Common Structural Rules for Oil Tankers, January 2006

Corrigenda 3

Rule Editorials

Notes: (1) These Rule Corrigenda enter into force on 1st April-2006.

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

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SECTION 2 – RULE PRINCIPLES

2 GENERAL ASSUMPTIONS

2.1 General

2.1.2 Classification Societies

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Reason for the Change:
Editorial (Updated A2 is now applicable in conjunction with SOLAS II-1/3-8, on towing and mooring equipment, which applies to ships constructed (i.e. keel laid or similar stage of construction) on or after 1 January 2007.)

5 APPLICATION OF PRINCIPLES

5.4 Load-capacity Based Requirements

5.4.1 General

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 partial safety factor
Corrigenda 3

5.6 Application of Rule Requirement

5.6.3 Design Verification – hull girder ultimate strength

5.6.3.1 The requirements for the ultimate strength of the hull girder are based on a partial safety 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.

Reason for the Change:
Editorial

SECTION 3 – RULE APPLICATION

1 NOTATIONS

1.1 Notations

1.1.1 General

1.1.1.2 In addition to 1.1.1.1, ships fully complying with the requirements of these Rules will also be assigned the notation CSR [CSR].

Reason for the Change:
Editorial
2 DOCUMENTATION, PLANS AND DATA REQUIREMENTS

2.2 Submission of Plans and Supporting Calculations

2.2.3 Plans to be supplied onboard the ship

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 8/1.41.3
(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

Reason for the Change:
(h) is added in association with the incorporation of IACS UR A2 (Rev.2) in Section 11.

5 CALCULATION AND EVALUATION OF SCANTLING REQUIREMENTS

5.1 Determination of Scantling Requirements for Plates

5.1.3 Design Verification – hull girder ultimate strength

5.1.3.3 The buckling evaluation is to be calculated using the stress distribution across the width of the panel defined with a reference stress taken at the edge with maximum stress and reduced stress at the other edge given as a fraction, $\Psi_\Phi$, defined in Table 10.3.1, of the reference stress.

Reason for the Change:
Editorial

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 Figure 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 Figure 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, from the edge, e.g. EPP 1 and 2 in Figure 3.5.3(a).

Reason for the Change:
Editorial

5.3 Calculation and Evaluation of Scantling Requirements for Primary Support Members

5.3.3 Bending requirements of primary support members

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, 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.

Reason for the Change:
Editorial and clarification that the equivalency may be also demonstrated by equivalent
deflection.

SECTION 4 – BASIC INFORMATION

1 DEFINITIONS

1.1 Principal Particulars

1.1.5 Draughts

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.

Reason for the Change:
Editorial (KC ID 394)
1.1.5.3 $T_{bal-n}$, 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).

**Reason for the Change:**
Editorial and cross reference for clarification of departure condition.

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.

**Reason for the Change:**
Editorial and cross reference for clarification of departure condition.

1.1.9 **Block coefficient**

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

$$C_b = \frac{\nabla}{LB_{WL}T_{sc}}$$

Where:

- $\nabla$ 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

**Reason for the Change:**
Editorial

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

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

Where:

- $\nabla_{LC}$ moulded displacement volume at the $T_{LC}$ in m$^3$
- $L$ rule length, as defined in 1.1.1.1
Reason for the Change:
Missing definition of $C_{b-LC}$ added. (Refer to KC ID143)

1.8 Glossary

1.8.1 Definitions of terms

<table>
<thead>
<tr>
<th>Terms</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Deep tank</td>
<td>Any tank which extends between two decks or the shell/inner bottom and the deck above or higher</td>
</tr>
<tr>
<td>Discharges</td>
<td>Any piping leading through the ship’s sides for conveying bilge water, circulating water, drains etc.</td>
</tr>
<tr>
<td>Docking bracket</td>
<td>A bracket located in the double bottom to locally strengthen the bottom structure for the purposes of docking</td>
</tr>
<tr>
<td>Double bottom structure</td>
<td>The shell plating with stiffeners below the top of the inner bottom and other elements below and including the inner bottom plating</td>
</tr>
<tr>
<td>Doubler</td>
<td>Small piece of plate which is attached to a larger area of plate that requires strengthening in that location. Usually at the attachment point of a stiffener</td>
</tr>
<tr>
<td>Double skin member</td>
<td>Double skin member is defined as a structural member where the idealized beam comprises webs, with top and bottom flanges formed by attached plating</td>
</tr>
<tr>
<td>Duct keel</td>
<td>A keel built of plates in box form extending the length of the cargo tank. It is used to house ballast and other piping leading forward which otherwise would have to run through the cargo tanks</td>
</tr>
<tr>
<td>Enclosed superstructure</td>
<td>The superstructure with bulkheads forward and/or aft fitted with weather tight doors and closing appliances</td>
</tr>
<tr>
<td>Engine room bulkhead</td>
<td>A transverse bulkhead either directly forward or aft of the engine room</td>
</tr>
<tr>
<td>Face plate</td>
<td>The section of a stiffening member attached to the plate via a web and is usually parallel to the plated surface</td>
</tr>
<tr>
<td>Flange</td>
<td>The section of a stiffening member, typically attached to the web, but is sometimes formed by bending the web over. It is usually parallel to the plated surface</td>
</tr>
<tr>
<td>Flat bar</td>
<td>A stiffener comprising only of a web</td>
</tr>
<tr>
<td>Floor</td>
<td>A bottom transverse member</td>
</tr>
<tr>
<td>Forecastle</td>
<td>A short superstructure situated at the bow</td>
</tr>
<tr>
<td>Fore peak</td>
<td>The area of the ship forward of the collision bulkhead</td>
</tr>
<tr>
<td>Fore peak deck</td>
<td>A short raised deck extending aft from the bow of the ship</td>
</tr>
<tr>
<td>Freeboard deck</td>
<td>Generally the uppermost complete deck exposed to weather and sea, which has permanent means of closing all exposed openings</td>
</tr>
<tr>
<td>Freeing port</td>
<td>An opening in the bulwarks to allow water shipped on deck to run freely overboard</td>
</tr>
<tr>
<td>Gangway</td>
<td>The raised walkway between superstructure, such as between the forecastle and bridge, or between the bridge and poop</td>
</tr>
</tbody>
</table>
2 STRUCTURAL IDEALISATION

2.2 Definition of Spacing and Supported Breadth

2.2.2 Spacing and supporting load breadth of primary support members

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 Figure 4.2.9.

Reason for the Change:
Editorial

2.2.3 Effective spacing of curved plating

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.

Reason for the Change:
Editorial

2.4 Geometrical Properties of Local Support Members

2.4.3 Effective plastic section modulus and shear area of stiffeners
2.4.3.2 The effective net plastic section modulus, \( Z_{pl-net} \), of local support members is to be taken as:

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

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
    - (c) the stiffener is attached to an abutting stiffener effective in bending (not a buckling stiffener) or bracket. The bracket is assumed to be bending effective when it is attached to another stiffener (not a buckling stiffener).

- \( d_w \) = depth of stiffener web, in mm:
  - \( h_{stf} - t_{f-net} \) 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 Figure 4.2.12

- \( \gamma = 0.25 \left( 1 + \sqrt{3 + 12 \beta} \right) \)

- \( \beta \) = 0.5 for all cases, except L profiles without a mid span tripping bracket

\[
\beta = \frac{10^6 t^2 w_{-net} f_b l_{f}^2}{80 b_f^2 t_{f-net} h_{f-ctr}^2 + \frac{t_{w-net}}{2b_f}}
\]

- 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 Figure 4.2.12. For bulb profiles, see Table 4.2.3 and Table 4.2.4
distance from mid thickness of stiffener web to the centre of the flange area:

\[ b_{f,ctr} = 0.5(b_f - t_{w,net}) \text{ for rolled angle profiles} \]
\[ = 0 \text{ for T profiles} \]
as given in Table 4.2.3 and Table 4.2.4 for bulb profiles

height of stiffener measured to the mid thickness of the flange:

\[ h_{f,ctr} = h_{stf} - 0.5 \ t_{f,net} \text{ for profiles with flange of rectangular shape except for L3 profiles} \]
\[ = h_{stf} - d_{edge} - 0.5 \ t_{f,net} \text{ for L3 profiles} \]
as given in Table 4.2.3 and Table 4.2.4 for bulb profiles

distance from upper edge of web to the top of the flange, in mm. For L3 profiles, see Figure 4.2.12

\[ f_b = 1.0 \text{ in general} \]
\[ = 0.8 \text{ for continuous flanges with end bracket(s). A continuous flange is defined as a flange that is not sniped and continuous through the primary support member} \]
\[ = 0.7 \text{ for non-continuous flanges with end bracket(s). A non-continuous flange is defined as a flange that is sniped at the primary support member or terminated at the support without aligned structure on the other side of the support} \]

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

\[ l_f \]
net flange thickness, in mm
\[ = 0 \text{ for flat bar stiffeners} \]
as given in Table 4.2.3 and Table 4.2.4 for bulb profiles

net web thickness, in mm

\[ \phi_w \]
angle between the stiffener web and the plate flange, see Figure 4.2.14, in degrees. \( \phi_w \) is to be taken as 90 degrees if the angle is greater than or equal to 75 degrees

**Reason for the Change:**
n and \( f_b \): Editorial

\( d_w \) and \( h_{f,ctr} \): Correction to obtain more accurate net dimensions of \( d_w \) and \( h_{f,ctr} \)

### 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 shear web area, \( A_{\text{web net50}} \), is to be taken as:

\[
A_{\text{web net50}} = 0.01 \cdot h_n \cdot t_{\text{web net50}} \text{ cm}^2
\]

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:
  - (d) \( h_w \)
  - (e) \( h_n3 + h_n4 \)
  - (f) \( h_n1 + h_n2 + h_n4 \)

- 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 Figure 4.2.16
- \( t_{\text{web net50}} \) net web thickness
  \[
  = t_{\text{web grs}} - 0.5 \cdot t_{\text{corr}} \text{ mm}
  \]
- \( t_{\text{web grs}} \) gross web thickness, in mm
- \( t_{\text{corr}} \) corrosion addition, as given in Section 6/3.2, in mm

**Reason for the Change:**
Editorial
Figure 4.2.16
Effective ShearWeb Area in way of Openings

Note
The figure shows effective web height for a single skin primary support member. The effective web height of a double skin primary support member follows the same principles.

Reason for the Change:
Editorial

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, $A_{\text{shear-net50}}$, is to be taken as:

$$A_{\text{shear-net50}} = 0.01 \, h_n \, t_w - \text{net50} + 1.3 \, A_{f\text{-net50}} \, \sin 2 \theta \, \sin \theta \text{ cm}^2$$

Where:

- $A_{f\text{-net50}}$ net flange/face plate area
  - $= 0.01 \, bf \, t_{f\text{-net50}} \text{ cm}^2$
- $b_f$ breadth of flange or face plate, in mm
- $t_{f\text{-net50}}$ net flange thickness
  - $= t_{f\text{grs}} - 0.5t_{corr} \text{ mm}$
- $t_{f\text{grs}}$ gross flange thickness, in mm
$t_{\text{corr}}$ corrosion addition, as given in Section 6/3.2, in mm

$\theta$ angle of slope of continuous flange, see Figure 4.2.17

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

$h_n$ effective web height, as defined in Figure 4.2.16, in mm

**Reason for the Change:**
Editorial

---

![Figure 4.2.17](image)

**Figure 4.2.17**
Effective Shear Web Area in way of Brackets

**Reason for the Change:**
Editorial (changes of title and location of arrow of “hn” in the figure to lower side of flange)

2.6 Geometrical Properties of the Hull Girder Cross-Section

2.6.4 Effective vertical hull girder shear area

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

**Reason for the Change:**
Clarification

3 STRUCTURE DESIGN DETAILS

3.3 Termination of Primary Support Members

3.3.2 End connection

3.3.2.2 The ends of brackets are generally to be soft-toed radiused 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.

Reason for the Change:
Clarification (KC ID 233)

3.3.3 Brackets

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.

Reason for the Change:
Inconsistent sentence (with the definition of effective bracket in 4/2.1.4.4) deleted (KC ID 234)

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.

Reason for the Change:
Editorial

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)

3.4.3.3 The load, \( W \), transmitted through the shear connection is to be taken as follows:
If the web stiffener is connected to the intersecting stiffener:

\[
W_i = W\left(\alpha_a + \frac{A_{1-net}}{4f_cA_{w-net} + A_{1-net}}\right) \text{ kN}
\]

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

\[
W_i = W \quad \text{if the web stiffener is not connected to the intersecting stiffener}
\]

Where:

- \( W \) the total load, in kN, as defined in 3.4.3.2
- \( \alpha_a \) panel aspect ratio, not to be taken greater than 0.25
  \[
  \alpha_a = \frac{s}{1000S}
  \]
- \( S \) 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:
  \[
  A_{1d-net} + A_{1c-net} \quad \text{cm}^2
  \]
  in case of a slit type slot connections area, \( A_{1-net} \) is given by:
  \[
  A_{1-net} = 2l_d t_{w-net} \times 10^{-2} \quad \text{cm}^2
  \]
  in case of a typical double lug or collar plate connection area, \( A_{1-net} \) is given by:
  \[
  A_{1-net} = 2f_1 l_c t_{c-net} \times 10^{-2} \quad \text{cm}^2
  \]
- \( A_{1d-net} \) net shear connection area excluding lug or collar plate, as given by the following and Figure 4.3.5:
  \[
  A_{1d-net} = l_d t_{w-net} \times 10^{-2} \quad \text{cm}^2
  \]
- \( l_d \) length of direct connection between stiffener and primary support member web, in mm
- \( t_{w-net} \) net web thickness of the primary support member, in mm
- \( A_{1c-net} \) net shear connection area with lug or collar plate, given by the following and Figure 4.3.5:
  \[
  A_{1c-net} = f_1 l_c t_{c-net} \times 10^{-2} \quad \text{cm}^2
  \]
- \( l_c \) length of connection between lug or collar plate and primary support member, in mm
- \( t_{c-net} \) net thickness of lug or collar plate, not to be taken greater than the net thickness of the adjacent primary support member web, in mm
- \( f_1 \) shear stiffness coefficient:
  \[
  = 1.0 \quad \text{for stiffeners of symmetrical cross section}
  \]
  \[
  = 140/w \quad \text{for stiffeners of asymmetrical cross section}
  \]
  but is not to be taken as greater than 1.0
- \( w \) the width of the cut-out for an asymmetrical stiffener, measured from the cut-out side of the stiffener web, in mm, as indicated in Figure 4.3.5
effective net cross-sectional area of the primary support member web stiffener in way of the connection including backing bracket where fitted, as shown in Figure 4.3.6, in cm². If the primary support member web stiffener incorporates a soft heel ending or soft heel and soft toe ending, $A_{w-net}$ is to be measured at the throat of the connection, as shown in Figure 4.3.6.

the collar load factor defined as follows:

for intersecting stiffeners of symmetrical cross section:

$\frac{A_{w-net}}{A}\cdot \alpha_k$ =

- 1.85 for $A_{w-net} \leq 14$
- $1.85 - 0.0441(A_{w-net} - 14)$ for $14 < A_{w-net} \leq 31$
- $1.1 - 0.013(A_{w-net} - 31)$ for $31 < A_{w-net} \leq 58$
- 0.75 for $A_{w-net} > 58$

for intersecting stiffeners of asymmetrical cross section:

$\frac{A_{w-net}}{A}\cdot \alpha_k$ =

- $0.68 + 0.0172 \cdot \frac{l_s}{A_{w-net}}$

where:

- $l_s$ = $l_c$ for a single lug or collar plate connection to the primary support member
- $l_s$ = $l_d$ for a single sided direct connection to the primary support member
- $l_s$ = mean of the connection length on both sides, i.e., in the case of a lug or collar plus a direct connection, $l_s = 0.5(l_c + l_d)$

Reason for the Change:
Clarification (KC ID 166)

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:

$W_2 = W\left(1 - \alpha_a - \frac{A_{1-net}}{4f_cA_{w-net} + A_{1-net}}\right)$ 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
- $\alpha_a$ panel aspect ratio
  
  $= \frac{s}{1000S}$

- $S$ primary support member spacing, in m
- $s$ stiffener spacing, in mm
SECTION 6 – MATERIALS AND WELDING

3 CORROSION ADDITIONS

3.3 Application of Corrosion Additions

3.3.3 Application for scantling assessment of plates and local support members

3.3.3.2 The net sectional properties of local support members are calculated by deducting the full corrosion margin, i.e. -1.0tcorr, from the web, flange and attached plate gross thicknesses as described in Section 4/2.4.1 and are to comply with required section modulus, moment of inertia and shear area as given in Section 4/3.4 and 8/2 to 8/7.

Reason for the Change:
Editorial

5 WELD DESIGN AND DIMENSIONS

5.5 Slot Welds

5.5.2 Closing plates

5.5.2.2 Slots are to be well rounded and have a minimum slot length, l_{slot}, of 90mm 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 140mm. Slots are not to be filled with welding.

Reason for the Change:
Correction of wrong wording (KC ID 295)

5.5.3 Rudder closing plates (void)
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, \( l_{\text{slot}} \), of 75mm and in general, a minimum width, \( w_{\text{slot}} \), of twice the side plating gross thickness. The ends of the slots are to be rounded. The space between the slots, \( s_{\text{slot}} \), is not to be greater than 150mm 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.

Reason for the Change:
Rudder is not part of scope of CSR for Tankers, hence deleted.

5.7 Determination of the Size of Welds

5.7.1 General

5.7.1.2 The leg length, \( l_{\text{leg}} \), as shown in Figure 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:

\[
\begin{align*}
(a) \quad l_{\text{leg}} &= f_1 \cdot t_{\text{p-grs}} \\
(b) \quad l_{\text{leg}} &= f_{\text{sd}} \cdot f_{\text{weld}} \cdot f_2 \cdot t_{\text{p-grs}} + t_{\text{gap}} \\
(c) \quad l_{\text{leg}} &= \text{as given in Table 6.5.2}
\end{align*}
\]

Where:

\[
\begin{align*}
&f_1 = 0.30 \text{ for double continuous welding} \\
&f_1 = 0.38 \text{ for intermittent welding} \\
&t_{\text{p-grs}} \text{ the gross plate thickness, in mm. Is generally to be taken as that of the abutting member (member being attached). See 5.7.1.5} \\
&f_{\text{sd}} \text{ correction factor taking into account the yield strength of the weld deposit:} \\
&\quad = \left( \frac{1}{k} \right)^{0.5} \left( \frac{235}{\sigma_{\text{weld}}} \right)^{0.75} \text{ but is not to be taken as less than 0.707} \\
&\sigma_{\text{weld}} \text{ minimum yield stress of the weld deposit, and is not to be less than:} \\
&\quad 305\text{N/mm}^2 \text{ for welding of normal strength steel} \\
&\quad 375\text{N/mm}^2 \text{ for welding of higher strength steels with yield strength of 265 to 355N/mm}^2 \\
&\quad 400\text{ N/mm}^2 \text{ for welding of higher strength steel with yield strength of 390N/mm}^2 \\
&\text{See 5.9.4 for additional requirements that are to be applied where the weld size is determined based on a weld deposit yield strength that exceeds the specified minimum value} \\
&k \text{ higher strength steel factor, as defined in 1.1.4. } k \text{ is to be based on the material of the abutting member} \\
&f_{\text{weld}} \text{ weld factor depending on the type of structural member, see 5.7.2, 5.7.3 and 5.7.4}
\end{align*}
\]
correction factor for the type of weld:
\[ f_2 \]
1.0 for double continuous fillet
\[ s_{ctr} / l_{weld} \] 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):
\[ = 2.0 \text{mm for } t_{p-grs} > 6.5\text{mm} \]
\[ = 2 \left( 1.25 - \frac{1}{f_2} \right) \text{mm for } t_{p-grs} \leq 6.5\text{mm} \]

Reason for the Change:
Editorial

5.7.3 Welding of primary support members

<table>
<thead>
<tr>
<th>Primary Support Member</th>
<th>Position (1)</th>
<th>In tanks</th>
<th>In dry spaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross face area, in cm²</td>
<td></td>
<td>To face plate</td>
<td>To plating</td>
</tr>
<tr>
<td>Greater than 30.0</td>
<td>30.0</td>
<td>0.20</td>
<td>0.26</td>
</tr>
<tr>
<td>Not greater than</td>
<td>65.0</td>
<td>0.12</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>95.0</td>
<td>0.20</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td>130.0</td>
<td>0.12</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>At ends</td>
<td>0.42</td>
<td>0.59 (3)</td>
</tr>
<tr>
<td></td>
<td>Remainder</td>
<td>0.30 (2)</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td>At ends</td>
<td>0.42</td>
<td>0.59 (3)</td>
</tr>
<tr>
<td></td>
<td>Remainder</td>
<td>0.59 (3)</td>
<td>0.59 (3)</td>
</tr>
<tr>
<td></td>
<td>At ends</td>
<td>0.42</td>
<td>0.59 (3)</td>
</tr>
<tr>
<td></td>
<td>Remainder</td>
<td>0.42</td>
<td>0.59 (3)</td>
</tr>
</tbody>
</table>

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.

Reason for the Change:
5.7.5 **Welding at the ends of stiffeners**

<table>
<thead>
<tr>
<th>Connection</th>
<th>Weld area, $A_{\text{weld}}$ in cm²</th>
<th>Weld Factor, $f_{\text{weld}}$ (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Stiffener welded direct to plating</td>
<td>0.25$A_{\text{stf-grs}}$ or 6.5 cm² whichever is the greater</td>
<td>0.38</td>
</tr>
<tr>
<td>(2) Bracketless connection of stiffeners, stiffener</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lapped to bracket or bracket lapped to stiffener:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) in dry space</td>
<td>$1.2 \sqrt{Z_{\text{grs}}}$</td>
<td>0.26</td>
</tr>
<tr>
<td>(b) in tank</td>
<td>$1.4 \sqrt{Z_{\text{grs}}}$</td>
<td>0.38</td>
</tr>
<tr>
<td>(c) main frame to tank side bracket in 0.15L forward</td>
<td>as (a) or (b)</td>
<td>0.38</td>
</tr>
<tr>
<td>(3) Bracket welded to face of stiffener and bracket</td>
<td></td>
<td></td>
</tr>
<tr>
<td>connection to plating</td>
<td></td>
<td>0.38</td>
</tr>
</tbody>
</table>

Where:
- $A_{\text{stf-grs}}$ gross cross sectional area of the stiffener, in cm²
- $A_{\text{weld}}$ weld area, in cm², and is calculated as total length of weld, in cm, times throat thickness, in cm (Where the gap exceeds 2mm the weld size is to be increased. See 5.7.1.6)
- $Z_{\text{grs}}$ the gross section modulus required, in cm³, of the stiffener on which the scantlings of the bracket are based

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

**Reason for the Change:**
Editorial

**SECTION 7 – LOADS**

2 **STATIC LOAD COMPONENTS**

2.2 **Local Static Loads**

2.2.3 **Static tank pressure**

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

$$P_{\text{in-air}} = \rho_{\text{air}}g_z \text{air} \quad \text{kN/m}^2$$

Where:

$z_{\text{air}}$ vertical distance from top of air pipe or overflow pipe to the load point, whichever is the lesser, see Figure 7.2.3, in m
\[ z_{tk} = z_{tk} + h_{air} \]

- \( \rho_{sw} \) density of sea water, 1.025 tonnes/m³
- \( g \) acceleration due to gravity, 9.81 m/s²
- \( h_{air} \) 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. See also Figure 7.2.3.

**Reason for the Change:**

Considering possible special overflow arrangement for flow-through ballast water exchange, revise the wording so that the exceptional cases more general, not limiting to overflow tank or equivalent. (KC ID 421)

---

**Figure 7.2.3**

Pressure-Heads and Distances used for Calculation of Static Tank Pressure

---

**Reason for the Change:**

Editorial (Four missing arrows are added at upper end of \( z_{tk} \) and \( z_{air} \).)
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, \( r_{\text{roll-gyr}} \), associated with the rule loading conditions or specified draughts are specified in Table 7.3.1.

<table>
<thead>
<tr>
<th>Table 7.3.1</th>
<th>( T_{\text{LC}} )</th>
<th>( GM )</th>
<th>( r_{\text{roll-gyr}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loaded at deep draught between 0.9( T_{\text{sc}} ) and ( T_{\text{sc}} )</td>
<td>( 0.12B )</td>
<td>0.12B</td>
<td></td>
</tr>
<tr>
<td>Loaded on reduced draught</td>
<td>( 0.6T_{\text{sc}} )</td>
<td>0.24B</td>
<td></td>
</tr>
<tr>
<td>In ballast</td>
<td>( T_{\text{bal}}, T_{\text{bal-n}} )</td>
<td>0.33B</td>
<td></td>
</tr>
<tr>
<td>( B )</td>
<td>moulded breadth, in m, as defined in Section 4/1.1.3.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( T_{\text{LC}} )</td>
<td>draught in the loading condition being considered, in m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( T_{\text{sc}} )</td>
<td>scantling draught, in m, as defined in Section 4/1.1.5.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( T_{\text{bal}} )</td>
<td>minimum design ballast draught, in m, as defined in Section 4/1.1.5.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( T_{\text{bal-n}} )</td>
<td>normal ballast draught, in m, as defined in Section 4/1.1.5.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Reason for the Change:
Editorial (Tbal-n was missing).

3.3 Ship Accelerations

3.3.3 Vertical accelerations

3.3.3.3 For fatigue strength:

\[ f_{\text{prob}} = 0.45 \]

\[ f_{\text{V}} = \left( \frac{C_{b-LC}}{C_{b}} \right)^2 \left( 1.2 - \frac{L}{1000} \right) \]

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

Reason for the Change:
Editorial

3.3.5 Longitudinal acceleration

3.3.5.1 The envelope longitudinal acceleration, \( a_{\text{lng}} \), at any position, is to be taken as:

\[ a_{\text{lng}} = 0.7 f_{\text{prob}} \sqrt{a_{\text{surge}}^2 + \left( \frac{L}{325} \left( g \sin \phi + a_{\text{pitch-x}} \right) \right)^2} \]

Reason for the Change:
Editorial
\[ a_{\text{surge}} = 0.2 g a_0 \text{ m/s}^2 \]

Where:

- \( a_{\text{surge}} \) is the longitudinal acceleration due to surge, and is to be taken as:
- \( g \) is the acceleration due to gravity, 9.81 m/s\(^2\)
- \( a_0 \) is the common acceleration parameter, as defined in Section 3.3.2.1

\[ a_{\text{pitch-x}} = f_v \varphi (2\pi / U_{\text{pitch}})^2 R_{\text{pitch}} \text{ m/s}^2 \]

- \( a_{\text{pitch-x}} \) is the longitudinal acceleration due to pitch, and is to be taken as:
- \( \varphi \) is the pitch angle, in radians, as defined in Section 3.2.3.2
- \( U_{\text{pitch}} \) is the pitch period, in seconds, as defined in Section 3.2.3.1
- \( R_{\text{pitch}} \) is the pitch radius and is to be taken as the greater of:
- \( z - \left( \frac{D}{4} + \frac{T_{\text{LC}}}{2} \right) \) or \( z - \left( \frac{D}{2} \right) \)

- \( T_{\text{LC}} \) is the draught in the loading condition being considered, in m
- \( D \) is the moulded depth, as defined in Section 4/1.1.4.1
- \( L \) is the rule length, as defined in Section 4/1.1.1.1
- \( z \) is the vertical coordinate, in m
- \( f_{\text{prob}} \) is as defined in Sections 3.3.5.2 and 3.3.5.3 as appropriate
- \( f_v \) is as defined in Sections 3.3.5.2 and 3.3.5.3 as appropriate

**Reason for the Change:**
Editorial

## 4 Sloshing and Impact Loads

### 4.3 Bottom Slamming Loads

#### 4.3.1 Application and limitations

4.3.1.1 The slamming loads in this section apply to ships with \( C_b \geq 0.7 \) and bottom slamming draught \( \geq 0.01L \text{ to } 0.02L \text{ and } \leq 0.045L \).

**Reason for the Change:**
1. This is a revision of applicable limit of the slamming pressure formulation reflecting the industry comments that a lot of vessels’ bottom slamming draughts are less than 0.02L during sequential ballast water exchange procedure, for which there are no criteria in the current CSR (KC ID 335).
2. The CSR pressure formulation is originally from an existing class rule, which is applicable for the slamming draft between 0.01L and 0.045L and has good service experience. When the existing rule was introduced into CSR, the lower limit was changed from 0.01L to 0.02L with simply taking the greatest lower limit of the three class
societies. However, since the pressure formulation and its applicable range should be considered as a complete set, and should not have been separated.

4.4 Bow Impact Loads

4.4.1 Application and limitations

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.

**Reason for the Change:**
Editorial

4.4.2 Bow impact pressure

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

\[ P_{im} = 1.025 f_{im} c_{im} V_{im}^2 \sin \gamma_{wl} \sin \theta_{wl} \text{ kN/m}^2 \]

Where:

- \( f_{im} \) = 0.55 at 0.1L aft of F.P.
- \( f_{im} \) = 0.9 at 0.0125L aft of F.P.
- \( f_{im} \) = 1.0 at and forward of F.P.

Intermediate values to be obtained by linear interpolation

\[ V_{im} = 0.514 V_{fwd} \sin \alpha_{wl} + \sqrt{L} \]

\( V_{fwd} \) = forward speed, in knots

\( V \) = service speed, in knots, as defined in Section 4/1.1.8.1

\( \alpha_{wl} \) = local waterline angle at the position considered, but is not to be taken as less than 35 degrees, see Figure 7.4.6.

\( \gamma_{wl} \) = 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 Figure 7.4.6.

\( c_{im} \) = 1.0 for positions between draughts T_{bal} and T_{sc}

\[ c_{im} = \sqrt{1 + \cos^2[90(\frac{h_f - 2h_o}{h_f})]} \text{ for positions above draught T_{sc}} \]

\( h_f \) = vertical distance from the waterline at draught T_{sc} to the highest deck at side, see Figure 7.4.6, in m

\( h_o \) = vertical distance from the waterline at draught T_{scf} to the position considered, see Figure 7.4.6, in m

\( L \) = rule length, in m, as defined in Section 4/1.1.1

\( T_{sc} \) = scantling draught, in m, as defined in Section 4/1.1.5.5
\( T_{\text{bul}} \) minimum design ballast draught, in m, for the normal ballast condition as defined in Section 4/1.1.5.2

\( \text{WL}_i \) waterline at the position considered, see Figure 7.4.6

**Guidance Note**

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

\[
\gamma_{wl} = \tan^{-1} \left( \frac{\tan \beta_{pl}}{\cos \alpha_{wl}} \right)
\]

Where

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

**Reason for the Change:**

1. \( \gamma_{wl} \): Clarification (KC ID241)
2. New Guidance Note:

The above formula in the Guidance Note was used in the 2nd Draft. However, it was revised to take the angle directly measured normal to the shell in the final text reflecting the industry comments since that is more accurate.

However, shipyards’ drawings do not normally show the angle measured normal to the shell. They normally show body plan angle measured in the section in transverse direction. It is not so easy to show such an angle measured normal to the shell at multiple sections on 2D drawing. Also, when such drawings are not available, it is difficult to proceed with the calculation without certain guidance in the Rules.

**SECTION 8 – SCANTLING REQUIREMENTS**

1 **LONGITUDINAL STRENGTH**

1.3 **Hull Girder Shear Strength**

1.3.2 **Assessment of hull girder shear strength**

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

\[
Q_{sw\text{-perm}} \leq Q_{v\text{-net50}} - Q_{v\text{-pos}} \quad \text{kN}
\]

for maximum permissible positive shear force

\[
Q_{sw\text{-perm}} \geq -Q_{v\text{-net50}} - Q_{v\text{-neg}} \quad \text{kN}
\]

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

\[
= \frac{\tau_{ij-perm} t_{ij-net50}}{1000 q_v} \text{ kN}
\]

\( \tau_{ij-perm} \) permissible hull girder shear stress, \( \tau_{perm} \) as given in Table 8.1.4, in N/mm\(^2\), for plate \( ij \)

\( Q_{wv-pos} \) positive vertical wave shear force, in kN, as defined in Table 8.1.4

\( Q_{wv-neg} \) negative vertical wave shear force, in kN, as defined in Table 8.1.4

\( t_{ij-net50} \) equivalent net thickness, \( t_{net50} \), for plate \( ij \), in mm. For longitudinal bulkheads between cargo tanks, \( t_{net50} \) is to be taken as \( t_{sfc-net50} \) and \( t_{str-k} \) 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 \( t_{w-grs} \) and \( t_{f-grs} \), in mm

\( t_{w-grs} \) gross thickness of the corrugation web, in mm

\( t_{f-grs} \) 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:

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

\( f_i \) 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 Figure 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\(^2\), 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

**Reason for the Change:**
The draft rules published June 2004 referred to unit shear flow, but also allowed for an alternative simplified calculation of \( q_v \) in case software for calculating shear flow of the hull girder was not available. Then during rule editing the meaning of the text was changed so that the simplified method became the rule and not an alternative to unit shear flow calculation.
2 CARGO TANK REGION

2.1 General

2.1.6 Minimum thickness for primary support members

2.1.6.1 The thickness of web plating and face plating of primary support members in the cargo tank region is to comply with the appropriate minimum thickness requirements given in Table 8.2.2.

<table>
<thead>
<tr>
<th>Scantling Location</th>
<th>Net Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double bottom centreline girder</td>
<td>5.5+0.025L₂</td>
</tr>
<tr>
<td>Other double bottom girders</td>
<td>5.5+0.02L₂</td>
</tr>
<tr>
<td>Double bottom floors, web plates of side transverses and stringers in double hull</td>
<td>5.0+0.015L₂</td>
</tr>
<tr>
<td>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.</td>
<td>5.5+0.015L₂</td>
</tr>
</tbody>
</table>

Where:

- \( L₂ \) rule length, \( L \), as defined in Section 4/1.1.1.1, but need not be taken greater than 300m

**Reason for the Change:**
Clarification (added missing member, KC ID 144)

2.2 Hull Envelope Plating

2.2.3 Bilge plating

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

\[
t_{net} = \frac{\sqrt{r^2 S_t P_{ex}}}{100} \text{ mm}
\]

Where:

- \( P_{ex} \) design sea pressure for the design load set 1 calculated at the lower turn of bilge, in kN/m²
- \( r \) effective bilge radius
  \[= r₀ + 0.5(a + b)\] mm
- \( r₀ \) radius of curvature, in mm. See Figure 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 Figure 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 Figure 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 \( s_b/4 \) 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 \( s_a/4 \) 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.

**Reason for the Change:**
Incorporation of “Rule Clarification” in Corrigenda 1.

### 2.5 Bulkheads

#### 2.5.6 Corrugated bulkheads

2.5.6.5 Where the corrugated bulkhead is built with flange and web plate of different thicknesses, 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:

\[
t_{m-net} = \sqrt{\frac{0.0005 b_p^2 |P|}{C_a \sigma_{yd}} - t_{n-net}^2} \quad \text{mm}
\]

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/m²
- \( C_a \) permissible bending stress coefficient:
  - \( 0.75 \) for acceptance criteria set AC1
  - \( 0.90 \) for acceptance criteria set AC2
- \( \sigma_{yd} \) specified minimum yield stress of the material, in N/mm²

**Reason for the Change:**
Clarification that the above requirement is for built-up corrugation, i.e., the thickness difference in the requirement is based on as-built thickness and not based on net required thickness (KC ID 399)

2.6 Primary Support Members

2.6.3 Floors and girders in double bottom

**Figure 8.2.6**

**Effective Shear Span of Floors**

Typical arrangement with hopper and end bracket

Typical arrangement with hopper and stool

*Reason for the Change:*
Editorial (triangle added in the upper figure to make end of span clear)

2.6.4 Deck transverses

2.6.4.1 The web depth of deck transverses is not to be less than:
(a) 0.20 $l_{bdg-dt}$ for deck transverses in the wing cargo tanks of ships with two longitudinal bulkheads
(b) 0.13 $l_{bdg-dt}$ 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 $l_{bdg-dt}$ for the deck transverses of ships with a centreline longitudinal bulkhead.
(d) See also 2.6.1.7

Where:

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

**Reason for the Change:**
Clarification

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.

\[
Z_{in-net50} = \frac{1000 M_{in}}{C_{s-pr} \sigma_{yd}} \text{ cm}^3
\]

\[
Z_{ex-net50} = \frac{1000 M_{ex}}{C_{s-pr} \sigma_{yd}} \text{ cm}^3
\]

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:

$$
= 0.042 \varphi L_{in-dt} S_{l_{bdg-dt}}^2 + M_{st} - 0.042 \varphi L_{in-dt} S_{l_{bdg-dt}}^2 + M_{st}
$$

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:

$$
= 0.042 \varphi L_{in-dt} S_{l_{bdg-dt}}^2 + M_{vw} - 0.042 \varphi L_{in-dt} S_{l_{bdg-dt}}^2 + M_{vw}
$$

but is not to be taken as less than $M_s$

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

$$
= c_{st} \beta_{st} L_{in-st} S_{l_{bdg-st}}^2 \text{ kNm}
$$

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 $l_{bdg-st-ct}$. 
bending moment transferred from the vertical web frame on the longitudinal bulkhead

\[ M_{vw} = c_{vw} \beta_{vw} P_{m-vw} S l_{bdg-vw}^2 \text{kNm} \]

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

\[ M_0 = 0.083 P_{m-dt} S l_{bdg-dt}^2 \text{kNm} \]

\[ M_{ex} = 0.067 P_{ex-dt} S l_{bdg-dt}^2 \text{kNm} \]

\( P_{in-dt} \) 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/m²

\( P_{in-st} \) 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/m²

\( P_{in-vw} \) 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/m²

\( P_{ex-dt} \) 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/m²

\[ \phi \Phi = 1 - 5 \left( \frac{y_{toe}}{l_{bdg-dt}} \right) \text{ but is not to be taken as less than 0.6} \]

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

\[ \beta_{ot} = 0.9 \left( \frac{l_{bdg-st}}{l_{bdg-dt}} \right) \left( \frac{I_{dt}}{I_{st}} \right) \text{ but is not to be taken as less than 0.10 or greater than 0.65} \]

\[ \beta_{mo} = 0.9 \left( \frac{l_{bdg-vw}}{l_{bdg-dt}} \right) \left( \frac{I_{dt}}{I_{vw}} \right) \text{ but is not to be taken as less than 0.10 or greater than 0.50} \]

\( S \) 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 Figure 8.2.7, but is not to be taken as less than 60% of the breadth of the tank at the location being considered
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:

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

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

Where:

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

$= 0.65 P_{in-dt} S l_{shr} + c_1 D b_{str} S \rho g \text{ kN}$

$Q_{ex}$ design shear force due to green sea pressure

$= 0.65 P_{ex-dt} S l_{shr} \text{ kN}$

$P_{in-dt}$ design cargo pressure for the design load set being considered,
calculated at mid point of effective bending span, $l_{bdg\text{-}dt}$, of the deck transverse located at mid tank, in kN/m²

$P_{ex\text{-}dt}$ design green sea pressure for the design load set being considered, calculated at mid point of effective bending span, $l_{bdg\text{-}dt}$, of the deck transverse located at mid tank, in kN/m²

$S$ 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

$l_{bdg\text{-}dt}$ effective bending span of the deck transverse, in m, see Section 4/2.1.4 and Figure 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

$\rho$ density of liquid in the tank, in tonnes/m³, not to be taken less than 1.025, see Section 3.1.8

$g$ acceleration due to gravity, 9.81 m/s²

$C_{t\text{-}pr}$ permissible shear stress coefficient for primary support member as given in Table 8.2.10

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

$\sigma_{yd}$ specified minimum yield stress of the material, in N/mm²

**Reason for the Change:**

Clarification (KC ID 151)

### 2.6.7 Horizontal stringers on transverse bulkheads

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

(a) 0.28 $l_{bdg\text{-}hs}$ for horizontal stringers in wing cargo tanks of ships with two longitudinal bulkheads

(b) 0.20 $l_{bdg\text{-}hs}$ 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 $l_{bdg\text{-}hs}$ 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 Section 4/2.1.4 and Figure 8.2.7

**Reason for the Change:**
Clarification

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

\[
Z_{net50} = \frac{1000 M}{C_{s-pr} \sigma_{yd}} \quad \text{cm}^3
\]

Where:

- \( M \) design bending moment:
  \[ = c \cdot P \cdot S \cdot l_{bdg-hs}^2 \quad \text{kNm} \]
- \( P \) 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/m²
- \( S \) 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 Figure 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
- \( \sigma_{yd} \) specified minimum yield stress of the material, in N/mm²

**Reason for the Change:**
Clarification

### 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:
\[ A_{\text{shr-50}} = \frac{10Q}{C_{t-pr} \tau_{yd}} \text{ cm}^2 \]

Where:
- \( Q \) = design shear force
  \[ = 0.5 \times P \times S \times l_{\text{shr}} \text{ kN} \]
- \( P \) = design pressure for the design load set being considered, calculated at mid point of effective bending span, \( l_{\text{bdg-hs}} \), and at mid point of the spacing, \( S \), of the horizontal stringer, in kN/m²
- \( S \) = sum of the half spacing (distance between stringers), on each side of the horizontal stringer under consideration, in m
- \( l_{\text{shr}} \) = effective shear span of the horizontal stringer, in m, see Section 4/2.1.5
- \( C_{t-pr} \) = permissible shear stress coefficient as given in Table 8.2.10
- \( \tau_{yd} \) = \[ \frac{\sigma_{yd}}{\sqrt{3}} \text{ N/mm}^2 \]
- \( \sigma_{yd} \) = specified minimum yield stress of the material, in N/mm²

**Reason for the Change:**
Clarification

3 **FORWARD OF THE FORWARD CARGO TANK**

3.2 **Bottom Structure**

3.2.6 **Plate stems**

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

\[ t_{\text{stem-net}} = \frac{L_2 \sqrt{235}}{12 \sigma_{yd}} \text{ mm, but need not be taken as greater than 21mm} \]

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
- \( \sigma_{yd} \) = specified minimum yield stress of the material, in N/mm²

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.

**Reason for the Change:**
Clarification

3.8 Miscellaneous Structures

3.8.2 Bulbous bow

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

Reason for the Change:
Clarification

3.9 Scantling Requirements

3.9.3 Primary support members

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

$$A_{shr\text{-}net50} = 10 \frac{f_{shr} \left| P \right| S l_{shr}}{C_t \tau_{yd}} \quad A_{w\text{-}net50} = 10 \frac{f_{shr} \left| P \right| S l_{shr}}{C_t \tau_{yd}} \quad \text{cm}^2$$

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

$\tau_{yd} = \frac{\sigma_{yd}}{\sqrt{3}} \quad \text{N/mm}^2$

$\sigma_{yd}$ specified minimum yield stress of the material, in N/mm$^2$

Reason for the Change:
Editorial
3.9.5 Pillars

3.9.5.1 The maximum load on a pillar, $W_{pill}$, is to be taken as the greatest value calculated for all applicable design load sets, as given in Table 8.3.8, and is to be less than or equal to the permissible pillar load as given by the following equation, where $W_{pill-perm}$ is based on the net properties of the pillar.

$$W_{pill} \leq W_{pill-perm}$$

Where:

- $W_{pill}$: applied axial load on pillar
  $$= P b_{a-sup} l_{a-sup} + W_{pill-upr} \quad \text{kN}$$
- $W_{pill-perm}$: permissible load on a pillar
  $$= 0.1 A_{pill-net50} \eta_{pill} \sigma_{crb} = 10 A_{pill-net50} \eta_{pill} \sigma_{crb} \quad \text{kN}$$
- $P$: design pressure for the design load set being considered, calculated at centre of the deck area supported by the pillar being considered, in kN/m²
- $b_{a-sup}$: mean breadth of area supported, in m
- $l_{a-sup}$: mean length of area supported, in m
- $W_{pill-upr}$: axial load from pillar or pillars above, in kN
- $A_{pill-net50}$: net cross section area of the pillar, in cm²
- $\eta_{pill}$: utilisation factor for the design load set being considered:
  $$= 0.5 \quad \text{for acceptance criteria set AC1}$$
  $$= 0.6 \quad \text{for acceptance criteria set AC2}$$
- $\sigma_{crb}$: critical buckling stress in compression of pillar based on the net sectional properties calculated in accordance with Section 10/3.5.1, in N/mm²

Reason for the Change:
Editorial (unit error corrected, KC ID196)

4 Machinery Space

4.3 Side Structure

4.3.3 Side shell local support members

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

4.3.3.3 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.

Reason for the Change:
Editorial:
1. Delete previous 4.3.3.2 since the effect of hull form for measuring the span has already been defined in Section 4/2.1.3.
2. Renumber current 4.3.3.3 to 4.3.3.2 accordingly.

## 6 Evaluation of Structure for Sloshing and Impact Loads

### 6.2 Sloshing in Tanks

<table>
<thead>
<tr>
<th>Acceptance Criteria Set</th>
<th>Structural Member</th>
<th>( \beta )</th>
<th>( \alpha )</th>
<th>( C_{a\text{-max}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC1</td>
<td>Longitudinally stiffened plating in the cargo tank region including <strong>but not limited to:</strong></td>
<td>0.9</td>
<td>0.5</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>- deck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- longitudinal plane bulkhead</td>
<td>0.9</td>
<td>1.0</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>- horizontal corrugated longitudinal bulkhead</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- longitudinal girders and stringers within the cargo tank region</td>
<td>0.8</td>
<td>0</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>Other strength members including:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- vertical corrugated longitudinal bulkhead</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- transverse plane bulkhead</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- transverse corrugated bulkhead</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- transverse stringers and web frames</td>
<td>0.8</td>
<td>0</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>- plating of tank boundaries and primary support members outside the cargo tank region</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[
\sigma_{hg} = \left( \frac{z - z_{NA-net50}}{I_{v-net50}} \right) \left( \frac{M_{w-perm-sea}}{I_{v-net50}} \right) \times 10^{-3} \text{ N/mm}^2
\]

\( z \) 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

\( M_{w-perm-sea} \) 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\(^4\)

\( \sigma_{yd} \) specified minimum yield stress of the material, in N/mm\(^2\)

**Reason for the Change:**
Clarification

<table>
<thead>
<tr>
<th>Table 8.6.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allowable Bending Stress Coefficient, ( C_s ), for Assessment of Sloshing on Stiffeners</td>
</tr>
</tbody>
</table>

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

\[
C_s = \beta_s \cdot \alpha_s \frac{\sigma_{yd}}{\sigma_{yd}} 
\]

but not to be taken greater than \( C_{s\text{-max}} \)

Where:

\( \alpha_s, \beta_s, C_{s\text{-max}} \)  
permissible bending stress factors and are to be taken as follows:

<table>
<thead>
<tr>
<th>Acceptance Criteria Set</th>
<th>Structural Member</th>
<th>( \beta_s )</th>
<th>( \alpha_s )</th>
<th>( C_{s\text{-max}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC1</td>
<td>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</td>
<td>0.85</td>
<td>1.0</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>Transverse or vertical stiffeners</td>
<td>0.7</td>
<td>0</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>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</td>
<td>0.75</td>
<td>0</td>
<td>0.75</td>
</tr>
</tbody>
</table>

\( \sigma_{yd} \)

specified minimum yield stress of the material, in N/mm\(^2\)

\( \sigma_{hg} \)

hull girder bending stress for the design load set being considered at the reference point defined in Section 3/5.2.2.5

\[
\sigma_{hg} = \left( \frac{z - z_{NA\text{-net50}}}{I_{v\text{-net50}}} \right) M_{sw\text{-perm\text{-sea}}} \text{N/mm}^2 \]

\( z \)

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

\( z_{NA\text{-net50}} \)

distance from the baseline to the horizontal neutral axis, as defined in Section 4/2.6.1, in m

\( M_{sw\text{-perm\text{-sea}} \text{}} \)

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.

\( I_{v\text{-net50}} \)

net vertical hull girder moment of inertia, at the longitudinal position being considered, as defined in Section 4/2.6.1, in m\(^4\)

\( \sigma_{yd} \)

specified minimum yield stress of the material, in N/mm\(^2\)

**Reason for the Change:**

Clarification

### 6.3 Bottom Slamming

#### 6.3.7 Primary support members

6.3.7.2 The net shear area, \( A_{\text{dir-sea\text{-net50}}} \), of each primary support member web at any position along its span is not to be less than:
\[ A_{drh-\text{net50}} = 10 \frac{Q_{dm}}{C \tau_{yd}} \quad A_{w-\text{net50}} = 10 \frac{Q_{dm}}{C \tau_{yd}} \text{ cm}^2 \]

Where:

- \( Q_{dm} \) the greatest shear force due to slamming for the position being considered, in kN, based on the application of a patch load, \( F_{dm} \) to the most onerous location, as determined in accordance with 6.3.7.3
- \( C \) permissible shear stress coefficient
  - = 0.9 for acceptance criteria set AC3
- \( \tau_{yd} \) = \( \frac{\sigma_{yd}}{\sqrt{3}} \) N/mm²
- \( \sigma_{yd} \) specified minimum yield stress of the material, in N/mm²

**Reason for the Change:**
Editorial

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

\[ t_{w-\text{net}} = \frac{s}{70} \sqrt{\frac{\sigma_{yd}}{235}} \text{ mm} \]

Where:

- \( s \) plate breadth, in mm, taken as the spacing between the web stiffeners
- \( \sigma_{yd} \) specified minimum yield stress of the material, in N/mm²

**Reason for the Change:**
Clarification that the spacing is of “web stiffeners”

### 6.4 Bow Impact

#### 6.4.3 Design to resist bow impact loads

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 are, in general to be fitted applied.

**Reason for the Change:**
Editorial
7 APPLICATION OF SCANTLING REQUIREMENTS TO OTHER STRUCTURE

7.1 General

7.1.1 Application

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.

Reason for the Change:
Editorial

7.2 Scantling Requirements

7.2.3 Primary support members

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

\[
A_{shr\text{-net50}} = \frac{10 f_{shr} |P| f_{shr}}{C_{i} \tau_{yd}} \frac{A_{w\text{-net50}}}{C_{i} \tau_{yd}} \quad \text{cm}^2, \text{ for lateral pressure loads}
\]

\[
A_{shr\text{-net50}} = \frac{10 f_{shr} |F|}{C_{i} \tau_{yd}} \frac{A_{w\text{-net50}}}{C_{i} \tau_{yd}} \quad \text{cm}^2, \text{ for point loads}
\]

\[
A_{shr\text{-net50}} = \frac{\sum 10 f_{shr-i} P_{l\text{shr}} + \sum 10 f_{shr-j} F_{l\text{shr}}}{C_{i} \tau_{yd}} \frac{A_{w\text{-net50}}}{C_{i} \tau_{yd}} \quad \text{cm}^2, \text{ for a combination of loads}
\]

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/m²
- \( S \) 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
- \( C_{i} \) 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

\[ \tau_{yd} = \frac{\sigma_{yd}}{\sqrt{3}} \quad \text{N/mm}^2 \]

\( \sigma_{yd} \) specified minimum yield stress of the material, in N/mm²

\( F \) 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

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.

**Reason for the Change:**
Editorial

3.4 Fatigue Assessment Methods

3.4.1 Nominal stress approach

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.

**Reason for the Change:**
Editorial
SECTION 10 – BUCKLING AND ULTIMATE STRENGTH

3 PRESCRIPTIVE BUCKLING REQUIREMENTS

3.2 Buckling of Plates

3.2.1 Uni-axial buckling of plates

3.2.1.3 The critical stresses, $\sigma_{xcr}$, $\sigma_{ycr}$, or $\tau_{cr}$, of plate panels subject to compression or shear, respectively, is to be taken as:

$\sigma_{xcr} = C_x \sigma_{yd}$

$\sigma_{ycr} = C_y \sigma_{yd}$

$\tau_{cr} = C_\tau \frac{\sigma_{yd}}{\sqrt{3}} \tau_{cr} = C_\tau \frac{\sigma_{yd}}{\sqrt{3}}$

Where:

$C_x, C_y, C_\tau$ reduction factors, as given in Table 10.3.1

Reason for the Change:
Editorial
Table 10.3.1
Buckling Factor and Reduction Factor for Plane Plate Panels

<table>
<thead>
<tr>
<th>Case</th>
<th>Stress ratio $\psi$</th>
<th>Aspect ratio $\alpha$</th>
<th>Buckling factor $K$</th>
<th>Reduction factor $C$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$1 \geq \psi \geq 0$</td>
<td>$\alpha &gt; 1$</td>
<td>$K = \frac{8.4}{\psi + 1.1}$</td>
<td>$C_x = 1$ for $\lambda \leq \lambda_c$</td>
</tr>
<tr>
<td></td>
<td>$0 &gt; \psi &gt; -1$</td>
<td>$\alpha &gt; 1$</td>
<td>$K = 7.63 - \psi (6.26 - 10\psi)$</td>
<td>$C_x = C \left(\frac{1}{\lambda} - \frac{0.22}{\lambda^2}\right)$ for $\lambda &gt; \lambda_c$</td>
</tr>
<tr>
<td></td>
<td>$\psi \leq -1$</td>
<td>$\alpha &gt; 1$</td>
<td>$K = 5.975(1 - \psi)^2$</td>
<td>$\lambda_c = \frac{c}{2} \left(1 + \sqrt{1 - \frac{0.88}{c}}\right)$</td>
</tr>
<tr>
<td>2</td>
<td>$1 \geq \psi \geq 0$</td>
<td>$\alpha \geq 1$</td>
<td>$K = \left(1 + \frac{1}{\alpha^2}\right)^2 \frac{2.1(1 + \psi)}{1.1 - \frac{\psi}{\alpha^2}(13.9 - 10\psi)}$</td>
<td>$C_y = C \left(\frac{1}{\lambda} - \frac{R + F^2(H - R)}{\lambda^2}\right)$</td>
</tr>
<tr>
<td></td>
<td>$1 \leq \alpha \leq 1.5$</td>
<td>$\alpha &gt; 1.5$</td>
<td>$K = \left[1 + \frac{1}{\alpha^2}\right] \frac{2.1(1 + \psi)}{1.1 - \frac{\psi}{\alpha^2}(13.9 - 10\psi)} - \frac{8.6}{\alpha^2}(5.87 + 1.87\alpha^2) + \frac{8.6}{\alpha^2}(5.87 - 10\psi)$</td>
<td>Where: $c = (1.25 - 0.12\psi) \leq 1.25$</td>
</tr>
<tr>
<td></td>
<td>$0 &gt; \psi &gt; -1$</td>
<td>$\alpha &gt; 1.5$</td>
<td>$K = \left[1 + \frac{1}{\alpha^2}\right] \frac{2.1(1 + \psi)}{1.1 - \frac{\psi}{\alpha^2}(13.9 - 10\psi)} - \frac{8.6}{\alpha^2}(5.87 + 1.87\alpha^2) + \frac{8.6}{\alpha^2}(5.87 - 10\psi)$</td>
<td>$\lambda_c = 0.5 c \left(1 + \sqrt{1 - 0.88 / c}\right)$</td>
</tr>
<tr>
<td></td>
<td>$\psi \leq -1$</td>
<td>$\alpha &gt; 1.5$</td>
<td>$K = \left[1 + \frac{1}{\alpha^2}\right] \frac{2.1(1 + \psi)}{1.1 - \frac{\psi}{\alpha^2}(13.9 - 10\psi)} - \frac{8.6}{\alpha^2}(5.87 + 1.87\alpha^2) + \frac{8.6}{\alpha^2}(5.87 - 10\psi)$</td>
<td>$c_1 = 1$ for $\sigma_y$ due to direct loads $^{(3)}$</td>
</tr>
<tr>
<td></td>
<td>$\alpha \geq 3 \frac{(1 - \psi)}{4}$</td>
<td>$\psi \leq -1$</td>
<td>$K = \left[1 + \frac{1}{\alpha^2}\right] \frac{2.1(1 + \psi)}{1.1 - \frac{\psi}{\alpha^2}(13.9 - 10\psi)} - \frac{8.6}{\alpha^2}(5.87 + 1.87\alpha^2) + \frac{8.6}{\alpha^2}(5.87 - 10\psi)$</td>
<td>$c_1 = 1$ for $\sigma_y$ due to bending (in general) $^{(2)}$</td>
</tr>
<tr>
<td></td>
<td>$\alpha &gt; 3 \frac{(1 - \psi)}{4}$</td>
<td></td>
<td>$K = \left[1 + \frac{1}{\alpha^2}\right] \frac{2.1(1 + \psi)}{1.1 - \frac{\psi}{\alpha^2}(13.9 - 10\psi)} - \frac{8.6}{\alpha^2}(5.87 + 1.87\alpha^2) + \frac{8.6}{\alpha^2}(5.87 - 10\psi)$</td>
<td>$c_1 = 0$ for $\sigma_y$ due to bending in extreme load cases (e.g. w/t. bhd.)</td>
</tr>
</tbody>
</table>

Where:

- $R = \lambda(1 - \lambda / c)$ for $\lambda < \lambda_c$
- $R = 0.22$ for $\lambda > \lambda_c$
- $\lambda_c = 0.5 c \left(1 + \sqrt{1 - 0.88 / c}\right)$
- $F = \left[1 - \left(\frac{K}{0.91} - 1\right)/\lambda_p^2\right] c_1 \geq 0$
- $\lambda_p^2 = \lambda^2 - 0.5$ and $1 \leq \lambda_p^2 \leq 3$
- $c_1 = 1$ for $\sigma_y$ due to direct loads $^{(3)}$
- $c_1 = (1 - 1 / a) \geq 0$ for $\sigma_y$ due to bending (in general) $^{(2)}$
- $c_1 = 0$ for $\sigma_y$ due to bending in extreme load cases (e.g. w/t. bhd.)
### Table 10.3.1 (Continued)

**Buckling Factor and Reduction Factor for Plane Plate Panels**

<table>
<thead>
<tr>
<th>Case</th>
<th>Stress ratio $\psi$</th>
<th>Aspect ratio $\alpha$</th>
<th>Buckling factor $K$</th>
<th>Reduction factor $C$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>$1 \geq \psi \geq 0$</td>
<td>$\alpha &gt; 0$</td>
<td>$K = \frac{4(0.425 + 1/\alpha^2)}{3\psi + 1}$</td>
<td>$C_x = 1$ for $\lambda \leq 0.7$</td>
</tr>
<tr>
<td></td>
<td>$0 &gt; \psi \geq -1$</td>
<td>$\alpha &gt; 0$</td>
<td>$K = 4(0.425 + 1/\alpha^2)(1 + \psi)\frac{-5\psi(1 - 3.42\psi)}{}$</td>
<td>$C_x = \frac{1}{\lambda^2 + 0.51}$ for $\lambda &gt; 0.7$</td>
</tr>
<tr>
<td>4</td>
<td>$1 \geq \psi \geq -1$</td>
<td>$\alpha &gt; 0$</td>
<td>$K = \left(0.425 + \frac{1}{\alpha^2}\right)\frac{3-\psi}{2}$</td>
<td>$C_r = 1$ for $\lambda \leq 0.84$</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>$\alpha \geq 1$</td>
<td>$K_r = \left[\frac{5.34 + 4}{\alpha^2}\right]$</td>
<td>$C_r = \frac{0.84}{\lambda}$ for $\lambda &gt; 0.84$</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>$0 &lt; \alpha &lt; 1$</td>
<td>$K_r = \left[\frac{4 + 5.34}{\alpha^2}\right]$</td>
<td></td>
</tr>
</tbody>
</table>

- $K = K_r \sqrt{3}$
- $K' = K$ according to Case 5
- $r = \frac{d_u}{l_u} \left(1 - \frac{d_k}{l_u}\right)$
- $\frac{d_u}{l_u} \leq 0.7$ and $\frac{d_k}{l_u} \leq 0.7$
Table 10.3.1 (Continued)
Buckling Factor and Reduction Factor for Plane Plate Panels

<table>
<thead>
<tr>
<th>Where:</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \psi ) the ratio between smallest and largest compressive stress as shown for Case 1-4</td>
</tr>
<tr>
<td>( l_s ) length in mm, of the shorter side of the plate panel for Cases 1 and 2</td>
</tr>
<tr>
<td>( l_a ) length in mm, of the side of the plate panel as defined for Cases 3, 4, 5 and 6</td>
</tr>
<tr>
<td>( \alpha ) aspect ratio of the plate panel</td>
</tr>
</tbody>
</table>

Edge boundary conditions:
- - - - - - - plate edge free
- - - - - - - plate edge simply supported

Notes
(1) Cases listed are general cases. Each stress component \((\sigma_x, \sigma_y)\) is to be understood in local coordinates.
(2) \( c_1 \) due to bending (in general) corresponds to straight edges (uniform displacement) of a plate panel integrated in a large structure. This value is to be applied for hull girder buckling and buckling of web plate of primary support members in way of openings.
(3) \( c_1 \) for direct loads corresponds to a plate panel with edges not restrained from pull-in which may result in non-straight edges

Reason for the Change:
Editorial (All “\( \psi \)” changed to “\( \psi / \alpha \)”. All “\( \alpha \)” changed to “\( \alpha \)”. Note, since the changes are simple, only the final changed symbols are shown in the text above.)
3.3 Buckling of Stiffeners

3.3.2 Column buckling mode

3.3.2.3 The bending stress, $\sigma_b$, in N/mm², in the stiffener is equal to:

$$\sigma_b = \frac{M_v + M_1}{1000 Z_{net}}$$

Where:

- $Z_{net}$: net section modulus of stiffener, in cm³, including effective breadth of plating according to 3.3.4.1.
  
  a) if lateral pressure is applied to the stiffener:

  $Z_{net}$ is the section modulus calculated at flange if the lateral pressure is applied on the same side as the stiffener.
  
  $Z_{net}$ is the section modulus calculated at attached plate if the lateral pressure is applied on the side opposite to the stiffener.

  b) if no lateral pressure is applied on the stiffener:

  $Z_{net}$ is the minimum section modulus among those calculated at flange and attached plate.

- $M_1$: bending moment, in Nmm, due to the lateral load $P$

$$M_1 = \frac{P s l_{stf}^2}{24} 10^3$$

- $P$: lateral load, in kN/m²

- $s$: stiffener spacing as defined in Section 4.2.2.1, in mm

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

- $M_0$: bending moment, in Nmm, due to the lateral deformation $w$ of stiffener

$$M_0 = F_E \left( \frac{P_z w}{c_f - P_z} \right)$$

where $(c_f - P_z) > 0$

- $F_E$: ideal elastic buckling force of the stiffener, in N

$$F_E = \left( \frac{\pi^2}{l_{stf}^2} \right) EI_{net} 10^{-2}$$

- $E$: modulus of elasticity, 206 000 N/mm²

- $I_{net}$: moment of inertia, in cm⁴, of the stiffener including effective width of attached plating according to 3.3.4.1. $I_{net}$ is to comply with the following requirement:

$$I_{net} \geq \frac{s t_{net}^3}{12} 10^{-4}$$

- $t_{net}$: net thickness of plate flange, to be taken as the mean thickness of the two attached plate panels, in mm
nominal lateral load, in N/mm², acting on the stiffener due to membrane stresses, $\sigma_x$, $\sigma_y$ and $\tau$, in the attached plate in way of the stiffener midspan:

$$P_z = \frac{t_{\text{net}}}{s} \left( \sigma_{sl} \left( \frac{\pi s}{1000 l_{stf}} \right)^2 + 2 \left( \frac{c_y \sigma_y + \sqrt{2} \tau}{s} \right) \right)^{1/2}$$

$$\sigma_{sl} = \sigma_x \left( 1 + \frac{A_{\text{net}}}{s l_{\text{net}}} \right) \text{ N/mm}^2$$

$$\tau = \left[ \tau - t_{\text{net}} \left( \sigma_{yd} \frac{m_1}{(1000 l_{stf})^2 + m_2} \right) \right] \geq 0$$

with $m_1$ and $m_2$ taken equal to

$$m_1 = 1.47 \quad m_2 = 0.49 \text{ for } \frac{1000 l_{stf}}{s} \geq 2.0$$

$$m_1 = 1.96 \quad m_2 = 0.37 \text{ for } \frac{1000 l_{stf}}{s} < 2.0$$

$\sigma_x$ compressive axial stress in the stiffener, in N/mm², in way of the midspan of the stiffener. See Section 3/5.2.3.1

$A_{\text{net}}$ net sectional area of the stiffener without attached plating, in mm²

$c_y$ factor taking into account the membrane stresses in the attached plating acting perpendicular to the stiffener’s axis

$$= 0.5 (1 + \psi) \text{ for } 0 \leq \psi \leq 1$$

$$= \frac{0.5}{1 - \psi} \text{ for } \psi < 0$$

$\psi_{\text{pf}}$ edge stress ratio for Case 2 according to Table 10.3.1

$\sigma_y$ membrane compressive stress in the attached plating acting perpendicular to the stiffener’s axis, in N/m²

$\tau$ shear membrane stress in the attached plating, in N/mm²

$\sigma_{yd}$ specified minimum yield stress of the material, in N/mm²

$w$ deformation of stiffener, in mm

$$w = w_0 + w_1$$

$w_0$ assumed imperfection, in mm.

$$w_0 = \min \left[ \frac{1000 l_{stf}}{250}, \frac{s}{250}, 10 \right]$$

For stiffeners sniped at both ends $w_0$ is not to be taken less than the distance from the midpoint of attached plating to the neutral axis of the stiffener calculated with the effective width of the attached plating according to 3.3.4.1

$w_1$ deformation of stiffener at midpoint of stiffener span due to lateral load $P$, in mm. In case of uniformly distributed load the
\( w_1 \) is to be taken as:

\[
\frac{P s l_{stf}^4}{384 \cdot E I_{net}^5} \times 10^5
\]

\( c_f \) elastic support provided by the stiffener, in N/mm²

\[
= F_E \frac{\pi^2}{l_{stf}} (1 + c_p) 10^{-6}
\]

\( c_p \)

\[
= \frac{1}{1 + 0.91 \left( \frac{12 l_{stf} 10^4}{s f_{net}^3} - 1 \right)}
\]

\( c_a \)

\[
= \left[ \frac{1000 l_{stf}}{2s} + \frac{2s}{1000 l_{stf}} \right]^2 \quad \text{for} \quad l_{stf} \geq \frac{2s}{1000}
\]

\[
= \left[ 1 + \left( \frac{1000 l_{stf}}{2s} \right)^2 \right]^2 \quad \text{for} \quad l_{stf} \leq \frac{2s}{1000}
\]

**Reason for the Change:**

Editorial

---

### 3.4 Primary Support Members

#### 3.4.1 Buckling of web plate of primary support members in way of openings

<table>
<thead>
<tr>
<th>Table 10.3.3 Reduction Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mode</strong></td>
</tr>
<tr>
<td>(a) without edge reinforcements</td>
</tr>
</tbody>
</table>
Table 10.3.3 (Continued)

<table>
<thead>
<tr>
<th>Mode</th>
<th>Reduction Factors</th>
<th>C_x, C_y</th>
<th>C_r</th>
</tr>
</thead>
<tbody>
<tr>
<td>(b) with edge reinforcements</td>
<td>Separate reduction factors are to be applied for areas P1 and P2 using: C_r for Case 1 or C_y, for Case 2, see Table 10.3.1 with stress ratio ( \psi = 1.0 ) ( \psi = 1.0 )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) example of hole in web</td>
<td>Panels P1 and P2 are to be evaluated in accordance with (a). Panel P3 is to be evaluated in accordance with (b)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note
1. Web panels to be considered for buckling in way of openings are shown shaded and numbered P1, P2, etc.

Reason for the Change:
Editorial

3.5 Other Structures

3.5.1 Struts, pillars and cross ties

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, \( \sigma_{ETF} \), 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:

\[
\zeta = 1 - \frac{\left( y_0^2 + z_0^2 \right) A_{net50}}{I_{pol-net50}} - \frac{z_0^2 A_{net50}}{I_{pol-net50}}
\]
**Reason for the Change:**
The definitions are corrected to suit asymmetric sections also, not only symmetric sections.

**Table 10.3.4 (Continued)**
**Cross Sectional Properties**

<table>
<thead>
<tr>
<th>Cross Sectional Properties</th>
<th>$I_{sw-net50} = \frac{1}{3}(b_f t_f^3 + d_{wet} t_{w-net50})^{10-4}$ cm$^4$</th>
<th>$I_{sw-net50} = \frac{1}{3}(b_{fu} t_{f-net50}^3 + 2 d_{wet} t_{w-net50}^3)\times10^{-4}$ cm$^4$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Net Cross-sectional Area</strong></td>
<td>$A_{net50}$ net cross-sectional area, in cm$^2$</td>
<td>$A_{net50}$ net cross-sectional area, in cm$^2$</td>
</tr>
<tr>
<td><strong>Net Polar Moment of Inertia</strong></td>
<td>$I_{pol-net50}$ net polar moment of inertia about the shear centre of cross section, as defined in 3.5.1.4</td>
<td>$I_{pol-net50}$ net polar moment of inertia about the shear centre of cross section, as defined in 3.5.1.4</td>
</tr>
<tr>
<td><strong>Elastic Torsional Buckling Stress</strong></td>
<td>$\sigma_{ET}$ elastic torsional buckling stress, as defined in 3.5.1.4</td>
<td>$\sigma_{ET}$ elastic torsional buckling stress, as defined in 3.5.1.4</td>
</tr>
<tr>
<td><strong>Elastic Column Compressive Buckling Stress</strong></td>
<td>$\sigma_E$ elastic column compressive buckling stress, as defined in 3.5.1.3</td>
<td>$\sigma_E$ elastic column compressive buckling stress, as defined in 3.5.1.3</td>
</tr>
</tbody>
</table>

**Corrigenda 3**

**Common Structural Rules for Oil Tankers**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y_0$</td>
<td>position of shear centre relative to the cross-sectional centroid, in cm, see Table 10.3.4;</td>
</tr>
<tr>
<td>$z_0$</td>
<td>position of shear centre relative to the cross-sectional centroid, in cm, see Table 10.3.4</td>
</tr>
<tr>
<td>$A_{net50}$</td>
<td>net cross-sectional area, in cm$^2$</td>
</tr>
<tr>
<td>$I_{pol-net50}$</td>
<td>net polar moment of inertia about the shear centre of cross section, as defined in 3.5.1.4</td>
</tr>
<tr>
<td>$\sigma_{ET}$</td>
<td>elastic torsional buckling stress, as defined in 3.5.1.4</td>
</tr>
<tr>
<td>$\sigma_E$</td>
<td>elastic column compressive buckling stress, as defined in 3.5.1.3</td>
</tr>
</tbody>
</table>

**Reason for the Change:**
The definitions are corrected to suit asymmetric sections also, not only symmetric sections.

**Table 10.3.4 (Continued)**
**Cross Sectional Properties**

<table>
<thead>
<tr>
<th>Cross Sectional Properties</th>
<th>$y_0 = 0$ cm</th>
<th>$y_0 = 0$ cm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Net Cross-sectional Area</strong></td>
<td>$z_0 = \frac{-0.5 d_{wet}^2 t_{w-net50}}{d_{wet} t_{w-net50} + b_f t_{f-net50}} \times10^{-1}$ cm</td>
<td>$z_0 = \frac{-0.5 d_{wet}^2 t_{w-net50}}{d_{wet} t_{w-net50} + b_f t_{f-net50}} \times10^{-1}$ cm</td>
</tr>
<tr>
<td><strong>Net Polar Moment of Inertia</strong></td>
<td>$c_{warp} = \frac{b_{fu}^3 t_{f-net50}^3 + 4 d_{wet}^3 t_{w-net50}^3}{144} \times10^{-6}$ cm$^6$</td>
<td>$c_{warp} = \frac{b_{fu}^3 t_{f-net50}^3 + 4 d_{wet}^3 t_{w-net50}^3}{144} \times10^{-6}$ cm$^6$</td>
</tr>
</tbody>
</table>

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**Common Structural Rules for Oil Tankers**

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<tr>
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<td>$z_0$</td>
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<tr>
<td>$A_{net50}$</td>
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</tr>
<tr>
<td>$I_{pol-net50}$</td>
<td>net polar moment of inertia about the shear centre of cross section, as defined in 3.5.1.4</td>
</tr>
<tr>
<td>$\sigma_{ET}$</td>
<td>elastic torsional buckling stress, as defined in 3.5.1.4</td>
</tr>
<tr>
<td>$\sigma_E$</td>
<td>elastic column compressive buckling stress, as defined in 3.5.1.3</td>
</tr>
</tbody>
</table>

**Reason for the Change:**
The definitions are corrected to suit asymmetric sections also, not only symmetric sections.

**Table 10.3.4 (Continued)**
**Cross Sectional Properties**

<table>
<thead>
<tr>
<th>Cross Sectional Properties</th>
<th>$I_{sw-net50} = \frac{1}{3}(b_f t_f^3 + d_{wet} t_{w-net50})^{10-4}$ cm$^4$</th>
<th>$I_{sw-net50} = \frac{1}{3}(b_{fu} t_{f-net50}^3 + 2 d_{wet} t_{w-net50}^3)\times10^{-4}$ cm$^4$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Net Cross-sectional Area</strong></td>
<td>$A_{net50}$ net cross-sectional area, in cm$^2$</td>
<td>$A_{net50}$ net cross-sectional area, in cm$^2$</td>
</tr>
<tr>
<td><strong>Net Polar Moment of Inertia</strong></td>
<td>$I_{pol-net50}$ net polar moment of inertia about the shear centre of cross section, as defined in 3.5.1.4</td>
<td>$I_{pol-net50}$ net polar moment of inertia about the shear centre of cross section, as defined in 3.5.1.4</td>
</tr>
<tr>
<td><strong>Elastic Torsional Buckling Stress</strong></td>
<td>$\sigma_{ET}$ elastic torsional buckling stress, as defined in 3.5.1.4</td>
<td>$\sigma_{ET}$ elastic torsional buckling stress, as defined in 3.5.1.4</td>
</tr>
<tr>
<td><strong>Elastic Column Compressive Buckling Stress</strong></td>
<td>$\sigma_E$ elastic column compressive buckling stress, as defined in 3.5.1.3</td>
<td>$\sigma_E$ elastic column compressive buckling stress, as defined in 3.5.1.3</td>
</tr>
</tbody>
</table>

**Corrigenda 3**

**Common Structural Rules for Oil Tankers**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$y_0$</td>
<td>position of shear centre relative to the cross-sectional centroid, in cm, see Table 10.3.4;</td>
</tr>
<tr>
<td>$z_0$</td>
<td>position of shear centre relative to the cross-sectional centroid, in cm, see Table 10.3.4</td>
</tr>
<tr>
<td>$A_{net50}$</td>
<td>net cross-sectional area, in cm$^2$</td>
</tr>
<tr>
<td>$I_{pol-net50}$</td>
<td>net polar moment of inertia about the shear centre of cross section, as defined in 3.5.1.4</td>
</tr>
<tr>
<td>$\sigma_{ET}$</td>
<td>elastic torsional buckling stress, as defined in 3.5.1.4</td>
</tr>
<tr>
<td>$\sigma_E$</td>
<td>elastic column compressive buckling stress, as defined in 3.5.1.3</td>
</tr>
</tbody>
</table>

**Reason for the Change:**
The definitions are corrected to suit asymmetric sections also, not only symmetric sections.
\[
I_{w-net50} = \frac{1}{3} \left( b_{f1} t_{f1-net50}^3 + 2 b_{f2} t_{f2-net50}^3 + b_{f3} t_{f3-net50}^3 + d_{wt} t_{w-net50}^3 \right) 10^{-4} \text{ cm}^4
\]

\[
y_0 = 0 \text{ cm}
\]

\[
z_o = z_s - \frac{(b_{f3} d_{wt} t_{f3-net50} + 0.5 d_{net}^2 t_{w-net50}) 10^{-1}}{d_{wt} t_{w-net50} + b_{f1} t_{f1-net50} + 2 b_{f2} t_{f2-net50} + b_{f3} t_{f3-net50}} \text{ cm}
\]

\[
c_{warp} = \left( \frac{I_{f1} z_s^2}{2} + \frac{I_{f2} b_{f1}^2}{I_{f3} (d_{wt} - z_s)^2} \right) 10^{-2} \text{ cm}^6
\]

\[
l_{f1} = \frac{(b_{f1} - t_{f2-net50})^3 t_{f1-net50}}{12} + \frac{b_{f2} t_{f2-net50} b_{f1}^2}{2} 10^{-4} \text{ cm}^4
\]

\[
l_{f2} = \frac{b_{f2}^3 t_{f2-net50}}{12} 10^{-4} \text{ cm}^4
\]

\[
l_{f3} = \frac{b_{f3}^3 t_{f3-net50}}{12} 10^{-4} \text{ cm}^4
\]

\[
z_s = \frac{I_{f3} d_{wt}}{I_{f1} + I_{f3}} 10^{-1} \text{ cm}
\]

**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.

**Reason for the Change:**

Editorial and clarification:

1. Correction of unit mismatch
2. \(z_o\) in the formula of \(C_{warp}\) corrected to \(z_s\), i.e. warping constant should be relative to shear centre.
3. Addition of a note for cross sectional properties not covered by this table. (KC ID 297)

### 3.5.2 Corrugated bulkheads

3.5.2.1 Local buckling of a unit flange of corrugated bulkheads is to be controlled according to 3.2.1.1, for Case 1, as shown in Table 10.3.1, applying stress ratio \(\psi = 1.0\).

**Reason for the Change:**

Editorial

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.

Reason for the Change:
Rule clarification

SECTION 11 – GENERAL REQUIREMENTS

1 HULL OPENINGS AND CLOSING ARRANGEMENTS

1.4 Deck Houses and Companionways

1.4.8 Pillars

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

\[
W_{\text{perm}} = (f_{s1} - h_{\text{pill}} f_{s2} / r_{\text{gyr-grs}}) A_{\text{pill-grs}} \quad \text{kN}
\]

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

- \( h_{\text{pill}} \) 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

- \( r_{\text{gyr-grs}} \) radius of gyration for gross pillar section, in cm²

- \( A_{\text{pill-grs}} \) gross cross sectional area of pillar, in cm²

Reason for the Change:
Editorial (Unit corrected for \( r_{\text{gyr-grs}} \))
2 CREW PROTECTION

2.1 Bulwarks and Guardrails

2.1.2 Construction of bulwarks

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 supported by stays having a spacing generally not greater than 2.0m.

Reason for the Change:
Clarification:
1. Rule clarification.
2. The spacing requirement given in 11/2.1.2.2 applies to bulwarks situated on the freeboard and forecastle deck only.

2.1.5 Additional requirements for deeper loading

2.1.5.1 Ships with Table Type A or B-100 Freeboard (i.e. a freeboard less than that based on Table Type B-60) are to have open rails fitted for a minimum of half the length of the exposed parts of the weather deck. Alternatively, if a continuous bulwark is fitted, the minimum freeing area is to be at least 33% of the total area of the bulwark. The freeing area is to be located in the lower part of the bulwark.

2.1.5.2 Where superstructures are connected by trunks, open rails are to be fitted for the whole length of the exposed parts of the freeboard deck.

2.1.5.3 Ships with Table Type B-60 Freeboard (i.e. a freeboard less than that based on Table Type B but not less than Table Type B-60) are to have a minimum freeing area of at least 25% of the total area of the bulwark.

Reason for the Change:
Editorial

3 SUPPORTING STRUCTURE AND STRUCTURAL APPENDAGES

3.1 Support for Deck Equipment

3.1.4 Supporting structure for cranes, derricks and lifting masts

3.1.4.9 The following plans and information are to be submitted for approval:
   (a) details of the supporting structure of the lifting appliance, including its connection of the deck
   (b) details of the Safe Working Load, self weight, vertical reaction forces and the maximum overturning moment in the supporting structure of the lifting appliance
3.1.4.18 For lifting appliances which are limited to use in harbour, the following load scenario is to be examined:
   (a) 130% of the Safe Working Load added to the lifting appliances self weight.

Reason for the Change:
Editorial

3.1.4.19 For lifting appliances which may be used for offshore operations the following is to be submitted for approval purposes:
   (a) the maximum sea state in which the lifting appliance is to be used
   (b) the worst case vertical and horizontal accelerations
   (c) the worst case wind loadings for the specified design sea state and wind environment.

   The load scenario to be examined is to account for these environmental loads. As a minimum, the following load scenario is to be examined:
   (a) 150% of the Safe Working Load added to the lifting appliances self weight.

   When a crane cab is fitted above the slewing ring, the load scenario is to be specially considered.

Reason for the Change:
Editorial

3.1.5 Supporting structures for components used in emergency towing arrangements on tankers

3.1.5.10 The design load for the connection of the strong-point and fittings to the deck and its supporting structure is to be taken as twice the Safe Working Load.

Reason for the Change:
Editorial

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

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.

**Reason for the Change:**
3.1.6.1, 3.1.6.9, 3.1.6.13 through 3.1.6.16 incorporate IACS UR A2 (Rev.2), which is mandatory for vessels with a keel laying date on or after January 2007 in accordance with IACS UI SC212.

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.

**Reason for the Change:**
Editorial

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.

**Reason for the Change:**
3.1.6.1, 3.1.6.9, 3.1.6.13 through 3.1.6.16 incorporate IACS UR A2 (Rev.2), which is mandatory for vessels with a keel laying date on or after January 2007 in accordance with IACS UI SC212.

3.1.6.10 The design load for the connection of shipboard fittings and their seats to the deck and its supporting structure is to be based on the line load as the greater of the following requirements, as applicable for the particular fitting and its intended use:

(a) in the case of normal towing in harbour or manoeuvring operations, 125% of the maximum towline load as indicated on the towing and mooring arrangement plan, or

(b) in the case of towing service other than that experienced in harbour or manoeuvring operations, such as escort service, the nominal breaking strength of towline according to Table 11.4.2 for the ship’s corresponding equipment number, or

(c) in the case of mooring operations 125% of the nominal breaking strength of the mooring line (hawser) or towline according to Table 11.4.2 for the ship’s corresponding equipment number.

**Reason for the Change:**
Editorial
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.

<table>
<thead>
<tr>
<th>Stresses</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct stress</td>
<td>$1.00 \sigma_{yd}$</td>
</tr>
<tr>
<td>Shear stress</td>
<td>$0.58 \sigma_{yd}$, $0.60 \sigma_{yd}$</td>
</tr>
</tbody>
</table>

Where:

$\sigma_{yd}$ specified minimum yield stress of the material, in N/mm²

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.

Reason for the Change:
3.1.6.1, 3.1.6.9, 3.1.6.13 through 3.1.6.16 incorporate IACS UR A2 (Rev.2), which is mandatory for vessels with a keel laying date on or after January 2007 in accordance with IACS UI SC212.

3.1.7 Supporting structure for other deck equipment or fitting which are subject to specific approval

3.1.7.6 Support for mast structures fitted with navigation aids is to be provided as follows:
(a) adequate primary support members for the mast are to be arranged in the form of bulkheads, deep beams or girders. Such members are to be arranged below or close to the mast structure.

(b) in order to transmit the loads from the mast structure to the primary supporting members, under-deck stiffening members are to be arranged below the mast structure forming the attachment of the mast to the deck.

(c) the deck thickness may be required to be increased to provide an adequate thickness for the weld attachments.

**Reason for the Change:**
Editorial

3.1.7.7 Supporting structure for breakwaters is to be designed to withstand the same design load as the breakwater itself. It is to be suitable for transmitting the loads from the breakwater into the main primary support members of the ship. Efficient under-deck stiffening is to be provided in way of the breakwater structure that forms the deck connection.

**Reason for the Change:**
Editorial

3. 3 Bilge Keels

3.3.2 Ground bars

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 14mm, whichever is the lesser.

**Reason for the Change:**
Editorial

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**APPENDIX A – HULL GIRDER ULTIMATE STRENGTH**

2 **CALCULATION OF HULL GIRDER ULTIMATE CAPACITY**

2.1 Single Step Ultimate Capacity Method

2.1.1 Procedure

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 Figure A.2.1. The hull girder ultimate bending moment capacity, \( M_{UL} \), is to be taken as:
$$M_{UL} = Z_{red} \sigma_{yd} \cdot 10^3 \text{ kNm}$$

Where:

- \(Z_{red}\) reduced section modulus of deck (to the mean deck height)
  \[
  Z_{red} = \frac{I_{red}}{z_{dk-mean} - z_{NA-red}} \text{ m}^3
  \]
- \(I_{red}\) 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:
  \[
  A_{eff} = \frac{\sigma_{UL}}{\sigma_{yd}} A_{net50} \text{ m}^2
  \]

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$^2$
- \(\sigma_{UL}\) 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 \(t_{net50}\)
- \(\sigma_{yd}\) 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

Reason for the Change:
Editorial

2.2 Simplified Method Based on an Incremental-iterative Approach
2.2.2 Assumptions and modelling of the hull girder cross-section

| Figure A.2.3 |
| Example of Defining Structural Elements |

a) Example showing side shell, inner hull side and deck

b) Example showing girder on longitudinal bulkhead

Reason for the Change:
Editorial

APPENDIX B – STRUCTURAL STRENGTH ASSESSMENT

1 GENERAL

1.2 Symbols, Units and Definitions

1.2.1 General

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
\[\sigma = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x\sigma_y + 3\tau_{xy}^2}\]

- \(a_t\): transverse acceleration, taken at centre of gravity of tank
- \(a_{log}\): longitudinal acceleration, taken at centre of gravity of tank
- \(E\): Modulus of Elasticity of steel, 2.06x10⁵ N/mm²
- \(M_{wv}\): vertical wave bending moment for a dynamic load case
- \(M_{sv}\): 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
- \(Q_{sv}\): 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
- \(\sigma_{yd}\): specified minimum yield stress of the material, N/mm²
- \(\sigma_{vm}\): von Mises stress
- \(\sigma_x\): axial stress in element x direction
- \(\sigma_y\): axial stress in element y direction
- \(\tau_{xy}\): element shear stress in x-y plane
- \(\delta_x\): displacement in x direction, in accordance with the coordinate system defined in Section 4/1.4
- \(\delta_y\): displacement in y direction, in accordance with the coordinate system defined in Section 4/1.4
- \(\delta_z\): displacement in z direction, in accordance with the coordinate system defined in Section 4/1.4
- \(\theta_x\): rotation about x axis, in accordance with the coordinate system defined in Section 4/1.4
- \(\theta_y\): rotation about y axis, in accordance with the coordinate system defined in Section 4/1.4
- \(\theta_z\): rotation about z axis, in accordance with the coordinate system defined in Section 4/1.4

*Reason for the Change:*
Editorial (more appropriate cross reference)

2 **Cargo Tank Structural Strength Analysis**
2.2 Structural Modelling

2.2.1 General

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:

\[ t_{FEM-\text{net}} = t_{\text{grs}} - 0.5t_{\text{corr}} \]

Where:
- \( t_{\text{grs}} \) gross thickness, as defined in 1.2
- \( t_{\text{corr}} \) corrosion addition, as defined in Section 6/3.2Table 6.3.1

Reason for the Change:
Editorial (more appropriate cross reference)

2.2.1.7 Corrugated bulkheads and bulkhead stools are to be modelled using shell plate elements, see Figure B.2.6. Diaphragms in the stools and internal longitudinal and vertical stiffeners on the stool plating are to be included in the model. Modelling is to be carried out as follows:

(a) the shell element mesh on the flange and web of the corrugation is in general to follow the stiffener spacing inside the bulkhead stool

(b) where difficulty occurs in matching the mesh on the corrugations directly with the mesh on the stool, it is acceptable to adjust the mesh on the stools in way of the corrugations in order that the corrugation bulkhead will retain its original geometrical shape. However, if the shape of the corrugation is adjusted in order to simplify the modelling procedure, this effect is to be taken into account in evaluation of stresses as described in 2.7.2.6.

(c) for a corrugated bulkhead without an upper stool and/or lower stool, it may be necessary to adjust the geometry in order to simplify the modelling. The adjustment is to be made such that the shape and position of the corrugations and primary supporting members are retained. Hence, the adjustment is to be made on stiffeners and plate seams if necessary.

Reason for the Change:
Editorial

2.2.1.14 Face plates of primary supporting members and brackets may be modelled using rod elements. The effective cross sectional area at the curved part of the face plate is to be calculated in accordance with Section 4/2.3.4. The cross sectional area of a rod element representing the tapering part of the face plate is to be based on the average cross sectional area of the face plate in way of the element length.

Reason for the Change:
Editorial
### Table B.2.2
**Representation of Openings in Girder - Primary Support Member Webs**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( h_o/h &lt; 0.35 ) and ( g_o &lt; 1.2 )</td>
<td>Openings do not need to be modelled</td>
</tr>
<tr>
<td>( 0.5 &gt; h_o/h \geq 0.35 ) and ( g_o &lt; 1.2 )</td>
<td>The plate modelled with mean thickness ( t_{1-net50} )</td>
</tr>
<tr>
<td>( h_o/h \leq 0.50 ) and ( 2 &gt; g_o \geq 1.2 )</td>
<td>The plate modelled with mean thickness ( t_{2-net50} )</td>
</tr>
<tr>
<td>( 0.5 &gt; h_o/h \geq 0.35 ) and ( 2 &gt; g_o \geq 1.2 )</td>
<td>The plate modelled with the minimum value of ( t_{1-net50} ) and ( t_{2-net50} )</td>
</tr>
<tr>
<td>( h_o/h \geq 0.5 ) or ( g_o \geq 2.0 )</td>
<td>The geometry of the opening is to be modelled</td>
</tr>
</tbody>
</table>

Where:

\[
g_o = 1 + \frac{l_o^2}{2.6(h - h_o)^2}
\]

\[
t_{1-net50} = \frac{h - h_o}{h} t_{w-net50}
\]

\[
t_{2-net50} = \frac{h - h_o}{h} t_{w-net50}
\]

\( t_{w-net50} \) - net web thickness

\( l_o \) - length of opening parallel to girder primary support member web direction, see Figure B.2.8

\( h_o \) - height of opening parallel to depth of web, see Figure B.2.8

\( h \) - height of web of girder primary support member in way of opening, see Figure B.2.8

\( t_{corr} \) - corrosion addition, as defined in Table 6.3.1 Section 6/3.2

**Note**

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

### Reason for the Change:

1. The 4th row and 5th row in the table are combined since \( t_{2-net50} \) is always lesser than \( t_{1-net50} \) and \( t_{2-net50} \)
2. Editorial

### 2.5 Procedure to Adjust Hull Girder Shear Forces and Bending Moments

#### 2.5.3 Procedure to adjust vertical shear force distribution

<table>
<thead>
<tr>
<th>Shell Type</th>
<th>Shear Force Distribution Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side Shell</td>
<td>( f = 0.055 + 0.097 \frac{A_{1-net50}}{A_{2-net50}} + 0.020 \frac{A_{2-net50}}{A_{3-net50}} )</td>
</tr>
<tr>
<td>Inner Hull</td>
<td>( f = 0.193 - 0.059 \frac{A_{1-net50}}{A_{2-net50}} + 0.058 \frac{A_{2-net50}}{A_{3-net50}} )</td>
</tr>
<tr>
<td>Structural Member</td>
<td>Formula</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Side Shell</td>
<td>$f = 0.055 + 0.097 \frac{A_{1\text{net50}}}{A_{2\text{net50}}} + 0.020 \frac{A_{2\text{net50}}}{A_{3\text{net50}}}$</td>
</tr>
<tr>
<td>Inner hull</td>
<td>$f = 0.193 - 0.059 \frac{A_{1\text{net50}}}{A_{2\text{net50}}} + 0.058 \frac{A_{2\text{net50}}}{A_{3\text{net50}}}$</td>
</tr>
<tr>
<td>CL longitudinal bulkhead</td>
<td>$f = 0.504 - 0.076 \frac{A_{1\text{net50}}}{A_{2\text{net50}}} - 0.156 \frac{A_{2\text{net50}}}{A_{3\text{net50}}}$</td>
</tr>
<tr>
<td>Side Shell</td>
<td>$f = 0.028 + 0.087 \frac{A_{1\text{net50}}}{A_{2\text{net50}}} + 0.023 \frac{A_{2\text{net50}}}{A_{3\text{net50}}}$</td>
</tr>
<tr>
<td>Inner hull</td>
<td>$f = 0.119 - 0.038 \frac{A_{1\text{net50}}}{A_{2\text{net50}}} + 0.072 \frac{A_{2\text{net50}}}{A_{3\text{net50}}}$</td>
</tr>
<tr>
<td>Longitudinal bulkhead</td>
<td>$f = 0.353 - 0.049 \frac{A_{1\text{net50}}}{A_{2\text{net50}}} - 0.095 \frac{A_{2\text{net50}}}{A_{3\text{net50}}}$</td>
</tr>
</tbody>
</table>

Where:
- $A_{1\text{net50}}$ plate sectional area of individual side shell (i.e. on one side), including bilge
- $A_{2\text{net50}}$ 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.
- $A_{3\text{net50}}$ plate sectional area of individual longitudinal bulkhead, including double bottom girder in way

**Note**
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.

**Reason for the Change:**
1. Editorial correction of symbols in the formulas
2. “vertical” removed since Section 4/2.6.4 is applicable for both horizontal and vertical corrugations

### 2.7 Result Evaluation

#### 2.7.3 Buckling assessment

2.7.3.1 Buckling capability is to be assessed for the plating and stiffened panels of longitudinal hull girder structural members, primary supporting 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 supporting members and tripping brackets is not assessed based on stress result obtained by the finite element analysis.
2.7.3.3 The buckling assessment is to be based on the stresses obtained from the finite element analysis in conjunction with buckling capacity model based on net thickness obtained by deducting the full corrosion addition thickness, $t_{corr}$, and any Owner’s extras from the proposed thickness. This thickness deduction applies to all plating, stiffener webs and face plates.

3  **Local Fine Mesh Structural Strength Analysis**

3.1  General

3.1.6 Screening criteria for Fine Mesh Analysis
Table B.3.2
Fine Mesh Analysis Screening Criteria for Bracket Toes of Primary Supporting Members

A fine mesh finite element analysis is to be carried out where:

\[ \lambda_y > 1.5 \] (load combination S + D)
\[ \lambda_y > 1.2 \] (load combination S)

Where:

- \( \lambda_y \) yield utilisation factor
- \( C_a \) = 1.0 - 0.2\( \left( \frac{R_a}{1400} \right)^2 \)
- \( b_1, b_2 \) height of plate element in way of bracket toe in cargo tank FE model, in mm
- \( A_{\text{bar-net50}} \) sectional area of bar element in cargo tank FE model representing the face plate of bracket, in mm²
- \( \sigma_{\text{bar}} \) bar element axial stress determined from cargo tank FE analysis, in N/mm²
- \( \sigma_{\text{vm}} \) von Mises stress of plate element in way of bracket toe determined from cargo tank FE analysis, in N/mm²
- \( t_{\text{net50}} \) thickness of plate element in way of bracket toe, in mm
- \( R_a \) leg length distance in mm, not to be taken as greater than 1400mm
- \( k \) higher strength steel factor, as defined in Section 6/1.1.4, but not to be taken as less than 0.78 for load combination S + D

Note
1. Screening criteria is only valid if the cargo tank finite element analysis and the derivation of element stresses is carried out in accordance with B/2.

Reason for the Change:
Editorial (title only)
3.2 Structural Modelling

3.2.1 General

3.2.1.2 The extent of the local finite element model is to be such that the calculated stresses at the areas of interest are not significantly affected by the imposed boundary conditions and application of loads. The boundary of the fine mesh model is to coincide with primary supporting members, such as girders, stringers and floors, in the cargo tank model.

*Reason for the Change:*
Editorial (title)

4 Evaluation of Hot Spot Stress for Fatigue Analysis

4.2 Structural Modelling

4.2.1 General

4.2.1.2 All structural parts, within an extent of at least 500mm in all directions leading up to the fatigue hot spot position, are to be modelled based on the net thickness, obtained by deducting half the corrosion addition thickness (i.e. \(0.5t_{corr}\)) from the gross thickness.

*Reason for the Change:*
Editorial

4.2.1.3 The cargo tank finite element model for fatigue assessment is to be modelled in accordance with 2.2, but based on net thickness obtained by deducting a quarter of the corrosion addition thickness (i.e. \(0.25t_{corr}\)) from the proposed thickness. Alternatively, if the cargo tank FE model for the strength assessment is used, which is based on a thickness deduction of \(0.5t_{corr}\), the calculated stresses are to be corrected using the modelling reduction factor, \(f_{model}\), given in Appendix C/2.4.2.7.

*Reason for the Change:*
Editorial

4.2.1.4 Where a separate local finite element model is used, the extent of the local model is to be such that the calculated stresses are not significantly affected by the imposed boundary conditions and application of loads. The boundary of the fine mesh model is to coincide with the primary supporting members, such as girders, stringers and floors, in the cargo tank model. The extent of the local finite element model of a hopper knuckle is described in 4.2.2.
Appendix C – Fatigue Strength Assessment

1 NOMINAL STRESS APPROACH

1.3.2 Selection of loading conditions

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, \( T_{\text{full}} \), see Section 4/1.1.5.4

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

1.4 Fatigue Damage Calculation

1.4.1 Fatigue strength determination

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:

\[
 f(S) = \frac{\xi}{f_1} \left( \frac{S}{f_1} \right)^{\xi-1} \exp \left( -\left( \frac{S}{f_1} \right)^\xi \right)
\]

Where:

- \( S \) stress range, in N/mm\(^2\)
- \( \xi \) Weibull probability distribution parameter, as defined in 1.4.1.6
- \( f_1 \) scale parameter
  \[ f_1 = \frac{S_g}{(\ln N_R)^{\xi}} \]
- \( N_R \) 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/mm²

**Reason for the Change:**
Editorial (Error in the formula corrected, KC ID 391)

<table>
<thead>
<tr>
<th>Table C.1.1</th>
<th>Distribution of ( f_{\text{Weibull}} ) factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plating Area</td>
<td>( f_{\text{Weibull}} ) (see note)</td>
</tr>
<tr>
<td>Bottom</td>
<td>0.9 at centreline and 0.95 at side</td>
</tr>
<tr>
<td>Side and bilge</td>
<td>1.1 at up to draught ( T_{LC} ) and 1.0 at deck</td>
</tr>
<tr>
<td>Deck</td>
<td>1.0</td>
</tr>
<tr>
<td>Inner bottom</td>
<td>1.0</td>
</tr>
<tr>
<td>Inner <strong>Hull Longitudinal Bulkhead side</strong></td>
<td>1.1 up to D/2 and 1.0 at deck</td>
</tr>
<tr>
<td>Inner Longitudinal Bulkhead</td>
<td>1.1 up to D/2 and 1.0 at deck</td>
</tr>
<tr>
<td>Centreline Longitudinal Bulkhead</td>
<td>1.1 up to D/2 and 1.0 at deck</td>
</tr>
</tbody>
</table>

**Reason for the Change:**
Editorial

### 1.4.4 Definition of stress components

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

\[
\sigma_{2A} = K_n K_t \frac{M}{Z_{net50}} \times 10^6 \text{ N/mm}^2
\]

Where:

- \( K_n \) stress factor for unsymmetrical profiles, as defined in 1.4.4.15
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

Reason for the Change:
Editorial

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 Figure C.1.6, are to be taken as:

$$K_{n1} = \frac{1 + \lambda \beta}{1 + \lambda \beta^2 \psi_z} K_{n2} = \frac{1 + \lambda \beta}{1 + \lambda \beta^2 \psi}$$

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:

$$\beta = 1 - \frac{2b_g}{b_f}$$

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 Figure C.1.7

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

$d_w$ depth of stiffener web, see Figure C.1.7, in mm

$\lambda$ factor, as defined in 1.4.4.17

$\psi_z$ 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

$$\frac{d_w^2 t_{w-net50}}{4Z_{net50}^2 10^7}$$

may be used as an approximate value.
Z_{net50} \text{ section modulus of stiffener including the full width of the attached plate, } s, \text{ with respect to a neutral axis normal to the stiffener web, in cm}^3. \text{ It is to be calculated based on the gross thickness minus the corrosion addition } 0.5t_{corr}.

Reason for the Change:
Editorial (\( \psi \) changed to \( \psi_z \) since \( \psi \) has been already used for some other definition in Section 10)

1.4.4.19 Total combined stress range, \( S \), is given by:

\[
S = f_{SN} \left| f_1 S_v + f_2 S_h + f_3 S_e + f_4 S_i \right| \text{ N/mm}^2
\]

Where:

\( f_1, f_2, f_3 \) stress range combination factors, representing the phase correlation between total stress range and each stress range component which is between 1.0 and -1.0, as defined in Tables C.1.2 to C.1.4 C.1.3 to C.1.5. Where the factor is greater than 1.0 it is to be taken as 1.0. Where the factor is less than -1.0 it is to be taken as -1.0

\( f_{SN} \) 1.06, factor to account for joints in combined protected and unprotected environment.

\( S_v \) corresponding stress range due to vertical bending moment, in N/mm\(^2\), as defined in 1.4.4.7

\( S_h \) corresponding stress range due to horizontal bending moment, in N/mm\(^2\), as defined in 1.4.4.9

\( S_e \) stress range due to external wave or internal tank pressure, in N/mm\(^2\), as defined in 1.4.4.12

\( S_i \) stress range due to external wave or internal tank pressure, in N/mm\(^2\), as defined in 1.4.4.12

Reason for the Change:
Editorial

<table>
<thead>
<tr>
<th>Stiffener location</th>
<th>( f_1 )</th>
<th>( f_2 )</th>
<th>( f_3 )</th>
<th>( f_4 )</th>
<th>( f_i )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ballast</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outer b Bottom shell</td>
<td>( a_i )</td>
<td>0.49</td>
<td>-1.04</td>
<td>0.26</td>
<td>( a_i (</td>
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<tr>
<td></td>
<td>( b_i )</td>
<td>0.97</td>
<td>0.87</td>
<td>0.56</td>
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<tr>
<td>Outer s Side shell and bilge below D/2</td>
<td>( a_i )</td>
<td>-1.48</td>
<td>0.50</td>
<td>-0.64</td>
<td>( a_i (z/D) + b_i )</td>
</tr>
<tr>
<td></td>
<td>( b_i )</td>
<td>0.94</td>
<td>0.40</td>
<td>0.72</td>
<td>0.04</td>
</tr>
<tr>
<td>Outer s Side shell above D/2</td>
<td>( a_i )</td>
<td>1.70</td>
<td>-1.00</td>
<td>-1.10</td>
<td>( a_i (z/D) + b_i )</td>
</tr>
<tr>
<td></td>
<td>( b_i )</td>
<td>-0.65</td>
<td>1.15</td>
<td>0.95</td>
<td>0.70</td>
</tr>
</tbody>
</table>
Reason for the Change:  
Editorial

---

**Table C.1.4**  
**Stress Range Combination Factors for Zone A**

<table>
<thead>
<tr>
<th>Stiffener location</th>
<th>( f_1 )</th>
<th>( f_2 )</th>
<th>( f_3 )</th>
<th>( f_4 )</th>
<th>( f_i )</th>
</tr>
</thead>
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<tr>
<td><strong>Ballast</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outer b Bottom shell</td>
<td>(-0.20)</td>
<td>(-0.80)</td>
<td>(1.20)</td>
<td>(1.50)</td>
<td></td>
</tr>
<tr>
<td><strong>Loaded</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inner b Bottom shell below D/2 (including hopper plate)</td>
<td>(-0.80)</td>
<td>(-1.70)</td>
<td>(0.00)</td>
<td>(2.60)</td>
<td></td>
</tr>
<tr>
<td>Inner b Bottom shell above D/2</td>
<td>(0.55)</td>
<td>(1.20)</td>
<td>(0.00)</td>
<td>(0.35)</td>
<td></td>
</tr>
<tr>
<td>Inner b Lower stool</td>
<td>(-0.71)</td>
<td>(1.13)</td>
<td>(0.00)</td>
<td>(0.55)</td>
<td></td>
</tr>
<tr>
<td>Inner b Bottom shell below D/2 (including hopper plate)</td>
<td>(0.55)</td>
<td>(1.20)</td>
<td>(0.00)</td>
<td>(0.35)</td>
<td></td>
</tr>
<tr>
<td>Inner b Bottom shell above D/2</td>
<td>(1.90)</td>
<td>(0.30)</td>
<td>(0.00)</td>
<td>(1.70)</td>
<td></td>
</tr>
<tr>
<td>Inner b Lower stool</td>
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<td>(0.00)</td>
<td>(1.80)</td>
<td></td>
</tr>
<tr>
<td>Deck and Upper stool</td>
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<td>(1.40)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td></td>
</tr>
<tr>
<td>Centreline longitudinal bulkhead below D/2</td>
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<td>(0.00)</td>
<td>(1.00)</td>
<td></td>
</tr>
<tr>
<td>Centreline longitudinal bulkhead above D/2</td>
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<td>(0.00)</td>
<td>(0.00)</td>
<td>(0.60)</td>
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<tr>
<td>Longitudinal bulkhead below D/2</td>
<td>(-0.80)</td>
<td>(0.00)</td>
<td>(0.00)</td>
<td>(1.70)</td>
<td></td>
</tr>
<tr>
<td>Longitudinal bulkhead above D/2</td>
<td>(0.60)</td>
<td>(0.40)</td>
<td>(0.00)</td>
<td>(0.05)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b_i)</td>
<td>(a_i)</td>
<td>(\frac{</td>
<td>y</td>
<td>}{B})</td>
</tr>
<tr>
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<td>-----------------</td>
</tr>
<tr>
<td><strong>Outer Side shell and bilge below D/2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a_i)</td>
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<td>1.20</td>
<td>-0.80</td>
<td>2.00</td>
<td>((z/D) + b_i)</td>
</tr>
<tr>
<td>(b_i)</td>
<td>0.20</td>
<td>0.00</td>
<td>0.60</td>
<td>-0.40</td>
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<tr>
<td><strong>Outer Side shell above D/2</strong></td>
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<td></td>
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<tr>
<td>(a_i)</td>
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<td>0.20</td>
<td>((z/D) + b_i)</td>
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<tr>
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<td>1.60</td>
<td>0.20</td>
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</tr>
<tr>
<td><strong>Inner bottom and Lower stool</strong></td>
<td></td>
<td></td>
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<td>((</td>
</tr>
<tr>
<td>(a_i)</td>
<td>-0.50</td>
<td>-1.90</td>
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<td>0.30</td>
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<tr>
<td>(b_i)</td>
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<td></td>
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<td>((z/D) + b_i)</td>
</tr>
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<td>0.20</td>
<td></td>
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<td>(b_i)</td>
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<td>0.00</td>
<td>0.90</td>
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</tr>
<tr>
<td><strong>Inner hull side shell above D/2</strong></td>
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<td></td>
<td></td>
<td></td>
<td>((z/D) + b_i)</td>
</tr>
<tr>
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<td>2.80</td>
<td>0.00</td>
<td>-0.50</td>
<td></td>
</tr>
<tr>
<td>(b_i)</td>
<td>0.30</td>
<td>-1.80</td>
<td>0.00</td>
<td>1.25</td>
<td></td>
</tr>
<tr>
<td><strong>Deck and Upper stool</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>((</td>
</tr>
<tr>
<td>(a_i)</td>
<td>0.00</td>
<td>0.70</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>(b_i)</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td><strong>Inner longitudinal bulkhead Below D/2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>((z/D) + b_i)</td>
</tr>
<tr>
<td>(a_i)</td>
<td>-1.20</td>
<td>2.00</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>(b_i)</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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</tr>
<tr>
<td><strong>Inner longitudinal bulkhead Above D/2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>((z/D) + b_i)</td>
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<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
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<td>0.00</td>
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<tr>
<td><strong>Centreline longitudinal bulkhead Below D/2</strong></td>
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<td></td>
<td></td>
<td></td>
<td>((z/D) + b_i)</td>
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<td>(a_i)</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
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</tr>
<tr>
<td>(b_i)</td>
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<tr>
<td><strong>Centreline longitudinal bulkhead Above D/2</strong></td>
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<td></td>
<td></td>
<td></td>
<td>((z/D) + b_i)</td>
</tr>
<tr>
<td>(a_i)</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>(b_i)</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td><strong>Loaded Centreline longitudinal bulkhead Below D/2</strong></td>
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<td>((z/D) + b_i)</td>
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**Reason for the Change:**
Editorial
### Table C.1.5
Stress Range Combination Factors for Zone F

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<th>Stiffener location</th>
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<th>$f_2$</th>
<th>$f_3$</th>
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<td>-0.40</td>
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<tr>
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<td>Centred longitudinal bulkhead below $D/2$</td>
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<tr>
<td>Centred longitudinal bulkhead above $D/2$</td>
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</tr>
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</table>

**Reason for the Change:**
1.5 Classification of Structural Details

1.5.1 General

1.5.1.2 In case 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 Note 6 of Table C.1.7.

Reason for the Change:
Editorial

1.6 Other Details

1.6.1 Scallops in way of block joints

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 Figure C.1.12 unless the specification in Section 8/1.5.1.3 for class F2 is satisfied.

Reason for the Change:
Editorial

2 Hot Spot Stress (FE Based) Approach

2.4 Fatigue Damage Calculation

2.4.2 Stresses to be used

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:

$$
S = f_{\text{model}} \left[ 0.85(S_{e1} + 0.25S_{e2}) - 0.3S_e \right] 
$$

for full load condition

$$
S = f_{\text{model}} \left[ 0.85(S_{e1} - 0.2S_{e2}) \right] 
$$

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/mm², 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/mm², see Table B.4.1
$S_t$  stress range due to dynamic tank pressure applied to FE-model, in N/mm², 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 $0.25\cdot t_{corr}$ for the FE model except in way of critical location (in way of a knuckle and within 500mm in all directions), which uses corrosion margin addition of $0.5\cdot t_{corr}$

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

Reason for the Change:
Editorial

APPENDIX D – BUCKLING STRENGTH ASSESSMENT

5  STRENGTH ASSESSMENT (FEM) – BUCKLING PROCEDURE

5.2  Structural Modelling and Capacity Assessment Method

5.2.1  General

5.2.1.2  The structural models are to be based on the net thickness obtained by deducting the full corrosion addition thickness, i.e. $-1.0\cdot t_{corr}$, and any owner’s extras from the proposed thickness. This thickness reduction applies to the plating and the stiffener web and face plate.

Reason for the Change:
Editorial

5.2.2  Stiffened panels

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 be 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. See Figure D.5.6.
Reason for the Change:
Editorial (Figure D.5.6 could be also used for stiffened panels, KC ID 267)

5.2.3 Un-stiffened panels

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 Figure D.5.5 and D.5.6. Where web stiffeners are not connected to the intersecting stiffeners, then the panel may be defined as shown in Figure D.5.6. The FE analysis is to represent the actual structure in order to derive realistic stress values for application to the equivalent rectangular panel. The stresses of all elements whose centroids are within the equivalent plate panel are to be considered for stress average in accordance with 5.3.2.1.

Reason for the Change:
Clarification (KC ID 267):
1. Clarification for Figure D.5.6
2. Added explanation for stresses to be used in idealised model.

![Figure D.5.6 Capacity Model for Web Plate](image)

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

Reason for the Change:
Clarification (KC ID 203)
5.4 Limitations of the Advanced Buckling Assessment Method

5.4.1 General

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

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<thead>
<tr>
<th>Structural elements</th>
<th>Buckling mode</th>
<th>Rule Reference</th>
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<tr>
<td>bilge plate</td>
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</tr>
<tr>
<td>primary support members</td>
<td>global (overall) buckling</td>
<td>Section 10/2.3</td>
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<tr>
<td>web plate of primary support members in way of openings</td>
<td>buckling of web plate</td>
<td>Section 10/3.4</td>
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<td>cross ties</td>
<td>global (overall) buckling</td>
<td>Section 10/3.5</td>
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<td>flange panel buckling</td>
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<tr>
<td></td>
<td>global (overall) buckling</td>
<td>Section 10/3.5</td>
</tr>
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</table>

Reason for the Change:
Editorial (missing items added)

Rule Clarification

6 ULTIMATE HULL GIRDER STRENGTH ASSESSMENT

6.3 Structural Modelling and Buckling Assessment

6.3.1 General

The buckling capacity models are to be based on the net thickness obtained by deducting half the corrosion addition thickness, i.e. -0.5\(t_{corr}\), and any owner’s extras from the proposed thickness. This thickness reduction applies to the plating and the stiffener web and face plate.

Reason for the Change:
Editorial