Common Structural Rules for Double Hull Oil Tankers, January 2006

Rule Change Notice 2 February 2008

Notes: (1) This Rule change shall apply to ships contracted for construction on or after 1 July 2008. The Rule change may be adopted before 1 July 2008 at the discretion of the Society.

For technical background for Rule Changes in this present document, reference is made to separate document Technical Background for Rule Change Notice 2.

SECTION 2 – RULE PRINCIPLES

3 DESIGN BASIS

3.1 General

3.1.8 Internal environment (cargo and water ballast tanks)

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.

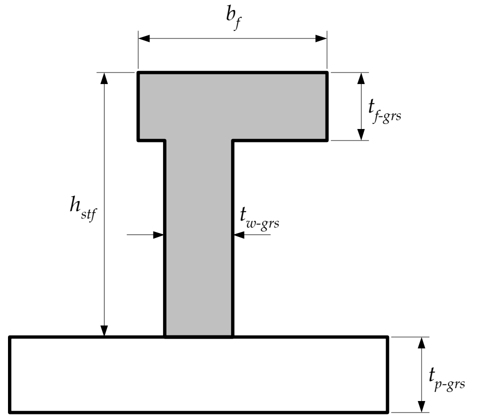
SECTION 4 – BASIC INFORMATION

2 STRUCTURAL IDEALISATION

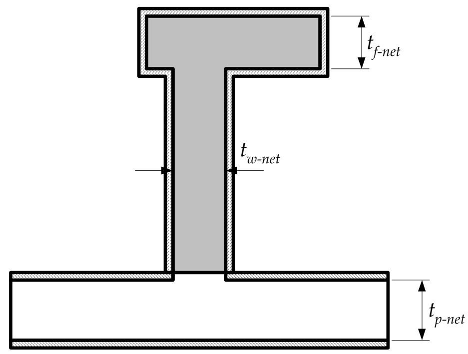
2.4 Geometrical Properties of Local Support Members

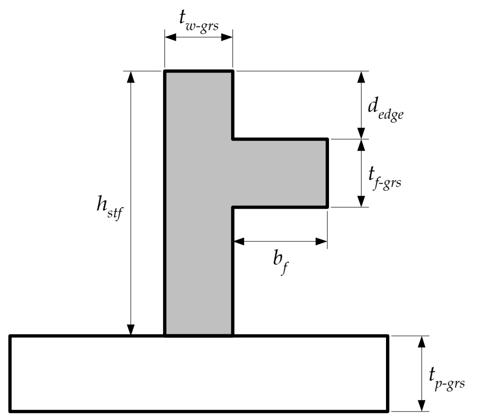
2.4.1 Calculation of net section properties for local support members

Figure 4.2.12 (Continued)
Net Sectional Properties of Local Support Members

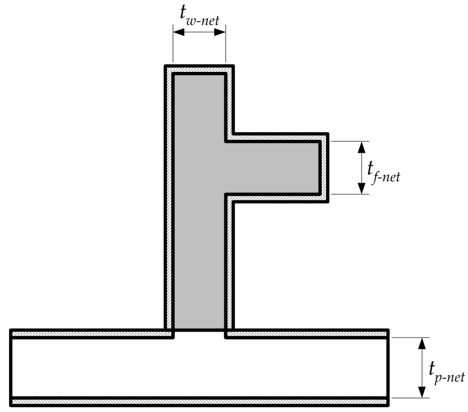


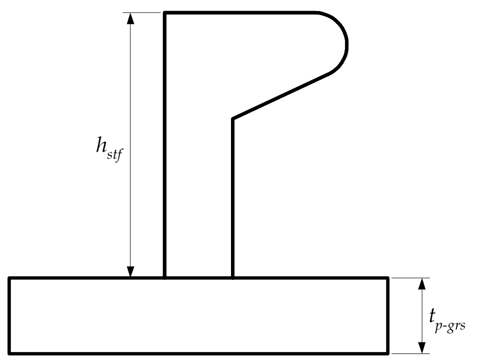
L2 – Profile



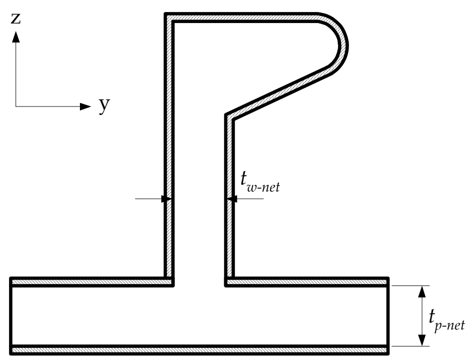


L3 – Profile





Bulb Profile and Similar Profiles



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*~~

~~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:

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

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

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

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

$$I_{bulb-net} = I_{bulb-grs} - \Delta I_{bulb-grs}\ t_{corr} \quad \text{cm}^4$$

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 *Figure 4.2.13*, are to be taken as:

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

$$A_{tot-net} = A_{bulb-net} + A_{p-net} \quad \text{mm}^2$$

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

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

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

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

cm^4

Where:

$A_{bulb-net}$ net cross-sectional area of the bulb profile, in mm^2, as given in *2.4.1.4*,

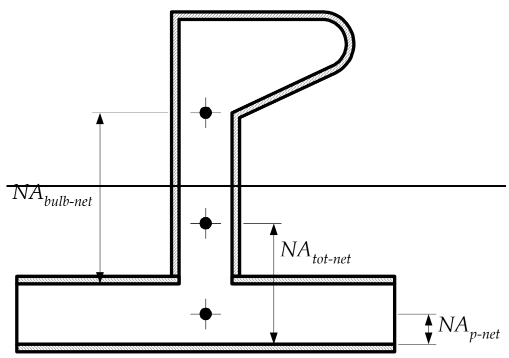
A_{p-net} net area of attached plating

~~$= t_{p-net}\ b_p$ mm²~~

~~t_{p-net}~~	~~net thickness of attached plate~~ ~~$= t_{p-grs} - t_{corr}$ 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 cm⁴~~
~~I_{p-net}~~	~~net moment of inertia of attached plating:~~

$$= \frac{1}{12} b_p t_{p-net}^{\ 3} \cdot 10^{-4} \quad cm^4$$

~~**Figure 4.2.13**~~
~~**Definition of Neutral Axis for Bulb Profiles with Attached Plating**~~



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

~~Profile height h_{stf} (mm)~~	~~$\Delta A_{bulb-grs}$ (mm² per mm corrosion)~~	~~$\Delta I_{bulb-grs}$ (cm⁴ 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

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

$A_{w-net50} = 0.01\, h_n\, t_{w-net50}$ <u>$\sin\varphi_w$</u> cm^2

Where:

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

(g) h_w

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

(i) $h_{n1} + h_{n2}$

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 *Figure 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

<u>φ_w</u> <u>angle between the web and attached plating, see *Figure 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</u>

2.5.2 Effective section modulus of primary support members

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:

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

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

$t_{f-net50} = t_{f-grs} - 0.5 t_{corr}$ 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 Bracket connections

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 *Figure 4.3.1(c)*

  2.0 times for other cases, see *Figure 4.3.1*

Where:

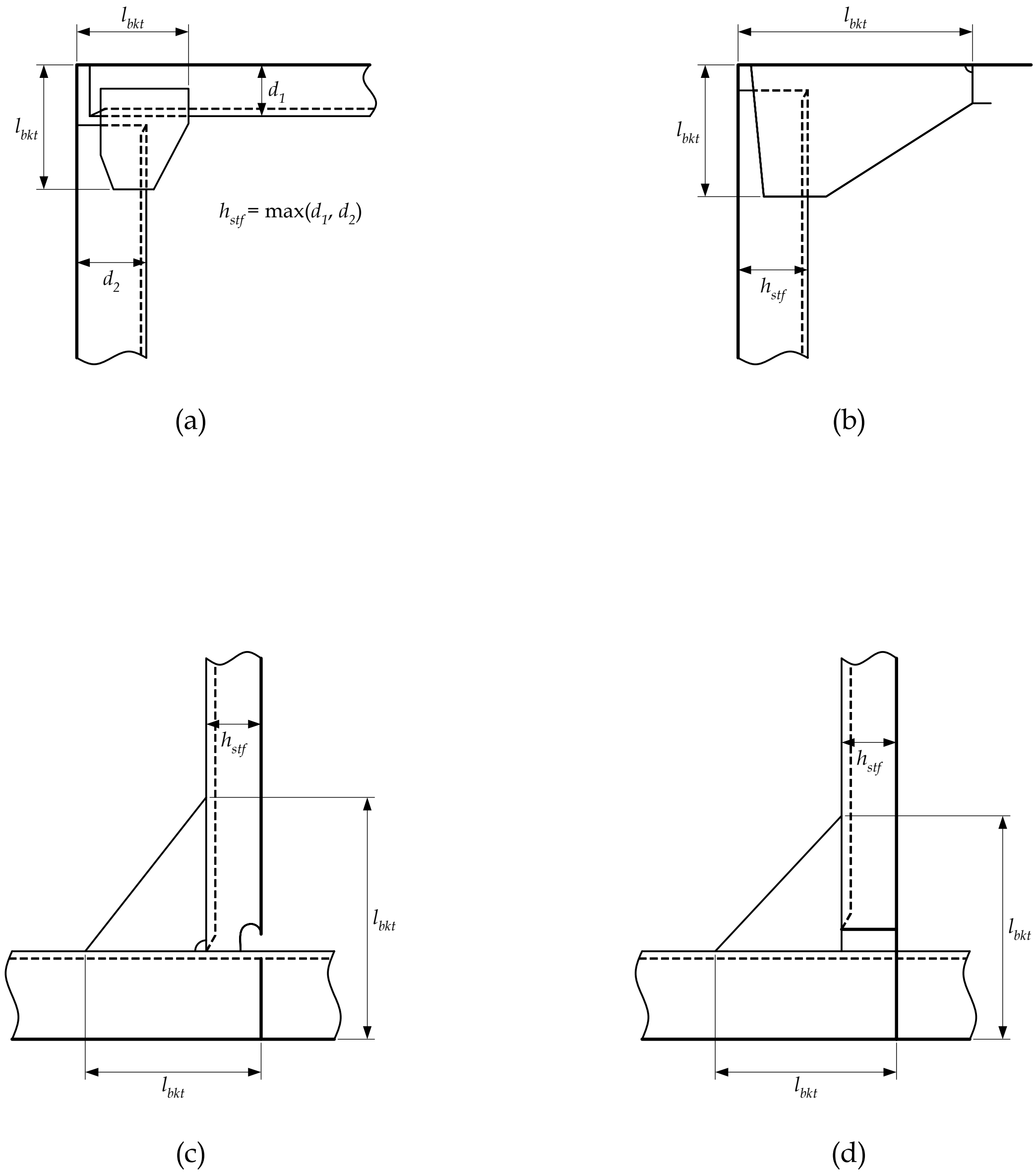
c_{bkt} 65 for brackets with flange or edge stiffener

70 for brackets without flange or edge stiffener

$Z_{rl\text{-}net}$ 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

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

Figure 4.3.1
Bracket Arm Length



Note :

- 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}.
- 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
Leg Size

Item	Minimum Leg Size(1), mm
(a) Gross plate thickness $t_{p\text{-}grs} \le 6.5$mm (5)	
Hand or automatic welding	4.0
Automatic deep penetration welding	4.0
(b) Gross plate thickness $t_{p\text{-}grs} > 6.5$mm (5)	
Hand or automatic welding	4.5
Automatic deep penetration welding	4.0
(c) Welds within 3m 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 5.5mm 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 3.5mm.

SECTION 8 – SCANTLING REQUIREMENT

1 LONGITUDINAL STRENGTH

1.1 Loading Guidance

1.1.2 Loading Manual

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:

(j) 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 with the calculations of the intermediate condition just before and just after ballasting and/or deballasting any ballast tank

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

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 Figure 8.2.1.*

4 MACHINERY SPACE

4.2 Bottom Structure

4.2.1 General

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

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*.~~

SECTION 10 – BUCKLING AND ULTIMATE STRENGTH

3 PRESCRIPTIVE BUCKLING REQUIREMENTS

3.3 Buckling of Stiffeners

3.3.4 Effective breadth of attached plating

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

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

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

1.3 Air ~~and Sounding~~ Pipes

1.3.1 General

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.

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
1. Intermediate values are to be obtained by linear interpolations.
2. See also *1.3.4* and *1.3.5* for ventilators in forward part of the ship.

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 0.25*L*, where the height of the exposed deck at the air pipe ~~or sounding pipe~~ is less than 0.1*L* 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*.

Table 11.1.5
Thickness and Bracket Standards for 760mm High Air Pipes

Nominal pipe size	Minimum fitted gross thickness, in mm	Maximum projected area of head, in cm^2	Height (1) of brackets, in mm
65A	6.0	-	-
80A	6.3	-	480
100A	7.0	-	460
125A	7.8	-	380
150A	8.5	-	300
175A	8.5	-	300
200A	8.5(2)	1900	300
250A	8.5(2)	2500	300 (2)
300A	8.5(2)	3200	300 (2)
350A	8.5(2)	3800	300 (2)

400A	8.5(2)	4500	300 (2)
Note 3. Brackets (see *1.3.3.2*) need not extend over the joint flange for the head. 4. Brackets are required where the gross thickness of the pipe section is less than 10.5mm, or where the tabulated projected head area is exceeded.			

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

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

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

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:

(k) at penetration pieces

(l) at weld or flange connections

(m) at toes of supporting brackets.

Bending stresses in the net section are not to exceed $0.8\sigma_{yd}$, 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 2mm 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

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:

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

Where:

Φ edge function defined in *2.3.3.1*

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

σ_{C1} critical stress, in N/mm^2:

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

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

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

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 x 10^5 N/mm^2

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

b_{eff-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

$A_{E-net50}$ net area, in cm², of stiffeners with attached plating of width b_{eff-p}

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

b_{eff-p} effective width, in mm, of the plating:

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

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

2.3.5 Torsional buckling of stiffeners

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:

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

Where:

Φ edge function defined in *2.3.3.1*

$A_{s-net50}$ net area of the stiffener, in cm², without attached plating

σ_{C2} critical stress, in N/mm²:

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

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

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

σ_{E2} Euler torsional buckling stress, in N/mm²

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

σ_{ET} reference stress for torsional buckling, in N/mm², 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/mm²:

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

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

β_p coefficient defined in *2.3.4*

2.3.7 Web local buckling of flat bar stiffeners

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/mm², defined in *2.3.5*

σ_{C4} critical stress, in N/mm²:

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

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

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

σ_{E4} Euler buckling stress, in N/mm²:

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

ε relative strain defined in *2.3.3.1*.

$A_{s-net50}$ net area of stiffener, in cm², *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

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:

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

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

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

Table C.1.7
Classification of Structural Details

Notes

1. Where the attachment length is less than or equal to 150mm, 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 8mm 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 0.1D 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 0.1D below deck at side are considered to satisfy this condition
6. 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 the highest point of the wave wetted zone or below 0.1D from the deck at side, whichever is lower.
   - Bottom
   - Inner hull longitudinal bulkhead below 0.1D from the deck at side
   - Hopper
   - Inner bottom

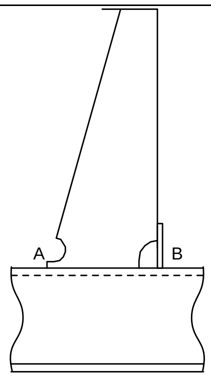
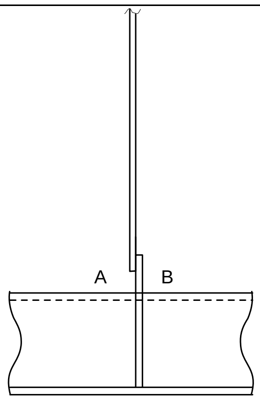
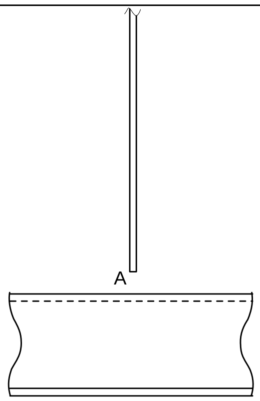
   The highest point of the wave wetted zone is defined as the full load draft plus h_{WL} as shown in Fig. C.1.1. Equivalence to Figure C.1.11 is to be demonstrated through a satisfactory fatigue assessment by using comparative FEM based hot spot stress of the cut-out in the primary support member and the collar.

   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 0.1D 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 0.1D from the deck at side.

7. 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.

   In way of other areas besides what is mentioned in Note 6, i.e. side above wave wetted zone, deck, inner hull areas within 0.1D 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.

Table C.1.7 (Continued)
Classification of Structural Details

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

Common Structural Rules for Double Hull Oil Tankers, January 2006

Technical Background for Rule Change Notice 2 February 2008

Technical Background for the Changes in:

Section 2/3.1.8.2 Cargo density for fatigue calculations

1. Reason for the Rule Change:
Section 2/3.1.8.2
This rule change aligns the rule text with what is already specified in Appendix C/1.3.2. The rules Section 2/3.1.8.2 refers to homogenous loading condition at scantling draught, T_{sc}, while Appendix C/1.3.2 refers to full load condition at design draught, T_{full}. Also the wording "full load condition" is added to clarify that partially filled condition with high density cargoes is excluded.

2. Impact on Scantling
Normally the minimum density of 0.9 tonnes/m^3 governs and is used in fatigue calculations. Also, cargo loaded condition is not very critical for fatigue strength of longitudinals between cargo and ballast tanks because the lateral pressure based main stress in longitudinal flange typically is compression when the cargo tank is full. Hence the rule change proposal has no or very minor impact on the scantlings, and no consequence assessment is considered necessary.

Section 4/2.4.1 Net sectional properties bulb profiles

1. Reason for the Rule Change:
Section 4/2.4.1
The simplified procedure was found to give overly conservative estimate of net section properties of bulb profiles than direct calculations according to Figure 4.2.12. Unlike plastic section properties, exact calculation of elastic section properties in accordance with Figure 4.2.12 is straightforward and is not complicated. Therefore, it was concluded that 4/2.4.1.3-4/2.4.1.5 is redundant and can be deleted.

2. Impact on Scantling
The rule change proposal is made to use more accurate elastic section properties by direct calculations rather than by the simplified procedure. Therefore, no consequence assessment is considered necessary.

Section 4/2.5.1 and 4/2.5.2 Effective shear area/Section Modulus of Primary Support Members

1. Reason for the Rule Change:
Section 4/2.5.1.2 and 4/2.5.2.1
The rules are amended to define shear area and section modulus for primary support members with the web not perpendicular on the plate flange. The rule change proposal

aligns the shear area and section modulus calculations of primary support members with what already applied to local support members.

2. Impact on Scantling

The rule change proposal has no or very minor impact on the scantlings, and no consequence assessment is considered necessary.

Section 4/3.2.3 Bracket connections

1. Reason for the Rule Change:

Section 4/3.2.3.4 and Figure 4.3.1

The rule change proposal incorporates the "Rule Clarification" in Corrigenda 1.

2. Impact on Scantling

The rule change proposal has no or very minor impact on the scantlings, and no consequence assessment is considered necessary. There is no difference from approval practise established by Corrigenda 1.

Section 6/Table 6.5.2 Leg Size

1. Reason for the Rule Change:

Table 6.5.2

Note 4 is introduced from the "Rule Clarification" in Corrigenda 1.

Note 5 is introduced and align the rules with current design practise. Minimum weld size 3.5mm is experienced as satisfactory and a too conservative minimum requirement for superstructure and deck house may increase the risk of weld distortion for the thin plates typically used.

2. Impact on Scantling

The rule change proposal has no impact on the scantlings, and no consequence assessment is considered necessary.

Section 8/1.1.2 Loading Manual

1. Reason for the Rule Change:

8/1.1.2.2, 8/1.1.2.5 and 8/1.1.2.6

The revisions 4 and 5 of UR S 11 were not in the scope of the CSR Oil Tanker development. The rules are updated based on the revision 5 (Jan 2006) of UR S11.2.1.2 through S11.2.1.5. This update was also requested through KC 320.
8/1.1.2.2 (a) last bullet point is modified to clarify the CSR with the UR S11.2.1.2 the first paragraph last sentence ("Also, where any ballasting and/or deballasting is intended during voyage, calculations of the intermediate condition just before and just after ballasting and/or deballasting any ballast tank are to be submitted and where approved included in the loading manual for guidance.").
8/1.1.2.5 and 8/1.1.2.6 correspond respectively to the applicable parts of UR S11.2.1.3 and 11.2.1.4. The content of UR S11.2.1.5 is included in 8/1.1.2.5.

2. Impact on scantling
The rules change proposal has no impact on scantling as the UR S11 should have been applied by designer. No consequence assessment is considered necessary.

Section 8/2.3.1 General

1. Reason for the Rule Change:
8/2.3.1.2
The requirement of the last paragraph of 8/2.3.1.2 (maximum stiffener spacing adjacent to bilge, "sa" and "sb") is to minimise rotation of the bilge shell at the outermost bottom longitudinal and/or the lowest side longitudinal caused by carry-over bending. However, it is found that this requirement may become overly conservative on some tanker designs particularly where design bilge radius is relatively small. Considering that strength of bilge shell is sufficiently covered by the requirements of 8/2.2.3, it was concluded that this requirement is redundant and can be removed.

2. Impact on Scantling
The rule change proposal may relax the requirements of spacing of the two outermost bottom longitudinals and/or the two lowest side longitudinals on some vessels not fitted with bilge brackets. The rule change proposal has no impact on the scantlings, and no consequence assessment is considered necessary.

Section 8/4.2.1 General

1. Reason for the Rule Change:
8/4.2.1.1 and 8/4.2.4.1
The update will align the rules with current design practice.
The double bottom and centreline girder height requirements of 8/4.2.1.1 and 8/4.2.4.1 may be considered as the requirements of the nominal height for regular part of the double bottom in engine room. Lesser double bottom height in local areas, such as local sunken inner bottom forming a small well or recess for arrangement of propulsion main engine, is common and may be acceptable provided that the overall strength including continuity of the longitudinal members of the double bottom is not thereby impaired.

2. Impact on Scantling

The rule change proposal has no impact on the scantlings, and no consequence assessment is considered necessary.

Section 10/3.3.4 Effective breadth of attached plating

1. Reason for the Rule Change:

10/3.3.4

The source of the definition of effective span of stiffeners, l_{eff}, is CSR for Bulk Carriers, however it was found that the definitions were not consistent between these two CSRs. The rule change proposal is made to fix the inconsistency.

2. Impact on Scantling

Due to the above correction, Xs value of the stiffeners with both ends fixed will reduce to approximately 80% - 90% as follows:

S	mm	850	850	850	850
Leff	m	3	4	5	6
Xs_1		0.871	0.950	0.979	0.993
0.6 x leff for fixed ends	m	1.8	2.4	3	3.6
Xs_2		0.662	0.785	0.871	0.926
Xs_2 / Xs_1		76%	83%	89%	93%

The effective breadth of plate flange for the stiffener may be reduced proportionally with the lesser of Cx value and Xs value as indicated below. Particularly for thinner attached plates and/or longer stiffener spans, Xs value does not govern. Therefore, the rule change proposal will give no change or a small increase on scantlings.

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

Section 11/1.3 Air and Sounding Pipes

1. Reason for the Rule Change:

11/1.3.1.1, 11/1.3.3.1, Table 11.1.4, 11/1.3.4.1, 11/1.3.4.2, 11/1.3.5, 11/.1.3.5.1

The CSR currently apply the requirements to air pipes also to sounding pipes. Although these requirements are based on IACS UI LL 36 and UR S27, UI LL 36 and UR S27 are applicable to air pipes but not applicable to sounding pipes. Therefore, it is found appropriate to remove the sounding pipes from the scope of the CSR. The sounding pipes will then be covered by the requirements of the individual class Society.

2. Impact on Scantling

The change will allow the scantlings of sounding pipes to be based on the requirements of the individual class Society currently applied, and there will be no particular increase for CSR tankers.

Appendix A/Chapter 2.3

1. Reason for the Rule Change:
This rule change is upgrading CSR Tank in line with Rule Change 1 for CSR Bulk.

Reference is made to technical background for Rule Change 1 CSR Bulk, Chapter 5- Hull Girder Strength, Appendix 1 Hull Girder Ultimate Strength, 2 Criteria for the calculation of the curve M-χ.

2 Scantling impact due to this modification

The modified buckling formula modification cause scantling increase of ships with transversely framing system as found on some bulk carrier designs. Longitudinal framing is normally used for longitudinal strength members on oil tankers and the rule change then cause no difference in scantling or local increases in areas with transversely stiffened plates.

Appendix C/Table C.1.7 Classification of Structural Details

1. Reason for the Rule Change:
Appendix C/Table C.1.7
The Notes 6 and 7 in the current text for the connection ID 31 and 32 in Table C.1.7 (connections without web stiffeners connected) do not fully and clearly address appropriate fatigue class to be used for each connection detail and location. Therefore, the notes are modified to simplify the fatigue classification of structural details particularly in the areas other than mentioned in Note 6. In the current text, there is a condition to apply class E in the areas other than deck and that mentioned in Note 6. In the rule change proposal, this condition is removed since it is always satisfied (assuming that the deck connections are satisfied using class F) and considered to be redundant. Further for details without web stiffeners connected, it is clarified that the required slot design is a precaution against cracking of primary support member in way of the cut out for longitudinal. This clarification is essential when we elaborate criteria for how to evaluate equivalent slot designs to those shown in Figure C.1.11.

2. Impact on Scantling
The changes of the required fatigue classes are as illustrated in Figures 1 and 2 below: As mentioned above, since the condition for applying class E in the areas other than deck and that mentioned in Note 6 is normally satisfied, there is no eventual difference in applied fatigue class by this rule change proposal. Consequently, no consequence assessment is considered necessary.

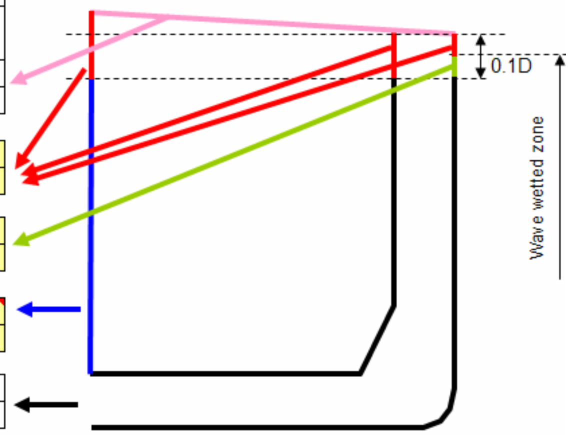
Figure 1

Table C.1.7 Note 5, 6, 7 for ID31 and ID32 where web stiffener is NOT connected

ID31 (Collar around face or full collar) — **F2 in general (with Notes 5 and 6)**
ID32 (NO collar around face) — **F in general (with Notes 6 and 7)**

1. Where top of wave wetted zone is within the range of 0.1D from deck at side

	ID 31	ID 32 (No collar around face)	
	Full Collar	Fig C.1.11 or equiv	Conventional slot
Current	F	F	F
Proposed	F	F	F
Current	F	F, E (see Note1)	F, E (see Note 1)
Proposed	F	E	E
Current	F	E	NA
Proposed	F	E	E
Current	F2	F, E (see Note1)	F, E (see Note1)
Proposed	F2	E	E
Current	F2	E	NA
Proposed	F2	E	NA

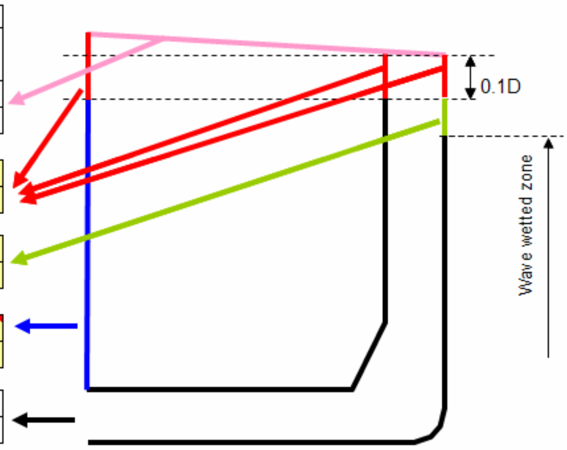


NOTES:
1. E if F with Hull Girder stress only is satisfied
NA - not permitted, except that accepted subject to demonstration using hotspot stress approach.

Figure 2

Where top of wave wetted zone is below the range of 0.1D from deck at side

	ID 31	ID 32 (No collar around face)	
	Full Collar	Fig C.1.11 or equiv	Conventional slot
Current	F	F	F
Proposed	F	F	F
Current	F	F, E (see Note1)	F, E (see Note 1)
Proposed	F	E	E
Current	F2	F, E (see Note1)	F, E (see Note 1)
Proposed	F2	E	E
Current	F2	F, E (see Note1)	F, E (see Note1)
Proposed	F2	E	E
Current	F2	E	NA
Proposed	F2	E	NA



NOTES:
1. E if F with Hull Girder stress only is satisfied
NA - not permitted, except that accepted subject to demonstration using hotspot stress approach.

***** End *****

Common Structural Rules for Double Hull Oil Tankers

Corrigenda 1
Rule Editorials

Notes: (1) These Rule Corrigenda enter into force on 1st July-2008.

(2) This document contains a copy of the affected rule along with the editorial change or clarification noted as applicable.

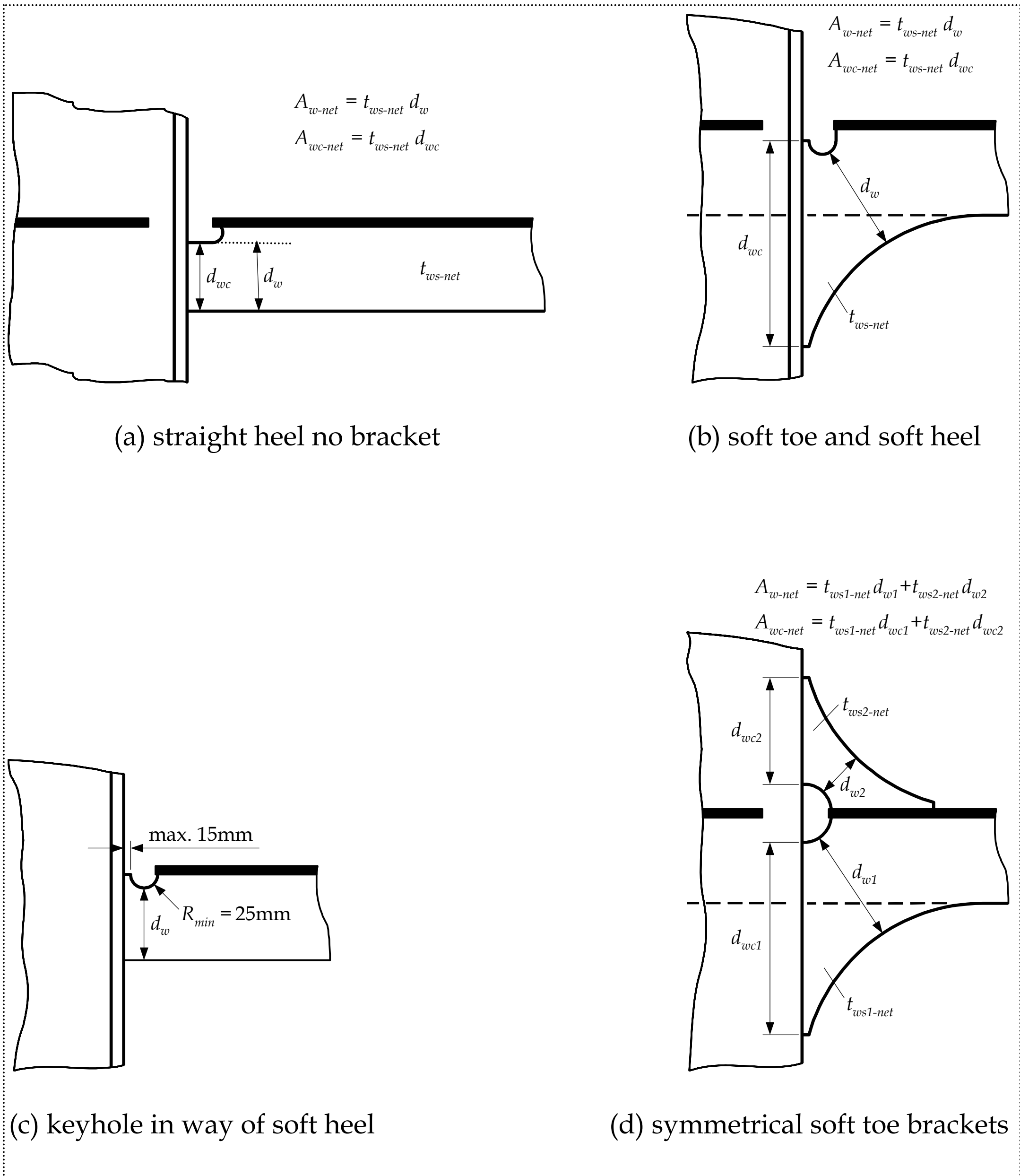
(3) These Rule Corrigenda should be read in conjunction with the 1 July 2008 consolidated edition of Double Hull Oil Tankers CSR (www.iacs.org.uk/publications / common structural rules).

Section 4 - Basic Information

3 STRUCTURE DESIGN DETAILS

3.4 Intersections of Continuous Local Support Members and Primary Support Members

Figure 4.3.6
Primary Support Member Web Stiffener Details



(a) straight heel no bracket

(b) soft toe and soft heel

(c) keyhole in way of soft heel

(d) symmetrical soft toe brackets

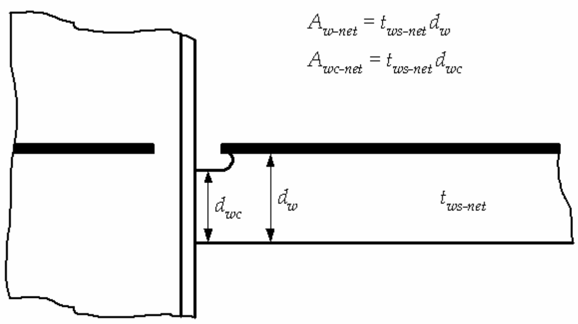
Where:

t_{ws-net}, $t_{ws1-net}$ and $t_{ws2-net}$	net thickness of the primary support member web stiffener/backing bracket, in mm
d_w, d_{w1} and d_{w2}	minimum depth of the primary support member web stiffener/backing bracket, in mm

d_{wc}, d_{wc1} and d_{wc2}	length of connection between the primary support member web stiffener/backing bracket and the local support stiffener, in mm
Note Except where specific dimensions are noted for the details of the keyhole in way of the soft heel, see *3.4.1.4*, the details shown in this figure are only used to illustrate symbols and definitions and are not intended to represent design guidance or recommendations.	

Reason for the Change:

The definition of dw is corrected in (a) (KC ID 466). The correction is not shown in figure above and old figure is therefore inserted below.



(a) straight heel no bracket

SECTION 8 – SCANTLING REQUIREMENTS

1 LONGITUDINAL STRENGTH

1.3 Hull Girder Shear Strength

1.3.3 Shear force correction for longitudinal bulkheads between cargo tanks

1.3.3.4 For ships with a centreline bulkhead between the cargo tanks, the correction factor, K_3, in way of transverse bulkheads is to be taken as:

$$K_3 = \left[0.40\left(1 - \frac{1}{1+n}\right) - f_3\right]$$

Where:

n number of floors between transverse bulkheads~~, excluding the floor in line with the wash bulkhead~~

f_3 shear force distribution factor, see *Figure 8.1.2*

Reason for the Change:

Correction of definition error

1.3.3.6 For ships with two longitudinal bulkheads between the cargo tanks, the correction factor, K_3, in way of transverse bulkhead is to be taken as:

$$K_3 = \left[0.5\left(1 - \frac{1}{1+n}\right)\left(\frac{1}{r+1}\right) - f_3\right]$$

Where:

n number of floors between transverse bulkheads~~, excluding the floor in line with the wash bulkhead~~

r ratio of the part load carried by the wash bulkheads and floors from longitudinal bulkhead to the double side and is given by:

$$r = \frac{1}{\left[\dfrac{A_{3-net50}}{A_{1-net50} + A_{2-net50}} + \dfrac{2\times10^4 b_{80}(n_s+1)A_{3-net50}}{l_{tk}(n_s A_{T-net50} + R)}\right]}$$

Note: for preliminary calculations, r may be taken as 0.5

l_{tk} length of cargo tank, between transverse bulkheads in the side cargo tank, in m

b_{80} 80% of the distance from longitudinal bulkhead to the inner hull longitudinal bulkhead ~~side~~, in m, at tank mid length

$A_{T-net50}$ net shear area of the transverse wash bulkhead, including the double bottom floor directly below, in the side cargo tank, in cm², taken as the smallest area in a vertical section. $A_{T\text{-}net50}$ is to be calculated with net thickness given by t_{grs} - $0.5t_{corr}$

$A_{1\text{-}net50}$ net area, as shown in *Figure 8.1.2,* in m²

$A_{2\text{-}net50}$ net area, as shown in *Figure 8.1.2,* in m²

$A_{3\text{-}net50}$ net area, as shown in *Figure 8.1.2,* in m²

f_3 shear force distribution factor, as shown in *Figure 8.1.2*

n_S number of wash bulkheads in the side cargo tank

R total efficiency of the transverse primary support members in the side tank

$$R = \left(\frac{n - n_s}{2} - 1\right)\frac{A_{Q-net50}}{\gamma} \quad \sout{R = \left(\frac{n}{2} - 1\right)\frac{A_{Q-net50}}{\gamma}} \quad \text{cm}^2$$

$$\gamma = 1 + \frac{300 {b_{80}}^2 A_{Q-net50}}{I_{psm-net50}}$$

$A_{Q\text{-}net50}$ net shear area, in cm², of a transverse primary support member in the wing cargo tank, taken as the sum of the net shear areas of floor, cross ties and deck transverse webs. $A_{Q\text{-}net50}$ is to be calculated using the net thickness given by t_{grs} - $0.5t_{corr.}$ The net shear area is to be calculated at the mid span of the members.

$I_{psm\text{-}net50}$ net moment of inertia for primary support members, in cm⁴, of a transverse primary support member in the wing cargo tank, taken as the sum of the moments of inertia of transverses and cross ties. It is to be calculated using the net thickness given by t_{grs} - $0.5t_{corr.}$ The net moment of inertia is to be calculated at the mid span of the member including an attached plate width equal to the primary support member spacing

t_{grs} gross plate thickness, in mm

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

Reason for the Change:

Correction of definition error of "n" and Editorial

1.4 Hull Girder Buckling Strength

1.4.2 Buckling assessment

1.4.2.6 The compressive buckling strength, of plate panels, is to satisfy the following criteria:

$$\eta \le \eta_{allow}$$

Where:

η buckling utilisation factor

$$\frac{\sigma_{hg-net50}}{\sigma_{cr}}$$

$\sigma_{hg\text{-}net50}$ hull girder compressive stress based on net hull girder sectional properties, in N/mm² as defined in *1.4.2.3*

σ_{cr} critical compressive buckling stress, σ_{xcr} or σ_{ycr} as appropriate, in N/mm², as specified in *Section 10/3.2.1.3*. The critical compressive buckling stress is to be calculated for the effects of hull girder compressive stress only. The effects of other membrane stresses and lateral pressure are to be ignored. The net thickness given as $t_{grs} - t_{corr}$ as described in Section 6/3.3.2.2 is to be used for calculation of σ_{cr}

η_{allow} allowable buckling utilisation factor:

= 1.0 for plate panels at or above 0.5*D*

= 0.90 for plate panels below 0.5*D*

Reason for the Change:

Editorial (KC ID 167)

1.4.2.8 The compressive buckling strength of longitudinal stiffeners is to satisfy the following criteria:

$$\eta \le \eta_{allow}$$

Where:

η greater of the buckling utilisation factors given in *Section 10/3.3.2.1* and *Section 10/3.3.3.1*. The buckling utilisation factor is to be calculated for the effects of hull girder compressive stress only. The effects of other membrane stresses and lateral pressure are to be ignored.

η_{allow} allowable buckling utilisation factor:

= 1.0 for stiffeners at or above 0.5*D*

= 0.90 for stiffeners below 0.5*D*

Reason for the Change:

Editorial (KC ID 167)

2 CARGO TANK REGION

2.1 General

2.1.4 General scantling requirements

2.1.4.8 Enlarged stiffeners (with or without web stiffening) used for Permanent Means of Access (PMA) are to comply with the following requirements:

a) Buckling strength including proportion (slenderness ratio) requirements for primary support members as follows:

- For stiffener web, see *Section 10/2.3.1.1(a), 10/3.2*.
- For stiffener flange, see *Section 10/2.3.1.1(b), 10/2.3.3.1*.
- For web stiffeners, see *Section 10/2.3.2.1, 10/2.3.2.2, 10/3.3*.

Note: Note 1 of table 10.2.1 is not applicable.

b) Buckling strength of longitudinal PMA platforms without web stiffeners may also be ensured using the criteria for local support members in *Section 10/2.2* and *Section 10/3.3*, including Note 1 of *Table 10.2.1*, provided shear buckling strength of web is verified in line with *Section 10/3.2*.

c) All other requirements for local support members as follows:

- Corrosion additions: requirements for local support members
- Minimum thickness: requirements for local support members
- Fatigue: requirements for local support members

Note: For primary support members (or part of it) used as a PMA platform the requirements for primary support members are to be applied.

Reason for the Change:

New paragraph, is added to clarify applicable requirements for enlarged stiffeners used for permanent means of access. (KC ID 572)

6 EVALUATION OF STRUCTURE FOR SLOSHING AND IMPACT LOADS

6.4 Bow Impact

6.4.7.6 The net shear area of the web, $A_{shr\text{-}net50}$ (~~$A_{w\text{-}net50}$~~), of each primary support member at the support/toe of end brackets is not to be less than:

$$A_{shr-net50} = \frac{5 f_{pt} P_{im} b_{slm} l_{shr}}{C_t \tau_{yd}}$$

~~$A_{w-net50} = \frac{5 f_{pt} P_{im} b_{slm} l_{shr}}{C_t \tau_{yd}}$~~ cm²

Where:

f_{pt} patch load modification factor

$$= \frac{l_{slm}}{l_{shr}}$$

l_{slm} extent of bow impact load area along the span

$= \sqrt{A_{slm}}$ m, but not to be taken as greater than l_{shr}

l_{shr} effective shear span, as defined in *Section 4/2.1.~~2~~5*, in m

P_{im} bow impact pressure as given in *Section 7/4.4* and calculated at the load calculation point defined in *Section 3/5.3.2*, in kN/m²

b_{slm} breadth of impact load area supported by the primary support member, to be taken as the spacing between primary support members as defined in *Section 4/2.2.2*, but not to be taken as greater than l_{slm}, in m

C_t permissible shear stress coefficient

= 0.75 for acceptance criteria set AC3

τ_{yd} $= \frac{\sigma_{yd}}{\sqrt{3}}$ N/mm²

σ_{yd} specified minimum yield stress of the material, in N/mm²

Reason for the Change:

Editorial

Section 10 – Buckling and Ultimate Strength

2 STIFFNESS AND PROPORTIONS

2.2 Plates and Local Support Members

2.2.1 Proportions of plate panels and local support members

Table 10.2.1
Slenderness Coefficients

Item		Coefficient
plate panel, C	hull envelope and tank boundaries	100
	other structure	125
stiffener web plate, C_w	angle and T profiles	75
	bulb profiles	41
	flat bars	22
flange/face plate(1), C_f	angle and T profiles	12

Note

1. The total flange breadth, b_f, for angle and T profiles is not to be less than: $b_f = 0.25 d_w$
2. Measurements of breadth and depth are based on gross scantlings ~~as described in Section 4/2.4.1.2.~~

Where:

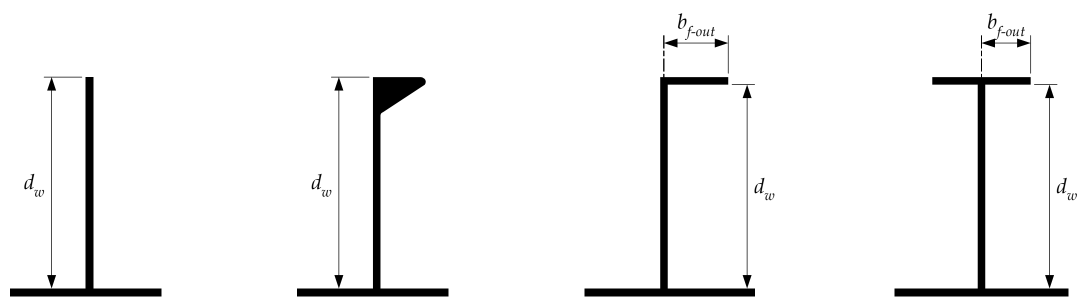
t_{net} net thickness of plate, in mm

d_w depth of web plate, in mm

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

$b_{f\text{-}out}$ breadth of flange outstands, in mm

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

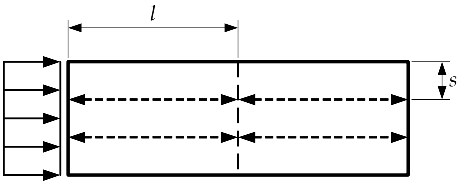
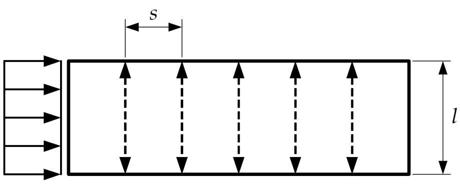


Flat bars   Bulb flats   Angles   T bars

Reason for the Change:

Editorial (Irrelevant cross reference deleted since 4/2.4.1.2 does not describe measuring based on gross scantling)

Table 10.2.2
Stiffness Criteria for Web Stiffening

Mode	Inertia requirements, cm⁴
(a) web stiffeners parallel to the ~~compression stresses~~ flanges of the primary support member 	$I_{net} = Cl^2 A_{net} \frac{\sigma_{yd}}{235}$
(b) web stiffeners normal to ~~compression stresses~~ flanges of the primary support member 	$I_{net} = 1.14\text{x}10^{-5} l \; s^2 t_{w-net} \left(2.5 \frac{1000l}{s} - 2 \frac{s}{1000l} \right) \frac{\sigma_{yd}}{235}$

Where:

C = 1.43 for longitudinal stiffeners in cargo tank region ~~subject to hull girder stresses~~

= 0.72 for other stiffeners

l length of web stiffener, in m.

For web stiffeners welded to local support members (LSM), the length is to be measured between the flanges of the local support members.

For sniped web stiffeners the length is to be measured between the lateral supports e.g. the total distance between the flanges of the primary support member as shown for Mode (b).

A_{net} net section area of web stiffener including attached plate assuming effective breadth of 80% of stiffener spacing s, in cm²

s spacing of stiffeners, in mm, as defined in *Section 4/2.2.1*

t_{w-net} net web thickness of the primary support member, in mm

σ_{yd} specified minimum yield stress of the material of the web plate of the primary support member, in N/mm²

Reason for the change:

Clarification

2.4.3 Requirements to edge reinforcements in way of openings and bracket edges

2.4.3.1 The depth of stiffener web, d_w, of edge stiffeners in way of openings and bracket edges is not to be less than:

~~$$d_w = Cl_{stf}\sqrt{\frac{\sigma_{yd}}{235}}$$~~

$$d_w = Cl\sqrt{\frac{\sigma_{yd}}{235}}$$ mm, or 50 mm, whichever is greater

Where:

l_{stf}	length of edge stiffener ~~between effective supports~~, in m
σ_{yd}	specified minimum yield stress of the material, in N/mm²
C	slenderness coefficient 75 for end brackets 50 for tripping brackets 50 for edge reinforcements in way of openings

Reason for the change:

Clarification

3 PRESCRIPTIVE BUCKLING REQUIREMENTS

3.3 Buckling of stiffeners

3.3.3 Torsional buckling mode

Table 10.3.2
Moments of Inertia

Section property	Flat bars	Bulb flats, angles and T bars
I_{P-net}	$\dfrac{d_w^3\, t_{w-net}}{3\text{x}10^4}$	$\left(\dfrac{A_{w-net}(e_f - 0.5t_{f-net})^2}{3} + A_{f-net}\, e_f^2\right)10^{-4}$
I_{T-net}	$\dfrac{d_w\, t_{w-net}^3}{3\text{x}10^4}\left(1-0.63\dfrac{t_{w-net}}{d_w}\right)$	~~$\dfrac{(e_f - 0.5t_{f-net})t_{w-net}^3}{3\text{x}10^4}\left(1-0.63\dfrac{t_{f-net}}{e_f - 0.5t_{f-net}}\right) + \dfrac{b_f\, t_{f-net}^3}{3\text{x}10^4}\left(1-0.63\dfrac{t_{f-net}}{b_f}\right)$~~ $\dfrac{(e_f - 0.5t_{f-net})t_{w-net}^3}{3\text{x}10^4}\left(1-0.63\dfrac{t_{w-net}}{e_f - 0.5t_{f-net}}\right)$ $+$ $\dfrac{b_f\, t_{f-net}^3}{3\text{x}10^4}\left(1-0.63\dfrac{t_{f-net}}{b_f}\right)$
$I_{\omega-net}$	$\dfrac{d_w^3\, t_{w-net}^3}{36\text{x}10^6}$	for bulb flats and angles: $\dfrac{A_{f-net}\, e_f^2\, b_f^2}{12\text{x}10^6}\left(\dfrac{A_{f-net} + 2.6A_{w-net}}{A_{f-net} + A_{w-net}}\right)$ for T bars: $\dfrac{b_f^3\, t_{f-net}\, e_f^2}{12\text{x}10^6}$

Reason for the change:
Editorial correction.
In the equation for St. Venant's moment of inertia $t_{f\text{-net}}$ is replaced with $t_{w\text{-net}}$ to align with CSR-BC.

Appendix A – Hull Girder Ultimate Strength

2 CALCULATION OF HULL GIRDER ULTIMATE CAPACITY

2.2 Simplified Method Based on an Incremental-iterative Approach

2.2.2 Assumption and modelling of the hull girder cross-section

2.2.2.4 The size and modelling of hard corner elements is to be as follows:

(a) it is to be assumed that the hard corner extends up to $s/2$ from the plate intersection for longitudinally stiffened plate, where s is the stiffener spacing

(b) it is to be assumed that the hard corner extends up to $20t_{grs}$ from the plate intersection for transversely stiffened plates, where t_{grs} is the gross plate thickness.

Note

For transversely stiffened plate, the effective breadth of plate for the load shortening portion of the stress-strain curve is to be taken as the full plate breadth, i.e. to the intersection of other plates – not from the end of the hard corner if any. ~~The area is to be taken as the breadth between the intersecting plates~~. The area on which the value of σ_{CR5} defined in 2.3.8.1 applies is to be taken as the breadth between the hard corners, i.e. excluding the end of the hard corner if any.

Reason for the change:

Clarification requested in KC question 427.

Appendix C - Fatigue Strength Assessment

2 FATIGUE DAMAGE CALCULATION

2.4 Hot Spot Stress (FE Based) Approach

2.4.2 Stresses to be used

2.4.2.6 The hot spot stress is defined as the surface stress at 0.5*t* away from the weld toe location, as shown in *Figure C.2.1*. ~~This stress may be~~ The hot spot stress is to be obtained by linear interpolation using the respective stress at the 1st and 2nd element from the structure intersection.

Reason for the change:
Clarification requested in KC question 509.

Appendix D – Buckling Strength Assessment

1.1 ADVANCED BUCKLING ANALYSIS

1.1.1 General

1.1.2.3 Use of alternative buckling procedures to the reference advanced buckling procedure is acceptable provided that the alternative procedure is verified against the test cases specified in the *Background to Appendix D* and where the permissible utilisation buckling factor for the alternative method, $\eta_{all\text{-}alt}$, complies with:

~~$\eta_{all-alt} \leq \eta_{all} \cdot \left(\dfrac{\eta_{ref-i}}{\eta_{alt-i}}\right)_{\min}$~~

$$\eta_{all-alt} \leq \eta_{all} \cdot \left(\frac{\eta_{alt-i}}{\eta_{reft-i}}\right)_{\min}$$

Where:

η_{all} permissible utilisation factor against buckling for plate and stiffened panels as specified in *Section 9/Table 9.2.2*

$\eta_{ref\text{-}i}$ utilisation factor for reference advanced buckling procedure for test case *i* specified in *Background to Appendix D*

$\eta_{alt\text{-}i}$ utilisation factor for alternative buckling procedure for test case *i* specified in *Background to Appendix D*

Reason for the change:
Correction of misprint in formula

5 STRENGTH ASSESSMENT (FEM) – BUCKLING PROCEDURE

5.2 Structural Modelling and Capacity Assessment Method

5.2.3 Un-stiffened panels

Table D.5.1
Structural Elements for the Strength Assessment (FEM)

Structural Elements	Idealisation	Assessment method[1]	Normal panel definition[2]
Longitudinal structure, see *Figure D.5.1*			
Longitudinally stiffened panels Shell envelope Deck Inner hull Hopper tank side Longitudinal bulkheads Centreline bulkheads	Stiffened panel	Method 1	Length: between web frames Width: between primary support members (PSM)[2]
Double bottom longitudinal girders in line with longitudinal bulkhead or connected to hopper tank side	Stiffened panel	Method 1	Length: between web frames Width: full web depth
Web of horizontal girders in double side tank connected to hopper tank side	Stiffened panel	Method 1	Length: between web frames Width: full web depth
Web of double bottom longitudinal girders not in line with longitudinal bulkhead or not connected to hopper tank side	Stiffened panel	Method 2	Length: between web frames Width: full web depth
Web of horizontal girders in double side tank not connected to hopper tank side	Stiffened panel	Method 2	Length: between web frames Width: full web depth
Web of single skin longitudinal girders	Un-stiffened panel	Method 2	Between local stiffeners/face plate/PSM
Transverse structure, see *Figure D.5.2*			
Web of transverse deck girders including brackets	Un-stiffened panel	Method 2	Between local stiffeners/face plate/PSM
Vertical web in double side tank	Stiffened panel	Method 2	Length: full web depth Width: between primary support members
All irregularly stiffened panels, e.g. Web panels in way of hopper tank and bilge	Un-stiffened panel	Method 2	Between local stiffeners/face plate/PSM
Double bottom floors	Stiffened panel	Method 2	Length: full web depth Width: between primary support members
Vertical web frame including brackets	Un-stiffened panel	Method 2	Between vertical web stiffeners/face plate/PSM
Cross tie web plate	Un-stiffened panel	Method 2	Between vertical web stiffeners/face plate/PSM
Transverse Oil-tight and Watertight bulkheads, see *Figure D.5.3* and Transverse wash bulkheads, see *Figure D.5.4*			
All regularly stiffened bulkhead panels	Stiffened panel	Method 1	Length: between primary support members Width: between primary support members
Regularly stiffened bulkhead with secondary buckling stiffeners perpendicular to regular stiffeners [3]	Stiffened panel	Method 1	Length: between primary support members Width: between primary support members
All irregularly stiffened bulkhead panels, e.g. web panels in way of hopper tank and bilge	Un-stiffened panel	Method 2	Between local stiffeners/face plate
Web plate of bulkhead stringers including brackets	Un-stiffened panel	Method 2	Between web stiffeners /face plate
Transverse Corrugated bulkheads			
Upper/lower stool including stiffeners	Stiffened panel	Method 1	Length: between internal web diaphragms Width: length of stool side
Stool internal web diaphragm	Un-stiffened panel	Method 2	Between local stiffeners /face plate / PSM

Note

1. The assessment method specifies which buckling strength assessment method is to be used, see *4.1*

2.	See structural idealisation, *3.1.3.*
3.	The secondary stiffener can be modelled as "sniped" or "continuous". The stiffener is considered "sniped" unless rotational end supports are provided at both ends An area stiffened by irregular buckling stiffeners only should be assessed by considering each plate in the panel as Unstiffened panel using Method 2.

Reason for the change:

Clarification

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