} z_o^2 + \frac{I_{f2} b_{f1}^2}{2} + I_{f3}\left(d_{wt} - z_o\right)^2\right)10^{-2}$~~ (cm^6) $I_{f1} = \left(\frac{\left(b_{f1} - t_{f2-net50}\right)^3 t_{f1-net50}}{12} + \frac{b_{f2} t_{f2-net50} b_{f1}^2}{2}\right)10^{-4}$ (cm^4) $I_{f2} = \frac{b_{f2}^3 t_{f2-net50}}{12} 10^{-4}$ (cm^4) $I_{f3} = \frac{b_{f3}^3 t_{f3-net50}}{12} 10^{-4}$ (cm^4) $z_s = \frac{I_{f3} d_{wt}}{I_{f1} + I_{f3}} 10^{-1}$ (cm)

Note :

1. All dimensions of thickness, breadth and depth are in *mm*
2. Cross sectional properties not covered by this table are to be obtained by direct calculation.

3.5.2 Corrugated bulkheads

Paragraph 3.5.2.2 has been amended as follows.

3.5.2.2 The overall buckling failure mode of corrugated bulkheads subjected to axial compression is to be checked for column buckling according to **3.5.1**(e.g. horizontally corrugated longitudinal bulkheads, vertically corrugated bulkheads subject to localised vertical forces). End constraint factor corresponding to pinned ends is to be applied except for fixed end support to be used in way of stool with width exceeding 2 *times* the depth of the corrugation.

Section 11 GENERAL REQUIREMENTS

1. Hull Openings and Closing Arrangements

1.4 Deck Houses and Companionways

1.4.8 Pillars

Paragraph 1.4.8.2 has been amended as follows.

1.4.8.2 The permissible loading on a pillar, W_{perm}, is given by:

$$W_{perm} = (f_{s1} - h_{pill}\, f_{s2}/r_{gyr\text{-}grs})A_{pill\text{-}grs} \qquad (kN)$$

Where:

f_{s1} : steel factor

12.09	normal strength steel
13.59	HT27 strength steel
16.11	HT32 strength steel
17.12	HT34 strength steel
18.12	HT36 strength steel
20.14	HT40 strength steel

h_{pill} : distance between the top of the pillar supporting deck or other structure to the underside of the supported beam or girder, in *m*

f_{s2} : steel factor

4.44	normal strength steel
5.57	HT27 strength steel
7.47	HT32 strength steel
8.24	HT34 strength steel
9.00	HT36 strength steel
10.52	HT40 strength steel

$r_{gyr\text{-}grs}$: radius of gyration for gross pillar section, in *cm*~~2~~

$A_{pill\text{-}grs}$: gross cross sectional area of pillar, in cm^2

2. Crew Protection

2.1 Bulwarks and Guardrails

2.1.2 Construction of bulwarks

Paragraph 2.1.2.2 has been amended as follows.

2.1.2.2 Plate bulwarks are to be stiffened by a top rail. Plate bulwarks on the freeboard deck and forecastle deck are to be ~~and~~ supported by stays having a spacing generally not greater than 2.0*m*.

3. Support Structure and Structural Appendages

3.1 Support Structure for Deck Equipment

3.1.6 Supporting structure for bollards and bitts, fairleads, stand rollers, chocks and capstans

Paragraph 3.1.6.1 has been amended as follows.

3.1.6.1 In general, shipboard fittings (bollards and bitts, fairleads, stand rollers and chocks) and capstans used for mooring, ~~towing~~ and ~~emergency~~ towing (other than as specified in **3.1.5**) of the vessel are to be fitted to the deck or bulwark structures using a purpose designed base or attachment.

Paragraph 3.1.6.8 has been amended as follows.

3.1.6.8 The scantlings of the support structure are to be dimensioned to ensure that for the loads ~~cases~~ specified in **3.1.6.10**, **3.1.6.11** and **3.1.6.12**, the calculated stresses in the support structure do not exceed the permissible stress levels specified in **3.1.6.13**.

Paragraph 3.1.6.9 has been amended as follows.

3.1.6.9 These requirements are to be assessed using a simplified engineering analysis based on elastic beam theory, two-dimensional grillage or finite-element analysis using ~~gross~~ net scantlings. The required gross thickness is obtained by adding the relevant full corrosion addition specified in **Section 6/3** to the required net thickness.

Paragraph 3.1.6.13 has been amended as follows.

3.1.6.13 For the design load specified in **3.1.6.10, 3.1.6.11** and **3.1.6.12** the stresses induced in the supporting structure and welds are not to exceed the permissible values given below based on the ~~gross~~ net thickness of the structure.~~:~~ The required gross thickness is obtained by adding the relevant full corrosion addition specified in **Section 6/3** to the required net thickness.

Direct stress 1.00 σ_{yd}
Shear stress ~~0.58~~ 0.60σ_{yd}
Where:

σ_{yd} : specified minimum yield stress of the material, in N/mm^2

Paragraph 3.1.6.15 and 3.1.6.16 have been added as follows.

3.1.6.15 The following requirements on Safe Working Load apply for a single post basis (no more than one turn of one cable).

(a) The Safe Working Load used for normal towing operations (e.g., harbour/manoeuvring) is not to exceed 80% of the design load per **3.1.6.10.(a)** and the Safe Working Load used for other towing operations (e.g., escort) is not to exceed the design load per **3.1.6.10.(b)**. For deck fittings used for both normal and other towing operations, the greater of the design loads of **3.1.6.10.(a)** and **3.1.6.10.(b)** is to be used.

(b) The Safe Working Load for mooring operations is not to exceed 80% of the design load per **3.1.6.10.(c)**.

(c) The Safe Working Load 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 **3.1.6.16** is to define the method of use of towing lines and/or mooring lines.

3.1.6.16 The Safe Working Load for the intended use for each deck fitting is to be noted in the towing and mooring arrangements plan available on board for the guidance of the Master. Information provided on the plan is to include in respect of each deck fitting:

(a) Location on the ship;
(b) Fitting type;
(c) SWL;
(d) Purpose (mooring/harbor towing/escort towing); and
(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 proper information on harbour/escorting operations.

3.3 Bilge Keels

3.3.2 Ground bars

Paragraph 3.3.2.2 has been amended as follows.

3.3.2.2 The ~~minimum~~ gross thickness of the ground bar is not to be ~~equal to~~ less than the gross thickness of the bilge strake or 14*mm*, whichever is the lesser.

Appendix A HULL GIRDER ULTIMATE STRENGTH

2. Calculation of Hull Girder Ultimate Capacity

2.1 Single Step Ultimate Capacity Method

2.1.1 Procedure

Paragraph 2.1.1.1 has been amended as follows.

2.1.1.1 The single step procedure for calculation of the sagging hull girder ultimate bending capacity is a simplified method based on a reduced hull girder bending stiffness accounting for buckling of the deck, see **Fig. A.2.1.** The hull girder ultimate bending moment capacity, M_U, is to be taken as:

$$M_U = Z_{red}\sigma_{yd} \cdot 10^3 \qquad (kNm)$$

Where:

Z_{red} : reduced section modulus of deck (to the mean deck height)

$$= \frac{I_{red}}{z_{dk-mean} - z_{NA-red}} \qquad (m^3)$$

I_{red} : reduced hull girder moment of inertia, in m^4. The inertia is to be calculated in accordance with **Section 4~~8~~/2.6.1.1,** using

- a hull girder net thickness of t_{net50} for all longitudinally effective members
- the effective net area after buckling of each stiffened panel of the deck, A_{eff}

A_{eff} : effective net area after buckling of the stiffened deck panel. The effective area is the proportion of stiffened deck panel that is effectively able to be stressed to yield

$$= \frac{\sigma_U}{\sigma_{yd}} A_{net50} \qquad (m^2)$$

Note :
The effective area of deck girders is to be taken as the net area of the girders using a thickness of t_{net50}.

A_{net50} : net area of the stiffened deck panel, in m^2

σ_U : buckling capacity of stiffened deck panel, in N/mm^2. To be calculated for each stiffened panel using

- the advanced buckling analysis method, see **Section 10/4** and **Appendix D**
- the net thickness t_{net50}

σ_{yd} : specified minimum yield stress of the material, in N/mm^2, that is used to determine the hull girder section modulus

$z_{dk-mean}$:vertical distance to the mean deck height, taken as the mean of the deck at side and the deck at centre line, measured from the baseline, in m

z_{NA-red} : vertical distance to the neutral axis of the reduced section measured from the baseline, in m

Appendix B STRUCTURAL STRENGTH ASSESSMENT

1. General

1.2 Symbols, Units and Definitions

1.2.1 General

Paragraph 1.2.1.1 has been amended as follows.

1.2.1.1 The symbols and definitions, applicable to this section, are given in **Section 4/1**, **Section 7** and as follows:

a_v	: vertical acceleration, taken at centre of gravity of tank
a_t	: transverse acceleration, taken at centre of gravity of tank
a_{lng}	: longitudinal acceleration, taken at centre of gravity of tank
E	: Modulus of Elasticity of steel, 2.06×10^5 N/mm^2
M_{wv}	: vertical wave bending moment for a dynamic load case
M_{sw}	: vertical still water bending moment for a finite element loading pattern
M_h	: horizontal wave bending moment for a dynamic load case
Q_{wv}	: vertical wave shear force for a dynamic load case
Q_{sw}	: vertical still water shear force for a finite element loading pattern
T_{LC}	: draught at the loading condition being considered
T_{sc}	: scantling draught, as defined in **Section 4/1.1.5.5**
T_{bal-em}	: emergency draught of ship
t_{grs}	: proposed new building gross thickness excluding Owner's extras, see **Section 2/6.3.4**
t_{corr}	: corrosion addition, as defined in **Section 6/3.2**~~**Table 6.3.1**~~
σ_{yd}	: specified minimum yield stress of the material, N/mm^2
σ_{vm}	: von Mises stress $= \sqrt{\sigma_x{}^2 + \sigma_y{}^2 - \sigma_x \sigma_y + 3\tau_{xy}{}^2}$
σ_x	: axial stress in element x direction
σ_y	: axial stress in element y direction
τ_{xy}	: element shear stress in x-y plane
δ_x	: displacement in x direction, in accordance with the coordinate system defined in **Section 4/1.4**
δ_y	: displacement in y direction, in accordance with the coordinate system defined in **Section 4/1.4**
δ_z	: displacement in z direction, in accordance with the coordinate system defined in **Section 4/1.4**
θ_x	: rotation about x axis, in accordance with the coordinate system defined in **Section 4/1.4**
θ_y	: rotation about y axis, in accordance with the coordinate system defined in **Section 4/1.4**
θ_z	: rotation about z axis, in accordance with the coordinate system defined in **Section 4/1.4**

2. Cargo Tank Structural Strength Analysis

2.2 Structural Modelling

2.2.1 General

Paragraph 2.2.1.5 has been amended as follows.

2.2.1.5 The reduced thickness used in the FE model of the cargo tanks, applicable to all plating and stiffener's web and flanges is to be calculated as follows:

$$t_{FEM-net50} = t_{grs} - 0.5t_{corr}$$

Where:

t_{grs} : gross thickness, as defined in **1.2**

t_{corr} : corrosion addition, as defined in **Section 6/3.2**~~**Table6.3.1**~~

Table B.2.2 has been amended as follows.

Table B.2.2 Representation of Openings in ~~Girder~~ Primary Support Member Webs

$h_o/h < 0.35$	and	$g_o < 1.2$	Openings do not need to be modelled
$0.5 > h_o/h \geq 0.35$	and	$g_o < 1.2$	The plate modelled with mean thickness $t_{1-net50}$
$h_o/h <$ 0.5~~0.35~~	and	$2 > g_o \geq 1.2$	The plate modelled with mean thickness $t_{2-net50}$
~~0.5 > h_o/h ≥ 0.35~~	~~and~~	~~2 > g_o ≥ 1.2~~	~~The plate modelled with the minimum value of $t_{1-net50}$ and $t_{2-net50}$~~
$h_o/h \geq 0.5$	or	$g_o \geq 2.0$	The geometry of the opening is to be modelled

Where:

g_o = $1 + \dfrac{l_o^2}{2.6(h-h_o)^2}$

$t_{1-net50}$ = $\dfrac{h-h_o}{h} t_{w-net50}$

$t_{2-net50}$ = $\dfrac{h-h_o}{hg_o} t_{w-net50}$

$t_{w-net50}$: net web thickness

l_o : length of opening parallel to ~~girder~~ primary support member web direction, see **Fig. B.2.8**

h_o : height of opening parallel to depth of web, see **Fig. B.2.8**

h : height of web of ~~girder~~ primary support member in way of opening, see **Fig. B.2.8**

t_{corr} : corrosion addition, as defined in ~~**Table 6.3.1**~~ **Section 6/3.2**

Notes:

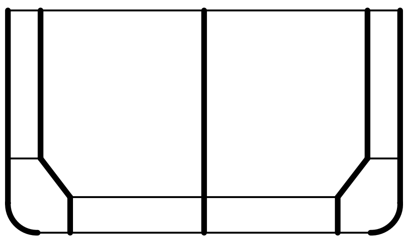
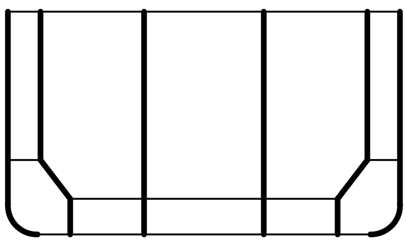
1. For sequential openings where the distance, d_o, between openings is less than $0.25h$, the length l_o is to be taken as the length across openings as shown in **Fig. B.2.9**.
2. The same unit is to be used for l_o, h_o and h.

2.5 Procedure to Adjust Hull Girder Shear Forces and Bending Moments

2.5.3 Procedure to adjust vertical shear force distribution

Table B.2.8 has been amended as follows.

Table B.2.8 Shear Force Distribution Factors

	Side Shell	$f = 0.055 + 0.097\frac{A_{1-net50}}{A_{2-net50}} + 0.020\frac{A_{2-net50}}{A_{3-net50}}$
	Inner hull	$f = 0.193 - 0.059\frac{A_{1-net50}}{A_{2-net50}} + 0.058\frac{A_{2-net50}}{A_{3-net50}}$
	CL longitudinal bulkhead	$f = 0.504 - 0.076\frac{A_{1-net50}}{A_{2-net50}} - 0.156\frac{A_{2-net50}}{A_{3-net50}}$
	Side Shell	$f = 0.028 + 0.087\frac{A_{1-net50}}{A_{2-net50}} + 0.023\frac{A_{2-net50}}{A_{3-net50}}$ ~~$f = 0.028 + 0.087\frac{A_{1-net50}}{A_{2-net50}} + 0.023\frac{A_{-net502}}{A_{3-net50}}$~~
	Inner hull	$f = 0.119 - 0.038\frac{A_{1-net50}}{A_{2-net50}} + 0.072\frac{A_{2-net50}}{A_{3-net50}}$
	Longitudinal bulkhead	$f = 0.353 - 0.049\frac{A_{1-net50}}{A_{2-net50}} - 0.095\frac{A_{2-net50}}{A_{3-net50}}$ ~~$f_3 = 0.353 - 0.049\frac{A_{1-net50}}{A_{2-net50}} - 0.095\frac{A_{2-net50}}{A_{3-net50}}$~~

Where:

$A_{1-net50}$: plate sectional area of individual side shell (i.e. on one side), including bilge

$A_{2-net50}$: plate sectional area of individual inner hull longitudinal bulkhead (i.e. on one side), including hopper slope plate, double bottom side girder in way and, where fitted, upper slope plating of inner hull.

$A_{3-net50}$: plate sectional area of individual longitudinal bulkhead, including double bottom girder in way

Notes:

1. Where part of the structural member is not vertical, the area is to be calculated using the projected area in the vertical direction.
2. All plate areas are to be calculated based on the modelled thickness of the cargo tank FE model, see **2.2.1.5**.
3. For ~~vertical~~ corrugated longitudinal bulkheads, the corrugation thickness for the calculation of shear force distribution factor, *f*, is to be corrected according to **Section 4/2.6.4**.

2.7 Result Evaluation

2.7.3 Buckling assessment

Paragraph 2.7.3.1 has been amended as follows.

2.7.3.1 Buckling capability is to be assessed for the plating and stiffened panels of longitudinal hull girder structural members, primary support~~ing structural~~ members and transverse bulkheads, including deck, double side, side, bottom, double bottom, hopper, transverse and vertical web frames, stringers, transverse and longitudinal bulkhead structures. Buckling capability of curved panels (e.g. bilge), face plate of primary support~~ing~~ members and tripping brackets is not assessed based on stress result obtained by the finite element analysis.

Appendix C – FATIGUE STRENGTH ASSESSMENT

1. Nominal Stress Approach

1.3.2 Selection of loading conditions

Paragraph 1.3.2.1 has been amended as follows.

1.3.2.1 Fatigue analyses are to be carried out for representative loading conditions according to the intended ship's operation. The following two loading conditions are to be examined:

(a) full load condition at design draught at departure, T_{full}, see **Section 4/1.1.5.4**

(b) ballast condition at normal ballast draught at departure, T_{bal-n}, see **Section 4/1.1.5.3**. If a normal ballast condition is not defined in the loading manual, minimum ballast draught, T_{bal}, see **Section 4/1.1.5.2**, should be used.

1.4 Fatigue Damage Calculation

1.4.1 Fatigue strength determination

Paragraph 1.4.1.5 has been amended as follows.

1.4.1.5 The probability density function of the long term distribution of stress ranges (hull girder + local bending) is to be represented by a two-parameter Weibull distribution. This assumption enables the use of a closed form equation for calculation of the fatigue life when the two parameters of the Weibull distribution are determined. The probability density function, *f(S)*, is to be taken as:

$$f(S) = \frac{\xi}{f_1}\left(\frac{S}{f_1}\right)^{\xi-1} exp\left(-\left(\frac{S}{f_1}\right)^{\xi}\right) \qquad \sout{f(S) = \frac{\xi}{f_1}\left(\frac{S}{f_1}\right)^{\xi-1} exp\left(-\frac{S}{f_1}\right)^{\xi}}$$

Where:

S : stress range, in N/mm^2

ξ : Weibull probability distribution parameter, as defined in **1.4.1.6**

f_1 : scale parameter

$$= \frac{S_R}{(lnN_R)^{1/\xi}}$$

N_R : number of cycles corresponding to the probability of exceedance of $1/N_R$

S_R : stress range with probability of exceedance of $1/N_R$, in N/mm^2

Table C.1.1 has been amended as follows.

Table C.1.1 Distribution of $f_{Weibull}$ factors

Plating Area	$f_{Weibull}$ (see **note**)
Bottom	0.9 at centreline and 0.95 at side
Side and bilge	1.1 at up to draught T_{LC} and 1.0 at deck
Deck	1.0
Inner bottom	1.0
Inner Hull Longitudinal Bulkhead ~~side~~	1.1 up to D/2 and 1.0 at deck
Inner Longitudinal Bulkhead	1.1 up to D/2 and 1.0 at deck
Centreline Longitudinal Bulkhead	1.1 up to D/2 and 1.0 at deck
Note: Intermediate values to be linearly interpolated	

1.4.4 Definition of stress components

Paragraph 1.4.4.11 has been amended as follows.

1.4.4.11 The stress amplitude produced by bending of stiffeners between girder supports (e.g. frames, bulkheads), σ_{2A}, is to be taken as:

$$\sigma_{2A} = K_n K_d \frac{M}{Z_{net50}} 10^3 \qquad (N/mm^2)$$

Where:

K_n : stress factor for unsymmetrical profiles, as defined in **1.4.4.15**

K_d : stress factor for bending stress in longitudinal stiffeners caused by relative deformation between supports, may be determined by FE analysis of the cargo hold model where the actual relative deformation is taken into account or taken as follows

1.0 at frame connections

1.15 for all longitudinals at transverse bulkhead connections including wash bulkheads except

(a) in full load condition:

1.3 for side and bilge longitudinals at mid position between lowest side stringer and ~~deck corner~~ at side

1.15 for side and bilge longitudinals at lowest side stringer and deck ~~corner~~ at side to be linearly interpolated between these two positions

Paragraph 1.4.4.15 has been amended as follows.

1.4.4.15 The stress concentration factors at the flange of un-symmetrical stiffeners on laterally loaded panels, K_{n1} and K_{n2}, as shown in **Fig. C.1.6**, are to be taken as:

$$K_{n1} = \frac{1+\lambda\beta}{1+\lambda\beta^2\psi_z}$$ ~~$K_{n1} = \frac{1+\lambda\beta}{1+\lambda\beta^2\psi}$~~ at the flange edge

$$K_{n2} = \frac{1+\lambda\beta^2}{1+\lambda\beta^2\psi_z}$$ ~~$K_{n2} = \frac{1+\lambda\beta^2}{1+\lambda\beta^2\psi}$~~ at the web

K_{n2} is typically used in the fatigue analysis of longitudinal end connections

Where:

β : $1-\frac{2b_g}{b_f}$ for built-up profiles

$1-\frac{t_{w-net50}}{b_f}$ for rolled angle profiles

b_g : breadth of flange from web centreline, in *mm*, see **Fig. C.1.7**

$t_{w-net50}$: net web thickness, in *mm*

d_w : depth of stiffener web, see **Fig. C.1.7**, in *mm*

λ : factor, as defined in **1.4.4.17**

ψ_z ~~ψ~~ : ratio between section modulus of the stiffener web with plate flange, as calculated at the flange and the section modulus of the complete panel stiffener

$\frac{d_w^2 t_{w-net50}}{4Z_{net50}10^3}$ may be used as an approximate value

Z_{net50} : section modulus of stiffener including the full width of the attached plate, *s*, with respect to a neutral axis normal to the stiffener web, in cm^3. It is to be calculated based on the gross thickness minus the corrosion addition $0.5t_{corr}$

1.5 Classification of Structural Details

1.5.1 General

Paragraph 1.5.1.2 has been amended as follows.

1.5.1.2 ~~In case w~~Where the primary support member web stiffeners are omitted or not connected to the longitudinals ~~pillar-less connections are adopted~~ in way of bottom, side and inner hull, see ~~n~~**Note 6 of Table C.1.7**.

1.6 Other Details

1.6.1 Scallops in way of block joints

Paragraph 1.6.1.1 has been amended as follows.

1.6.1.1 Scallops in way of block joints in the cargo tank region, located on the strength deck, and down to $0.1D$ from the deck ~~corner~~ at side are to be designed according to **Fig. C.1.12** unless the specification in **Section 8/1.5.1.3** for class F2 is satisfied.

2. Hot Spot Stress (FE Based) Approach

2.4. Fatigue Damage Calculation

2.4.2 Stresses to be used

Paragraph 2.4.2.7 has been amended as follows.

2.4.2.7 Stress range components along the direction perpendicular to the weld, due to the loads defined in *2.3*, are to be calculated based on **Appendix B/4**. The total combined stress range, S, is to be taken as:

$$S = f_{model}\left|0.85(S_{e1} + 0.25S_{e2}) - 0.3S_i\right| \quad \text{for full load condition}$$

$$S = f_{model}\left|0.85(S_{e1} - 0.2S_{e2})\right| \quad \text{for ballast load condition}$$

Where:

S_{e1} : stress range due to dynamic wave pressure applied to FE-model on the side where the hopper knuckle is to be investigated, in N/mm^2, see **Table B.4.1**

S_{e2} : stress range due to dynamic wave pressure applied to FE-model on the side of the hull where the hopper knuckle is not analysed, in N/mm^2, see **Table B.4.1**

S_i : stress range due to dynamic tank pressure applied to FE-model, in N/mm^2, see **Appendix B/4.5.2.4** and **Table B.4.1**

f_{model} : 1.0 if the FE model is made according to net thickness for fatigue, i.e. using corrosion ~~margin~~ addition of $0.25t_{corr}$ for the FE model except in way of critical location (in way of a knuckle and within 500*mm* in all directions), which uses corrosion ~~margin~~ addition of $0.5t_{corr}$

0.95 if the FE model for strength assessment is used. FE model for strength assessment applies a corrosion ~~margin~~ addition of $0.5t_{corr}$ for the whole model including structure in way of critical location

Appendix D - Buckling Strength Assessment

5. Strength Assessment (FEM) – Buckling Procedure

5.2 Structural Modelling and Capacity Assessment Method

5.2.2 Stiffened panels

Paragraph 5.2.2.2 has been amended as follows.

5.2.2.2 In general, the assessment method is to model changes in plate thickness, stiffener size and spacing. However where the advanced buckling method is unable to correctly model these changes, the calculations are to be performed separately for each stiffener and plate between the stiffeners. Plate thickness, stiffener properties and stiffener spacing at the considered location are to be assumed for the whole panel. If the plate thickness, stiffener properties and stiffener spacing varies within the stiffened panel, the calculations are to be performed for all configurations of the panel. Where the panel between stiffeners consists of several plate thickness the weighted average thickness may by used for the thickness of the plating for assessment of the corresponding stiffener/plating combination. Calculation of weighted average is to be in accordance with **5.2.3.3**.<u>See **Fig. D.5.6**.</u>

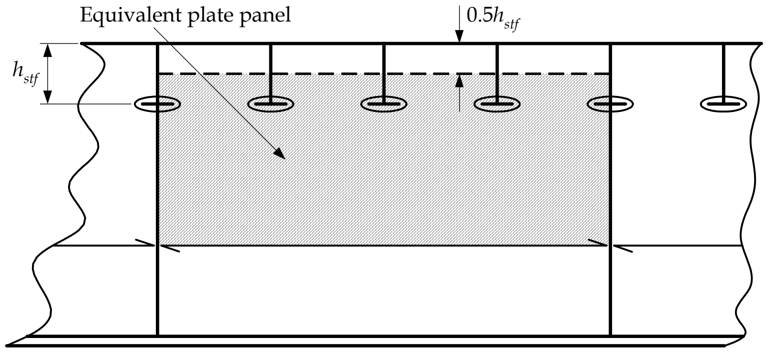
5.2.3 Un-stiffened panels

Paragraph 5.2.3.2 has been amended as follows.

5.2.3.2 In way of web frames, stringers and brackets, the geometry of the panel (i.e. plate bounded by web stiffeners/face plate) may not have a rectangular shape. Where the advanced buckling method is unable to correctly model the panel geometry, then an equivalent rectangular panel is to be defined as shown in **Fig. D.5.5** ~~**and D.5.6**~~. <u>Where web stiffeners are not connected to the intersecting stiffeners, then the panel may be defined a shown in **Fig. D.5.6**.</u> The FE analysis is to represent the actual structure in order to derive realistic stress values for application to the equivalent rectangular panel. <u>The stresses of all elements whose centroids are within the equivalent plate panel are to be connected for stress average in accordance with **5.3.2.1**.</u>

Fig. D.5.6 has been amended as follows.

Fig. D.5.6 Capacity Model for Web Plate



Note

The correction of panel breadth is applicable also for other slot configurations ~~with or without collar plates~~ provided <u>that</u> the web <u>or</u> ~~/~~collar plate is attached to <u>at least one side of</u> the passing stiffener.

5.4. Limitations of the Advanced Buckling Assessment Method

5.4.1 General

Paragraph 5.4.1.1 has been amended as follows.

5.4.1.1 ~~The following structural elements are not covered by the advanced buckling assessment and are to be assessed according to **Table D.5.2**.~~ <u>In the absence of a suitable advanced buckling method, then the following structural elements can be assessed according to **Table D.5.2**.</u>

Table D.5.2 has been amended as follows.

Table D.5.2 ~~Requirements to Structural Elements not Covered by Advanced Buckling Assessment~~

<u>Requirements for structures where there is no advanced buckling method available</u>

Structural elements	Buckling mode	Rule Reference
bilge plate	transverse elastic buckling	**Section 8/2.2.3**
primary support members	global (overall) buckling and torsional buckling	**Section 10/2.3**
web plate of primary support members in way of openings	buckling of web plate	**Section 10/3.4**
cross ties	global (overall) buckling	**Section 10/3.5**
<u>corrugated bulkheads</u>	<u>flange panel buckling</u>	**<u>Section 10/3.2</u>**
	<u>global (overall) buckling</u>	**<u>Section 10/3.5</u>**

EFFECTIVE DATE AND APPLICATION (Amendment 1-1)

1. The effective date of the amendments is 1 April 2006.

2. Notwithstanding the amendments to the Rules, the current requirements may apply to ships for which the date of contract for construction* is before the effective date.
*"contract for construction" is defined in IACS Procedural Requirement(PR) No.29 (Rev.4).

IACS PR No.29 (Rev.4)

1. The date of "contract for construction" of a vessel is the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder. This date and the construction numbers (i.e. hull numbers) of all the vessels included in the contract are to be declared to the classification society by the party applying for the assignment of class to a newbuilding.

2. The date of "contract for construction" of a series of vessels, including specified optional vessels for which the option is ultimately exercised, is the date on which the contract to build the series is signed between the prospective owner and the shipbuilder.
For the purpose of this Procedural Requirement, vessels built under a single contract for construction are considered a "series of vessels" if they are built to the same approved plans for classification purposes. However, vessels within a series may have design alterations from the original design provided:
(1) such alterations do not affect matters related to classification, or
(2) If the alterations are subject to classification requirements, these alterations are to comply with the classification requirements in effect on the date on which the alterations are contracted between the prospective owner and the shipbuilder or, in the absence of the alteration contract, comply with the classification requirements in effect on the date on which the alterations are submitted to the Society for approval.
The optional vessels will be considered part of the same series of vessels if the option is exercised not later than 1 year after the contract to build the series was signed.

3. If a contract for construction is later amended to include additional vessels or additional options, the date of "contract for construction" for such vessels is the date on which the amendment to the contract, is signed between the prospective owner and the shipbuilder. The amendment to the contract is to be considered as a "new contract" to which **1.** and **2.** above apply.

4. If a contract for construction is amended to change the ship type, the date of "contract for construction" of this modified vessel, or vessels, is the date on which revised contract or new contract is signed between the Owner, or Owners, and the shipbuilder.

Notes:
1. This Procedural Requirement applies to all IACS Members and Associates.
2. This Procedural Requirement is effective for ships "contracted for construction" on or after 1 January 2005.
3. Revision 2 of this Procedural Requirement is effective for ships "contracted for construction" on or after 1 April 2006.
4. Revision 3 of this Procedural Requirement was approved on 5 January 2007 with immediate effect.
5. Revision 4 of this Procedural Requirement was adopted on 21 June 2007 with immediate effect.

Amendment 1-2

Section 2 RULE PRINCIPLES

3. Design Basis

3.1 General

3.1.8 Internal environment (cargo and water ballast tanks)

Paragraph 3.1.8.2 has been amended as follows.

3.1.8.2 For the fatigue assessment of cargo tank structures, a representative mean cargo density throughout the ship's life is to be used. The representative mean density is to be taken as 0.9 *tonnes/m*^{3} or the cargo density from the homogeneous ~~scantling draught condition~~ full load condition at the full load design draught T_{full}, if this is higher.

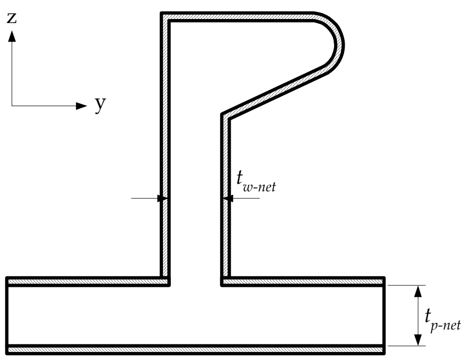
Section 4 BASIC INFORMATION

2. Structural Idealisation

2.4 Geometrical Properties of Local Support Members

2.4.1 Calculation of net section properties for local support members

Part of Fig.4.2.12 has been amended as follows.



The net cross-sectional area, the moment of inertia about the *y*-axis and the associated neutral axis position of the profile is to be determined assuming the corrosion magnitude $0.5t_{corr}$ deducted from the surface of the profile cross-section~~, see **2.4.1.3**~~

Paragraph 2.4.1.3, 2.4.1.4 and 2.4.1.5 have been deleted.

~~2.4.1.3 The combined net properties of *HP* and the *JIS* bulb profiles with attached plate flange are to be determined based on the net sectional properties of the profile, see **2.4.1.4**, which are then added to the attached plate flange.~~

~~2.4.1.4 The net sectional properties of the bulb profile without the attached plating are to be taken as:~~

~~(a) the net cross-sectional area of the bulb profile, $A_{bulb-net}$, is to be taken as:~~

$$A_{bulb-net} = A_{bulb-grs} - \Delta A_{bulb-grs}\, t_{corr} \quad (mm^2)$$

~~(b) the neutral axis position of the net bulb profile, $NA_{bulb-net}$, is to be taken as:~~

$$NA_{bulb-net} \cong NA_{bulb-grs} \quad (mm)$$

~~(c) the net moment of inertia of the bulb profile, $I_{bulb-net}$, is to be taken as:~~

$$I_{bulb-net} = I_{bulb-grs} - \Delta I_{bulb-grs}\, t_{corr} \qquad (cm^4)$$

Where:

$\Delta A_{bulb-grs}$	: as given in **Table 4.2.1** and **Table 4.2.2** for the profile height under consideration, in *mm*[2]
$\Delta I_{bulb-grs}$	: as given in **Table 4.2.1** and **Table 4.2.2** for the profile height under consideration, in *cm*[4]
$A_{bulb-grs}$	: cross-sectional area for the bulb profile under consideration with the nominal height and nominal gross web thickness, in *mm*[2]
$I_{bulb-grs}$	: moment of inertia for the bulb profile under consideration with the nominal height and nominal gross web thickness, in *cm*[4]
$NA_{bulb-grs}$	: neutral axis position above the lower edge of the web for the bulb profile under consideration with the nominal height and nominal gross web thickness, in *mm*
t_{corr}	: corrosion addition, as given in **Section 6/3.2**, in *mm*, for the local support member under consideration

2.4.1.5 The net profile properties of the bulb profiles including attached plating, as shown in **Fig. 4.2.13**, are to be taken as:

(a) the net cross-sectional area of the bulb profile including attached plating, $A_{tot-net}$, is to be taken as:

$$A_{tot-net} = A_{bulb-net} + A_{p-net} \qquad (mm^2)$$

(b) the neutral axis position of the net bulb profile including attached plating, $NA_{tot-net}$, is to be taken as:

$$NA_{tot-net} = \frac{A_{bulb-net}\left(NA_{bulb-net} + t_{p-net}\right) + 0.5 A_{p-net} t_{p-net}}{A_{tot-net}} \qquad (mm)$$

(c) the net moment of inertia of the bulb profile including attached plating, $I_{tot-net}$, is to be taken as:

$$I_{tot-net} = I_{bulb-net} + I_{p-net} + A_{bulb-net}\left(NA_{bulb-net} + t_{p-net} - NA_{tot-net}\right)^2 \cdot 10^{-4} + A_{p-net}\left(NA_{tot-net} - 0.5 t_{p-net}\right)^2 \cdot 10^{-4} \qquad (cm^4)$$

Where:

$A_{bulb-net}$	: net cross-sectional area of the bulb profile, in *mm*[2], as given in **2.4.1.4**
A_{p-net}	: net area of attached plating $= t_{p-net}\, b_p \quad (mm^2)$
t_{p-net}	: net thickness of attached plate $= t_{p-grs} - t_{corr} \quad (mm)$
t_{p-grs}	: gross thickness of attached plate, in *mm*
t_{corr}	: corrosion addition, as given in **Section 6/3.2**, in *mm*
b_p	: breadth of attached plating, in *mm*
$NA_{bulb-net}$	: neutral axis of the net bulb profile, in *mm*, as given in **2.4.1.4**
$I_{bulb-net}$	: net moment of inertia of the bulb profile, as given in **2.4.1.4**, in *cm*[4]
I_{p-net}	: net moment of inertia of attached plating:

$$= \frac{1}{12} b_p t_{p-net}^{3} 10^{-4} \qquad (cm^4)$$

Fig.4.2.13 has been deleted.

Fig. 4.2.13 Definition of Neutral Axis for Bulb Profiles with Attached Plating

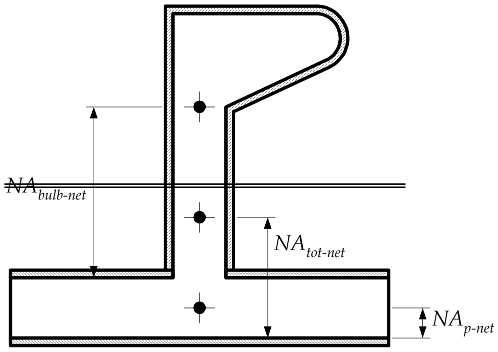


Table 4.2.1 and Table 4.2.2 have been deleted.

Table 4.2.1 Correction Factors for Net *HP* Bulb Profile Data

Profile height h_{stf} (mm)	$\Delta A_{bulb-grs}$ (mm^2 per mm corrosion)	$\Delta I_{bulb-grs}$ (cm^4 per mm corrosion)
200	253	100
220	279	133
240	305	173
260	330	220
280	357	276
300	383	339
320	409	413
340	435	496
370	474	640
400	513	810
430	552	1007

Table 4.2.2 Correction Factors for Net *JIS* Bulb Profile Data

Profile height h_{stf} (mm)	$\Delta A_{bulb-grs}$ (mm^2 per mm corrosion)	$\Delta I_{bulb-grs}$ (cm^4 per mm corrosion)
180	202	72
200	225	100
230	258	152
250	281	197

2.5 Geometrical Properties of Primary Support Members

2.5.1 Effective shear area of primary support members

Paragraph 2.5.1.2 has been amended as follows.

2.5.1.2 For single and double skin primary support members, the effective net web area, $A_{w\text{-}net50}$, is to be taken as:

$A_{w\text{-}net50} = 0.01\ h_n\ t_{w\text{-}net50}\ \underline{\sin\varphi_w}$ (cm^2)

Where:

h_n : for a single skin primary support member, see **Fig. 4.2.16**, the effective web height, in *mm*, is to be taken as the lesser of

(a) h_w

(b) $h_{n3} + h_{n4}$

(c) $h_{n1} + h_{n2} + h_{n4}$

: for a double skin primary support member, the same principle is to be adopted in determining the effective web height.

h_w : web height of primary support member, in *mm*

h_{n1}, h_{n2}, h_{n3}, h_{n4} : as shown in **Fig. 4.2.16**

$t_{w\text{-}net50}$: net web thickness

$= t_{w\text{-}grs} - 0.5\ t_{corr}$ (mm)

$t_{w\text{-}grs}$: gross web thickness, in *mm*

t_{corr} : corrosion addition, as given in **Section 6/3.2**, in *mm*

$\underline{\varphi_w}$: angle between the web and attached plating, see **Fig.4.2.14**, in *degrees*. φ_w is to be taken as 90 *degrees* if the angle is greater than or equal to 75 *degrees*

2.5.2 Effective section modulus of primary support members

Paragraph 2.5.2.1 has been amended as follows.

2.5.2.1 The net section modulus of primary support members is to be calculated using the net thicknesses of the attached plate, web and face plate (or top attached plate for double skin girders), where the net thicknesses are to be taken as:

$t_{w\text{-}net50} = t_{w\text{-}grs} - 0.5t_{corr}$ *mm*, for the net web thickness

$t_{p\text{-}net50} = t_{p\text{-}grs} - 0.5t_{corr}$ *mm*, for the net lower attached plate thickness

$t_{f\text{-}net50} = t_{f\text{-}grs} - 0.5t_{corr}$ *mm*, for the net upper attached plate or face plate

Where:

$t_{w\text{-}grs}$: gross web thickness, in *mm*

$t_{p\text{-}grs}$: gross thickness of lower attached plate, in *mm*

$t_{f\text{-}grs}$: gross thickness of upper attached plate or face plate, in *mm*

t_{corr} : corrosion addition, as given in **Section 6/3.2**, in *mm*

Note :

See **2.3.4** for curved face plates of primary support members

Where angle between the primary support member web and the plate flange is less than 75 degrees, the section modulus is to be directly calculated.

3. Structure Design Details

3.2 Termination of Local Support Members

3.2.3 Bracketed connections

Paragraph 3.2.3.4 has been amended as follows.

3.2.3.4 Brackets to provide fixity of end rotation are to be fitted at the ends of discontinuous local support members, except as otherwise permitted by **3.2.4**. The end brackets are to have arm lengths, l_{bkt}, not less than:

$$l_{bkt} = c_{bkt}\sqrt{\frac{Z_{rl-net}}{t_{bkt-net}}}$$ *mm*, but is not to be less than:

1.8 times the depth of the stiffener web for connections where the end of the stiffener web is supported and the bracket is welded in line with the stiffener web or with offset necessary to enable welding, see **Fig. 4.3.1(c)**

2.0 times for other cases, see **Figure 4.3.1(a), (b)** and **(d)**

Where:

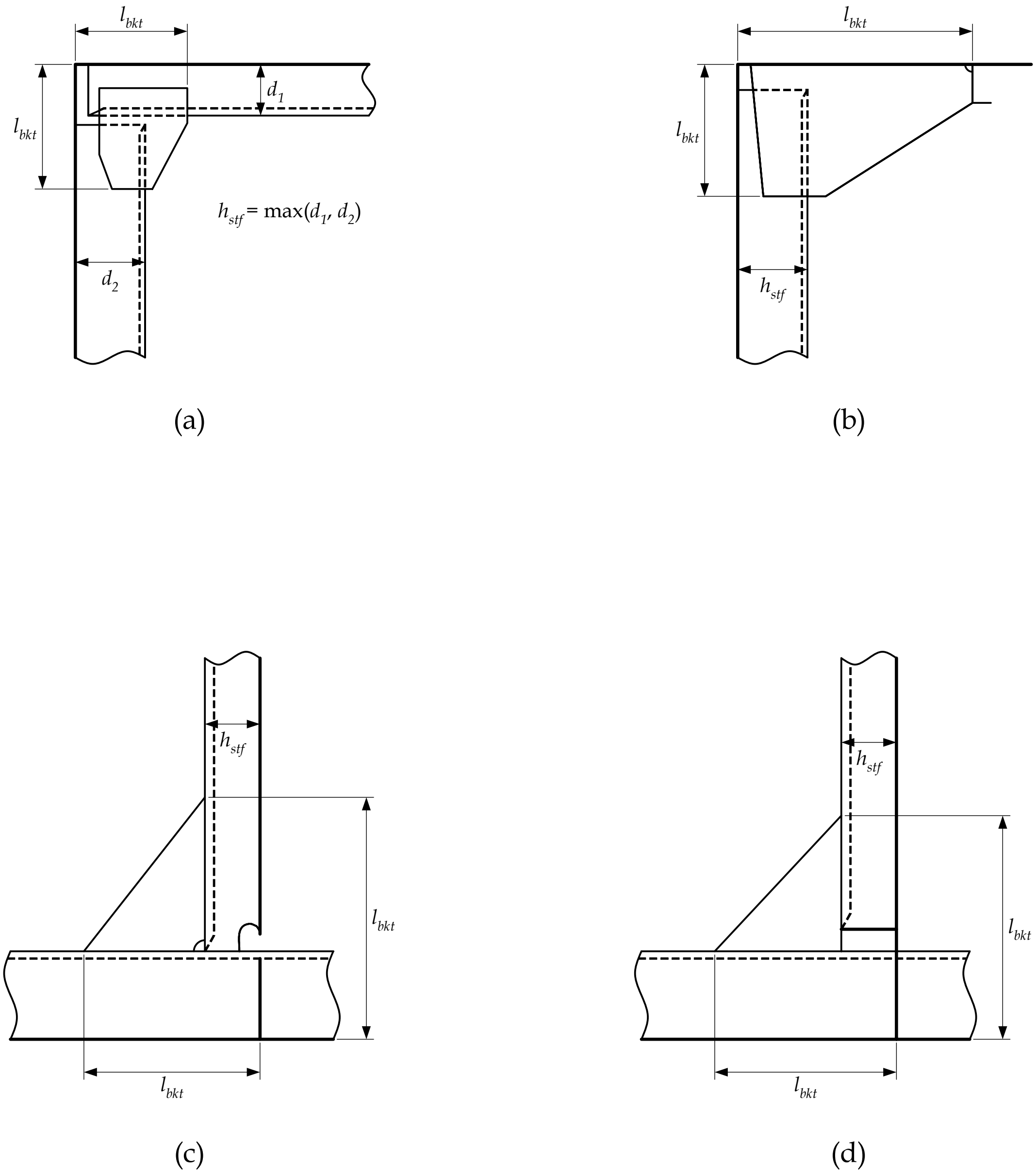
c_{bkt} 65 for brackets with flange or edge stiffener
70 for brackets without flange or edge stiffener

Z_{rl-net} : net rule section modulus, for the stiffener, in cm^3. In the case of two stiffeners connected, it need not be taken as greater than that of the smallest connected stiffener

$t_{bkt-net}$: minimum net bracket thickness, as defined in **3.2.3.3**

In Fig.4.3.1 Note has been added as follows.

Fig. 4.3.1 Bracket Arm Length



Note

1. For stiffeners of configuration **(b)** that are not lapped, the bracket arm length l_{bkt} is not to be less than the stiffener height h_{stf}.
2. For stiffener arrangements similar to **(c)** and **(d)** where the smaller attached stiffener, labelled as h_{stf}, is connected to a primary support member or bulkhead, the height of the bracket is not to be less than the height of the attached stiffener, h_{stf}.

Section 6 Materials and Welding

5. Weld Design and Dimensions

5.11 Alternatives

5.11.1 General

5.11.1.2 The leg length limits given in **Table 6.5.2** are to be complied with in all cases.

Table 6.5.2 has been amended as follows.

Table 6.5.2 Leg Size

Item	Minimum Leg Size[1], *mm*
(a) Gross plate thickness $t_{p\text{-}grs} \leq 6.5mm$[5]	
Hand or automatic welding	4.0
Automatic deep penetration welding	4.0
(b) Gross plate thickness $t_{p\text{-}grs} > 6.5mm$[5]	
Hand or automatic welding	4.5
Automatic deep penetration welding	4.0
(c) Welds within 3*m* below top of ballast and cargo tanks[2] [4]	6.5
(d) All welds in cargo tank region, except in (c) [4]	6.0

Note
1. In all cases, the limiting value is to be taken as the greatest of the applicable values given above.
2. Only applicable to cargo and ballast tanks with weather deck as the tank top.
3. See **5.9.3** for provisions to reduce minimum leg size.
4. A reduction to 5.5*mm* leg size for the secondary structural elements such as carling, buckling stiffeners and tripping brackets may be applied without additional gap control.
5. For superstructure and deck houses, the minimum leg length may be taken as 3.5*mm*.

Section 8 SCANTLING REQUIREMENTS

1. Longitudinal Strength

1.1 Loading Guidance

1.1.2 Loading Manual

Paragraph 1.1.2.2 has been amended as follows.

1.1.2.2 The following loading conditions and design loading and ballast conditions upon which the approval of the hull scantlings is based are, as a minimum, to be included in the Loading Manual:

(a) Seagoing conditions including both departure and arrival conditions

- homogeneous loading conditions including a condition at the scantling draft (homogeneous loading conditions shall not include filling of dry and clean ballast tanks)
- a normal ballast condition where:

  the ballast tanks may be full, partially full or empty. Where partially full options are exercised, the conditions in **1.1.2.5** are to be complied with

  all cargo tanks are to be empty including cargo tanks suitable for the carriage of water ballast at sea

  the propeller is to be fully immersed, and

  the trim is to be by the stern and is not to exceed 0.015*L*, where *L* is as defined in **Section 4/1.1.1**
- a heavy ballast condition where:

  the draught at the forward perpendicular is not to be less than that for the normal ballast condition

  ballast tanks in the cargo tank region or aft of the cargo tank region may be full, partially full or empty. Where the partially full options are exercised, the conditions in **1.1.2.5** are to be complied with

  the fore peak water ballast tank is to be full. If upper and lower fore peak tanks are fitted, the lower is required to be full. The upper fore peak tank may be full, partially full or empty.

  all cargo tanks are to be empty including cargo tanks 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*L*, where *L* is as defined in **Section 4/1.1.1**

  any specified non-uniform distribution of loading

  conditions with high density cargo including the maximum design cargo density, when applicable

  mid-voyage conditions relating to tank cleaning or other operations where these differ significantly from the ballast conditions

  conditions covering ballast water exchange procedures <u>with the calculations of the intermediate condition just before and just after ballasting and/or deballasting any ballast tank</u>

Paragraph 1.1.2.5 and 1.1.2.6 have been amended as follows.

1.1.2.5 Ballast loading conditions involving partially filled peak and/or other ballast tanks in any departure, arrival or intermediate condition are not permitted to be used as design loading conditions unless, for all filling levels between empty and full, the resulting stress levels are within the stress and buckling acceptance criteria ~~where alternative filling levels would result in higher stress levels~~. ~~The partial filling of such tanks is however permitted in service providing, for all filling levels between empty and full, the stress levels are below the stress and buckling acceptance criteria.~~ For design purposes this criteria will be satisfied if the stress levels are within ~~below~~ the stress and buckling acceptance criteria for loading conditions with the appropriate tanks full, ~~and/or~~ empty and partially filled at intended level in any departure, arrival or intermediate condition. The corresponding full, ~~or~~ empty and partially filled tank conditions are to be considered as design conditions for calculation of the still water bending moment and shear force, but these do not need to comply with propeller immersion and trim requirements as specified in **1.1.2.2(a)**. Where multiple ballast tanks are intended to be partially filled, all combinations of full, empty or partially filled at intended levels for those tanks are to be investigated. These requirements are not applicable to ballast water exchange using the sequential method.

1.1.2.6 In cargo loading conditions, the requirements for partially filled ballast tanks as specified in **1.1.2.5** are applicable to the peak ballast tanks only. ~~In cargo loading conditions, partial filling of peak tanks is not permitted unless, for all filling levels between empty and full, the resulting stress levels are below the stress and buckling acceptance criteria. For design purposes this criteria will be satisfied if the stress levels are below the stress and buckling acceptance criteria for loading conditions with the appropriate tanks full and/or empty. The corresponding full or empty tank conditions are to be considered as design conditions for calculation of the still water bending moment and shear force, but these do not need to comply with propeller immersion and trim requirements.~~

2. Cargo Tank Region

2.3 Hull Envelope Framing

2.3.1 General

Paragraph 2.3.1.2 has been amended as follows.

2.3.1.2 Where longitudinals are omitted in way of the bilge, a longitudinal is to be fitted at the bottom and at the side close to the position where the curvature of the bilge plate starts. The distance between the lower turn of bilge and the outermost bottom longitudinal, *a*, is generally not to be greater than one-third of the spacing between the two outermost bottom longitudinals, s_a. Similarly, the distance between the upper turn of the bilge and the lowest side longitudinal, *b*, is generally not to be greater than one-third of the spacing between the two lowest side longitudinals, s_b. ~~In addition, where no intermediate brackets are fitted between the transverses, s_a and s_b are not to be greater than one-third of the bilge radius or 50 *times* the applicable local shell plating thickness, whichever is the greater.~~ See **Fig. 8.2.1**.

4. Machinery Space

4.2 Bottom Structure

4.2.1 General

Paragraph 4.2.1.1 has been amended as follows.

4.2.1.1 In general, a double bottom is to be fitted in the machinery space. The depth of the double bottom is to be at least the same as required in the cargo tank region, see **Section 5/3.2.1**. Where the depth of the double bottom in the machinery space differs from that in the adjacent spaces, continuity of the longitudinal material is to be maintained by sloping the inner bottom over a suitable longitudinal extent. Lesser double bottom height may be accepted in local areas provided that the overall strength of the double bottom structure is not thereby impaired.

4.2.4 Girders and floors

Paragraph 4.2.4.1 has been amended as follows.

4.2.4.1 The double bottom is to be arranged with a centreline girder. ~~The depth of the centreline girder is to be at least the same as the required depth for the double bottom in the cargo tank region, see **Section 5/3.2.1**.~~

3. Prescriptive Buckling Requirements

3.3 Buckling of Stiffeners

3.3.4 Effective breadth of attached plating

Paragraph 3.3.4.1 has been amended as follows.

3.3.4.1 The effective breadth of attached plating of ordinary stiffeners is to be taken as:

$$b_{eff} = \min(C_x s, \ \chi_s s)$$

Where:

~~$$\chi_s = 0.0035\left(\frac{1000\ l_{stf}}{s}\right)^3 - 0.0673\left(\frac{1000\ l_{stf}}{s}\right)^2 + 0.4422\left(\frac{1000\ l_{stf}}{s}\right) - 0.0056 \le 1.0$$~~

$$\chi_s = 0.0035\left(\frac{1000\ l_{eff}}{s}\right)^3 - 0.0673\left(\frac{1000\ l_{eff}}{s}\right)^2 + 0.4422\left(\frac{1000\ l_{eff}}{s}\right) - 0.0056 \le 1.0$$

s : stiffener spacing as defined in **Section 4/2.2.1**, in *mm*

C_x : average reduction factor for buckling of the two attached plate panels, according to Case 1 in **Table 10.3.1**

l_{stf} : span of stiffener, in *m*, equal to spacing between primary support members

l_{eff} : Effective span of stiffeners in m

$l_{eff} = l_{stf}$ if simply supported at both ends

$l_{eff} = 0.6 l_{stf}$ if fixed at both ends

Section 11 GENERAL REQUIREMENTS

1. Hull Openings and Closing Arrangements

Paragraph 1.3 has been amended as follows.

1.3 Air ~~and Sounding~~ Pipes

1.3.1 General

Paragraph 1.3.1.1 has been amended as follows.

1.3.1.1 Air ~~and sounding~~ pipes are to comply with the requirements of **1.3.2** through **1.3.6** and are also to be in accordance with any relevant requirements for machinery of the individual Classification Societies.

Paragraph 1.3.3 and 1.3.3.1 have been amended as follows.

1.3.3 Details, arrangement and scantlings for air ~~and sounding~~ pipes

1.3.3.1 The wall thicknesses of air ~~and sounding~~ pipes, where exposed to weather, are not to be taken less than that given in **Table 11.1.4**.

Table 11.1.4 Minimum wall Thickness for Air ~~and Sounding~~ Pipes

External diameter, in *mm*	Gross minimum wall thickness, in *mm*
$d_{air} \leq 80$	6.0
$d_{air} \geq 165$	8.5
Where: d_{air} : external diameter of pipe, in *mm*	
Note : Intermediate values are to be obtained by linear interpolations. See also **1.3.4** and **1.3.5** for ventilators in forward part of the ship.	

Paragraph 1.3.4 and 1.3.4.1 have been amended as follows.

1.3.4 Applied loading on air ~~and sounding~~ pipes

1.3.4.1 Air ~~and sounding~~ pipes on an exposed deck within the forward $0.25L$, where the height of the exposed deck at the air pipe ~~or sounding pipe~~ is less than $0.1L$ or $22m$, whichever is less, from the summer load waterline are to comply with the requirements of **1.3.4.2** through **1.3.4.3** and **1.3.5.1**.

Paragraph 1.3.4.2 has been amended as follows.

1.3.4.2 The pressures acting on air ~~and sounding~~ pipes and their closing devices, P_{pipe}, are given by:

$$P_{pipe} = 0.5\rho_{sw} v_{sea}{}^2 C_1 C_2 C_3 \qquad (kN/m^2)$$

Where:

ρ_{sw} : density of sea water, 1.025 *tonnes/m*^{3}
v_{sea} : velocity of water over the fore deck, 13.5 *m/sec*
C_1 : shape coefficient:
- 0.5 for pipes
- 1.3 for pipe or ventilator heads in general
- 0.8 for pipe or ventilator heads of cylindrical form with its axis in the vertical direction

C_2 : slamming coefficient, **3.2**
C_3 : protection coefficient:
- 0.7 for pipes and ventilator heads located immediately behind a breakwater or forecastle
- 1.0 elsewhere, including immediately behind a bulwark

Paragraph 1.3.5 and 1.3.5.1 have been amended as follows.

1.3.5 Strength requirements for air ~~and sounding~~ pipes and their closing devices

1.3.5.1 Bending moments and stresses in air pipes ~~and sounding pipes~~ are to be calculated at critical positions:

(a) at penetration pieces
(b) at weld or flange connections
(c) at toes of supporting brackets.

Bending stresses in the net section are not to exceed 0.8 σ_{yd} , where σ_{yd} is the specified minimum yield stress or 0.2% proof stress of the steel at room temperature. Irrespective of corrosion protection, a corrosion addition to the net section of 2*mm* is then to be applied.

Appendix A HULL GIRDER ULTIMATE STRENGTH

2. Calculation of Hull Girder Ultimate Capacity

2.3 Stress-strain Curves *σ-ε* (or Load-end Shortening Curves)

2.3.4 Beam column buckling

Paragraph 2.3.4.1 has been amended as follows.

2.3.4.1 The equation describing the shortening portion of the stress strain curve σ_{CR1}-ε for the beam column buckling of stiffeners is to be obtained from the following formula:

$$\sigma_{CR1} = \Phi \sigma_{C1} \left(\frac{A_{s-net50} + 10^{-2} b_{eff-p} t_{net50}}{A_{s-net50} + 10^{-2} s t_{net50}} \right) \qquad (N/mm^2)$$

Where:

Φ :edge function defined in **2.3.3.1**

$A_{s\text{-}net50}$:net area of the stiffener, in cm^2, without attached plating

σ_{C1} :critical stress, in N/mm^2

$$\sigma_{C1} = \frac{\sigma_{E1}}{\varepsilon} \qquad \text{for} \quad \sigma_{E1} \le \frac{\sigma_{yd}}{2}\varepsilon$$

~~$\sigma_{C1} = \sigma_{yd}\left(1 - \frac{\Phi \sigma_{yd} \varepsilon}{4\sigma_{E1}}\right)$~~ $\qquad \text{for} \quad \sigma_{E1} > \frac{\sigma_{yd}}{2}\varepsilon$

$$\sigma_{C1} = \sigma_{yd}\left(1 - \frac{\sigma_{yd} \varepsilon}{4\sigma_{E1}}\right)$$

ε :relative strain defined in **2.3.3.1**

σ_{E1} :Euler column buckling stress, in N/mm^2

$$\sigma_{E1} = \pi^2 E \frac{I_{E-net50}}{A_{E-net50} l_{stf}^2} 10^{-4}$$

E :modulus of elasticity, 2.06×10^5 (N/mm^2)

$I_{E\text{-}net50}$:net moment of inertia of stiffeners, in cm^4, with attached plating of width $b_{eff\text{-}s}$

$b_{eff\text{-}s}$:effective width, in *mm*, of the attached plating for the stiffener

$$b_{eff-s} = \frac{s}{\beta_p} \qquad \text{for} \quad \beta_p > 1.0$$

$$b_{eff-s} = s \qquad \text{for} \quad \beta_p \le 1.0$$

β_p $= \frac{s}{t_{net50}} \sqrt{\frac{\varepsilon \sigma_{yd}}{E}}$

s :plate breadth, in *mm*, taken as the spacing between the stiffeners, as defined in **Section 4/2.2.1**

t_{net50} :net thickness of attached plating, in *mm*

$A_{E\text{-}net50}$:net area, in cm^2, of stiffeners with attached plating of width $b_{eff\text{-}p}$

l_{stf} :span of stiffener, in *m*, equal to spacing between primary support members

$b_{eff\text{-}p}$:effective width, in *mm*, of the plating

$$b_{eff-p} = \left(\frac{2.25}{\beta_p} - \frac{1.25}{\beta_p^2} \right) s \qquad \text{for} \quad \beta_p > 1.25$$

$$b_{eff-p} = s \qquad \text{for} \quad \beta_p \le 1.25$$

2.3.5 Torsional buckling of stiffeners

Paragraph 2.3.5.1 has been amended as follows.

2.3.5.1 The equation describing the shortening portion of the stress-strain curve σ_{CR2}-ε for the lateral-flexural buckling of stiffeners is to be obtained according to the following formula:

$$\sigma_{CR2} = \Phi \frac{A_{s-net50}\sigma_{C2} + 10^{-2} s t_{net50}\sigma_{CP}}{A_{s-net50} + 10^{-2} s t_{net50}} \qquad (N/mm^2)$$

Where:

Φ :edge function defined in **2.3.3.1**

$A_{s\text{-}net50}$:net area of the stiffener, in cm^2, without attached plating

σ_{C2} :critical stress, in: N/mm^2

$$\sigma_{C2} = \frac{\sigma_{E2}}{\varepsilon} \qquad \text{for} \quad \sigma_{E2} \le \frac{\sigma_{yd}}{2}\varepsilon$$

~~$\sigma_{C2} = \sigma_{yd}\left(1 - \frac{\Phi\sigma_{yd}\varepsilon}{4\sigma_{E2}}\right)$~~ for $\sigma_{E2} > \frac{\sigma_{yd}}{2}\varepsilon$

$$\sigma_{C2} = \sigma_{yd}\left(1 - \frac{\sigma_{yd}\varepsilon}{4\sigma_{E2}}\right)$$

σ_{E2} :Euler torsional buckling stress, in N/mm^2

$\sigma_{E2} = \sigma_{ET}$

σ_{ET} :reference stress for torsional buckling, in N/mm^2, defined in **Section 10/3.3.3.1**, calculated based on gross thickness minus the corrosion addition $0.5t_{corr}$.

ε :relative strain defined in **2.3.3.1**

s :plate breadth, in *mm*, taken as the spacing between the stiffeners, as defined in **Section 4/2.2.1**

t_{net50} :net thickness of attached plating, in *mm*

σ_{CP} :ultimate strength of the attached plating for the stiffener, in N/mm^2

$$\sigma_{CP} = \left(\frac{2.25}{\beta_p} - \frac{1.25}{\beta_p^2} \right) \sigma_{yd} \qquad \text{for} \quad \beta_p > 1.25$$

$$\sigma_{CP} = \sigma_{yd} \qquad \text{for} \quad \beta_p \le 1.25$$

β_p : coefficient defined in **2.3.4**

2.3.7 Web local buckling of flat bar stiffeners

Paragraph 2.3.7.1 has been amended as follows.

2.3.7.1 The equation describing the shortening portion of the stress-strain curve σ_{CR4}-ε for the web local buckling of flat bar stiffeners is to be obtained from the following formula:

$$\sigma_{CR4} = \Phi\left(\frac{st_{net50}\sigma_{CP} + 10^{-2}A_{s-net50}\sigma_{C4}}{st_{net50} + 10^{-2}A_{s-net50}}\right)$$

Where:

Φ :edge function defined in **2.3.3.1**

σ_{CP} :ultimate strength of the attached plating, in N/mm^2, defined in **2.3.5**

σ_{C4} :critical stress, in N/mm^2

$$\sigma_{C4} = \frac{\sigma_{E4}}{\varepsilon} \quad \text{for} \quad \sigma_{E4} \le \frac{\sigma_{yd}}{2}\varepsilon$$

~~$$\sigma_{C4} = \sigma_{yd}\left(1 - \frac{\Phi\sigma_{yd}\varepsilon}{4\sigma_{E4}}\right)$$~~ for $\sigma_{E4} > \frac{\sigma_{yd}}{2}\varepsilon$

$$\sigma_{C4} = \sigma_{yd}\left(1 - \frac{\sigma_{yd}\varepsilon}{4\sigma_{E4}}\right)$$

σ_{E4} :Euler buckling stress, in N/mm^2

$$\sigma_{E4} = 160000\left(\frac{t_{w-net50}}{d_w}\right)^2$$

ε :relative strain defined in **2.3.3.1.**

$A_{s-net50}$:net area of stiffener, in cm^2, *see* **2.3.5.1**

$t_{w-net50}$:net thickness of web, in *mm*

d_w :depth of the web, in *mm*

s :plate breadth, in *mm*, taken as the spacing between the stiffeners, as defined in **Section 4/2.2.1**

t_{net50} :net thickness of attached plating, in *mm*

2.3.8 Buckling of transversely stiffened plate panels

Paragraph 2.3.8.1 has been amended as follows.

2.3.8.1 The equation describing the shortening portion of the stress-strain curve σ_{CR5}-ε for the buckling of transversely stiffened panels is to be obtained from the following formula:

$$\sigma_{CR5} = \min \begin{cases} \sigma_{yd}\left[\dfrac{s}{1000 l_{stf}}\left(\dfrac{2.25}{\beta_p} - \dfrac{1.25}{\beta_w^2}\right) + 0.1\left(1 - \dfrac{s}{1000 l_{stf}}\right)\left(1 + \dfrac{1}{\beta_p^2}\right)^2\right] \\ \sigma_{yd}\Phi \end{cases}$$

$$\sigma_{CR5} = \min \begin{cases} \Phi\sigma_{yd}\left[\dfrac{s}{1000 l_{stf}}\left(\dfrac{2.25}{\beta_p} - \dfrac{1.25}{\beta_w^2}\right) + 0.1\left(1 - \dfrac{s}{1000 l_{stf}}\right)\left(1 + \dfrac{1}{\beta_p^2}\right)^2\right] \\ \sigma_{yd}\Phi \end{cases} \quad (N/mm^2)$$

Where:

β_p :coefficient defined in **2.3.4.1**

Φ :edge function defined in **2.3.3.1**

s :plate breadth, in *mm*, taken as the spacing between the stiffeners, as defined in **Section 4/2.2.1**

l_{stf} :stiffener span, in *m*, equal to spacing between primary support members

σ_{yd} :specified minimum yield stress of the material, in N/mm^2

Appendix C – FATIGUE STRENGTH ASSESSMENT

1. Nominal Stress Approach

1.4 Fatigue Damage Calculation

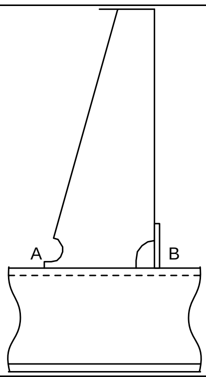
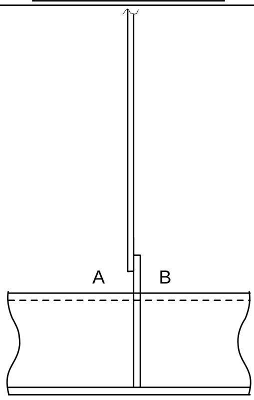
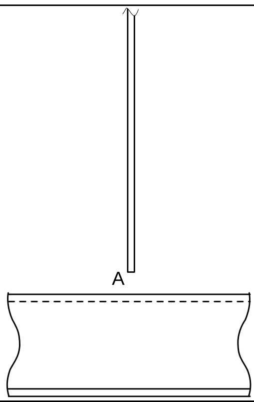
Part of Table C.1.7 has been amended as follows.

Table C.1.7 Classification of Structural Details

Notes 1. Where the attachment length is less than or equal to 150*mm*, the S-N curve is to may be upgraded one class from those specified in the table. For example, if the class shown in the table is *F2*, upgrade to *F*. Attachment length is defined as the length of the weld attachment on the longitudinal stiffener face plate without deduction of scallop. 2. Where the longitudinal stiffener is a flat bar and there is a stiffener/bracket welded to the face, the S-N curve is to be downgraded by one class from those specified in the table. For example, if the class shown in the table is F, downgrade to *F2*; if the class shown in the table is *F2*, downgrade to *G*. This also applies to unsymmetrical profiles where there is less than 8*mm* clearance between the edge of the stiffener flange and the face of the attachment, e.g. bulb or angle profiles where the stated clearance cannot be achieved. 3. Lapped connections (attachments welded to the web of the longitudinals) should not be adopted and therefore these are not covered by the table. 4. For connections fitted with a soft heel, class *F* may be used if it is predominantly subjected to axial loading. Stiffeners fitted on deck and within 0.1*D* below deck at side are considered to satisfy this condition. 5. For connections fitted with a tight collar around the face plate (i.e., connection type **ID25** through **30**) or a full collar (i.e., connection type **ID31**), class *F* may be used if subjected to axial loading. Stiffeners fitted on deck and within 0.1*D* below deck at side are considered to satisfy this condition 6. ID32 is applicable in cases where web stiffeners are omitted or are not connected to the longitudinal stiffener face plate. In the dynamic wave wetted zone at side and below, in way of bottom and in way of inner hull below 0.1*D* from the deck at side, a water-tight collar or alternatively a detail design for cut-outs as shown in Figure C.1.11 or equivalent is to be adopted. Other designs are subject to a satisfactory fatigue assessment by using comparative FEM based hot spot stress. For detail design of cut-outs as shown in Figure C.1.11 or equivalent, the S-N curve may be upgraded to *E* for the dynamic wave wetted zone at side and below, in way of bottom and in way of inner hull below 0.1*D* from the deck at side. **ID31** and **32** show details where web stiffeners are omitted or are not connected to the longitudinal stiffener face plate. A full collar (i.e. connection type **ID 31**) or alternatively a detail design for cut-outs as shown in **Figure C.1.11** or equivalent is required in way of: ・ Side below the highest point of the wave wetted zone or below 0.1*D* from the deck at side, whichever is lower. ・ Bottom ・ Inner hull longitudinal bulkhead below 0.1*D* from the deck at side ・ Hopper ・ Inner bottom The highest point of the wave wetted zone is defined as the full load draft plus h_{WL} as shown in **Fig. C.1.1**. Equivalence to **Figure C.1.11** is to be demonstrated through a satisfactory fatigue assessment by using comparative FEM based hot spot stress of the cut-out in the primary support member and the collar.

~~7. In way of other areas besides what is mentioned in Note 6, i.e. side above wave wetted zone, deck, inner hull areas within 0.1*D* from the deck at side, in cases where web stiffeners are omitted or not connected to the longitudinal stiffener face plate, conventional slot configurations are permitted and an F class is in general to be applied, as described in ID 32. E class may however be applied with combined global and local stress ranges provided 25 years is achieved applying *F* class considering global stress range only. Stress range combination factors for deck may be used to obtain the global stress range in this instance.~~

For connection type **ID32** having no collar welded to the face plate, class *F* is to be used in way of longitudinals in the strength deck irrespective of slot configuration. In other areas class *E* may be used irrespective of slot configuration.

ID	Connection type	Critical Locations Notes (1), (2), (3)	
		A	B
30		F	F2(5 only)
31		F2(5,6 only)	F2(5,6 only)
32		F(6, 7 only)	N/A

EFFECTIVE DATE AND APPLICATION

1. The effective date of the amendments is 1 July 2008.

2. Notwithstanding the amendments to the Rules, the current requirements apply to ships for which the date of contract for construction* is before the effective date.

3. Notwithstanding the provision of preceding **2.**, the amendments to the Rules may apply, upon request by the owner of a ship, to ships for which the date of contract for construction* is before the effective date.

*"contract for construction" is defined in IACS Procedural Requirement(PR) No.29 (Rev.4).

IACS PR No.29 (Rev.4)

1. The date of "contract for construction" of a vessel is the date on which the contract to build the vessel is signed between the prospective owner and the shipbuilder. This date and the construction numbers (i.e. hull numbers) of all the vessels included in the contract are to be declared to the classification society by the party applying for the assignment of class to a newbuilding.

2. The date of "contract for construction" of a series of vessels, including specified optional vessels for which the option is ultimately exercised, is the date on which the contract to build the series is signed between the prospective owner and the shipbuilder.
For the purpose of this Procedural Requirement, vessels built under a single contract for construction are considered a "series of vessels" if they are built to the same approved plans for classification purposes. However, vessels within a series may have design alterations from the original design provided:
(1) such alterations do not affect matters related to classification, or
(2) If the alterations are subject to classification requirements, these alterations are to comply with the classification requirements in effect on the date on which the alterations are contracted between the prospective owner and the shipbuilder or, in the absence of the alteration contract, comply with the classification requirements in effect on the date on which the alterations are submitted to the Society for approval.
The optional vessels will be considered part of the same series of vessels if the option is exercised not later than 1 year after the contract to build the series was signed.

3. If a contract for construction is later amended to include additional vessels or additional options, the date of "contract for construction" for such vessels is the date on which the amendment to the contract, is signed between the prospective owner and the shipbuilder. The amendment to the contract is to be considered as a "new contract" to which **1.** and **2.** above apply.

4. If a contract for construction is amended to change the ship type, the date of "contract for construction" of this modified vessel, or vessels, is the date on which revised contract or new contract is signed between the Owner, or Owners, and the shipbuilder.

Notes:
1. This Procedural Requirement applies to all IACS Members and Associates.
2. This Procedural Requirement is effective for ships "contracted for construction" on or after 1 January 2005.
3. Revision 2 of this Procedural Requirement is effective for ships "contracted for construction" on or after 1 April 2006.
4. Revision 3 of this Procedural Requirement was approved on 5 January 2007 with immediate effect.
5. Revision 4 of this Procedural Requirement was adopted on 21 June 2007 with immediate effect.