Common Structural Rules for Double Hull Oil Tankers, July 2008

Rule Change Notice No.1 January 2009 (Amended, Nov 2009)

Notes: (1) These Rule Changes enter into force on 1 February 2010.

(2) Note that the January 2009 version of this RCN 1 contained changes to para 8/5.3.1.1, however following further technical review, IACS Council agreed that these changes should be withdrawn and thus they are not included in this amended document.

For technical background for Rule Changes in this present document, reference is made to separate document Technical Background for Rule Change Notice No.1.

SECTION 4 - BASIC INFORMATION

3 STRUCTURE DESIGN DETAILS

3.2 Termination of Local Support Members

3.2.5 Sniped ends

3.2.5.1 Stiffeners with sniped ends may be used where dynamic loads are small and where the incidence of vibration is considered to be small, i.e. structure not in the stern area and structure not in the vicinity of engines or generators, provided the net thickness of plating supported by the stiffener, t_{p-net}, is not less than:

$$t_{p-net} = c_1\sqrt{\left(1000\,l - \frac{s}{2}\right)\frac{sPk}{10^6}}$$ ~~$$t_{p-net} = c_1\sqrt{\left(1000\,l - \frac{s}{2}\right)\frac{sPk}{1000}}$$~~ mm

Where:

l stiffener span, in m

s stiffener spacing, in mm, as defined in *2.2*

P design pressure for the stiffener for the design load set being considered, in kN/m². The design load sets and method to derive the design pressure are to be taken in accordance with the following criteria, which define the acceptance criteria set to be used:

a) *Table 8.2.5* in the cargo tank region

b) *Section 8/3.9.2.2* in the area forward of the forward cargo tank, and in the aft end

c) *Section 8/4.8.1.2* in the machinery space

k higher strength steel factor, as defined in *Section 6/1.1.4*

c_1 coefficient for the design load set being considered, to be taken as:

=1.2 for acceptance criteria set AC1

=~~1.0~~ 1.1 for acceptance criteria set AC2

3.4 Intersection of Continuous Local Support Members and Primary Support Members

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

New:

3.4.3.5 bis1 When total load, W, is bottom slamming or bow impact loads the following criteria apply in lieu of 3.4.3.3-3.4.3.5 :

$$0.9W \le \frac{(A_{1-net}\tau_{perm} + A_{w-net}\sigma_{perm})}{10} \text{ kN}$$

A_{1-net} effective net shear area in cm² of the connection, as defined in 3.4.3.3.

A_{w-net} effective net cross-sectional area in cm² of the primary support member web stiffener in way of the connection including backing bracket where fitted, as defined in 3.4.3.3.

σ_{perm} permissible direct stress given in *Table 4.3.1* for AC-3, in N/mm²

τ_{perm} permissible shear stress given in *Table 4.3.1* for AC-3, in N/mm²

SECTION 8 - SCANTLING REQUIREMENTS

2 CARGO TANK REGION

2.1 General

2.1.5 Minimum thickness for plating and local support members

Table 8.2.1
Minimum Net Thickness for Plating and Local Support Members in the Cargo Tank Region

Scantling Location			Net Thickness (mm)
Plating	**Shell** ~~**Hull envelope up to T_{sc} + 4.6m**~~	Keel plating	6.5 ~~5.5~~+0.03L_2
		Bottom shell/bilge/side shell	4.5 ~~3.5~~+0.03L_2
	Upper Deck ~~**Hull envelope above T_{sc} + 4.6m**~~	~~Side shell/upper deck~~	4.5+0.02L_2
	Other ~~**Hull internal**~~ **structure**	Hull internal tank boundaries	4.5+0.02L_2
		Non-tight bulkheads, bulkheads between dry spaces and other plates in general	4.5+0.01L_2
Local support members	Local support members on tight boundaries		3.5+0.015L_2
	Local support members on other structure		2.5+0.015L_2
Tripping brackets			5.0+0.015L_2
Where: ~~T_{sc} as defined in *Section 4/1.1.5.5*~~ L_2 rule length, *L*, as defined in *Section 4/1.1.1.1*, but need not be taken greater than 300m			

2.5 Bulkheads

2.5.7 Vertically corrugated bulkheads

2.5.7.9 For ships with a moulded depth, see *Section 4/1.1.4*, less than 16m, the lower stool may be eliminated provided the following requirements are complied with:

(a) general:

- double bottom floors or girders are to be fitted in line with the corrugation flanges for transverse or longitudinal bulkheads, respectively
- brackets/carlings are to be fitted below the inner bottom and hopper tank in line with corrugation webs. Where this is not practicable gusset plates with shedder plates are to be fitted, see item (c) below and *Figure 8.2.3*
- the corrugated bulkhead and its supporting structure is to be assessed by Finite Element (FE) analysis in accordance with *Section 9/2*. In addition the

local scantlings requirements of *2.5.6.4* and *2.5.6.5* and the minimum corrugation depth requirement of *2.5.7.4* are to be applied.

(b) inner bottom and hopper tank plating:

- ~~the net thickness of~~ the inner bottom and hopper tank in way of the corrugation ~~is not to be less than the net thickness of the attached corrugated bulkhead and~~ is to be of at least the same material yield strength as the attached corrugation

(c) supporting structure:

- within the region of the corrugation depth below the inner bottom the net thickness of the supporting double bottom floors or girders is not to be less than the net thickness of the corrugated bulkhead flange at the lower end and is to be of at least the same material yield strength
- the upper ends of vertical stiffeners on supporting double bottom floors or girders are to be bracketed to adjacent structure
- brackets/carlings arranged in line with the corrugation web are to have a depth of not less than 0.5 times the corrugation depth and a net thickness not less than 80% of the net thickness of the corrugation webs and are to be of at least the same material yield strength
- cut outs for stiffeners in way of supporting double bottom floors and girders in line with corrugation flanges are to be fitted with full collar plates
- where support is provided by gussets with shedder plates, the height of the gusset plate, see h_g in *Figure 8.2.3*, is to be at least equal to the corrugation depth, and gussets with shedder plates are to be arranged in every corrugation. The gusset plates are to be fitted in line with and between the corrugation flanges. The net thickness of the gusset and shedder plates are not to be less than 100% and 80%, respectively, of the net thickness of the corrugation flanges and are to be of at least the same material yield strength. Also see *2.5.7.11*.
- scallops in brackets, gusset plates and shedder plates in way of the connections to the inner bottom or corrugation flange and web are not permitted.

2.6 Primary Support Members

2.6.8 Cross ties

2.6.8.1 The maximum applied design axial load on cross ties, W_{ct}, is to be less than or equal to the permissible load, $W_{ct\text{-}perm}$, as given by:

$$W_{ct} \le W_{ct-perm}$$

Where:

W_{ct} applied axial load

$$= P\, b_{ct}\, S \quad \text{kN}$$

$W_{ct\text{-}perm}$ permissible load

$$= 0.1\, A_{ct-net50}\, \eta_{ct}\, \sigma_{cr} \quad \text{kN}$$

P	maximum design pressure for all the applicable design load sets being considered, calculated at centre of the area supported by the cross tie located at mid tank, in kN/m^2
b_{ct}	where cross tie is fitted in centre cargo tank: $= 0.5\ l_{bdg-vw}$ where cross ties are fitted in wing cargo tanks: $= 0.5\ l_{bdg-vw}$, for design cargo pressure from the centre cargo tank $= 0.5\ l_{bdg-st}$ for design sea pressure
l_{bdg-vw}	effective bending span of the vertical web frame on the longitudinal bulkhead, in m, see *Section 4/2.1.4* and *Figure 8.2.7*.
l_{bdg-st}	effective bending span of the side transverse, in m, see *Section 4/2.1* and *Figure 8.2.7*.
S	primary support member spacing, in m, as defined in *Section 4/2.2.2*
η_{ct}	utilisation factor, to be taken as: = ~~0.50~~ 0.65 for acceptance criteria set AC1 = ~~0.60~~ 0.75 for acceptance criteria set AC2
σ_{cr}	critical buckling stress in compression of the cross tie, in N/mm^2, as calculated using the net sectional properties in accordance with *Section 10/3.5.1*, where the effective length of the cross tie is to be taken as follows, in m: (a) for cross tie in centre tank: distance between the flanges of longitudinal stiffeners on the starboard and port longitudinal bulkheads to which the cross tie's horizontal stiffeners are attached (b) for cross tie in wing tank: distance between the flanges of longitudinal stiffeners on the longitudinal bulkhead to which the cross tie's horizontal stiffeners are attached, and the inner hull plating
$A_{ct-net50}$	net cross sectional area of the cross tie, in cm^2

3 FORWARD OF THE FORWARD CARGO TANK

3.1 General

3.1.4 Minimum thickness

Table 8.3.1
Minimum Net Thickness of Structure Forward of the Forward Cargo Tank

Scantling Location			Net Thickness (mm)
Plating	**Shell** ~~**Hull envelope up to T_{sc} + 4.6m**~~	Keel plating	See *2.1.5.1*
		Bottom shell/bilge/side shell plating	See *2.1.5.1*
	Upper Deck ~~**Hull envelope above T_{sc} + 4.6m**~~	~~Side shell/upper deck plating~~	See *2.1.5.1*
	Other ~~**Hull internal**~~ **structure**	Hull internal tank boundaries	See *2.1.5.1*
		Non-tight bulkheads, bulkheads between dry spaces and other plates in general	See *2.1.5.1*
		Pillar bulkheads	7.5
		Breasthooks	6.5
Floors and bottom girders			$5.5 + 0.02L_2$
Web plating of primary support members			$6.5 + 0.015L_2$
Local support members			See *2.1.5.1*
Tripping brackets			See *2.1.5.1*

Where:
~~T_{sc} scantling draught, in m, as defined in *Section 4/1.1.5.5*~~
L_2 rule length, L, in m, as defined in *Section 4/1.1.1.1*, but need not be taken greater than 300m

3.4 Deck Structure

3.4.1 Deck plating

3.4.1.2 ~~In addition to the requirements of *3.4.1.1*, the net plating thickness of decks, t_{net}, is not to be less than:~~

~~$t_{net} = 0.009s$ mm~~

~~Where:~~

~~s stiffener spacing, in mm , as defined in *Section 4/2.2*~~

(void)

3.4.3 Deck primary support structure

3.4.3.2 The web depth of primary support members is not to be less than 10% and 7% of the unsupported span in bending in tanks and in dry spaces, respectively, and is not to be less than 2.5 times the depth of the slots if the slots are not closed. Unsupported span in bending is bending span as defined *in Section 4/2.1.4* or in case of a grillage structure , the distance between connections to other primary support members. ~~Web~~

~~plating of primary support members is to have a depth of not less than 10% of the unsupported span in bending.~~

3.5 Tank Bulkheads

3.5.3 Scantlings of tank boundary bulkheads

3.5.3.4 Web plating of primary support members is to have a depth of not less than 14% of the unsupported span in bending, and is not to be less than 2.5 times the depth of the slots if the slots are not closed.

3.6 Watertight Boundaries

3.6.3 Scantlings of watertight boundaries

3.6.3.4 Web plating of primary support members is to have a depth of not less than 10% of the unsupported span in bending, and is not to be less than 2.5 times the depth of the slots if the slots are not closed.

4 MACHINERY SPACE

4.1 General

4.1.5 Minimum thickness

Table 8.4.1
Minimum Net Thickness of Structure in the Machinery Space

Scantling Location			**Net Thickness (mm)**
Plating	**Shell** **~~Hull envelope up to T_{sc} + 4.6m~~**	Keel plating	See *2.1.5.1*
		Bottom shell/bilge/side shell plating	See *2.1.5.1*
	Upper Deck **~~Hull envelope above T_{sc} + 4.6m~~**	~~Side shell/upper deck plating~~	See *2.1.5.1*
	Other ~~Hull internal~~ structure	Hull internal tank boundaries	See *2.1.5.1*
		Non-tight bulkheads, bulkheads between dry spaces and other plates in general	See *2.1.5.1*
		Lower decks and flats	3.3 + 0.0067s
		Inner bottom	6.5 + 0.02L_2
Bottom centreline girder			See *2.1.6.1*
Floors and bottom longitudinal girders off centreline			5.5 + 0.02L_2
Web plating of primary support members			5.5 + 0.015 L_2
Local support members			See *2.1.5.1*
Tripping brackets			See *2.1.5.1*

Where:
~~T_{sc} scantling draught, in m, as defined in *Section 4/1.1.5.5*~~
L_2 rule length, L, as defined in *Section 4/1.1.1.1*, but need not be taken greater than 300m
s stiffener spacing, in mm, as defined in *Section 4/2.2*

4.4 Deck Structure

4.4.2 Deck scantlings

4.4.2.5 The web depth of primary support members is not to be less than 10% and 7% of the unsupported span in bending in tanks and in dry spaces, respectively, and is not to be less than 2.5 times the depth of the slots if the slots are not closed. Unsupported span in bending is bending span as defined in *Section 4/2.1.4* or in case of a grillage structure the distance between connections to other primary support members. ~~Web plating of primary support members is to have a depth of not less than 10% of the unsupported span in bending.~~

4.6 Tank Bulkheads

4.6.3 Scantlings of tank boundary bulkheads

4.6.3.4 Web plating of primary support members is to have a depth of not less than 14% of the unsupported span in bending <u>and not less than 2.5 times the depth of the slots if the slots are not closed.</u>

4.7 Watertight Boundaries

4.7.2 Scantlings of watertight boundaries

4.7.2.4 Web plating of primary support members is to have a depth of not less than 10% of the unsupported span in bending <u>and not less than 2.5 times the depth of the slots if the slots are not closed.</u>

5 AFT END

5.1 General

5.1.4 Minimum thickness

Table 8.5.1
Minimum Net Thickness of Structure Aft of the Aft Peak Bulkhead

Scantling Location			Net Thickness (mm)
Plating	**Shell** ~~**Hull envelope up to** T_{se} **+ 4.6m**~~	Keel plating	See *2.1.5.1*
		Bottom shell/bilge/side shell plating	See *2.1.5.1*
	Upper Deck ~~**Hull envelope above** T_{se} **+ 4.6m**~~	~~Side shell/upper deck plating~~	See *2.1.5.1*
	Other ~~**Hull internal**~~ **structure**	Hull internal tank boundaries	See *2.1.5.1*
		Non-tight bulkheads, bulkheads between dry spaces and other plates in general	See *2.1.5.1*
		Pillar bulkheads	7.5
Bottom girders and aft peak floors			5.5 + 0.02L_2
Web plating of primary support members			6.5 + 0.015L_2
Local support members			See *2.1.5.1*
Tripping brackets			See *2.1.5.1*

Where:

~~T_{se} scantling draught, in m, as defined in *Section 4/1.1.5.5*~~

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

5.4 Deck Structure

5.4.1 Deck Plating

5.4.1.2 ~~In addition to the requirements of *5.4.1.1*, the net plating thickness of decks, t_{net}, is not to be less than:~~

~~$t_{net} = 0.009s$ mm~~

~~Where:~~

~~s stiffener spacing, in mm, as defined in *Section 4/2.2*~~

(void)

5.4.3 Deck primary support members

5.4.3.2 The web depth of primary support members is not to be less than 10% and 7% of the unsupported span in bending in tanks and in dry spaces, respectively, and is not to be less than 2.5 times the depth of the slots if the slots are not closed. Unsupported span in bending is bending span as defined in *Section 4/2.1.4* or in case of a grillage structure the distance between connections to other primary support members. ~~Web plating of primary support members is to have a depth of not less than 10% of the unsupported span in bending.~~

5.5 Tank Bulkheads

5.5.3 Scantlings of tank boundary bulkheads

5.5.3.4 Web plating of primary support members is to have a depth of not less than 14% of the unsupported span in bending and not less than 2.5 times the depth of the slots if the slots are not closed.

5.6 Watertight Boundaries

5.6.3 Scantlings of watertight boundaries

5.6.3.4 Web plating of primary support members is to have a depth of not less than 10% of the unsupported span in bending and not less than 2.5 times the depth of the slots if the slots are not closed.

Section 9 – Design Verification

2 STRENGTH ASSESSMENT (FEM)

2.2 Cargo Tank Structural Strength Analysis

Table 9.2.2
Maximum Permissible Utilisation Factor Against Buckling

Structural component	**Buckling utilisation factor**
Plate and stiffened panels [3]	$\eta \le 1.0$ (load combination S + D) $\eta \le 0.8$ (load combination S)
Web plate in way of openings	$\eta \le 1.0$ (load combination S + D) $\eta \le 0.8$ (load combination S)
Pillar buckling of cross tie structure	$\eta \le$ ~~0.50~~ 0.75(load combination S + D) $\eta \le$ ~~0.40~~ 0.65(load combination S)
Corrugated bulkheads - flange buckling - column buckling	$\eta \le 0.9$ (load combination S + D) $\eta \le 0.72$ (load combination S)

Where:

η utilisation factor against buckling calculated in accordance with *Appendix D/5* and *Appendix B/2.7.3*. Also see *Section 10/3.4.1* for web plate in way of openings and *Section 10/3.5.1* for cross tie structure

Note

1. Buckling capability of curved panels (e.g. bilge plate), face plate and tripping bracket of primary supporting members are not assessed based on finite element stress result
2. Where a lower stool is not fitted to a transverse or longitudinal corrugated bulkhead, the maximum permissible buckling utilisation factors are to be reduced by 10% in accordance with *2.2.5.5*
3. Permissible buckling utilisation factors specified in this table are applicable for the reference advanced buckling method given in *Appendix D/1.1.2*. If alternative buckling procedures are used the permissible utilisation factors are to be assessed and if required adjusted to meet acceptance criteria for equivalence specified in *Appendix D/1.1.2*.

Section 10 – Buckling and Ultimate Strength

3 PRESCRIPTIVE BUCKLING REQUIREMENTS

3.3 Buckling of Stiffeners

3.3.3 Torsional buckling mode

3.3.3.1 The torsional buckling mode is to be verified against the allowable buckling utilisation factor, η_{allow}, see *3.1.1.2*. The buckling utilisation factor for torsional buckling of stiffeners is to be taken as:

$$\eta = \frac{\sigma_x}{C_T\,\sigma_{yd}}$$

Where:

σ_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*

C_T torsional buckling coefficient

$= 1.0$ for $\lambda_T \le 0.2$

$= \dfrac{1}{\Phi + \sqrt{\Phi^2 - \lambda_T^2}}$ for $\lambda_T > 0.2$

$\Phi = 0.5(1 + 0.21(\lambda_T - 0.2) + \lambda_T^2)$

λ_T reference degree of slenderness for torsional buckling

$= \sqrt{\dfrac{\sigma_{yd}}{\sigma_{ET}}}$

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

$= \dfrac{E}{I_{p-net}}\left(\dfrac{\varepsilon\pi^2 I_{\omega-net}10^{-4}}{l_t^2} + 0.385 I_{T-net}\right)$

~~for I_{P-net}, I_{T-net}, $I_{\omega-net}$ see *Figure 10.3.1* and *Table 10.3.2*~~

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

E modulus of elasticity, 206 000 N/mm²

I_{P-net} net polar moment of inertia of the stiffener about point C, in cm⁴, as shown in *Figure 10.3.1* and T*able 10.3.2*~~, in cm⁴~~

I_{T-net} net St. Venant's moment of inertia of the stiffener, in cm⁴, as shown in *Table 10.3.2*

$I_{\omega-net}$ net sectorial moment of inertia of the stiffener about point C, in cm⁶, as shown in *Figure 10.3.1* and Table 10.3.2~~, in cm⁶~~

ε degree of fixation

$$= \frac{1 + 100}{\sqrt{\frac{l_t^4}{I_{\omega-net}\left(\frac{s}{t_{net}^3} + \frac{4(e_f - 0.5t_{f-net})}{3t_{w-net}^3}\right)}}}$$

$$= \frac{1 + 1000}{\sqrt{\frac{l_t^4}{\frac{3}{4}\pi^4 I_{\omega-net}\left(\frac{s}{t_{net}^3} + \frac{4(e_f - 0.5t_{f-net})}{3t_{w-net}^3}\right)}}}$$

l_t torsional buckling length to be taken equal the distance between tripping supports, in m

d_w depth of web plate, in mm

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

b_f flange breadth, in mm

t_{f-net} net flange thickness, in mm

e_f distance from connection to plate (C in *Figure 10.3.1*) to centre of flange, in mm

$= (d_w - 0.5t_{f-net})$ for bulb flats

$= (d_w + 0.5t_{f-net})$ for angles and T bars

A_{w-net} net web area, in mm²

$= (e_f - 0.5t_{f-net})t_{w-net}$

A_{f-net} net flange area, in mm²

$= b_f\, t_{f-net}$

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

3.5 Other Structures

3.5.1 Struts, pillars and cross ties

3.5.1.3 The elastic compressive column buckling stress, σ_E, of pillars subject to axial compression is to be taken as:

$$\sigma_E = 0.001 E f_{end} \frac{I_{net50}}{A_{pill-net50}\, l_{pill}^{\;2}} \quad \text{N/mm}^2$$

Where:

I_{net50} net moment of inertia about the weakest axis of the cross-section, in cm⁴

$A_{pill\text{-}net50}$ net cross-sectional area of the pillar, in cm²

f_{end} end constraint factor:

1.0 where both ends are pinned

2.0 where one end is pinned and the other end is fixed

4.0 where both ends are fixed

A pillar end may be considered fixed when effective brackets are fitted. These brackets are to be supported by structural members with greater bending stiffness than the pillar.

Column buckling capacity for cross tie shall be calculated using f_{end} equal to 2.0 and span as defined in *8/2.6.8.1*

E modulus of elasticity, 206 000, in N/mm²

l_{pill} unsupported length of the pillar, in m

3.5.1.4 The elastic torsional buckling stress, σ_{ET}, with respect to axial compression of pillars is to be taken as:

$$\sigma_{ET} = \frac{GI_{sv-net50}}{I_{pol-net50}} + \frac{0.001 f_{end} E c_{warp}}{I_{pol-net50} l_{pill}^2} \quad \text{N/mm}^2$$

Where:

G shear modulus

$$= \frac{E}{2(1+\upsilon)}$$

E modulus of elasticity, 206 000, in N/mm²

v Poisson's ratio, 0.3

$I_{sv-net50}$ net St. Venants moment of inertia, in cm⁴, see *Table 10.3.4*

$I_{pol-net50}$ net polar moment of inertia about the shear centre of cross section, in cm⁴

$$= I_{y-net50} + I_{z-net50} + A_{net50}\left(y_0^2 + z_0^2\right)$$

f_{end} end constraint factor:

1.0 where both ends are pinned

2.0 where one end is pinned and the other end is fixed

4.0 where both ends are fixed

Elastic torsional buckling capacity for cross tie shall be calculated using f_{end} equal to 2.0 and span as defined in *8/2.6.8.1*

c_{warp} warping constant, in cm⁶, see *Table 10.3.4*

l_{pill} unsupported length of the pillar, in m

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

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

A_{net50} net cross-sectional area, in cm²

$I_{y-net50}$ net moment of inertia about y-axis, in cm⁴

$I_{z-net50}$ net moment of inertia about z-axis, in cm⁴

Appendix C – Fatigue Strength Assessment

1 NOMINAL STRESS APPROACH

1.4 Fatigue Damage Calculation

1.4.5 Selection of S-N curves

1.4.5.14 The benefits of weld toe grinding should not be taken into consideration at the design stage. However, an exception may be made for the weld connection between the hopper plate and inner bottom if the calculated fatigue life is greater than one half of the design fatigue life or minimum 17 years excluding the grinding effects, whichever is greater. ~~the required design fatigue life can not be satisfied by means of practical design options such as increasing local thickness, extending weld leg length and modifying local geometry. The calculated fatigue life is to be greater than 17 years excluding grinding effects.~~ Where grinding is applied, full details of the grinding standard including the extent, smoothness particulars, final weld profile, and grinding workmanship and quality acceptance criteria are to be clearly shown on the applicable drawings and submitted for review together with supporting calculations indicating the proposed factor on the calculated fatigue life. Grinding is preferably to be carried out by rotary burr and to extend below the plate surface in order to remove toe defects and the ground area is to have effective corrosion protection. The treatment is to produce a smooth concave profile at the weld toe with the depth of the depression penetrating into the plate surface to at least 0.5mm below the bottom of any visible undercut. The depth of groove produced is to be kept to a minimum, and, in general, kept to a maximum of 1mm. In no circumstances is the grinding depth to exceed 2mm or 7% of the plate gross thickness, whichever is smaller. Grinding has to extend to areas well outside the highest stress region. Provided these recommendations are followed, an improvement in fatigue life up ~~to a maximum of 2 times may~~ to the design fatigue life will be granted.

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Common Structural Rules for Double Hull Oil Tankers, July 2008

Technical Background for Rule Change Notice No.1 January 2009 (Amended, Nov 2009*)

** Technical Background text relating to changes to para 8/5.3.1.1 deleted in accordance with IACS Council's decision that these changes should be removed from RCN 1 and not be implemented.*

Section 4/3.2.5 Sniped ends

1. Reason for the Rule Change:
Section 4/3.2.5.1
The rule change corrects a unit error in the formula and an error in the coefficient c_1 in AC2.

2. Background
The coefficient c_1=1.20 for AC1 is based on DNV Rules coefficient of 1.25 adjusted for the net scantling approach in CSR Tank. The ratio between the values c_1 values for AC2 and AC1 has by mistake been set to 1.20 which is the typical ratio between permissible stresses for AC2 and AC1. The coefficient c_1 apply directly to the thickness requirement and 1.20 in plate thickness corresponds to a permissible stress ratio (AC2 vs. AC1) of 1.44 which is too high. Hence the c_1 for AC2 should be increased to 1.1 which results in stress ratio 1.10^2=1.21 between AC2 and AC1.

3. Impact in Scantlings
The correction may cause increased plate thickness for plates with sniped stiffeners. However the formula is rarely determining scantlings for oil tankers and should not have significant consequences.

Section 4/3.4.3 Connection between primary support members and intersecting stiffeners (local support members)

1. Reason for the Rule Change:
Section 4/3.4.3
The connection area criteria is developed and tested considering AC1 and AC2. The prescriptive distribution between web and top stiffeners are not found justified when applied on impact pressure and acceptance criteria AC3 as stiffeners are evaluated using plastic criteria.

2. Background
A new paragraph 3.4.3.5 bis1 is introduced so that the criteria consider the total plastic capacity of end connection in case of impact load. This is consistent with application of plastic criteria for stiffeners in connection with impact loads.

3. Impact in Scantlings
The correction will in areas with bottom slamming or bow impact load provide a correction to an unintended increase of top stiffeners size in previous version of CSR Tank.

Connection area calculated for typical bottom longitudinal connections, gross scantlings							
		Product carrier (MS)			Suezmax (HT)		
		Pre CSR 1)	CSR	RC3	Pre CSR 1)	CSR	RC3
Top stiffener	Area[cm^2]	20	64	60	46	53	46
	size [mm]	150x13.5	250x25.5	250x24	250x18.5	250x21	250x18.5
Shear Connection	Area[cm^2]	104	118	104	182	182	182
	t [mm]	13.5	17.0	13.5	16.5	16.5	16.5
1) Pre CSR is highest value calculated according to DNV and LR Rules.							

Section 8/Table 8.2.1 Minimum Net Thickness for Plating and Local Support Members, in the Cargo Tank Region

1. Reason for the Rule Change:

Section 8/Table 8.2.1

The changes are made to correct for an unintended reduction of shell plate thickness outside of cargo area in CSR tank compared to individual class society rules. The correction to minimum thickness criteria for shell plate applies for the full length of vessel however this criterion is not ruling within the cargo area. The formulas are at the same time simplified as described below.

1. The current minimum thickness requirements for keel, bottom shell and side shell plates are revised as follows:
   a. Increase the minimum thickness requirements for keel, bottom shell and side shell for up to Tsc+4.6m by 1.0mm.
   b. Increase the minimum thickness requirement for side shell above Tsc+4.6m to the same as the requirements for "up to Tsc+4.6m", i.e. there will be only one minimum thickness requirement for side shell.
   c. Consequently, the current wording "hull envelop above Tsc+4.6m" is changed to "Upper deck" to cover only upper deck and to exclude the upper part of side shell.

2. Since the minimum thickness tables for outside cargo tank region (i.e. Tables 8.3.1, 8.4.1 and 8.5.1 for fore end, engine room and aft end, respectively) also refer to the minimum thickness table for cargo tank region (Table 8.2.1), the same changes are also made to the tables for outside cargo tank region.

2. Background

The minimum thickness requirements of CSR are derived from the existing class rules (ABS, LR and DNV) with the following considerations:

- Some existing class rules have corrections for higher strength materials. However, such higher tensile steel correction factors were not introduced in CSR since CSR minimum thickness requirements are not stress based requirements, but are absolute minimum thickness requirements for general robustness, corrosion and durability. Instead, CSR minimum thickness requirements were generally calibrated with the requirements for higher tensile steels since many existing vessels with higher tensile steels were built for compliance with such requirements.
- Some existing class rules have correction for stiffener spacing. However, such correction was not introduced in CSR for the same reasons as mention above.
- Adjustment was made for the difference of the existing gross scantling and CSR's net scantlings.

Comparison of the minimum thickness requirements has been made between CSR for tankers, the existing class rules and CSR for Bulk Carriers. This comparison has been made only for side shell plating since side shell is the most critical part for compliance with the minimum thickness requirements considering that:

- CSR minimum thicknesses for side shell and bottom shell are the same.

- For bottom shell, since the local pressure based requirements are significantly large in combination with the hull girder stress, the minimum thickness does not govern at all.
- For keel plate, CSR requires 2mm addition to the bottom shell.
- For side shell, the local pressure based requirements are not large at the upper part.

The following tables indicate the results of the comparison in gross required thicknesses since the CSR Tankers/Bulk Carriers and the existing class requirements have different criteria in terms of "Net vs. Gross" thickness. Also, even in CSR, corrosion addition is different depending on the compartment/atmospheric condition. Therefore, the comparison has been made for the two locations, i.e. in way of engine room (dry space, CSR t_{corr}=2mm) and in way of upper part of water ballast tank (CSR t_{corr}=3.5mm) as follows:

Comparison of Minimum Gross Thickness for Side Shell in way of Engine Room (Dry space)

Criteria		Ship Length (m)			
Abbreviation	Description	150	200	250	300
CSR/T-	CSR for Tanker (current) $= 3.5+0.03L+t_{corr}$	10.0	11.5	13.0	14.5
CSR-T-Rev	**CSR for Tanker Proposed Revision** $= 4.5+0.03L+t_{corr}$	**11.0**	**12.5**	**14.0**	**15.5**
CSR-B	CSR for Bulk Carrier $= 0.85L$^0.5$+t_{corr}$	12.4	14.0	15.4	16.7
DNV	DNV up to 4.6 m above Tsc (3-1-7/C102)=5.0+0.04L/(f_1)^0.5+t_k	11.0	13.0	15.0	17.0
LR	LR shell at ends (3-3/Table 3.2.1) =(6.5+0.033L)*(k_s/S_{std})^0.5	11.7	13.1	14.8	16.4
ABS	ABS shell at ends (3-2-2/5.1), t_{ms}=0.035(L+29)+0.009s	13.5	15.2	17.0	18.7

Note:
1. Existing class Rules are calculated for MS and s=800mm (where s is used)
2. The reduced thickness 4.6m above Tsca is not applicable to reference vessels checked and is not included in the table.

3. Impact in Scantlings

In most areas of the shell, the required thicknesses are determined by the requirements other than the minimum thickness, e.g. local pressure, quay requirements, longitudinal strength, hull girder ultimate strength etc. Therefore, in general, the increased minimum thickness requirements will have no impact on the lower part of the shell plating, but may have slight impact for upper part of the shell for limited location.

				Product	Aframax	Suezmax	VLCC2	VLCC1
			L=	173	231	259	312	316
Aft Peak	as built	tgross	mm	13.5	14.5	17.0	19.0	19.5
	CSR	tcorr	mm	2.5	2.5	3.5	3.0	2.5
	CSR RC3	**tgross**	**mm**	12.2	13.9	15.8	16.5	16.0
	Increase from CSR Apr.2006			1.0	1.0	1.0	1.0	1.0
	Increase from as built pre-CSR			-1.3	-0.6	-1.2	-2.5	-3.5
Eng Rm	as built	tgross	mm	13.0	14.5	16.0	19.5	18.0
	CSR	tcorr	mm	2.5	2.5	2.5	2.5	2.5
	CSR RC3	**tgross**	**mm**	**12.2**	**13.9**	**14.8**	**16.0**	**16.0**
	Increase from CSR Apr.2006			1.0	1.0	1.0	1.0	1.0
	Increase from as built pre-CSR			-0.8	-0.6	-1.2	-3.5	-2.0
Cargo Area	as built	tgross	mm	13.0	15.0	15.5	17.5	18.0
	CSR	tcorr	mm	3.5	3.5	3.5	3.5	3.5
	CSR RC3	**tgross**	**mm**	**13.2**	**14.9**	**15.8**	**17.0**	**17.0**
	Increase from CSR Apr.2006			1.0	1.0	1.0	1.0	1.0
	Increase from as built pre-CSR			0.2	-0.1	0.3	-0.5	-1.0

Section 8/2.5.7 Vertically corrugated bulkhead

1. Reason for the Rule Change:
Section 8/2.5.7.9
The requirement to thickness of inner bottom plate equal to thickness of corrugated bulkhead cause extreme thickness increase of inner bottom plate compare to existing design.

2. Background
The requirement to inner bottom plate thickness equal to thickness of the corrugation was introduced with CSR and is not known from individual class society rules. The requirement was introduced for consistency with similar top plate requirement for lower stool as copied from UR S18 for corrugated bulkhead on bulk carrier.
However for practical application occasionally more than 100% increase of inner bottom plate has been experienced compared to existing design without finding a technical justification. UR S18 or CSR bulk has no requirement to thickness of inner bottom plate under corrugation and the requirement is deleted.

3. Impact in Scantlings
Local increases of inner bottom plates under corrugated bulkhead, typically between 50% and 150%, as consequence of previous CSR will not apply.

Section 8/2.6.8 Cross Ties

Section 8/2.6.8.1
See background of Section 10/3.5

Section 8/Table 8.3.1 Minimum Net Thickness of Structure Forward of the Forward Cargo Tank

Section 8/Table 8.3.1
See background of Section 8/Table 8.2.1

Section 8/3.4.1 Deck plating

1. Reason for the Rule Change:
Section 8/3.4.1.2
The requirement in Section 8/3.4.1.2 is a slenderness (spacing/thickness) ratio based requirement similar to the general slenderness ratio requirement given in Section 10/2. Having compared this requirement with Section 10/2, it is found that the requirement of Section 8/3.4.1.2 is not governing at all, i.e.:

Maximum slenderness ratio in accordance with Section 8/3.4.1.2:
t=0.009s
Therefore, s/t=1/0.009=111

Maximum slenderness ratio in accordance with Section 10/2.2.1.1:

For mild steel:	s/t= 100*(235/235)^0.5=100	<111
For HT32:	s/t= 100*(235/315)^0.5=86	<111
For HT36:	s/t= 100*(235/355)^0.5=81	<111

As shown above, the slenderness ratio requirements in Section 10/2 are more stringent than 8/3.4.1.2 for all the materials. Since the requirements in Section 10/2 are anyway to be complied with, the requirement of 8/3.4.1.2 is redundant, and therefore, proposed to be deleted.

2. Impact in Scantlings
Owing to the above reasons, there is no impact for this change.

Section 8/3.4.3 Deck Primary Support Structure

1. Reason for the Rule Change:
Section 8/3.4.3.2
The requirements to minimum height of deck transverse 2.5xdepth of slot should apply in general.

2. Background
The requirement should generally apply but had fallen out in previous versions. The stiffness requirement for primary support member is updated in line with proven designs.

3. Impact in Scantlings
Some known designs are checked and found to comply with this requirement without modifications.

Section 8/3.5.3 Scantlings of tank boundary bulkheads

Section 8/3.5.3.4
See background of Section 8/3.4.3.2

Section 8/3.6.3 Scantlings of watertight boundaries

Section 8/3.6.3.4
See background of Section 8/3.4.3.2

Section 8/Table 8.4.1 Minimum Net Thickness of Structure in the Machinery Space

Section 8/Table 8.4.1
See background of Section 8/Table 8.2.1

Section 8/4.4.2 Deck Scantlings

Section 8/4.4.2.5
See background of Section 8/3.4.3.2

Section 8/4.6.3 Scantling of boundary bulkheads

Section 8/4.4.3.4
See background Section 8/3.4.3.2

Section 8/4.7.2 Scantling of watertight boundaries

Section 8/4.7.2.4
See background of Section 8/3.4.3.2

Section 8/Table 8.5.1 Minimum Net Thickness of Structure Aft of the Aft Peak Bulkhead

Section 8/Table 8.5.1
See background of Section 8/Table 8.2.1

Section 8/5.4.1 Deck Plating

Section 8/5.4.1.2
See background of Section 8/3.4.1.2

Section 8/5.4.3 Deck primary support members

Section 8/5.4.3.2
See background of Section 8/3.4.3.2

Section 8/5.5.3 Scantling of tank boundary bulkheads

Section 8/5.5.3.4
See background of Section 8/3.4.3.2

Section 8/5.6.3 Scantlings of watertight boundaries

Section 8/5.6.3.4
See background of Section 8/3.4.3.2

Section 9/Table 9.2.2 Maximum Permissible Utilisation Factor Against Buckling

Section 9/Table 9.2.2
See background of Section 10/3.5

Section 10/3.3.3 Torsional buckling mode

1. Reason for the Rule Change:
Section 10/3.3.3.1
The formula is updated to include factor $3/4\pi^4$ as found in CSR bulk.

2. Background
The factor is a correction for net scantling used in CSR Bulk however which by mistake has fallen out when the harmonized buckling formula was included in CSR Tank.

3. Impact in Scantlings
Evaluation of impact on scantlings is not considered necessary.

Section 10/3.5.1 Struts, pillars and cross tie

1. Reason for the Rule Change:
Section 10/3.5.1.3 and 3.5.1.4
CSR introduced, in addition to column buckling, a torsional buckling control for capacity check of pillars and cross tie. This formula has not been considered in previous consequence studies and extreme scantling increases are experienced when used in combination current safety factors for cross tie buckling. Investigations have therefore been carried out to verify the formula and also to provide a standard for end constraint factors and effective span to be

used for cross tie analysis. This rule change comes as a consequence of this investigation and should be seen in relation with changes proposed in 8/2.6.8.1 and in Table 9.2.2.

2. Background

Buckling control of cross ties have prior to implementation of CSR been limited to check of column buckling mode, and buckling of local strength members. Conservative utilisation factors have compensated for known uncertainties in the buckling capacity formulas.

The buckling control in CSR also includes torsional buckling of pillars and cross ties. For the cross tie this buckling mode is generally found most critical, and with current utilisation factors for buckling, CSR indicate a stress level in cross ties for existing VLCC design far above allowable.

In order to verify the new formula non linear finite element analysis has been carried out. A typical cross tie design was modelled with two different lengths (Fig.1). The longest beam has same length as the effective span for cross tie on a reference vessel. The buckling capacity was calculated using prescriptive formula 10/3.5.1.4 and then compared with result from non linear FE analysis. The comparison carried out with fixed and hinged ends gave consistent results and it is concluded that the formula provide realistic buckling capacity.

It has been suggested to assume fixed ends in case the cross tie web is connected to PMA platforms at the longitudinal bulkhead. A new non linear FE analysis was carried out using a model as shown in (Fig.2) and including adjacent structure to an extent found necessary to determine the end constraint of the cross ties. Pressure loads were gradually applied at bulkhead plates in each end of the model until axial compression in the cross tie caused failure.

In the first analysis the PMA platform tripped in way of end brackets of the cross tie and provided a weak point (Fig.2). Then the model was upgraded with a tripping bracket on the PMA platform close to cross tie toe (Fig.3) and capacity increased about 10%.

Both analyses confirm torsional buckling is the critical failure mode. Further for this failure end constraint fixed (f_{end}=4) is found not realistic. The rules are therefore upgraded to require f_{end} to be taken 2 which is almost hinged.

With the corrections proposed in 10/3.5.1.4 and with upgrading of allowable utilisation factors in 8/2.6.8.1 and in Table 9.2.2, the buckling capacity calculations for cross tie provide accurate results and ensure cross tie witch are more robust than for existing tankers.

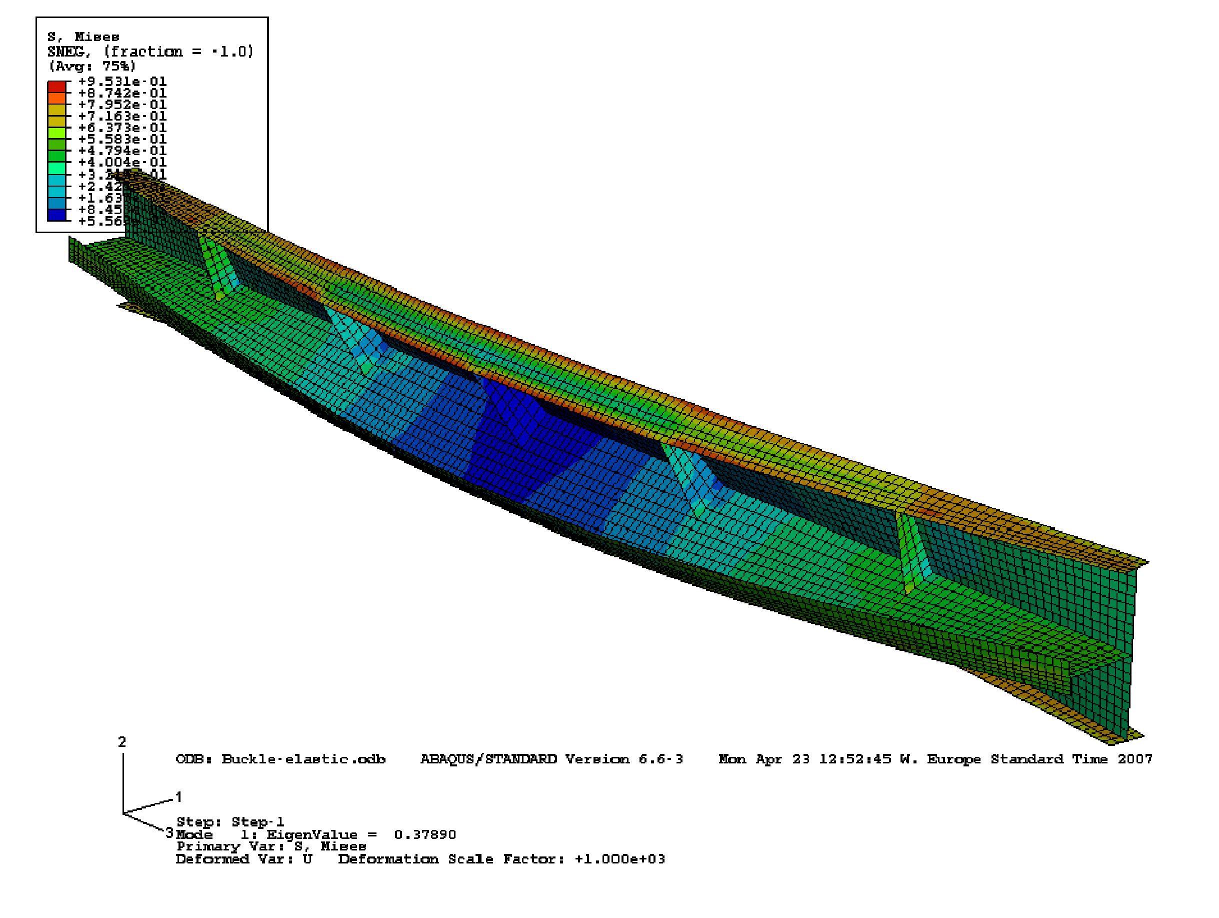

Fig 1 Reference beam

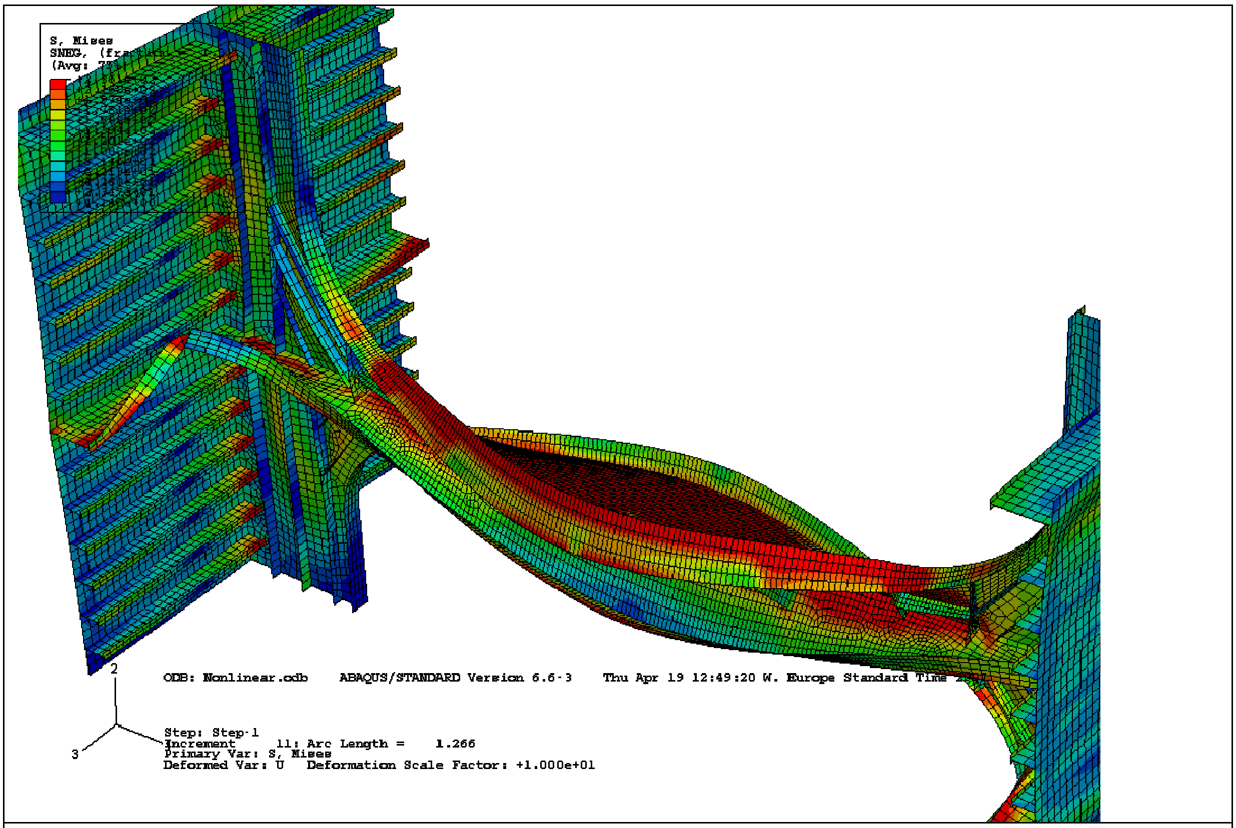

Fig 2 Cross tie

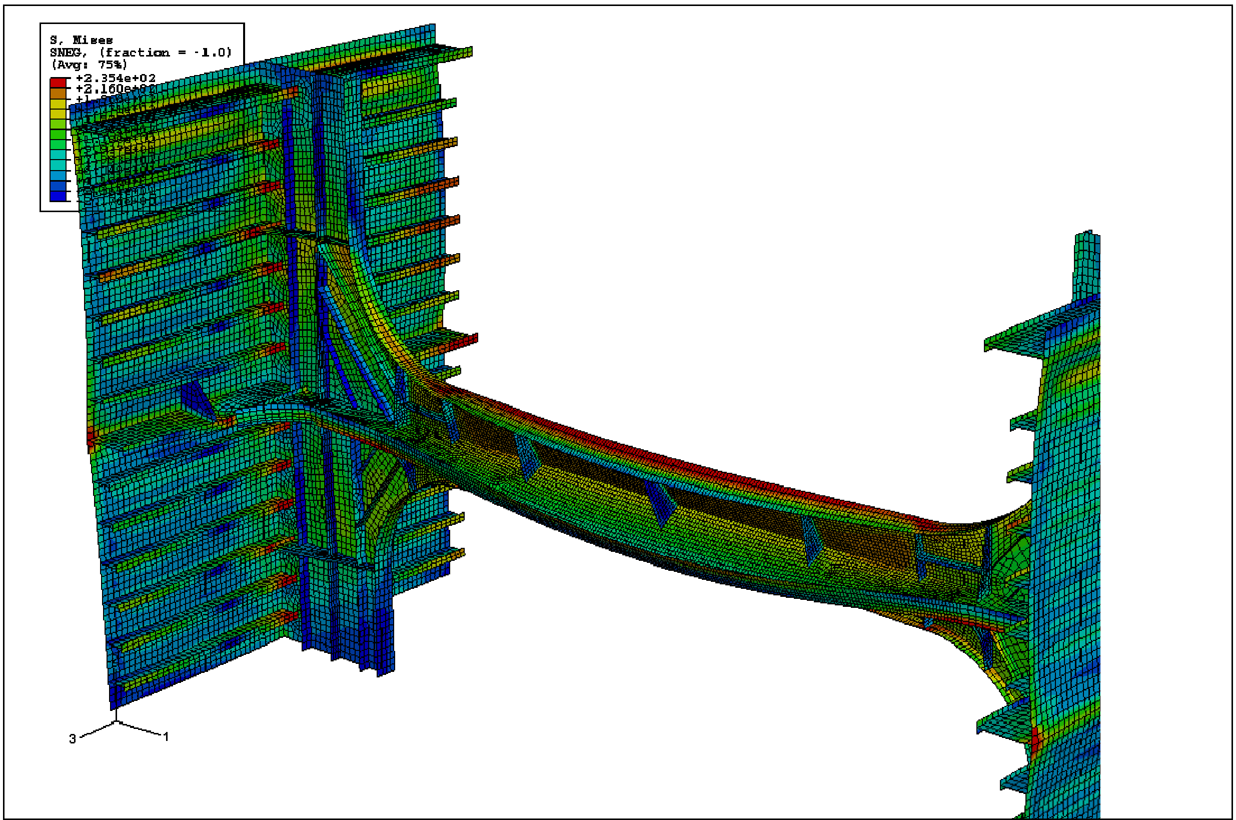

Fig 3 Cross tie with tripping bracket at PMA platform

Summary of Results :
Comparison torsional buckling formula in CSR and non linear analysis

Model	f_{end}	CSR Tank 10/3.5.1.4 El.buckling	CSR Tank 10/3.5.1.4 Critical Stress	Non-linear Analysis El.buckling	Non-linear Analysis Critical Stress
Full model(Fig.2)	2	149	142	151	142
Full model with tripping brackets (Fig.3)	2			171	150
Reference model, short 15m	1	152	144	147	131
	4	520	208	469	216
Reference model, long 20m (Fig.1) same as span for cross tie in Fig.2	1	89	89	89	-
	2	149	142	-	-
	4	271	184	252	188

3. Impact in Scantlings

The consequence study confirms the rule change will ensure cross tie which are equally strong or stronger than what is typically required by individual Class Societies Rules. The comparison only shows results for the static condition AC1. The reason is that the total load on cross tie in AC1 is not significantly different from AC2 and AC1 will therefore always determine the scantlings. The allowable utilisation factors for AC2 are however adjusted to 0.75 to maintain a consistent relation between AC1 and AC2.

		5 reference VLCC's				
		1	2	3	4	5
AC1	**Actual stress – equal to or less than allowable according to individual class society rules before CSR**	**139**	**129**	**113**	**107**	**118**
CSR April 2006	**Utilsation factor**	**0.4**	**0.4**	**0.4**	**0.4**	**0.4**
	f_{end}= 4 (fixed support)					
	Allowable column buckling	93	92	91	92	93
	Allowable torsion buckling	84	78	72	80	77
	$\sigma_{act} / \sigma_{allowApr2006}$	166 %	166 %	158 %	134 %	152 %
RC3	**Utilsation factor**	**0.65**	**0.65**	**0.65**	**0.65**	**0.65**
	f_{end}= 2					
	Allowable column buckling	149	147	142	148	149
	Allowable torsion buckling	121	105	85	110	103
	$\sigma_{act} / \sigma_{allowRC3}$	114 %	123 %	133 %	97 %	115 %
	$\sigma_{allowApr2006} / \sigma_{allowRC3}$	69 %	74 %	85 %	72 %	75 %

Appendix C/1.4.5 Selection of S-N Curves

1. Reason for the Rule Change:
Appendix C/1.4.5.14
The rules are modified to improve the clarity.

2. Impact in Scantlings
No significant impact on scantlings is expected.

***** End *****