Common Structural Rules for Double Hull Oil Tankers

Corrigenda 1
Rule Editorials

Notes:  (1) These Rule Corrigenda enter into force on 1st July 2008.
(2) This document contains a copy of the affected rule along with the editorial change or clarification noted as applicable.
(3) These Rule Corrigenda should be read in conjunction with the 1 July 2008 consolidated edition of Double Hull Oil Tankers CSR (www.iacs.org.uk/publications / common structural rules).

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Section 4 - Basic Information

3 Structure Design Details

3.4 Intersections of Continuous Local Support Members and Primary Support Members

Figure 4.3.6
Primary Support Member Web Stiffener Details

Where:

\[ t_{ws-net}, t_{ws1-net}, \text{ and } t_{ws2-net} \]  net thickness of the primary support member web stiffener/backing bracket, in mm

\[ d_{w1}, d_{w2} \text{ and } d_{w2} \] minimum depth of the primary support member web stiffener/backing bracket, in mm
| $d_{w3}$, $d_{w1}$ and $d_{w2}$ | length of connection between the primary support member web stiffener/backing bracket and the local support stiffener, in mm |

**Note**
Except where specific dimensions are noted for the details of the keyhole in way of the soft heel, see 3.4.1.4, the details shown in this figure are only used to illustrate symbols and definitions and are not intended to represent design guidance or recommendations.

**Reason for the Change:**
The definition of $d_w$ is corrected in (a) (KC ID 466). The correction is not shown in figure above and old figure is therefore inserted below.

(a) straight heel no bracket
SECTION 8 – SCANTLING REQUIREMENTS

1 LONGITUDINAL STRENGTH

1.3 Hull Girder Shear Strength

1.3.3 Shear force correction for longitudinal bulkheads between cargo tanks

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

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

Where:

- $n$ number of floors between transverse bulkheads, excluding the floor in line with the wash bulkhead
- $f_3$ shear force distribution factor, see Figure 8.1.2

Reason for the Change:
Correction of definition error

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

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

Where:

- $n$ number of floors between transverse bulkheads, excluding the floor in line with the wash bulkhead
- $r$ ratio of the part load carried by the wash bulkheads and floors from longitudinal bulkhead to the double side and is given by:

$$r = \frac{1}{\frac{A_{1 \text{-net50}} + A_{2 \text{-net50}}}{A_{1 \text{-net50}} + A_{2 \text{-net50}}} + \frac{2 \times 10^4 b_{30}(n_s + 1)A_{3 \text{-net50}}}{l_{tk} n_s A_{T \text{-net50}} + R}}$$

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

- $l_{tk}$ length of cargo tank, between transverse bulkheads in the side cargo tank, in m
- $b_{80}$ 80% of the distance from longitudinal bulkhead to the inner hull longitudinal bulkhead side, in m, at tank mid length
- $A_{T \text{-net50}}$ net shear area of the transverse wash bulkhead, including the...
double bottom floor directly below, in the side cargo tank, in cm$^2$, taken as the smallest area in a vertical section. $A_{T\text{-net50}}$ is to be calculated with net thickness given by $t_{grs} - 0.5t_{corr}$.

- $A_{1\text{-net50}}$: net area, as shown in Figure 8.1.2, in m$^2$
- $A_{2\text{-net50}}$: net area, as shown in Figure 8.1.2, in m$^2$
- $A_{3\text{-net50}}$: net area, as shown in Figure 8.1.2, in m$^2$
- $f_3$: shear force distribution factor, as shown in Figure 8.1.2
- $n_S$: number of wash bulkheads in the side cargo tank
- $R$: total efficiency of the transverse primary support members in the side tank

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

$$\gamma = 1 + \frac{300b_8^2}{I_{psm\text{-net50}}}$$

- $A_{Q\text{-net50}}$: net shear area, in cm$^2$, of a transverse primary support member in the wing cargo tank, taken as the sum of the net shear areas of floor, cross ties and deck transverse webs. $A_{Q\text{-net50}}$ is to be calculated using the net thickness given by $t_{grs} - 0.5t_{corr}$. The net shear area is to be calculated at the mid span of the members.

- $I_{psm\text{-net50}}$: net moment of inertia for primary support members, in cm$^4$, of a transverse primary support member in the wing cargo tank, taken as the sum of the moments of inertia of transverses and cross ties. It is to be calculated using the net thickness given by $t_{grs} - 0.5t_{corr}$. The net moment of inertia is to be calculated at the mid span of the member including an attached plate width equal to the primary support member spacing.

- $t_{grs}$: gross plate thickness, in mm
- $t_{corr}$: corrosion addition, in mm, as defined in Section 6/3.2

Reason for the Change:
Correction of definition error of “n” and Editorial
1.4 Hull Girder Buckling Strength

1.4.2 Buckling assessment

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

\[ \eta \leq \eta_{allow} \]

Where:

\( \eta \) buckling utilisation factor

\[ \frac{\sigma_{hg-net50}}{\sigma_{cr}} \]

\( \sigma_{hg-net50} \) hull girder compressive stress based on net hull girder sectional properties, in N/mm\(^2\) as defined in 1.4.2.3

\( \sigma_{cr} \) critical compressive buckling stress, \( \sigma_{cr} \) or \( \sigma_{ycr} \) as appropriate, in N/mm\(^2\), as specified in Section 10/3.2.1.3. The critical compressive buckling stress is to be calculated for the effects of hull girder compressive stress only. The effects of other membrane stresses and lateral pressure are to be ignored. The net thickness given as \( t_{grs} - t_{corr} \) as described in Section 6/3.3.2.2 is to be used for calculation of \( \sigma_{cr} \)

\( \eta_{allow} \) allowable buckling utilisation factor:

\begin{align*}
\text{= 1.0 for plate panels at or above 0.5D} \\
\text{= 0.90 for plate panels below 0.5D}
\end{align*}

Reason for the Change:
Editorial (KC ID 167)

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

\[ \eta \leq \eta_{allow} \]

Where:

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

\( \eta_{allow} \) allowable buckling utilisation factor:

\begin{align*}
\text{= 1.0 for stiffeners at or above 0.5D} \\
\text{= 0.90 for stiffeners below 0.5D}
\end{align*}

Reason for the Change:
Editorial (KC ID 167)
2 CARGO TANK REGION

2.1 General

2.1.4 General scantling requirements

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

a) Buckling strength including proportion (slenderness ratio) requirements for primary support members as follows:
   • For stiffener web, see Section 10/2.3.1.1(a), 10/3.2.
   • For stiffener flange, see Section 10/2.3.1.1(b), 10/2.3.3.1.
   • For web stiffeners, see Section 10/2.3.2.1, 10/2.3.2.2, 10/3.3.
   Note: Note 1 of table 10.2.1 is not applicable.

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

c) All other requirements for local support members as follows:
   • Corrosion additions: requirements for local support members
   • Minimum thickness: requirements for local support members
   • Fatigue: requirements for local support members
   Note: For primary support members (or part of it) used as a PMA platform the requirements for primary support members are to be applied.

Reason for the Change:
New paragraph, is added to clarify applicable requirements for enlarged stiffeners used for permanent means of access. (KC ID 572)
6 Evaluation of Structure for Sloshing and Impact Loads

6.4 Bow Impact

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

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

Where:

- $f_{pt}$: patch load modification factor
- $l_{slm}$: extent of bow impact load area along the span
- $l_{shr}$: effective shear span, as defined in Section 4/2.1.25, in m
- $P_{im}$: bow impact pressure as given in Section 7/4.4 and calculated at the load calculation point defined in Section 3/5.3.2, in kN/m$^2$
- $b_{slm}$: breadth of impact load area supported by the primary support member, to be taken as the spacing between primary support members as defined in Section 4/2.2.2, but not to be taken as greater than $l_{slm}$, in m
- $C_t$: permissible shear stress coefficient
- $\tau_{yd}$: $\frac{\sigma_{yd}}{\sqrt{3}}$, N/mm$^2$
- $\sigma_{yd}$: specified minimum yield stress of the material, in N/mm$^2$

Reason for the Change:
Editorial
Section 10 – Buckling and Ultimate Strength

2 STIFFNESS AND PROPORTIONS

2.2 Plates and Local Support Members

2.2.1 Proportions of plate panels and local support members

<table>
<thead>
<tr>
<th>Item</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>hull envelope and tank boundaries</td>
<td>100</td>
</tr>
<tr>
<td>other structure</td>
<td>125</td>
</tr>
<tr>
<td>angle and T profiles</td>
<td>75</td>
</tr>
<tr>
<td>bulb profiles</td>
<td>41</td>
</tr>
<tr>
<td>flat bars</td>
<td>22</td>
</tr>
</tbody>
</table>

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

Where:
- \( t_{net} \) net thickness of plate, in mm
- \( d_w \) depth of web plate, in mm
- \( t_{w,net} \) net web thickness, in mm
- \( b_{f, out} \) breadth of flange outstands, in mm
- \( t_{f,net} \) net flange thickness, in mm

Reason for the Change:
Editorial (Irrelevant cross reference deleted since 4/2.4.1.2 does not describe measuring based on gross scantling)
### Table 10.2.2

**Stiffness Criteria for Web Stiffening**

<table>
<thead>
<tr>
<th>Mode</th>
<th>Inertia requirements, cm$^4$</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) web stiffeners parallel to the compression stresses flanges of the primary support member</td>
<td>$I_{net} = Cl^2 A_{net} \frac{\sigma_{yd}}{235}$</td>
</tr>
<tr>
<td>(b) web stiffeners normal to compression stresses flanges of the primary support member</td>
<td>$I_{net} = 1.14 \times 10^{-5} l s^2 t_{w-net} \left( \frac{2.5 \times 1000l}{s} - 2 \times \frac{s}{1000l} \right) \frac{\sigma_{yd}}{235}$</td>
</tr>
</tbody>
</table>

Where:

- $C = 1.43$ for longitudinal stiffeners in cargo tank region subject to hull girder stresses
- $C = 0.72$ for other stiffeners
- $l$ is the length of web stiffener, in m.
- $l$ is to be measured between the flanges of the local support members for web stiffeners welded to local support members (LSM).
- $l$ is to be measured between the lateral supports, e.g. the total distance between the flanges of the primary support member as shown for Mode (b).
- $A_{net}$ is the net section area of the web stiffener including attached plate assuming effective breadth of 80% of stiffener spacing $s$, in cm$^2$
- $s$ is the spacing of stiffeners, in mm, as defined in Section 4/2.2.1
- $t_{w-net}$ is the net web thickness of the primary support member, in mm
- $\sigma_{yd}$ is the specified minimum yield stress of the material of the web plate of the primary support member, in N/mm$^2$

**Reason for the change:**

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

2.4.3.1 The depth of stiffener web, \( d_{w} \), of edge stiffeners in way of openings and bracket edges is not to be less than:

\[
d_w = Cl_{stf} \sqrt{\frac{\sigma_{yd}}{235}}
\]

\[
d_w = Cl \left[ \frac{\sigma_{yd}}{235} \right] \text{mm, or 50 mm, whichever is greater}
\]

Where:

- \( l_{stf} \) is the length of edge stiffener between effective supports, in m
- \( \sigma_{yd} \) is the specified minimum yield stress of the material, in N/mm\(^2\)
- \( C \) is the slenderness coefficient
  - 75 for end brackets
  - 50 for tripping brackets
  - 50 for edge reinforcements in way of openings

**Reason for the change:**
Clarification
## 3 Prescriptive Buckling Requirements

### 3.3 Buckling of stiffeners

#### 3.3.3 Torsional buckling mode

<table>
<thead>
<tr>
<th>Section property</th>
<th>Flat bars</th>
<th>Bulb flats, angles and T bars</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{p-network}$</td>
<td>$d_w^3 t_{w-network}$ (3x10^4)</td>
<td>(\left(\frac{A_{w-network} \left(e_f - 0.5t_{f-network}\right)^2}{3} + A_{f-network} e_f^2\right)10^{-4})</td>
</tr>
<tr>
<td>$I_{T-network}$</td>
<td>$d_w t_{w-network}^3 \left(1 - 0.63 \frac{t_{w-network}}{d_w}\right)$ (3x10^4)</td>
<td>(\left(\frac{(e_f - 0.5t_{f-network})t_{w-network}^3}{3x10^4} \left(1 - 0.63 \frac{t_{w-network}}{e_f - 0.5t_{f-network}}\right)\right)) + (\left(\frac{b_f t_{f-network}^3}{3x10^4} \left(1 - 0.63 \frac{t_{f-network}}{b_f}\right)\right))</td>
</tr>
<tr>
<td>$I_{w-network}$</td>
<td>$\frac{d_w^3 t_{w-network}^3}{36x10^6}$</td>
<td>for bulb flats and angles: (\frac{A_{f-network} e_f^2 b_f^2 \left(A_{f-network} + 2.6A_{w-network}\right)}{12x10^6} \left(\frac{A_{f-network} + A_{w-network}}{A_{f-network} + A_{w-network}}\right)) for T bars: (\frac{b_f^3 t_{f-network}^3 e_f^2}{12x10^6})</td>
</tr>
</tbody>
</table>

Reason for the change:
Editorial correction.

In the equation for St. Venant's moment of inertia $t_{f-network}$ is replaced with $t_{w-network}$ to align with CSR-BC.
Appendix A – Hull Girder Ultimate Strength

2 Calculation of Hull Girder Ultimate Capacity

2.2 Simplified Method Based on an Incremental-iterative Approach

2.2.2 Assumption and modelling of the hull girder cross-section

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

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

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

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

Reason for the change:
Clarification requested in KC question 427.
Appendix C - Fatigue Strength Assessment

2 FATIGUE DAMAGE CALCULATION

2.4 Hot Spot Stress (FE Based) Approach

2.4.2 Stresses to be used

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

Reason for the change:
Clarification requested in KC question 509.
Appendix D – Buckling Strength Assessment

1.1 ADVANCED BUCKLING ANALYSIS

1.1.1 General

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

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

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

Where:

- $\eta_{all}$: permissible utilisation factor against buckling for plate and stiffened panels as specified in Section 9/Table 9.2.2
- $\eta_{ref-i}$: utilisation factor for reference advanced buckling procedure for test case $i$ specified in Background to Appendix D
- $\eta_{alt-i}$: utilisation factor for alternative buckling procedure for test case $i$ specified in Background to Appendix D

Reason for the change:
Correction of misprint in formula

5 STRENGTH ASSESSMENT (FEM) – BUCKLING PROCEDURE

5.2 Structural Modelling and Capacity Assessment Method

5.2.3 Un-stiffened panels
### Table D.5.1
### Structural Elements for the Strength Assessment (FEM)

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

**Note**

1. The assessment method specifies which buckling strength assessment method is to be used, see 4.1
2. See structural idealisation, 3.1.3.

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

*Reason for the change:*

Clarification

0000