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.

Note: When the word '(void)' appears in the text, it means that the concerned part has been deleted. This is to keep the numbering of the remainder unchanged.

SECTION 2 – RULE PRINCIPLES

2 GENERAL ASSUMPTIONS

2.1 General

2.1.2 Classification Societies

Table 2.2.1
IACS Unified Requirements Applicable to Oil Tankers

Number	Title
A1	*Equipment*
A2	*Shipboard fittings and supporting hull structures associated with towing and mooring on conventional vessels*
S1	*Requirements for Loading Conditions, Loading Manuals and Loading Instruments*
S2	*Definitions of ship's length L and block coefficient C_b*
S3	*Strength of end bulkheads of superstructures and deckhouses*
S4	*Criteria for use of high tensile steel with yield points of 315 N/mm² and 355N/mm² (with respect to longitudinal strength)*
S5	*Calculation of midship section moduli for conventional ship for ship's scantlings*
S6	*Use of steel grades for various hull members – ships of 90m in length and above*
S7	*Minimum longitudinal strength Standards*
S11	*Longitudinal strength Standard*
S13	*Strength of bottom forward in oil tankers*
S14	*Testing procedures of Watertight Compartments*
S26	*Strength and securing of Small Hatches on the Exposed Fore Deck*
S27	*Strength Requirements for Fore Deck Fittings and Arrangements*

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 ~~p~~Partial safety ~~f~~Factor

(PF) method is applied. The partial safety factor format is applied for this highly critical failure mode to better account for uncertainties related to static loads, dynamic loads and capacity formulations.

Reason for the Change:
Editorial

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

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, Ψ ~~φ~~, 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~~s_{epp}, 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

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

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:

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

Where:

∇ moulded displacement volume at the scantling draught, in m^3

L rule length, as defined in *1.1.1.1*

B_{WL} moulded breadth measured amidships, in m, at the scantling draught waterline

T_{sc} scantling draught, as defined in *1.1.5.5*

Reason for the Change:

Editorial

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

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

Where:

∇_{LC} moulded displacement volume at the T_{LC}, in m^3

L rule length, as defined in *1.1.1.1*

B_{WL} moulded breadth measured amidships, in m, at the T_{LC}

T_{LC} draught at amidships, in m, in the loading condition being considered.

Reason for the Change:

Missing definition of $C_{b\text{-}LC}$ added. (Refer to KC ID143)

1.8 Glossary

1.8.1 Definitions of terms

Table 4.1.1 (Continued)
Definitions of Terms

Terms	Definition
Deep tank	any tank which extends between two decks or the shell/inner bottom and the deck above or higher
Discharges	Any piping leading through the ship's sides for conveying bilge water, circulating water, drains etc.
Docking bracket	A bracket located in the double bottom to locally strengthen the bottom structure for the purposes of docking
Double bottom structure	The shell plating with stiffeners below the top of the inner bottom and other elements below and including the inner bottom plating
Doubler	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
Double skin member	Double skin member is defined as a structural member where the idealized beam comprises webs, with top and bottom flanges formed by attached plating
Duct keel	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
Enclosed superstructure	The superstructure with bulkheads forward and/or aft fitted with weather tight doors and closing appliances
Engine room bulkhead	A transverse bulkhead either directly forward or aft of the engine room
Face plate	The section of a stiffening member attached to the plate via a web and is usually parallel to the plated surface
Flange	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
Flat bar	A stiffener comprising only of a web
Floor	A bottom transverse member
Forecastle	A short superstructure situated at the bow
Fore peak	The area of the ship forward of the collision bulkhead
Fore peak deck	A short raised deck extending aft from the bow of the ship
Freeboard deck	Generally the uppermost complete deck exposed to weather and sea, which has permanent means of closing all exposed openings
Freeing port	An opening in the bulwarks to allow water shipped on deck to run freely overboard
Gangway	The raised walkway between superstructure, such as between the forecastle and bridge, or between the bridge and poop

Girder	A collective term for primary supporting structural members
Gudgeon	A block with a hole in the centre to receive the pintle of a rudder; located on the stern post, it supports and allows the rudder to swing
Gunwale	The upper edge of the ship's sides
Gusset	A ~~triangular~~ plate, usually fitted to distribute forces at a strength connection between two structural members
Hatch ways	Openings, generally rectangular, in a ship's deck affording access into the compartment below
Hawse pipe	Steel pipe through which the hawser or cable of anchor passes, located in the ship's bow on either side of the stem, also known as spurling pipe
Hawser	Large steel wire or fibre rope used for towing or mooring
Hopper plating	Plating running the length of a compartment sloping between the inner bottom ~~tank top~~ and vertical portion of inner hull longitudinal bulkhead ~~side shell~~
HP	Holland Profile

Reason for the Change:

Editorial

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:

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

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~~beams~~

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

d_w depth of stiffener web, in mm:

= h_{stf} - $t_{f\text{-net}}$~~grs~~ for T, L (rolled and built up) and L2 profiles

= h_{stf} for flat bar and L3 profiles

to be taken as given in *Table 4.2.3* and *Table 4.2.4* for bulb profiles

h_{stf} stiffener height, in mm, see *Figure 4.2.12*

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

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

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

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

A_{f-net} net cross-sectional area of flange, in mm^2:

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

= 0 for flat bar stiffeners

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

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

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

$= 0$ for T profiles

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

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

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

$= h_{stf} - d_{edge} - 0.5\ t_{f-netgrs}$ for L3 profiles

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

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

f_b = 1.0 in general

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

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

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

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

= 0 for flat bar stiffeners

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

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

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

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, $A_{shr-net50}$ (formerly $A_{w-net50}$), is to be taken as:

$$A_{shr-net50} = 0.01\, h_n\, t_{w-net50} \quad \text{cm}^2$$

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*

$t_{w-net50}$ net web thickness

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

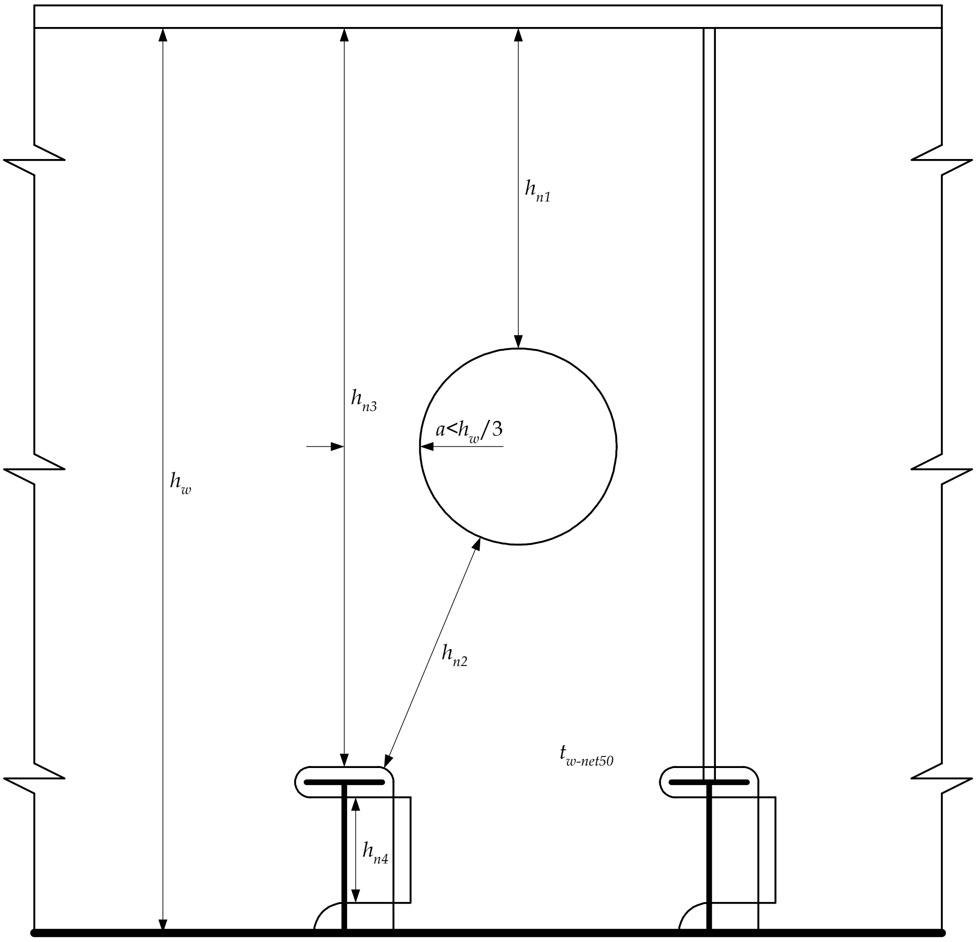
t_{w-grs} gross web thickness, in mm

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

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 shearweb area, $A_{shrw\text{-}net50}$, is to be taken as:

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

Where:

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

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

b_f breadth of flange or face plate, in mm

$t_{f\text{-}net50}$ net flange thickness

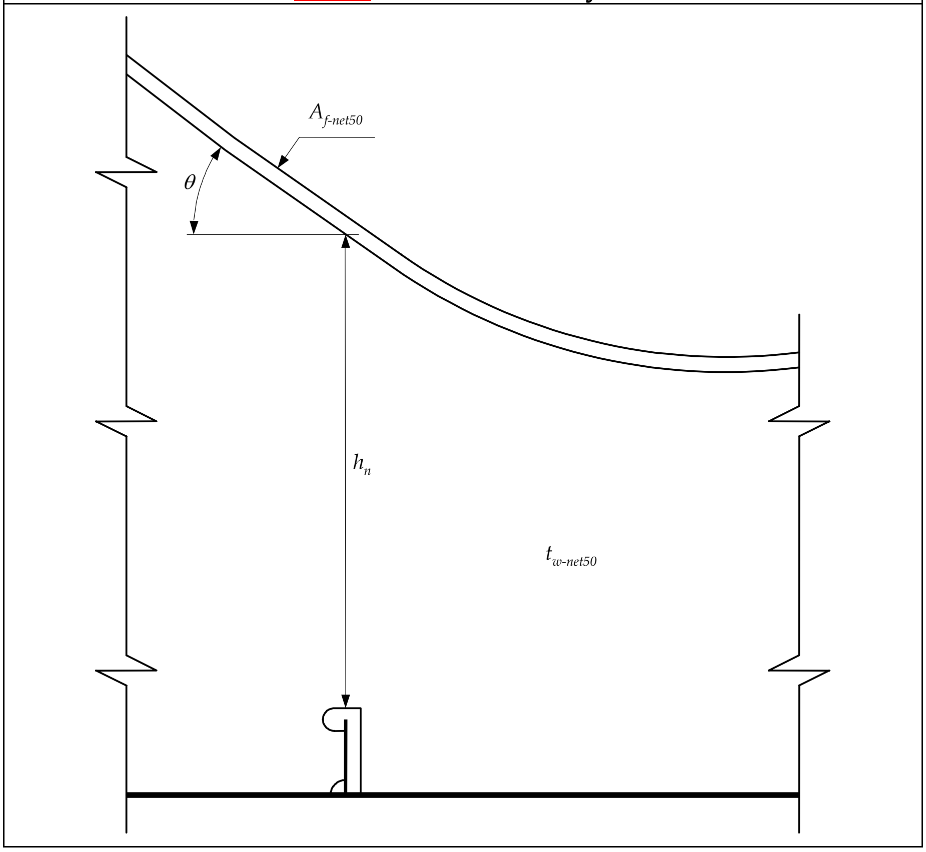
$= t_{f\text{-}grs} - 0.5 t_{corr}$ mm

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

t_{corr}	corrosion addition, as given in *Section 6/3.2*, in mm
θ	angle of slope of continuous flange, see *Figure 4.2.17*
$t_{w\text{-}net50}$	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
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, $t_{cg\text{-}net50}$, is only applicable for the calculation of the effective area, $A_{eff\text{-}net50}$, and shear force distribution factor, f_i, as defined in *Section 8/1.3.2.2.*

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

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 toesradius 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_1, transmitted through the shear connection is to be taken as follows.:

If the web stiffener is connected to the intersecting stiffener:

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

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

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

Where:

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

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

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

S primary support member spacing, in m

s stiffener spacing, in mm

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

$$A_{1d-net} + A_{1c-net} \quad \text{cm}^2$$

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

$$A_{1-net} = 2 l_d t_{w-net} 10^{-2} \quad \text{cm}^2$$

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

$$A_{1-net} = 2 f_1 l_c t_{c-net} 10^{-2} \quad \text{cm}^2$$

A_{1d-net} net shear connection area excluding lug or collar plate, as given by the following and *Figure 4.3.5*:

$$A_{1d-net} = l_d t_{w-net} 10^{-2} \quad \text{cm}^2$$

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*:

$$A_{1c-net} = f_1 l_c t_{c-net} 10^{-2} \quad \text{cm}^2$$

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 for stiffeners of symmetrical cross section

= $140/w$ 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*

$A_{w\text{-}net}$ 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, $A_{w\text{-}net}$, is to be measured at the throat of the connection, as shown in *Figure 4.3.6*.

f_c the collar load factor defined as follows:

for intersecting stiffeners of symmetrical cross section:

$= 1.85$ for $A_{w\text{-}net} \le 14$

$= 1.85 - 0.0441(A_{w\text{-}net} - 14)$ for $14 < A_{w\text{-}net} \le 31$

$= 1.1 - 0.013(A_{w\text{-}net} - 31)$ for $31 < A_{w\text{-}net} \le 58$

$= 0.75$ for $A_{w\text{-}net} > 58$

for intersecting stiffeners of asymmetrical cross section:

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

where:

$l_s = l_c$ for a single lug or collar plate connection to the primary support member

$= l_d$ for a single sided direct connection to the primary support member

$=$ 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:

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

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

$W_2 = 0$

Where:

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

α_a panel aspect ratio

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

S primary support member spacing, in m

s stiffener spacing, in mm

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

Reason for the Change:
Clarification (KC ID 166)

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~~ addition, i.e. -1.0t_{corr}, 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_{slot}, of 75mm and in general, a minimum width, w_{slot}, of twice the side plating gross thickness. The ends of the slots are to be rounded. The space between the slots, s_{slot}, is not to be greater than 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*. (void)

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_{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:

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

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

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

Where:

f_1 = 0.30 for double continuous welding

= 0.38 for intermittent welding

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

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

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

σ_{weld} minimum yield stress of the weld deposit, and is not to be less than:

305N/mm² for welding of normal strength steel

375N/mm² for welding of higher strength steels with yield strength of 265 to 355N/mm²

400 N/mm² for welding of higher strength steel with yield strength of 390N/mm²

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

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

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

f_2 correction factor for the type of weld:

1.0 for double continuous fillet

$\frac{s_{ctr}}{l_{weld}}$ for intermittent or chain welding

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

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

t_{gap} allowance for weld gap (lesser gaps may be permitted, see *5.9.2*):

=2.0mm for $t_{p\text{-}grs} > 6.5$mm

$= 2\left(1.25 - \frac{1}{f_2}\right)$ mm for $t_{p\text{-}grs} \le 6.5$mm

Reason for the Change:

Editorial

5.7.3 Welding of primary support members

Table 6.5.4
Connection of Primary Support Members

Primary Support Member gross face area, in cm²		Position (1)	Weld factor, f_{weld}			
			In tanks		In dry spaces	
Greater than	Not greater than		To face plate	To plating	To face plate	To plating
	30.0	At ends	0.20	0.26	0.20	0.20
		Remainder	0.12	0.20	0.12	0.15
30.0	65.0	At ends	0.20	0.38	0.20	0.20
		Remainder	0.12	0.26	0.12	0.15
65.0	95.0	At ends	0.42	0.59 (3)	0.20	0.30
		Remainder	0.30 (2)	0.42	0.15	0.20
95.0	130.0	At ends	0.42	0.59 (3)	0.30	0.42
		Remainder	0.30 (2)	0.42	0.20	0.30
130.0		At ends	0.59	0.59 (3)	0.42	0.59 (3)
		Remainder	0.42	0.42	0.30	0.42

Note

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

Reason for the Change:

Editorial

5.7.5 Welding at the ends of stiffeners

Table 6.5.5
Stiffener End Connection Welds

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

Where:

$A_{stf\text{-}grs}$ gross cross sectional area of the stiffener, in cm²

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

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

Where:

z_{air} vertical distance from top of air pipe or overflow pipe to the load point, whichever is the lesser, see *Figure 7.2.3*, in m

$= z_{tk} + h_{air}$

ρ_{sw} density of sea water, 1.025tonnes/m³

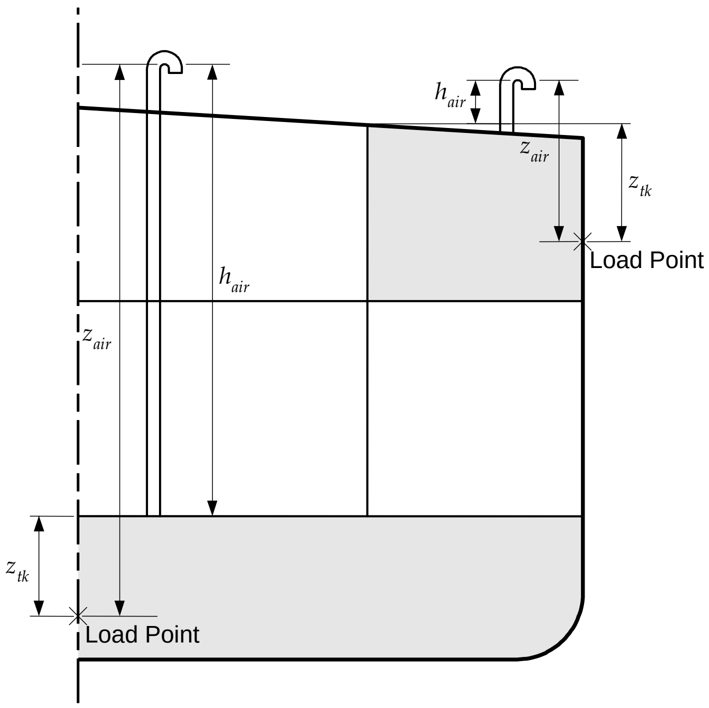
g acceleration due to gravity, 9.81m/s²

h_{air} height of air pipe or overflow pipe, in m, is not to be taken less than 0.76m 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 0.76m above deck at side unless a lesser height is approved by the flag Administration ~~the tanks are arranged with overflow tank or equivalent~~. See also *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 ztk ,and zair.)

3.1 General

3.1.3 Metacentric height and roll radius of gyration

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

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

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

Where:

B moulded breadth, in m, as defined in *Section 4/1.1.3.1*

T_{LC} draught in the loading condition being considered, in m

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

T_{bal} minimum design ballast draught, in m, as defined in *Section 4/1.1.5.2*

$T_{bal\text{-}n}$ normal ballast draught, in m, as defined in *Section 4/1.1.5.3*

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_{prob} is to be taken as 0.45

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

Where:

$C_{b\text{-}LC}$ 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_{lng}, at any position, is to be taken as:

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

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

m/s²

Where:

a_{surge} longitudinal acceleration due to surge, is to be taken as:
$= 0.2 g a_0$ m/s²

$a_{pitch-x}$ longitudinal acceleration due to pitch, is to be taken as:
$= f_V \varphi (2\pi / U_{pitch})^2 R_{pitch}$ m/s²

φ pitch angle, in rads, as defined in *3.2.3.2*

U_{pitch} pitch period, in secs, as defined in *3.2.3.1*

R_{pitch} pitch radius and is to be taken as the greater of $z - \left(\frac{D}{4} + \frac{T_{LC}}{2}\right)$ or $z - \left(\frac{D}{2}\right)$, in m

g acceleration due to gravity, 9.81m/s²

a_0 common acceleration parameter, as defined in *3.3.2.1*

T_{LC} draught in the loading condition being considered, in m

D moulded depth, in m, as defined in *Section 4/1.1.4.1*

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

z vertical coordinate, in m

f_{prob} as defined in *3.3.5.2* and *3.3.5.3* as appropriate

f_V as defined in *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 ≥ 0.01*L* ~~0.02*L*~~ and ≤ 0.045*L*.

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:

$$P_{im} = 1.025 f_{im} c_{im} V_{im}^2 \sin \gamma_{wl} \quad \text{kN/m}^2$$

Where:

f_{im} 0.55 at 0.1L aft of F.P.

0.9 at 0.0125L aft of F.P.

1.0 at and forward of F.P.

intermediate values to be obtained by linear interpolation

V_{im} impact speed, in m/s

$= 0.514 V_{fwd} \sin \alpha_{wl} + \sqrt{L}$

V_{fwd} forward speed, in knots

= 0.75V but is not to be taken as less than 10

V service speed, in knots, as defined in *Section 4/1.1.8.1*

α_{wl} local waterline angle at the position considered, but is not to be taken as less than 35 degrees, see *Figure 7.4.6*.

γ_{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}

$= \sqrt{1 + \cos^2 [90 \frac{(h_{fb} - 2h_o)}{h_{fb}}]}$ for positions above draught T_{sc}

h_{fb} vertical distance from the waterline at draught T_{sc} to the highest deck at side, see *Figure 7.4.6*, in m

h_o vertical distance from the waterline at draught T_{sc}, to the position considered, see *Figure 7.4.6*, in m

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

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

T_{bal} minimum design ballast draught, in m, for the normal ballast condition as defined in *Section 4/1.1.5.2*

WL_j waterline at the position considered, see *Figure 7.4.6*

Guidance Note

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

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

Where

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

Reason for the Change:

1. γ_{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, $Q_{sw\text{-}perm\text{-}sea}$ and $Q_{sw\text{-}perm\text{-}harb}$ are to satisfy:

$$Q_{sw-perm} \le Q_{v-net50} - Q_{wv-pos} \quad \text{kN}$$

for maximum permissible positive shear force

$$Q_{sw-perm} \ge -Q_{v-net50} - Q_{wv-neg} \quad \text{kN}$$

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

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

$$= \frac{\tau_{ij-perm} t_{ij-net50}}{1000 q_v} \quad \text{kN}$$

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

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

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

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

t_{net50} net thickness of plate, in mm

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

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

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

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

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

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

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

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.*

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

$I_{v\text{-}net50}$ 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_z 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 8.2.2
Minimum Net Thickness for Primary Support Members in Cargo Tank Region

Scantling Location	Net Thickness (mm)
Double bottom centreline girder	$5.5+0.025L_2$
Other double bottom girders	$5.5+0.02L_2$
Double bottom floors, web plates of side transverses and stringers in double hull	$5.0+0.015L_2$
Web and flanges of vertical web frames on longitudinal bulkheads, horizontal stringers on transverse bulkhead, ~~and~~ deck transverses (above and below upper deck) and cross ties.	$5.5+0.015L_2$

Where:

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

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:

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

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

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

r_0 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 ~~thicknesses are different~~, then the thicker net plating thickness, t_{m-net}, is to be taken as the greatest value calculated for all applicable design load sets, as given in *Table 8.2.7*, and given by:

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

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

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

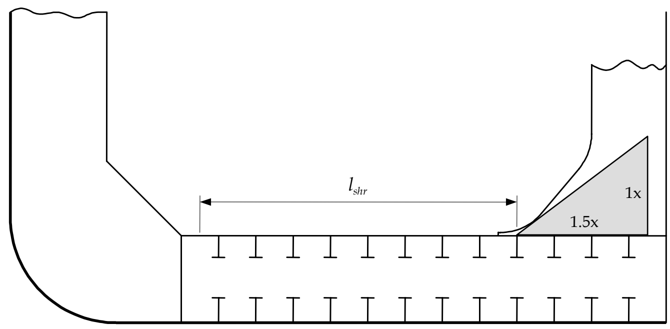
Reason for the Change:

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)

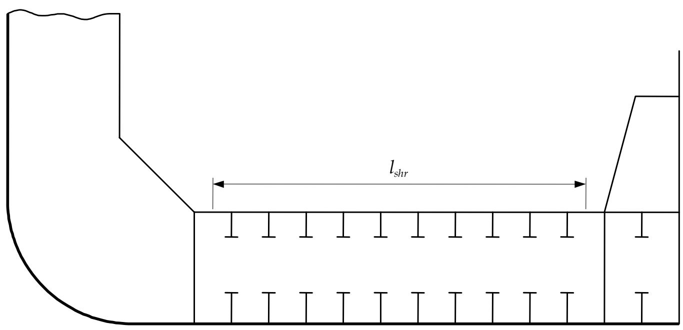
2.6 Primary Support Members

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

<u>*Reason for the Change:*</u>
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.

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

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

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:

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

but is not to be taken as less than M_o

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

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

but is not to be taken as less than M_o

M_{st} bending moment transferred from the side transverse

$$= c_{st}\,\beta_{st}\,P_{in-st}\,S\,l_{bdg-st}^{\,2} \quad \text{kNm}$$

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 $l_{bdg-st-ct}$.

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

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

where $l_{bdg-vw-ct}$ is greater than $0.7 l_{bdg-vw}$, then l_{bdg-vw} in the above formula may be taken as $l_{bdg-vw-ct}$.

for vertically corrugated bulkheads, M_{vw} is to be taken equal to bending moment in upper end of corrugation over the spacing between deck transverses

M_0 minimum bending moment

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

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

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

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

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

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

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

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

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

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

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

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

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

$l_{bdg\text{-}st}$	effective bending span of the side transverse, in m, between the deck transverse and the bilge hopper, see *Section 4/2.1.4* and *Figure 8.2.7*
$l_{bdg\text{-}st\text{-}ct}$	effective bending span of the side transverse, in m, between the deck transverse and the mid depth of the cross tie, where fitted in wing cargo tank, see *Section 4/2.1.4*
$l_{bdg\text{-}vw}$	effective bending span of the vertical web frame on the longitudinal bulkhead, in m, between the deck transverse and the bottom structure, see *Section 4/2.1.4* and *Figure 8.2.7*.
$l_{bdg\text{-}vw\text{-}ct}$	effective bending span of the vertical web frame on longitudinal bulkhead, in m, between the deck transverse and the mid depth of the cross tie, see *Section 4/2.1.4*
I_{dt}	net moment of inertia of the deck transverse with an effective breadth of attached plating specified in *Section 4/2.3.2.3*, in cm^4
I_{st}	net moment of inertia of the side transverse with an effective breadth of attached plating specified in *Section 4/2.3.2.3*, in cm^4
I_{vw}	net moment of inertia of the longitudinal bulkhead vertical web frame with an effective breadth of attached plating specified in *Section 4/2.3.2.3*, in cm^4
c_{st}	as defined in *Table 8.2.12*
c_{vw}	as defined in *Table 8.2.12*
$C_{s\text{-}pr}$	permissible bending stress coefficient for primary support member as given in *Table 8.2.10*
σ_{yd}	specified minimum yield stress of the material, in N/mm^2

<u>*Reason for the Change:*</u>

Clarification (KC ID 151)

Editorial (φ changed to φ_t to distinguish from φ used for pitch angle)

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

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

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

Where:

Q_{in}	design shear force due to cargo pressure $= 0.65\,P_{in-dt}\,S\,l_{shr} + c_1\,D\,b_{ctr}\,S\,\rho\,g$ kN
Q_{ex}	design shear force due to green sea pressure $= 0.65\,P_{ex-dt}\,S\,l_{shr}$ kN
$P_{in\text{-}dt}$	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_{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

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

l_{shr} effective shear span, of the deck transverse, in m, see *Section 4/2.1.5*

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

ρ 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-pr} permissible shear stress coefficient for primary support member as given in *Table 8.2.10*

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

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

(b) $0.20\ l_{bdg-hs}$ for horizontal stringers in centre tanks of ships with two longitudinal bulkheads, but the web depth of horizontal stringers in centre tank is not to be less than required depth for a horizontal stringer in wing cargo tanks

(c) $0.20\ l_{bdg-hs}$ for horizontal stringers of ships with a centreline longitudinal bulkhead

(d) see also *2.6.1.7*.

Where:

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

$= c\,P\,S\,l_{bdg-hs}^{\;2}$ kNm

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

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

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

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

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:

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

Where:

Q design shear force

$= 0.5\,P\,S\,l_{shr}$ kN

P design pressure for the design load set being considered, calculated at mid point of effective bending span, l_{bdg-hs}, and at mid point of the spacing, S, of the horizontal stringer, in kN/m²

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

l_{shr} effective shear span of the horizontal stringer, in m, see *Section 4/2.1.5*

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

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

σ_{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_{bal}, ~~waterline~~ at the stem and the scantling draught, T_{sc}, the plate stem net thickness, $t_{stem-net}$, is not to be less than:

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

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

σ_{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, $A_{shr\cancel{w}-net50}$, is to be taken as the greatest value for all applicable design load sets, as given in *Table 8.3.8*, and given by:

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

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/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*, in m

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

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

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

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

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

$= P\, b_{a-\sup}\, l_{a-\sup} + W_{pill-upr}$ kN

$W_{pill-perm}$ permissible load on a pillar

$= 0.1 A_{pill-net50}\, \eta_{pill}\, \sigma_{crb}$ ~~$= 10 A_{pill-net50}\, \eta_{pill}\, \sigma_{crb}$~~ 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/m^2

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 cm^2

η_{pill} utilisation factor for the design load set being considered:

= 0.5 for acceptance criteria set AC1

= 0.6 for acceptance criteria set AC2

σ_{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/mm^2

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

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

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

Where:

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

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

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

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

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

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

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

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

Reason for the Change:

Clarification

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

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

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

Where:

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

<table>
<tr><th>Acceptance Criteria Set</th><th colspan="2">Structural Member</th><th>β_s</th><th>α_s</th><th>C_{s-max}</th></tr>
<tr><td rowspan="3">AC1</td><td rowspan="2">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>Longitudinal stiffeners</td><td>0.85</td><td>1.0</td><td>0.75</td></tr>
<tr><td>Transverse or vertical stiffeners</td><td>0.7</td><td>0</td><td>0.7</td></tr>
<tr><td colspan="2">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>
</table>

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

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

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

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

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

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

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

Reason for the Change:
Clarification

6.3 Bottom Slamming

6.3.7 Primary support members

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

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

Where:

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

C_t permissible shear stress coefficient

= 0.9 for acceptance criteria set AC3

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

σ_{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-net}, of primary support members adjacent to the shell is not to be less than:

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

Where:

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

σ_{yd} specified minimum yield stress of the material, in N/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 isare, in general to be fittedapplied.

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}~~$_{w}$~~$_{-net50}$, is to be taken as the greatest value for all applicable design load sets given in *Table 8.7.2*, and given by:

$$A_{shr-net50} = \frac{10 f_{shr} |P| S l_{shr}}{C_t \tau_{yd}}$$ ~~$A_{w-net50} = \frac{10 f_{shr} |P| S l_{shr}}{C_t \tau_{yd}}$~~ cm², for lateral pressure loads

$$A_{shr-net50} = \frac{10 f_{shr} |F|}{C_t \tau_{yd}}$$ ~~$A_{w-net50} = \frac{10 f_{shr} |F|}{C_t \tau_{yd}}$~~ cm², for point loads

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

cm², 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_t permissible shear stress coefficient for the design load set being considered as given in *Tables 8.2.10* or *8.3.7*, as applicable for the individual member being considered

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

σ_{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

Reason for the Change:

Editorial

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, σ_{xcr}, σ_{ycr} or τ_{cr}, of plate panels subject to compression or shear, respectively, is to be taken as:

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

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

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

Where:

C_x, C_y, C_τ 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

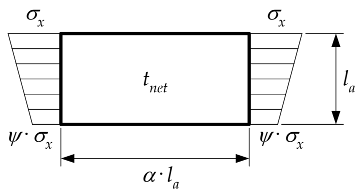
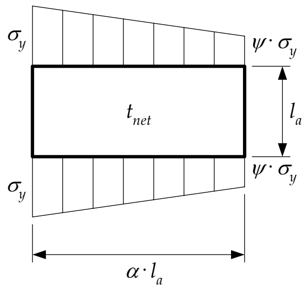
Case	Stress ratio ψ	Aspect ratio α	Buckling factor K	Reduction factor C
1 	$1 \geq \psi \geq 0$	$\alpha > 1$	$K = \dfrac{8.4}{\psi + 1.1}$	$C_x = 1$ for $\lambda \leq \lambda_c$ $C_x = c\left(\dfrac{1}{\lambda} - \dfrac{0.22}{\lambda^2}\right)$ for $\lambda > \lambda_c$ Where: $c = (1.25 - 0.12\psi) \leq 1.25$ $\lambda_c = \dfrac{c}{2}\left(1 + \sqrt{1 - \dfrac{0.88}{c}}\right)$
	$0 > \psi > -1$		$K = 7.63 - \psi(6.26 - 10\psi)$	
	$\psi \leq -1$		$K = 5.975(1-\psi)^2$	
2 	$1 \geq \psi \geq 0$	$\alpha \geq 1$	$K = \left(1 + \dfrac{1}{\alpha^2}\right)^2 \dfrac{2.1}{(\psi + 1.1)}$	$C_y = c\left(\dfrac{1}{\lambda} - \dfrac{R + F^2(H - R)}{\lambda^2}\right)$ Where: $c = (1.25 - 0.12\psi) \leq 1.25$ $R = \lambda(1 - \lambda / c)$ for $\lambda < \lambda_c$ $R = 0.22$ for $\lambda \geq \lambda_c$ $\lambda_c = 0.5\,c\left(1 + \sqrt{1 - 0.88/c}\right)$ $F = \left(1 - \left(\dfrac{K}{0.91} - 1\right) / \lambda_p^2\right) c_1 \geq 0$ $\lambda_p^2 = \lambda^2 - 0.5$ and $1 \leq \lambda_p^2 \leq 3$ $c_1 = 1$ for σ_y due to direct loads (3) $c_1 = (1 - 1/a) \geq 0$ for σ_y due to bending (in general) (2) $c_1 = 0$ for σ_y due to bending in extreme load cases (e.g. w/t. bhds.) $H = \lambda - \dfrac{2\lambda}{c(T + \sqrt{T^2 - 4})} \geq R$ $T = \lambda + \dfrac{14}{15\lambda} + \dfrac{1}{3}$
	$0 > \psi > -1$	$1 \leq \alpha \leq 1.5$	$K = \left[1 + \dfrac{1}{\alpha^2}\right]^2 \dfrac{2.1(1+\psi)}{1.1} - \dfrac{\psi}{\alpha^2}(13.9 - 10\psi)$	
		$\alpha > 1.5$	$K = \left[1 + \dfrac{1}{\alpha^2}\right]^2 \dfrac{2.1(1+\psi)}{1.1} - \dfrac{\psi}{\alpha^2}(5.87 + 1.87\alpha^2 + \dfrac{8.6}{\alpha^2} - 10\psi)$	
	$\psi \leq -1$	$1 \leq \alpha \leq \dfrac{3(1-\psi)}{4}$	$K = \left(\dfrac{1-\psi}{\alpha}\right)^2 5.975$	
		$\alpha > \dfrac{3(1-\psi)}{4}$	$K = \left(\dfrac{1-\psi}{\alpha}\right)^2 3.9675 + 0.5375\left(\dfrac{1-\psi}{\alpha}\right)^4 + 1.87$	

Table 10.3.1 (Continued)
Buckling Factor and Reduction Factor for Plane Plate Panels

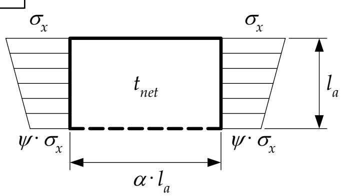
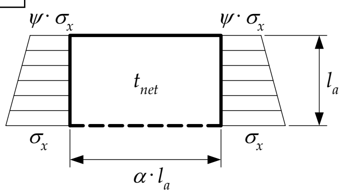
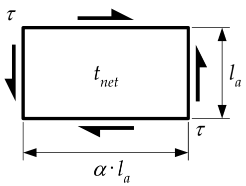
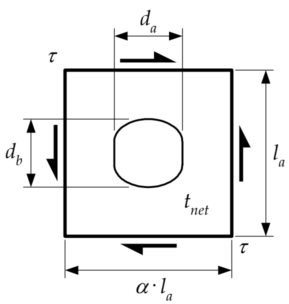
Case	Stress ratio ψ	Aspect ratio α	Buckling factor K	Reduction factor C
3 	$1 \geq \psi \geq 0$	$\alpha > 0$	$K = \frac{4(0.425 + 1/\alpha^2)}{3\psi + 1}$	$C_x = 1$ for $\lambda \leq 0.7$ $C_x = \frac{1}{\lambda^2 + 0.51}$ for $\lambda > 0.7$
	$0 > \psi \geq -1$		$K = 4(0.425 + 1/\alpha^2)(1+\psi)$ $-5\psi(1 - 3.42\psi)$	
4 	$1 \geq \psi \geq -1$	$\alpha > 0$	$K = \left(0.425 + \frac{1}{\alpha^2}\right)\frac{3-\psi}{2}$	
5 	-		$K = K_\tau \sqrt{3}$	$C_\tau = 1$ for $\lambda \leq 0.84$ $C_\tau = \frac{0.84}{\lambda}$ for $\lambda > 0.84$
		$\alpha \geq 1$	$K_\tau = \left[5.34 + \frac{4}{\alpha^2}\right]$	
		$0 < \alpha < 1$	$K_\tau = \left[4 + \frac{5.34}{\alpha^2}\right]$	
6 	-		$K = K' r$ $K' = K$ according to Case 5 r = opening red. factor $r = \left(1 - \frac{d_a}{\alpha l_a}\right)\left(1 - \frac{d_b}{l_a}\right)$ $\frac{d_a}{\alpha l_a} \leq 0.7$ and $\frac{d_b}{l_a} \leq 0.7$	

Table 10.3.1 (Continued) Buckling Factor and Reduction Factor for Plane Plate Panels	
Where:	
ψ	the ratio between smallest and largest compressive stress as shown for Case 1-4
l_a	length in mm, of the shorter side of the plate panel for Cases 1 and 2
l_a	length in mm, of the side of the plate panel as defined for Cases 3, 4, 5 and 6
α	aspect ratio of the plate panel
Edge boundary conditions:	
- - - - - - - - -	plate edge free
————————	plate edge simply supported
Notes	
(1)	Cases listed are general cases. Each stress component (σ_x, σ_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 " ψ " changed to " ψ". All "a" changed to "α". 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, σ_b, in N/mm², in the stiffener is equal to:

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

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

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

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

$$= F_E \left(\frac{P_z w}{c_f - P_z} \right) \qquad \text{where } (c_f - P_z) > 0$$

F_E ideal elastic buckling force of the stiffener, in N

$$= \left(\frac{\pi^2}{l_{stf}^{\,2}} \right) E I_{net} \, 10^{-2}$$

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:

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

t_{net} net thickness of plate flange, to be taken as the mean thickness of the two attached plate panels, in mm

P_z nominal lateral load, in N/mm², acting on the stiffener due to membrane stresses, σ_x, σ_y and τ_1, in the attached plate in way of the stiffener midspan:

$$= \frac{t_{net}}{s}\left(\sigma_{xl}\left(\frac{\pi\, s}{1000\, l_{stf}}\right)^2 + 2\, c_y\, \sigma_y + \sqrt{2}\,\tau_1\right)$$

σ_{xl}

$$= \sigma_x\left(1 + \frac{A_{net}}{s\, t_{net}}\right) \quad \text{N/mm}^2$$

τ_1

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

with m_1 and m_2 taken equal to

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

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

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*

A_{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

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

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

ψ ~~Ψ~~ edge stress ratio for Case 2 according to *Table 10.3.1*

σ_y membrane compressive stress in the attached plating acting perpendicular to the stiffener's axis, in N/m²

τ shear membrane stress in the attached plating, in N/mm²

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

w deformation of stiffener, in mm

$$= w_0 + w_1$$

w_0 assumed imperfection, in mm.

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

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:

$$= \frac{P\, s\, l_{stf}^{\ 4}}{384 \cdot E\, I_{net}} 10^5$$

c_f elastic support provided by the stiffener, in N/mm[2]

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

c_p

$$= \frac{1}{1 + \frac{0.91}{c_a}\left(\frac{12\, I_{net}\, 10^4}{s\, t_{net}^{\ 3}} - 1\right)}$$

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

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

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

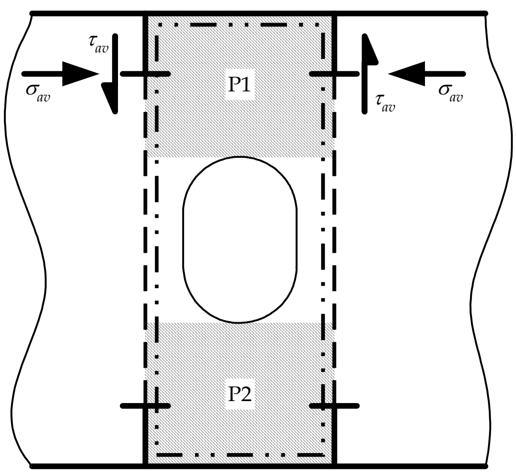
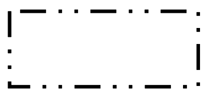
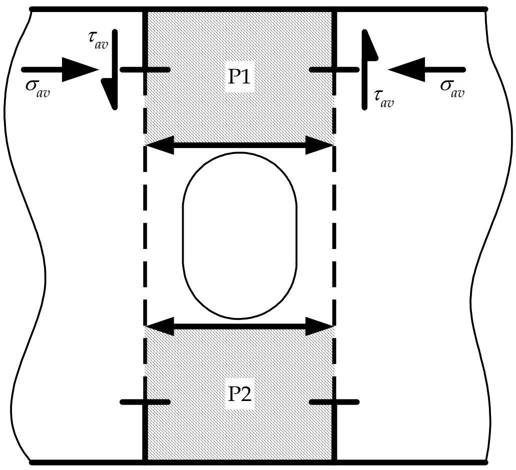
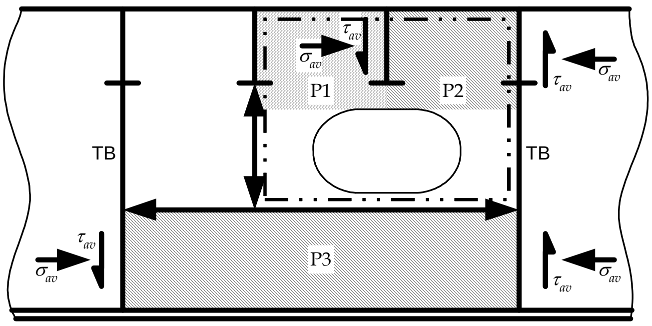
Table 10.3.3 Reduction Factors		
Mode	C_x, C_y	C_τ
(a) without edge reinforcements  	Separate reduction factors are to be applied to areas P1 and P2 using Case 3, *Table 10.3.1*, with edge stress ratio: $\psi = 1.0$ ~~$\psi = 1.0$~~	A common reduction factor is to be applied to areas P1 and P2 using Case 6, *Table 10.3.1* for area marked: 

Table 10.3.3 (Continued) Reduction Factors		
Mode	C_x, C_y	C_τ
(b) with edge reinforcements  	Separate reduction factors are to be applied for areas P1 and P2 using: C_x for Case 1 or C_y, for Case 2, see *Table 10.3.1* with stress ratio $\psi = 1.0$ ~~$\psi = 1.0$~~	Separate reduction factors are to be applied for areas P1 and P2 using Case 5, *Table 10.3.1*
(c) example of hole in web  	Panels P1 and P2 are to be evaluated in accordance with (a). Panel P3 is to be evaluated in accordance with (b)	
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, σ_{ETF}, with respect to axial compression is to be taken as:

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

Where:

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

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

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

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

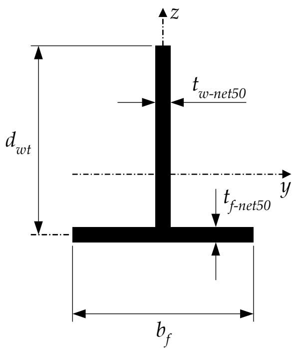
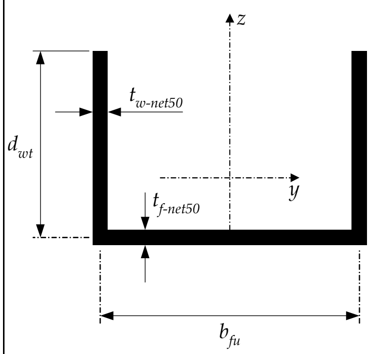
$I_{pol\text{-}net50}$ net polar moment of inertia about the shear centre of cross section, as defined in *3.5.1.4*

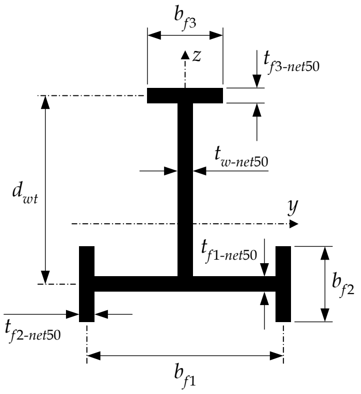
σ_{ET} elastic torsional buckling stress, as defined in *3.5.1.4*

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

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	
single symmetrical sections	
	$I_{sv-net50} = \frac{1}{3}\left(b_f t_{f-net50}^3 + d_{wt} t_{w-net50}^3\right)10^{-4}$ cm⁴
	$y_0 = 0$ cm $z_0 = -\frac{0.5 d_{wt}^2 t_{w-net50}}{d_{wt} t_{w-net50} + b_f t_{f-net50}} 10^{-1}$ cm $c_{warp} = \frac{b_f^3 t_{f-net50}^3 + 4 d_{wt}^3 t_{w-net50}^3}{144} 10^{-6}$ cm⁶
	$I_{sv-net50} = \frac{1}{3}\left(b_{fu} t_{f-net50}^3 + 2 d_{wt} t_{w-net50}^3\right)10^{-4}$ cm⁴
	$y_0 = 0$ cm $z_0 = -\frac{d_{wt}^2\, t_{w-net50} 10^{-1}}{2 d_{wt}\, t_{w-net50} + b_f\, t_{f-net50}} - \frac{0.5\, d_{wt}^2\, t_{w-net50} 10^{-1}}{d_{wt}\, t_{w-net50} + b_{fu}\, t_{f-net50}/6}$ cm $c_{warp} = \frac{b_{fu}^2 d_{wt}^3 t_{w-net50}\left(3 d_{wt} t_{w-net50} + 2 b_{fu} t_{f-net50}\right)}{12\left(6 d_{wt} t_{w-net50} + b_{fu} t_{f-net50}\right)} 10^{-6}$ cm⁶
	$I_{sv-net50} = \frac{1}{3}\left(b_{f1} t_{f1-net50}^3 + 2 b_{f2} t_{f2-net50}^3 + b_{f3} t_{f3-net50}^3 + d_{wt} t_{w-net50}^3\right)10^{-4}$ cm⁴

	$I_{sv-net50} = \frac{1}{3}\left(b_{f1}t_{f1-net50}^3 + 2b_{f2}t_{f2-net50}^3 + b_{f3}t_{f3-net50}^3 + d_{wt}t_{w-net50}^3\right)10^{-4}$ cm⁴
	$y_0 = 0$ cm $z_o = z_s - \frac{(b_{f3}\, d_{wt}\, t_{f3-net50} + 0.5 d_{wt}^2\, t_{w-net50})10^{-1}}{d_{wt}\, t_{w-net50} + b_{f1}\, t_{f1-net50} + 2b_{f2}\, t_{f2-net50} + b_{f3}\, t_{f3-net50}}$ cm ~~$c_{warp} = \left(I_{f1}\, z_o^2 + \frac{I_{f2}\, b_{f1}^2}{2} + I_{f3}\,(d_{wt} - z_o)^2\right)10^{-2}$~~ $c_{warp} = I_{f1} z_s^2 + \frac{I_{f2}\, b_{f1}^2}{200} + I_{f3}\left(\frac{d_{wt}}{10} - z_s\right)^2$ cm⁶ $I_{f1} = \left(\frac{(b_{f1} - t_{f2\text{-net50}})^3\, t_{f1-net50}}{12} + \frac{b_{f2}\, t_{f2-net50}\, b_{f1}^2}{2}\right)10^{-4}$ cm⁴ $I_{f2} = \frac{b_{f2}^3\, t_{f2-net50}}{12}10^{-4}$ cm⁴ $I_{f3} = \frac{b_{f3}^3\, t_{f3-net50}}{12}10^{-4}$ cm⁴ $z_s = \frac{I_{f3}\, d_{wt}}{I_{f1} + I_{f3}}10^{-1}$ cm

Note

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

Reason for the Change:

Editorial and clarification:

1. Correction of unit mismatch
2. z_0 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 ψ = 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_{perm}, is given by:

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

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

f_{s2} steel factor:

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

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

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

Reason for the Change:

Editorial (Unit corrected for $r_{gyr\text{-}grs}$)

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 ~~and~~ 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 ~~s~~Safe ~~w~~Working ~~l~~Load, self weight, vertical reaction forces and the maximum overturning moment in the supporting structure of the lifting appliance

(c) for offshore operation, the maximum sea state in which the lifting appliance is to be used.

Reason for the Change:
Editorial

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 ~~s~~Safe ~~w~~Working ~~l~~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 ~~s~~Safe ~~w~~Working ~~l~~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 ~~s~~Safe ~~w~~Working ~~l~~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.

Direct stress 1.00 σ_{yd}

Shear stress ~~0.58~~0.60 σ_{yd}

Where:

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

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~~ 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

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_U, is to be taken as:

$$M_U = Z_{red}\sigma_{yd} \cdot 10^3 \quad \text{kNm}$$

Where:

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

$$= \frac{I_{red}}{z_{dk-mean} - z_{NA-red}} \quad \text{m}^3$$

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:

$$= \frac{\sigma_U}{\sigma_{yd}} A_{net50} \quad \text{m}^2$$

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

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

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

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

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

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

Reason for the Change:

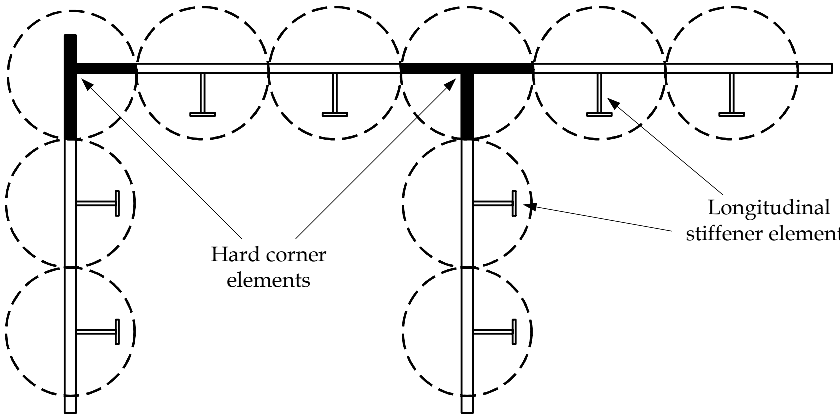
Editorial

2.2 Simplified Method Based on an Incremental-iterative Approach

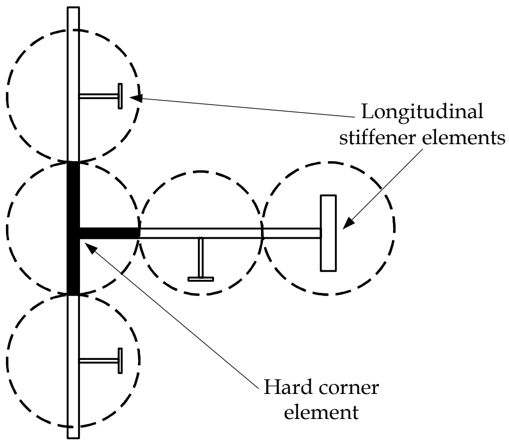
2.2.2 Assumptions and modelling of the hull girder cross-section

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

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

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:

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

Where:

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

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

<u>*Reason for the Change:*</u>

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 support~~ing~~ members are retained. Hence, the adjustment is to be made on stiffeners and plate seams if necessary.

<u>*Reason for the Change:*</u>

Editorial

2.2.1.14 Face plates of primary support~~ing~~ 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.

<u>*Reason for the Change:*</u>

Editorial

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

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

Where:

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

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

$$t_{2\text{-}net50} = \frac{h - h_o}{h \, g_o} t_{w-net50}$$

$t_{w\text{-}net50}$ 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 $0.25h$, 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:

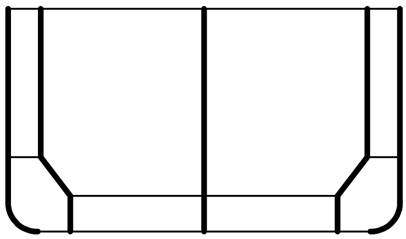
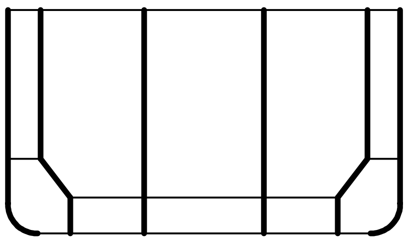
1. The 4th row and 5th row in the table are combined since $t_{2\text{-}net50}$ is always lesser than $t_{1\text{-}net50}$ and $t_{2\text{-}net50}$
2. Editorial

2.5 Procedure to Adjust Hull Girder Shear Forces and Bending Moments

2.5.3 Procedure to adjust vertical shear force distribution

Table B.2.8
Shear Force Distribution Factors

	Side Shell	$f = 0.055 + 0.097 \frac{A_{1-net50}}{A_{2-net50}} + 0.020 \frac{A_{2-net50}}{A_{3-net50}}$
	Inner hull	$f = 0.193 - 0.059 \frac{A_{1-net50}}{A_{2-net50}} + 0.058 \frac{A_{2-net50}}{A_{3-net50}}$

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

Where:

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

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

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

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

Reason for the Change:
Editorial

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.

Reason for the Change:
Editorial

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 Support~~ing~~ 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:

λ_y yield utilisation factor

$$= C_a \left(0.75 \left(\frac{b_2}{b_1} \right)^{0.5} \left| \sigma_{vm} \right| + 0.55 \left(\frac{A_{bar-net50}}{b_1 t_{net50}} \right)^{0.5} \left| \sigma_{bar} \right| \right) \frac{k}{235}$$

$$C_a = 1.0 - 0.2 \left(\frac{R_a}{1400} \right)^2$$

b_1, b_2 height of plate element in way of bracket toe in cargo tank FE model, in mm

$A_{bar-net50}$ sectional area of bar element in cargo tank FE model representing the face plate of bracket, in mm²

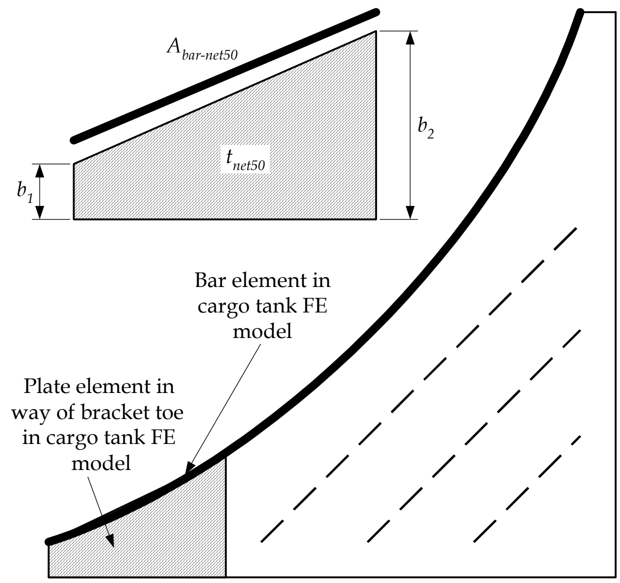
σ_{bar} bar element axial stress determined from cargo tank FE analysis, in N/mm²

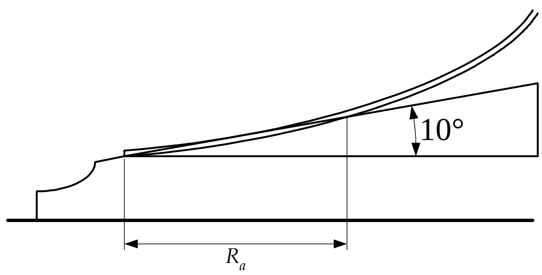
σ_{vm} von Mises stress of plate element in way of bracket toe determined from cargo tank FE analysis, in N/mm²

t_{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 support~~ing~~ 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 support~~ing~~ 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*.

Reason for the Change:

Editorial

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_{full}, see *Section 4/1.1.5.4*

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

Reason for the Change:

Clarification

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:

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

Where:

S stress range, in N/mm²

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

f_1 scale parameter

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

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

S_R stress range with probability of exceedance of $1/N_R$, in N/mm²

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

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

<u>*Reason for the Change:*</u>
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), σ_{2A}, is to be taken as:

$$\sigma_{2A} = K_n K_d \frac{M}{Z_{net50}} 10^6 \quad \text{N/mm}^2$$

Where:

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

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

1.0 at frame connections

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

(a) in full load condition:

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

1.15 for side and bilge longitudinals at lowest side stringer and deck ~~corner~~ at side

to be linearly interpolated between these two positions

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:

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

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

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

Where:

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

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

b_g breadth of flange from web centreline, in mm, see *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

λ factor, as defined in *1.4.4.17*

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

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

Z_{net50} section modulus of stiffener including the full width of the attached plate, s, with respect to a neutral axis normal to the stiffener web, in cm³. It is to be calculated based on the gross thickness minus the corrosion addition $0.5t_{corr}$

Reason for the Change:

Editorial (ψ changed to ψ_z since ψ has been already used for some other definition in Section 10)

1.4.4.19 Total combined stress range, S, is given by:

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

Where:

f_1, f_2, f_3 and f_4 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/mm², as defined in *1.4.4.7*

S_h corresponding stress range due to horizontal bending moment, in N/mm², as defined in *1.4.4.9*

S_e stress range due to external wave or internal tank pressure, in N/mm², as defined in *1.4.4.12*

S_i stress range due to external wave or internal tank pressure, in N/mm², as defined in *1.4.4.12*

Reason for the Change:

Editorial

Table C.1.3
Stress Range Combination Factors for Zone M

	Stiffener location		f_1	f_2	f_3	f_4	f_i
Ballast	~~Outer b~~Bottom shell	a_i	-0.49	0.49	-1.04	-0.13	$a_i (\lvert y \rvert/B) + b_i$
		b_i	0.97	0.17	0.87	0.56	
	~~Outer s~~Side shell and bilge below $D/2$	a_i	-1.48	0.50	-0.64	0.72	$a_i (z/D) + b_i$
		b_i	0.94	0.40	0.72	0.04	
	~~Outer s~~Side shell above $D/2$	a_i	1.70	-1.00	-1.10	-0.60	$a_i (z/D) + b_i$
		b_i	-0.65	1.15	0.95	0.70	

	Inner bottom and Lower stool	a_i	-0.18	0.34	0.00	-0.30	a_i (|y|/B) + b_i
		b_i	0.90	0.22	0.00	0.74	
	Inner hull ~~side shell~~ below $D/2$ (including hopper plate)	a_i	-1.70	-0.90	0.00	1.04	a_i (z/D) + b_i
		b_i	1.15	0.70	0.00	0.45	
	Inner hull ~~side shell~~ above $D/2$	a_i	1.40	0.50	0.00	-1.94	a_i (z/D) + b_i
		b_i	-0.40	0.00	0.00	1.94	
	Deck and Upper stool	a_i	-0.15	1.05	0.00	0.00	a_i (|y|/B) + b_i
		b_i	1.02	-0.27	0.00	0.00	
	Centreline longitudinal bulkhead Below $D/2$	a_i	0.00	0.00	0.00	0.00	a_i (z/D) + b_i
		b_i	1.00	0.00	0.00	0.00	
	Centreline longitudinal bulkhead Above $D/2$	a_i	0.00	0.00	0.00	0.00	a_i (z/D) + b_i
		b_i	1.00	0.00	0.00	0.00	
	Longitudinal bulkhead below $D/2$	a_i	-0.20	1.30	0.00	0.00	a_i (z/D) + b_i
		b_i	1.00	0.10	0.00	0.00	
	Longitudinal bulkhead above $D/2$	a_i	0.20	-1.30	0.00	0.00	a_i (z/D) + b_i
		b_i	0.80	1.40	0.00	0.00	
Loaded	~~Outer b~~Bottom shell	a_i	-0.43	0.78	-0.77	0.00	a_i (|y|/B) + b_i
		b_i	0.98	0.13	0.75	0.00	
	~~Outer s~~Side shell and bilge below $D/2$	a_i	-0.29	-0.47	0.14	0.00	a_i (z/D) + b_i
		b_i	0.19	0.78	0.92	0.00	
	~~Outer s~~Side shell above $D/2$	a_i	1.77	-0.05	-1.20	0.00	a_i (z/D) + b_i
		b_i	-0.84	0.57	1.59	0.00	
	Inner bottom and Lower stool	a_i	-0.71	1.13	0.00	0.55	a_i (|y|/B) + b_i
		b_i	1.03	0.18	0.00	-0.18	
	Inner hull ~~side shell~~ below $D/2$ (including hopper plate)	a_i	-0.80	-1.70	0.00	2.60	a_i (z/D) + b_i
		b_i	0.55	1.20	0.00	-0.35	
	Inner hull ~~side shell~~ above $D/2$	a_i	1.90	0.30	0.00	-1.70	a_i (z/D) + b_i
		b_i	-0.80	0.20	0.00	1.80	
	Deck and Upper stool	a_i	-0.26	1.40	0.00	0.00	a_i (|y|/B) + b_i
		b_i	1.02	-0.16	0.00	0.00	
	Centreline longitudinal bulkhead below $D/2$	a_i	-1.40	0.00	0.00	1.00	a_i (z/D) + b_i
		b_i	0.75	0.00	0.00	0.60	
	Centreline longitudinal bulkhead above $D/2$	a_i	1.70	0.00	0.00	-1.20	a_i (z/D) + b_i
		b_i	-0.80	0.00	0.00	1.70	
	Longitudinal bulkhead below $D/2$	a_i	-0.60	0.40	0.00	1.10	a_i (z/D) + b_i
		b_i	1.00	0.40	0.00	0.05	
	Longitudinal bulkhead above $D/2$	a_i	0.60	-0.84	0.00	-0.84	a_i (z/D) + b_i
		b_i	0.40	1.02	0.00	1.02	

Reason for the Change:

Editorial

Table C.1.4
Stress Range Combination Factors for Zone A

	Stiffener location		f_1	f_2	f_3	f_4	f_i
Ballast	~~Outer b~~Bottom shell	a_i	-0.20	-0.80	1.20	1.50	a_i (|y|/B) + b_i

		b_i	0.00	0.50	-0.25	1.07	
	~~Outer s~~Side shell and bilge below D/2	a_i	-1.00	1.20	-0.80	2.00	$a_i (z/D) + b_i$
		b_i	0.20	0.00	0.60	-0.40	
	~~Outer s~~Side shell above $D/2$	a_i	3.40	-1.20	-2.80	0.80	$a_i (z/D) + b_i$
		b_i	-2.00	1.20	1.60	0.20	
	Inner bottom and Lower stool	a_i	-0.50	-1.90	0.00	0.30	$a_i (\|y\|/B) + b_i$
		b_i	-0.05	0.60	0.00	0.85	
	Inner hull ~~side shell~~ below D/2	a_i	8.20	-2.80	0.00	0.20	$a_i (z/D) + b_i$
		b_i	-3.50	1.00	0.00	0.90	
	Inner hull ~~side shell~~ above D/2	a_i	0.60	2.80	0.00	-0.50	$a_i (z/D) + b_i$
		b_i	0.30	-1.80	0.00	1.25	
	Deck and Upper stool	a_i	0.00	0.70	0.00	0.00	$a_i (\|y\|/B) + b_i$
		b_i	1.00	0.00	0.00	0.00	
	Inner longitudinal bulkhead Below D/2	a_i	-1.20	2.00	0.00	0.00	$a_i (z/D) + b_i$
		b_i	1.10	0.00	0.00	0.00	
	Inner longitudinal bulkhead Above D/2	a_i	1.50	-2.70	0.00	0.00	$a_i (z/D) + b_i$
		b_i	-0.25	2.35	0.00	0.00	
	Centreline~~al~~ longitudinal bulkhead Below D/2	a_i	0.00	0.00	0.00	0.00	$a_i (z/D) + b_i$
		b_i	1.00	0.00	0.00	0.00	$a_i (z/D) + b_i$
	Centreline~~al~~ longitudinal bulkhead Above D/2	a_i	0.00	0.00	0.00	0.00	$a_i (z/D) + b_i$
		b_i	1.00	0.00	0.00	0.00	$a_i (z/D) + b_i$
Loaded	~~Outer b~~Bottom shell	a_i	-2.20	1.50	2.60	0.00	$a_i (\|y\|/B) + b_i$
		b_i	1.20	-0.15	-0.30	0.00	
	~~Outer s~~Side shell and bilge below $D/2$	a_i	-1.20	-1.20	0.60	0.00	$a_i (z/D) + b_i$
		b_i	0.30	0.80	0.70	0.00	
	~~Outer s~~Side shell above $D/2$	a_i	3.00	-0.30	-0.50	0.00	$a_i (z/D) + b_i$
		b_i	-1.80	0.35	1.25	0.00	
	Inner bottom and Lower stool	a_i	-1.00	2.30	0.00	-0.20	$a_i (\|y\|/B) + b_i$
		b_i	1.00	-0.10	0.00	0.00	
	Inner hull ~~side shell~~ below $D/2$	a_i	-0.80	1.00	0.00	1.00	$a_i (z/D) + b_i$
		b_i	0.20	0.00	0.00	0.50	
	Inner hull ~~side shell~~ above $D/2$	a_i	3.20	-1.00	0.00	-0.80	$a_i (z/D) + b_i$
		b_i	-1.80	1.00	0.00	1.40	
	Deck and Upper stool	a_i	-0.10	1.50	0.00	0.00	$a_i (\|y\|/B) + b_i$
		b_i	1.00	-0.15	0.00	0.00	
	Inner longitudinal bulkhead Below D/2	a_i	-0.80	0.30	0.00	1.00	$a_i (z/D) + b_i$
		b_i	1.00	0.50	0.00	0.30	
	Inner longitudinal bulkhead Above D/2	a_i	0.20	-0.90	0.00	-0.08	$a_i (z/D) + b_i$
		b_i	0.50	1.10	0.00	0.84	
	Centreline~~al~~ longitudinal bulkhead Below D/2	a_i	-1.10	0.00	0.00	0.44	$a_i (z/D) + b_i$
		b_i	0.60	0.00	0.00	0.80	$a_i (z/D) + b_i$
	Centreline~~al~~ longitudinal bulkhead Above D/2	a_i	1.30	0.00	0.00	-0.56	$a_i (z/D) + b_i$
		b_i	-0.60	0.00	0.00	1.30	$a_i (z/D) + b_i$

Reason for the Change:

Editorial

Table C.1.5
Stress Range Combination Factors for Zone F

	Stiffener location		f_1	f_2	f_3	f_4	f_i
Ballast	~~Outer b~~Bottom shell	a_i	-0.90	1.00	2.40	-1.20	$a_i\ (\lvert y\rvert/B) + b_i$
		b_i	0.85	-0.10	-1.00	1.10	
	~~Outer s~~Side shell and bilge below $D/2$	a_i	-0.60	-0.40	1.00	-1.80	$a_i\ (z/D) + b_i$
		b_i	0.00	0.50	-0.15	0.90	
	~~Outer s~~Side shell above $D/2$	a_i	0.60	-0.90	-2.70	3.00	$a_i\ (z/D) + b_i$
		b_i	-0.60	0.75	1.70	-1.50	
	Inner bottom and Lower stool	a_i	-0.30	-1.00	0.00	0.00	$a_i\ (\lvert y\rvert/B) + b_i$
		b_i	0.90	0.25	0.00	1.00	
	Inner hull ~~side shell~~ below $D/2$	a_i	-12.00	-2.40	0.00	1.20	$a_i\ (z/D) + b_i$
		b_i	5.00	1.00	0.00	0.50	
	Inner hull ~~side shell~~ above $D/2$	a_i	3.00	1.40	0.00	-0.90	$a_i\ (z/D) + b_i$
		b_i	-2.50	-0.90	0.00	1.55	
	Deck and Upper stool	a_i	0.00	1.00	0.00	0.00	$a_i\ (\lvert y\rvert/B) + b_i$
		b_i	1.00	-0.10	0.00	0.00	
	Inner longitudinal bulkhead Below D/2	a_i	-1.80	1.90	0.00	0.00	$a_i\ (z/D) + b_i$
		b_i	1.30	0.00	0.00	0.00	
	Inner longitudinal bulkhead Above D/2	a_i	1.80	-2.50	0.00	0.00	$a_i\ (z/D) + b_i$
		b_i	-0.50	2.20	0.00	0.00	
	Centreline~~al~~ longitudinal bulkhead Below D/2	a_i	0.00	0.00	0.00	0.00	$a_i\ (z/D) + b_i$
		b_i	1.00	0.00	0.00	0.00	$a_i\ (z/D) + b_i$
	Centreline~~al~~ longitudinal bulkhead Above D/2	a_i	0.00	0.00	0.00	0.00	$a_i\ (z/D) + b_i$
		b_i	1.00	0.00	0.00	0.00	$a_i\ (z/D) + b_i$
Loaded	~~Outer b~~Bottom shell	a_i	-0.60	-0.15	0.00	0.00	$a_i\ (\lvert y\rvert/B) + b_i$
		b_i	-0.45	0.05	1.00	0.00	
	~~Outer s~~Side shell and bilge below $D/2$	a_i	-1.20	0.18	0.00	0.00	$a_i\ (z/D) + b_i$
		b_i	0.00	-0.03	1.00	0.00	
	~~Outer s~~Side shell above $D/2$	a_i	4.00	0.02	0.00	0.00	$a_i\ (z/D) + b_i$
		b_i	-2.60	0.05	1.00	0.00	
	Inner bottom and Lower stool	a_i	2.80	2.20	0.00	-1.00	$a_i\ (\lvert y\rvert/B) + b_i$
		b_i	-0.80	-0.30	0.00	1.10	
	Inner hull ~~side shell~~ below $D/2$	a_i	10.20	1.60	0.00	0.00	$a_i\ (z/D) + b_i$
		b_i	-4.50	-0.60	0.00	1.00	
	Inner hull ~~side shell~~ above $D/2$	a_i	-0.80	-0.90	0.00	0.00	$a_i\ (z/D) + b_i$
		b_i	1.00	0.65	0.00	1.00	
	Deck and Upper stool	a_i	-0.24	1.80	0.00	0.00	$a_i\ (\lvert y\rvert/B) + b_i$
		b_i	1.00	0.00	0.00	0.00	
	Inner longitudinal bulkhead Below D/2	a_i	-2.10	-1.00	0.00	1.50	$a_i\ (z/D) + b_i$
		b_i	1.15	0.60	0.00	0.35	
	Inner longitudinal bulkhead Above D/2	a_i	0.40	-0.30	0.00	-0.40	$a_i\ (z/D) + b_i$
		b_i	-0.10	0.25	0.00	1.30	
	Centreline~~al~~ longitudinal bulkhead Below D/2	a_i	-0.60	0.00	0.00	0.00	$a_i\ (z/D) + b_i$
		b_i	0.25	0.00	0.00	1.00	$a_i\ (z/D) + b_i$
	Centreline~~al~~ longitudinal bulkhead Above D/2	a_i	0.20	0.00	0.00	0.00	$a_i\ (z/D) + b_i$
		b_i	-0.15	0.00	0.00	1.00	$a_i\ (z/D) + b_i$

Reason for the Change:

Editorial

1.5 Classification of Structural Details

1.5.1 General

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

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 0.1*D* 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:

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

$$S = f_{model}\left|0.85(S_{e1} - 0.2S_{e2})\right|$$ 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_i 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 $0.25t_{corr}$ 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 $0.5t_{corr}$

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

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. $-1.0t_{corr}$, 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 by used for the thickness of the plating for assessment of the corresponding stiffener/plating combination. Calculation of weighted average is to be in accordance with *5.2.3.3*. 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

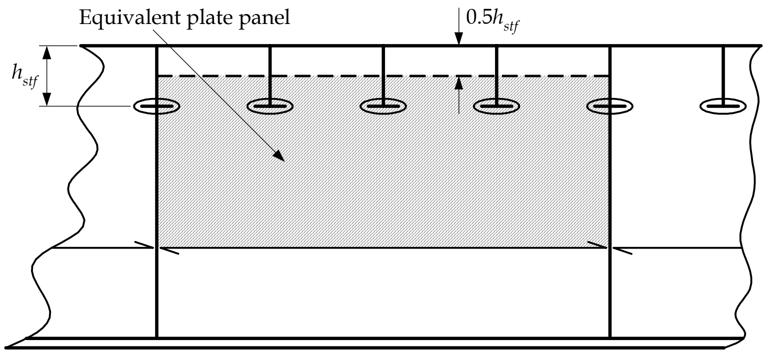
5.2.3.2 In way of web frames, stringers and brackets, the geometry of the panel (i.e. plate bounded by web stiffeners/face plate) may not have a rectangular shape. Where the advanced buckling method is unable to correctly model the panel geometry, then an equivalent rectangular panel is to be defined 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



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

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

Table D.5.2
~~Requirements to Structural Elements not Covered by Advanced Buckling Assessment~~
Requirements for structures where there is no advanced buckling method available

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

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

6.3.1.3 The buckling capacity models are to be based on the net thickness obtained by deducting half the corrosion addition ~~thickness~~, i.e. $-0.5t_{corr}$, 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