IACS
Common Structural Rules for Double Hull Oil Tankers, January 2006

Corrigenda 1
Rule Editorials and Clarifications

April 2006

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.

SECTION 2 – RULE PRINCIPLES

2 GENERAL ASSUMPTIONS

2.1 General

2.1.1 International and national regulations

2.1.1.3 The Rules incorporate the IACS unified requirements as shown in *Table* ~~*2.4.1*~~*2.2.1*.

Rule Editorial:
Editorial correction – error in reference.

2.1.3 Responsibilities of Classification Societies, builders and owners

2.1.3.1 These Rules address the hull structural aspects of classification and do not include requirements related to the verification of compliance with the Rules during construction and operation. The verification of compliance with these Rules is the responsibility of all parties and requires that proper care and conduct is shown by all parties involved in its implementation. These responsibilities include:

(a) general aspects:

- relevant information and documentation involved in the design, construction and operation is to be communicated between all parties in a clear and efficient manner. The builder is responsible for providing design documentation according to requirements specified in the Rules. Other requirements for information and documentation are specified by the requirements and approval procedures of the individual Classification Societies
- quality systems are applied to the design, construction, operation and maintenance activities to assist compliance with the requirements of the Rules.

(b) design aspects:

- it is the responsibility of the owner to specify the intended use of the ship, and the responsibility of the builder to ensure that the operational capability of the design fulfils the owner's requirements as well as the structural requirements given in the Rules
- the builder shall identify and document the operational limits for the ship so that the ship can be safely and efficiently operated within these limits
- verification of the design is performed by the builder to check compliance with provisions contained in the Rules in addition to national and international regulations
- the design is performed by appropriately qualified, competent and experienced personnel
- the classification society is responsible for a technical review ~~and audit~~ of the design plans and related documents for a ship to verify compliance with the appropriate classification rules.

(c) construction aspects:

- the builder is responsible for ensuring that adequate supervision and quality control is provided during the construction
- construction is to be carried out by qualified and experienced personnel
- workmanship, including alignment and tolerances, is to be in accordance with acceptable shipbuilding standards
- the Classification Society is responsible for ~~auditing~~ surveying to verify that the construction and quality control are in accordance with the plans and procedures.

(d) operational aspects:

- the owner is to ensure that the operations personnel are aware of, and comply with, the operational limitations of the ship
- the owner is to provide operations personnel with sufficient training such that the ship is properly handled to ensure that the loads and resulting stresses imposed on the structure are minimised
- the owner is to ensure that the ship is maintained in good condition and in accordance with the Classification Society survey scheme and also in accordance with the international and national regulations and requirements
- the Classification Society is responsible for ~~auditing~~ surveying to verify that the vessel maintains its condition of class in accordance with the Classification Society survey scheme.

Rule Editorial:
The term surveying is commonly used in existing Rules and more descriptive of the work done by the surveyor.

3 DESIGN BASIS

3.1 General

3.1.7 External environment

3.1.7.4 The Rules assume that the structural assessment of hull strength members is valid for the following design temperatures:

(e) lowest daily mean temperature in air is -15 ˚C

(f) lowest daily mean temperature in sea water is 0 ˚C

Ships operating for long periods in areas with lower daily mean air temperature may be subject to additional requirements as specified by the individual Classification Society.

Rule Editorial:
It is possible that this can be misinterpreted to mean certification of all equipment fitted on board.

3.1.8 Internal environment (cargo and water ballast tanks)

3.1.8.5 The design aspects and assumption upon which corrosion ~~margins~~ additions in the Rules are specified are as follows:

(a) the corrosion ~~margins~~ additions are based on a combination of experience and a statistical evaluation of historical corrosion measurements. The corrosion ~~margins~~ additions are based on the carriage of a mixture of crude and other oil products with various degrees of corrosive properties

(b) the corrosion ~~margins~~ additions are based on the design life, see *3.1.3.1*

(c) ballast tanks are coated. Requirements for coating application and maintenance are excluded from the Rules.

3.1.8.6 The values for corrosion ~~margins~~ additions and wastage allowance are specified in *Section 6/3* and *Section 12* respectively.

Rule Editorial:
Editorial correction.

5 APPLICATION OF PRINCIPLES

5.4 Load-capacity Based Requirements

5.4.1 General

5.4.1.8 The acceptance criteria set AC1 is applied when the combined characteristic loads are frequently occurring, typically for the static design load combinations, but also applied for the sloshing design loads. This means that the loads occur on a frequent or regular basis. The allowable stress for a frequent load is lower than for an extreme load to take into account effects of:

(a) repeated yield ~~(low cycle fatigue)~~

(b) allowance for some dynamics

(c) margins for operational mistakes.

Rule Editorial:
Move reference to low cycle fatigue to background to avoid confusion regarding scope of Rules.

5.4.3 Design loads for fatigue requirements

5.4.3.3 The fatigue analysis is calculated for two representative loading conditions covering the ship's intended operation. These two conditions are:

(a) full load homogeneous conditions at design draught

(b) normal ballast condition.

The proportion of the ship's sailing life in the full load condition is 50% and in ballast 50%. It is assumed that 15% of the ships' life is in harbour/sheltered water. It is consequently assumed that the ship will be sailing in open waters in full load condition for 42.5% of the ships life and in the ballast condition for 42.5% of the ship's life.

Rule Editorial:
Clarification needed due to confusion recorded by users.

5.5 Materials

5.5.1 General

5.5.1.1 Higher material properties are selected for highly critical structural elements which are subjected to high loads ~~and low service temperatures~~ in order to reduce the risk of propagation of brittle fracture.

Rule Editorial:
Delete reference to low service temperature as this causes confusion. Brittle fracture implicitly relates to low temperatures. All exposed structural elements are assumed subject to the design temperature given in *3.1.7.4*.

SECTION 3 – RULE APPLICATION

2 DOCUMENTATION, PLANS AND DATA REQUIREMENTS

2.2 Submission of Plans and Supporting Calculations

2.2.2.2 The following supporting documents are to be submitted:

(a) general arrangement

(b) capacity plan

(c) lines plan or equivalent

(d) dry-docking plan, where developed

(e) freeboard plan or equivalent, showing freeboards and items relative to the conditions of assignment

~~(f)list of applicable statutory regulations, see *Section 2/4* and *Section 3/3.3*.~~

Rule Editorial:

In the current Rules the list of statutory regulations is not presently a part of the formal list of information requested. It is normally requested through the Class Request. Hence this maintains current protocol.

Rule Clarification:

A capacity plan does not have to be submitted provided information defining the tank boundaries/contents/volumes/centroids and height of air pipes is provided. For example, this information is sometimes provided in the loading manual, and in that case a capacity plan is not required to be submitted.

4 EQUIVALENCE PROCEDURE

4.1 General

4.1.1 Rule applications

4.1.1.3 Special consideration will be given to the application of the Rules incorporating design parameters which are outside the design basis of *Section 2/3*, for example:

(f) increased fatigue life

(g) increased corrosion ~~margins~~additions

(h) increased cargo density.

Rule Editorial:

Editorial correction.

5 CALCULATION AND EVALUATION OF SCANTLING REQUIREMENTS

5.2 Determination of Scantlings of Stiffeners

5.2.5 Shear area requirements of stiffeners

5.2.5.3 The requirements in *Section 8* are to be evaluated against the actual shear area of the stiffener, based on the effective shear height of the stiffener as given in *Section 4/2.4.2* and based on the specified minimum yield of the stiffener.

Rule Editorial:

Update needed to clarify that specified minimum yield of stiffener is to be used even if the yield stress for the attached plate is lower.

5.3 Calculation and Evaluation of Scantling Requirements for Primary Support Members

5.3.2 Shear requirements of primary support members

5.3.2.3 These requirements are to be evaluated against the actual shear area and the specified minimum yield of the web plate of the primary support member. The actual shear area of the primary support member is defined as the web thickness multiplied by the total height including flanges. The effect of brackets may be included in the calculation of effective span, but are not to be included in the calculation of actual shear area.

Rule Editorial:

Update needed to clarify that specified minimum yield of primary support member is to be used even if the yield stress for the attached plate is lower.

5.4 Rounding of Calculated Thickness

5.4.1 Required gross thickness

5.4.1.1 The minimum required gross thickness of any member to be fitted at the new-building stage, exclusive of any owners' extras, is to be taken as the rounded net thickness required plus the appropriate corrosion ~~margin~~addition.

Rule Editorial:
Editorial correction.

SECTION 4 – BASIC INFORMATION

2 STRUCTURAL IDEALISATION

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:

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

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

Rule Editorial:
Editorial correction. Symbol for angle is missing.

2.5 Geometrical Properties of Primary Support Members

2.5.1 Effective web area of primary support members

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

$A_{w-net50} = 0.01\, h_n\, t_{w-net50}$ 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:

(a) h_w

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

(c) $h_{n1} + h_{n2} + h_{n4}$

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

Rule Editorial:
Editorial correction. Error in c).

3 STRUCTURE DESIGN DETAILS

3.2 Termination of Local Support Members

3.2.3 Bracketed connections

3.2.3.4 Brackets to provide fixity of end rotation are to be fitted at the ends of discontinuous local support members, except as otherwise permitted by *3.2.4*. The end brackets are to have arm lengths, $l_{bkt,}$ not less than:

$$l_{bkt} = c_{bkt}\sqrt{\frac{Z_{rl-net}}{t_{bkt-net}}}$$ mm, but is not to be less than:

1.8 times the depth of the stiffener web for connections where the end of the stiffener web is supported and the bracket is welded in line with the stiffener web, see *Figure 4.3.1(c)*

2.0 times for other cases, see *Figure 4.3.1(a), (b) and (d)*

Where:

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

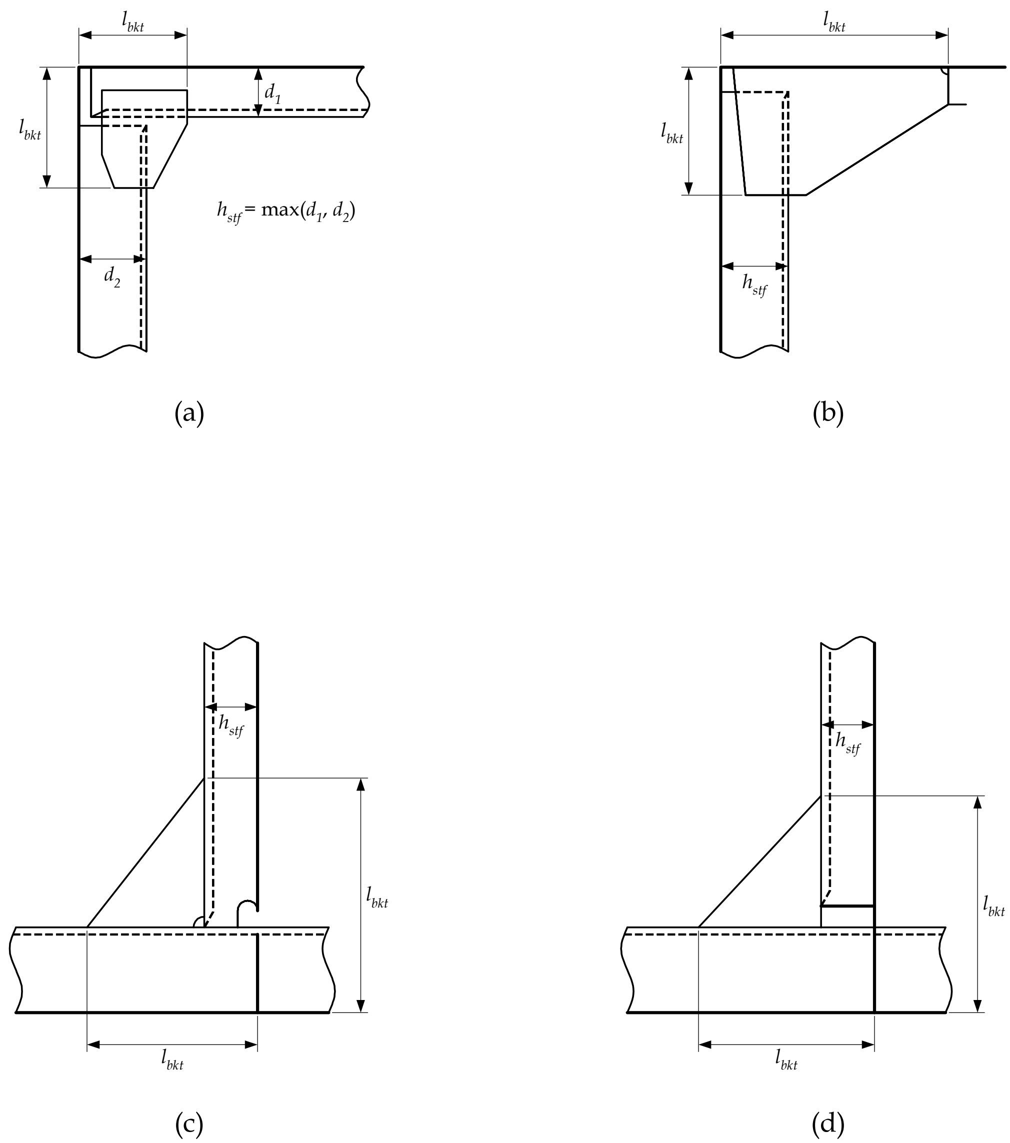
70 for brackets without flange or edge stiffener

Z_{rl-net} net rule section modulus, for the stiffener, in cm^3. In the case of two stiffeners connected, it need not be taken as greater than that of the smallest connected stiffener

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

Rule Editorial:
Clarification of reference to Figure.

Figure 4.3.1
Bracket Arm Length



<u>*Rule Clarification:*</u>

- Brackets welded to the face plate but offset to enable welding, are in this context, considered in line with the web and hence the 1.8 times the depth of the stiffener web minimum requirement is applicable.
- For stiffeners of configuration (b) that are not lapped the bracket arm length l_{bkt} is not to be less than the stiffener height h_{stf}
- For stiffener arrangements similar to (c) and (d) where the smaller attached stiffener, labelled as h_{stf}, is connected to a primary support member or bulkhead the height of the bracket is not to be less than the height of the attached stiffener, h_{stf}.

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)

Table 4.3.2 Weld Factors for Connection between Stiffeners and Primary Support Members	
Item	Weld factor
Primary support member stiffener to intersecting stiffener	~~$0.6\ \sigma_w$~~ $0.6\ \sigma_{wc}$ / σ_{perm} not to be less than 0.38
Shear connection inclusive lug or collar plate	0.38
Shear connection inclusive lug or collar plate, where the web stiffener of the primary support member is not connected to the intersection stiffener	$0.6\ \tau_w / \tau_{perm}$ not to be less than 0.44
Where: τ_w shear stress, as defined in *3.4.3.5* σ_w as defined in *3.4.3.5* τ_{perm} permissible shear stress, in N/mm², see *Table 4.3.1* σ_{perm} permissible direct stress, in N/mm² see *Table 4.3.1*	

Rule Editorial:
Editorial correction required to ensure consistent terminology with *4/3.4.3.5*.

3.5 Openings

3.5.4 Manholes and lightening holes requiring reinforcement

3.5.4.2 The web plate is to be ~~specially~~ stiffened at openings when the mean shear stress, as determined by application of the requirements of *Section 8* or *Section 9/2*, is greater than 50N/mm² for acceptance criteria set AC1 or greater than 60N/mm² for acceptance criteria set AC2. The stiffening arrangement is to ensure buckling strength as required by *Section 10* under application of the loading as required in *Section 8* or *Section 9/2*.

Rule Editorial:
Deletion of the ambiguous term '*specially*' to avoid misunderstanding of requirement related to stiffening around openings.

SECTION 6 – MATERIALS AND WELDING

4 FABRICATION

4.3 Hot Forming

4.3.1 Temperature requirements

4.3.1.1 Steel is not to be formed between the upper and lower critical temperatures. If the forming temperature exceeds 650°C for as-rolled, controlled rolled, thermo-mechanical controlled rolled or normalised steels, or is not at least 28°C lower than the tempering temperature for quenched and tempered steels, mechanical tests are to be made to assure that these temperatures have not adversely affected both the tensile and impact properties of the steel. Where curve forming or fairing, by line or spot heating, is carried out in accordance with *4.3.2.1* these mechanical tests are not required.

Rule Editorial:
Clarification to avoid ambiguity.

4.3.1.2 Confirmation is required to demonstrate the mechanical properties after further heating ~~there is no reduction in the mechanical properties~~meet the requirements specified~~,~~ by a procedure test using representative material, when considering further heating other than in *4.3.1.1* of thermo-mechanically controlled steels (TMCP plates) for forming and~~,~~ stress relieving~~, or for high heat input welding~~.

Rule Editorial:
Clarification to avoid ambiguity.

4.4 Welding

4.4.1 General

4.4.1.1 All welding is to be carried out by approved welders, in accordance with approved welding procedures, using approved welding consumables and is to comply with the Rules for Materials of the individual Classification Society. ~~The assembly sequence and welding sequence are to be agreed prior to construction and are to be to the satisfaction of the Surveyor, see *Sub-Section 5*.~~

Rule Editorial:
Clarification to reflect actual practice.

5 WELD DESIGN AND DIMENSIONS

5.1 General

5.1.3 Tolerance requirements

5.1.3.1 The gaps between the faying surfaces of members being joined are to be kept to a minimum or in accordance with approved specification.

Rule Editorial:
Clarification that gaps are to be kept within the approved value but not necessarily to a minimum if specifically requested. The standard gap is 2.0mm but may be increased if accounted for in weld size, ref. 6/5.1.3.2

5.4 Lapped Joints

5.4.1 General

5.4.1.2 Where overlaps are adopted, the width of the overlap, w_{lap}, is not to be less than three times, but not greater than four times, the gross thickness of the thinner of the plates being joined. See *Figure 6.5.6*. Where the gross thickness of the thinner plate being joined has a thickness of 25mm or more the overlap will be subject to special consideration.

5.4.1.3 The overlaps for lugs and collars in way of cut-outs for the passage of stiffeners through webs and bulkhead plating are not to be less than three times the thickness of the lug in generalbut need not be greater than 50mm. The joints are to be positioned to allow adequate access for completion of sound welds.

5.4.1.35.4.1.4 The faying surfaces of lap joints are to be in close contact and both edges of the overlap are to have continuous fillet welds.

Rule Editorial:
Clarification that the maximum overlap width of four times the plate thickness does not apply to lug connections.

5.4.2 Overlapped end connections

5.4.2.1 Overlapped end connections of longitudinal strength members within the 0.4*L* midship region are to have continuous fillet welds on both edges. Each leg length is to be equal in size to the gross thickness of the thinner of the two plates being joined. All other overlLapped end connections, where accepted by the Rules, are to have continuous welds on each edge with leg length, l_{leg}, as shown in *Figure 6.5.6*, such that the sum of the two leg lengths is not less than 1.5 times the gross thickness of the thinner plate.

Rule Editorial:
Clarification needed. According to yards and Class material experts it is practically impossible to comply with the first part of the requirement as a leg equal to the thickness of the plate requires welding at the edge of the plate. As we do not allow lapped longitudinal strength members within 0.4L anyway the first part of the text is deleted.

5.7 Determination of the Size of Welds

Table 6.5.2
Leg Size

Item	Minimum Leg Size(1), mm
(a) Gross plate thickness $t_{p\text{-}grs} \le 6.5$mm	
Hand or automatic welding	4.0
Automatic deep penetration welding	4.0
(b) Gross plate thickness $t_{p\text{-}grs} > 6.5$mm	
Hand or automatic welding	4.5
Automatic deep penetration welding	4.0
(c) Welds within 3m below top of ballast and cargo tanks(2)	6.5
(d) All welds in cargo tank region, except in (c)	6.0

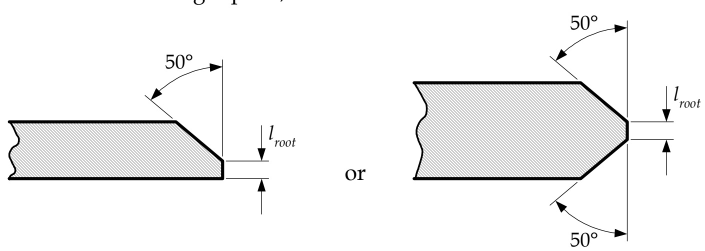
Note
1. In all cases, the limiting value is to be taken as the greatest of the applicable values given above.
2. Only applicable to cargo and ballast tanks with weather deck as the tank top.
3. See *5.9.3* for provisions to reduce minimum leg size.

Rule Clarification:
For items c) and d) a reduction to 5.5mm leg for the secondary structural elements of carling, buckling stiffeners and tripping brackets may be applied without additional gap control.

Table 6.5.3
Weld Connection of Strength Deck Plating to Sheer Strake

Stringer gross plate thickness, in mm	Weld type
$t_{p\text{-}grs} \leq 15$	Double continuous fillet weld with a leg size of 0.60 $t_{p\text{-}grs}$ + 2.0mm
$15 < t_{p\text{-}grs} \leq 20$	Single vee preparation to provide included angle of 50° with root face length $l_{root} < t_{p\text{-}grs}/3$ in conjunction with a continuous fillet weld with a weld factor of 0.35 or Double vee preparation to provide included angle of 50° with root face length $l_{root} < t_{p\text{-}grs}/3$
$t_{p\text{-}grs} > 20$	Double vee preparation to provide included angle of 50° with root face length $l_{root} < t_{p\text{-}grs}/3$, but not to be greater than 10mm

Where $t_{p\text{-}grs}$ = gross thickness of stringer plate, in mm



single vee preparation double vee preparation

Note

1. Welding procedure, including joint preparation, is to be specified and approved for individual builders.
2. Where structural members pass through the boundary of a tank a leak stopper is to be arranged in accordance with 4.4.4.~~, and leakage into the adjacent space could be hazardous or undesirable, full penetration welding is to be adopted for at least 150mm on each side of boundary.~~
3. Alternative connections will be specially considered.

Rule Editorial:

Clarification needed. The text for leak stoppers was not in accordance with Section 6/4.4.4. In order to avoid misunderstanding and inconsistent requirements reference is made to the Rule text instead.

SECTION 7 – LOADS

2 STATIC LOAD COMPONENTS

2.1 Static Hull Girder Loads

2.1.1 Permissible hull girder still water bending moment

2.1.1.5 The permissible hull girder hogging and sagging still water bending moment envelopes for seagoing operations, $M_{sw\text{-}perm\text{-}sea}$, are to envelop the minimum hull girder hogging and sagging still water bending moments given in *2.1.2.1 and 2.1.2.2* and the most severe hogging and sagging hull girder still water bending moments calculated for any seagoing loading condition given in the loading manual. The requirements for the loading conditions are given in *Section 8/1.1.2*.

2.1.1.6 The permissible hull girder hogging and sagging still water bending moment envelopes for harbour/sheltered water operation, $M_{sw\text{-}perm\text{-}harb}$, are to envelop the minimum hull girder hogging and sagging still water bending moments given in ~~*2.1.2.2*~~*2.1.2.3* and the most severe hogging and sagging hull girder still water bending moments calculated for any harbour/sheltered water loading condition given in the loading manual and are not to be less than the permissible envelopes for seagoing operation, $M_{sw\text{-}perm\text{-}sea}$.

Rule Editorial:
Editorial correction – error in reference.

SECTION 8 – SCANTLING REQUIREMENTS

1 LONGITUDINAL STRENGTH

1.3 Hull Girder Shear Strength

1.3.3 Shear force correction for longitudinal bulkheads between cargo tanks

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

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

Where:

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

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

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

$$r = \frac{1}{\left[\frac{A_{3-net50}}{A_{1-net50} + A_{2-net50}} + \frac{2\times 10^4 b_{80}(n_s+1)A_{3-net50}}{l_{tk}(n_s A_{T-net50} + R)}\right]}$$

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

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

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

$A_{T-net50}$ net shear area of the transverse wash bulkhead, including the double bottom floor directly below, in the side cargo tank, in cm^2, taken as the smallest area in a vertical section. $A_{T-net50}$ is to be calculated with net thickness given by t_{grs} - $0.5t_{corr}$

$A_{1-net50}$ net area, as shown in *Figure 8.1.2*, in m^2

$A_{2-net50}$ net area, as shown in *Figure 8.1.2*, in m^2

$A_{3-net50}$ net area, as shown in *Figure 8.1.2*, in m^2

~~F_3~~ f_3 shear force distribution factor, as shown in *Figure 8.1.2*

n_S number of wash bulkheads in the side cargo tank

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

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

γ $= 1 + \dfrac{300 {b_{80}}^2 A_{Q-net50}}{I_{psm-net50}}$ ~~cm²~~

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

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

t_{grs} gross plate thickness, in mm

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

Rule Editorial:
Editorial correction and correction of error in formula.

1.6 Tapering and Structural Continuity of Longitudinal Hull Girder Elements

1.6.5 Structural continuity of longitudinal bulkheads

1.6.5.1 Suitable scarphing arrangements are to be made to ensure continuity of strength and the avoidance of abrupt structural changes. In particular longitudinal bulkheads are to be terminated at an effective transverse bulkhead and large transition brackets shall be fitted in line with the longitudinal bulkhead.

Rule Clarification:
Termination at deck and bottom incorporating brackets with a minimum leg length of 0.05D is considered to comply with requirement of large transition brackets.

2 CARGO TANK REGION

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*

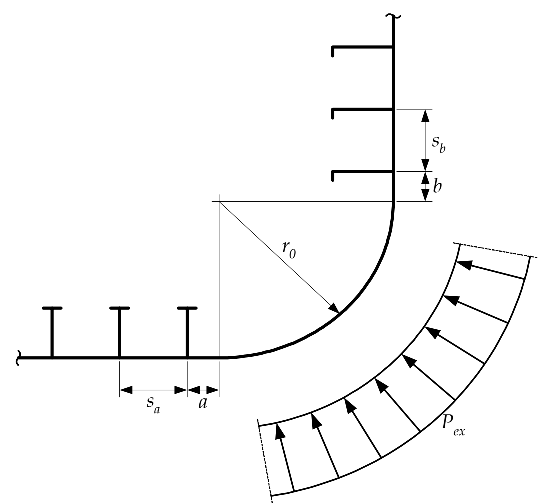
S_t distance between transverse stiffeners, webs or bilge brackets, in m

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.

The bilge keel is not considered as "longitudinal stiffening" for the application of this requirement.

Figure 8.2.1
Unstiffened Bilge Plating



Rule Clarification:

The thickness requirement given by 8/2.2.3.2 applies to the curved part of the plating. For production reasons the block joints are typically located in the straight plate just below the lowest stiffener on the side shell. Any increased thickness required in the curved plate does not have to extend to the next adjacent plate above the bilge provided the plate seam is not more than s_b/4 below the lower side stiffener. Similarly the bilge plating requirement does not apply to the flat part of the bottom plating provided this does not extend further than s_a/4 beyond the outboard bottom longitudinal.

Regularly longitudinal stiffened bilge plating is to be assessed as a stiffened plate.

2.5 Bulkheads

2.5.6 Corrugated bulkheads in cargo tanks

Rule Clarification:

Only the local plate requirements in 8/2.5.6 and FE apply to horizontal corrugated bulkheads.

2.6 Primary Support Members

2.6.4 Deck transverses

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, $l_{bdg\text{-}dt}$, of the deck transverse located at mid tank, in kN/m²

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

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

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

$l_{bdg\text{-}dt}$ effective bending span of the deck transverse, in m, see *Section 4/2.1.4* and *Figure 8.2.7*, but is not to be taken as less than 60% of the breadth of the tank

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 2/~~5.1.8~~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

Rule Editorial:
Correction of reference.

6 EVALUATION OF STRUCTURE FOR SLOSHING AND IMPACT LOADS

6.3 Bottom Slamming

6.3.7 Primary support members

6.3.7.3 For simple arrangements of primary support members, where the grillage affect may be ignored, the shear force, Q_{slm}, is given by:

$$Q_{slm} = f_{pt}\, f_{dist}\, F_{slm} \quad \text{kN}$$

Where:

f_{pt} Correction factor for the proportion of patch load acting on a single primary support member

$= 0.5\left(f_{slm}{}^{3} - 2 f_{slm}{}^{2} + 2\right)$

f_{slm} patch load modification factor

$= 0.5 \dfrac{b_{slm}}{S}$, but not to be greater than 1.0

f_{dist} factor for the greatest shear force distribution along the span, see *Figure 8.6.5*

F_{slm} $= P_{slm}\, l_{slm}\, b_{slm}$

P_{slm} bottom slamming pressure as given in *Section 7/4.3* and calculated at the load calculation point defined in *Section 3/5.3.2*, in kN/m²

l_{slm} extent of slamming load area along the span

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

l_{shr} effective shear span, as defined in *Section 4/2.1.5*, in m

b_{slm} breadth of impact area supported by primary support member

$= \sqrt{A_{slm}}$ m, but not to be greater than S

A_{slm} as defined in *6.3.6.1*

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

Rule Editorial:
Clarification that the patch load modification factor, f_{slm}, can not be greater than 1.0.

Rule Clarification:
Q_{slm} can be derived from direct calculations (see 8/6.3.7.4), also for simple arrangements of primary support members.

SECTION 9 – DESIGN VERIFICATION

2 STRENGTH ASSESSMENT (FEM)

2.2 Cargo Tank Structural Strength Analysis

2.2.5 Acceptance criteria

Table 9.2.1
Maximum Permissible Stresses

Structural component	Yield utilisation factor
Internal structure in tanks	
Plating of all non-tight structural members including transverse web frame structure, wash bulkheads, internal web, horizontal stringers, floors and girders. Face plate of primary support members modelled using plate or rod elements	$\lambda_y \le 1.0$ (load combination S + D) $\lambda_y \le 0.8$ (load combination S)
Structure on tank boundaries	
Plating of deck, sides, inner sides, hopper plate, bilge plate, plane and corrugated cargo tank longitudinal bulkheads	$\lambda_y \le 0.9$ (load combination S + D) $\lambda_y \le 0.72$ (load combination S)
Plating of inner bottom, bottom, plane transverse bulkheads and corrugated bulkheads. Tight floors, girders and webs	$\lambda_y \le 0.8$ (load combination S + D) $\lambda_y \le 0.64$ (load combination S)

Where:

λ_y yield utilisation factor

$= \frac{\sigma_{vm}}{\sigma_{yd}}$ for plate elements in general

$= \frac{\sigma_{rod}}{\sigma_{yd}}$ for rod elements in general

σ_{vm} von Mises stress calculated based on membrane stresses at element's centroid, in N/mm^2

σ_{rod} axial stress in rod element, in N/mm^2

σ_{yd} specified minimum yield stress of the material, in N/mm^2, but not to be taken as greater than 315 N/mm^2 for load combination S + D in areas of stress concentration (2)

Note

1. Structural items given in the table are for guidance only. Stresses for all parts of the FE model specified in *2.2.5.2* are to be verified against the permissible stress criteria. See also *Appendix B/2.7.1*
2. Areas of stress concentration are corners of openings, knuckle joints, toes and heels of primary supporting structural members and stiffeners
3. Where a lower stool is not fitted to a transverse or longitudinal corrugated bulkhead, the maximum permissible stresses are to be reduced by 10% in accordance with *2.2.5.5*.
4.

Rule Clarification:
The yield utilisation factor for longitudinal bulkheads between cargo tanks may be taken as for non-tight structural members for FE load cases where either both sides of the bulkhead are empty or both sides are loaded.

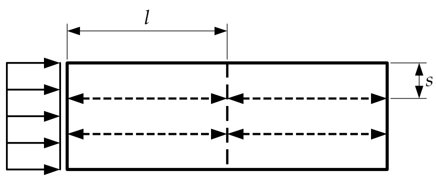
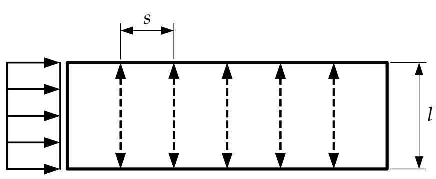
SECTION 10 – BUCKLING AND ULTIMATE STRENGTH

2 STIFFNESS AND PROPORTIONS

2.3 Primary Support Members

2.3.2 Stiffness requirements

Table 10.2.2
Stiffness Criteria for Web Stiffening

Mode	Inertia requirements, cm^4
(a) web stiffeners parallel to compression stresses 	~~$I_{net} = 0.72 l^2 A_{net} \frac{\sigma_{yd}}{235}$~~ $I_{net} = C l^2 A_{net} \frac{\sigma_{yd}}{235}$
(b) web stiffeners normal to compression stresses 	$I_{net} = 1.14 x 10^{-5} l\ s^2 t_{w-net} \left(2.5 \frac{1000 l}{s} - 2 \frac{s}{1000 l} \right) \frac{\sigma_{yd}}{235}$

Where:

<u>C</u> <u>= 1.43 for longitudinal stiffeners subject to hull girder stresses</u>
<u>= 0.72 for other stiffeners</u>

l length of web stiffener, in m.
For web stiffeners welded to local support members (LSM), the length is to be measured between the flanges of the local support members.
For sniped web stiffeners the length is to be measured between the lateral supports e.g. the total distance between the flanges of the primary support member as shown for Mode (b).

A_{net} net section area of web stiffener including attached plate assuming effective breadth of 80% of stiffener spacing s, in cm^2

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

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

σ_{yd} specified minimum yield stress of the material of the web plate of the primary support member, in N/mm^2

<u>Rule Editorial:</u>
Clarification of C factor to use for stiffeners on primary support members. The correction is made to be consistent with 10/2.2.2.1.

2.3.3 Spacing between flange supports or tripping brackets

2.3.3.1 The torsional buckling mode of primary support members is to be controlled by flange supports or tripping brackets. The unsupported length of the flange of the primary support member, i.e. the distance between tripping brackets, s_{bkt}, is not to be greater than:

$$s_{bkt} = b_f C \sqrt{\frac{A_{f-net}}{\left(A_{f-net} + \frac{A_{w-net}}{3}\right)}\left(\frac{235}{\sigma_{yd}}\right)}$$

$$s_{bkt} = b_f C \sqrt{\frac{A_{f-net50}}{\left(A_{f-net50} + \frac{A_{w-net50}}{3}\right)}\left(\frac{235}{\sigma_{yd}}\right)}$$ m, but need not be less than $s_{bkt-min}$

Where:

b_f breadth of flange, in mm

C slenderness coefficient:

= 0.022 for symmetrical flanges

= 0.033 for one sided flanges

$A_{f-net50}$ net cross-sectional area of flange, in cm²

$A_{w-net50}$ net cross-sectional area of the web plate, in cm²

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

$s_{bkt-min}$ = 3.0m for primary support members in the cargo tank region, on tank boundaries or on the hull envelope including external decks

= 4.0m for primary support members in other areas

Rule Editorial:

Correction of subscripts for net thickness.

2.4 Other Structure

2.4.2 Proportions of brackets

2.4.2.1 The net thickness of end brackets, $t_{bkt-net}$, is except as specified in *2.4.2.2* not to be less than:

$$t_{bkt} = \frac{d_{bkt}}{C}\sqrt{\frac{\sigma_{yd}}{235}} \qquad t_{bkt-net} = \frac{d_{bkt}}{C}\sqrt{\frac{\sigma_{yd}}{235}} \text{ mm}$$

Where:

d_{bkt} depth of brackets, in mm. See *Table 10.2.3*

C slenderness coefficient as defined in *Table 10.2.3*

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

Rule Editorial:
Correction of subscripts for net thickness.

2.4.2.3 Tripping brackets on primary support members are to be stiffened by a flange or edge stiffener if the effective length of the edge, l_{bkt}, is greater than:

~~$l_{bkt} = 75t_{bkt}$~~ $l_{bkt} = 75t_{bkt-net}$ mm

Where:

$t_{bkt-net}$ bracket thickness, in mm

Rule Editorial:
Correction of subscripts for net thickness.

3 PRESCRIPTIVE BUCKLING REQUIREMENTS

3.3 Buckling of Stiffeners

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

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

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:

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

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

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. ~~This is to be taken as the average axial stress acting on the following area:~~

~~$A_{net} + s\, t_{net}$~~ 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

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

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

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/mm²

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

c_p

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

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

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

<u>*Rule Editorial:*</u>
Correction to ensure consistency with 10/3.3.2.2.

3.3.3 Torsional buckling mode

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

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

Where:

σ_x compressive axial stress in the stiffener, in N/mm², ~~according to 3.3.2.1~~in way of the midspan of the stiffener. See *Section 3/5.2.3.1*

C_T torsional buckling coefficient

$= 1.0$ for $\lambda_T \leq 0.2$

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

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

λ_T reference degree of slenderness for torsional buckling

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

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

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

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

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

E modulus of elasticity, 206 000 N/mm²

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

I_{T-net} net St. Venant's moment of inertia of the stiffener, in cm⁴

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

ε degree of fixation

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

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

d_w depth of web plate, in mm

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

b_f flange breadth, in mm

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

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

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

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

A_{w-net} net web area, in mm²

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

A_{f-net} net flange area, in mm²

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

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

Rule Editorial:

Correction to ensure consistency with 10/3.3.2.2.

SECTION 11 – GENERAL REQUIREMENTS

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

Rule Clarification:
The spacing requirement given in *11/2.1.2.2* applies to bulwarks situated on the freeboard and forecastle deck only.

3 SUPPORT STRUCTURE AND STRUCTURAL APPENDAGES

3.1 Support Structure for Deck Equipment

3.1.2 Supporting structures for anchoring windlass and chain stopper

3.1.2.9 The following forces are to be applied separately in the load cases that are to be examined for the design loads due to green seas in the forward 0.25*L*, see *Figure 11.3.1*:

$P_x = 200A_x$ kN, acting normal to the shaft axis

$P_y = 150A_y f$ kN, acting parallel to the shaft axis (inboard and outboard directions to be examined separately)

Where:

A_x projected frontal area, in m^2

A_y projected side area, in m^2

f $= 1 + B_W/H$, but not to be taken greater than 2.5

B_W breadth of windlass measured parallel to the shaft axis, in m. See *Figure 11.3.1*

H overall height of windlass, in m, see *Figure 11.3.1*

Rule Editorial:
Editorial correction + clarification that Px and Py are assessed separately.

3.1.3 Supporting structure for mooring winches

3.1.3.3 The Rated Pull is defined as the maximum load which the mooring winch is designed to exert during operation and is to be stated on the mooring winch foundation/support plan.

3.1.3.4 The Holding Load is defined as the maximum load which the mooring winch is designed to resist during operation and is to be taken as the design brake holding load or equivalent and is to be stated on the mooring winch foundation/support plan.

Rule Editorial:
Clarification regarding specification of Rated pull and Holding load.

3.1.3.8 Each of the following load cases are to be examined for design loads due to mooring operation:

(a)	mooring winch at maximum pull:	100% of the rated pull
(b)	mooring winch with brake effective:	100% of the holding load
(c)	line strength:	125% of the breaking strength of the mooring line (hawser) required by *Table 11.4.2* for the ship's corresponding equipment number

Rated pull and holding load are defined in *3.1.3.3* and *3.1.3.4*. The design load is to be applied through the mooring line according to the arrangement shown on the mooring arrangement plan.

Rule Editorial:
Clarification of load direction to be consistent with MSC Circ 1175.

4 EQUIPMENT

4.2 Anchors and Mooring Equipment

4.2.18 Mooring winches

4.2.18.1 Mooring winch design and capacity are not subject to approval by the Society as a condition of Classification. Mooring winch plans and information are to be submitted for approval of the supporting structure in way of the winch and for the connection of the mooring winch to its foundation and the connection of the foundation to the deck, as required by *3.1.3*.

Guidance Note:
Mooring winches should be fitted with drum brakes, the strength of which is to be sufficient to prevent unreeling of the mooring line when the rope tension is equal to 80 percent of that for a rope with breaking strength equal to the greater of the maximum breaking strength of the rope ~~anticipated to be used throughout the service life of the ship~~specified on the mooring arrangement plan or that according to *Table 11.4.2* for the ship's corresponding equipment number, as fitted on the first layer on the winch drum.

Rule Editorial:
Clarification of guidance note to avoid ambiguity.

APPENDIX A –HULL GIRDER ULTIMATE STRENGTH

2 CALCULATION OF HULL GIRDER ULTIMATE CAPACITY

2.2 Simplified Method Based on an Incremental-iterative Approach

2.2.1 Procedure

2.2.1.7 The main steps of the incremental-iterative approach are summarised as follows (see also *Figure A.2.2*):

Step 1 Divide the hull girder transverse section into structural elements, ie longitudinal stiffened panels (one stiffener per element), hard corners and transversely stiffened panels, see *2.2.2.2*.

Step 2 Derive the stress-strain curves (or so called load-end shortening curves) for all structural elements, see *2.3*.

Step 3 Derive the expected maximum required curvature κ_F, see *2.2.1.8*. The curvature step size $\Delta\kappa$ is to be taken as $\kappa_F/300$. The curvature for the first step, κ_1 is to be taken as $\Delta\kappa$.

Derive the neutral axis z_{NA-i} for the first incremental step (i=1) with the value of the elastic hull girder section modulus, $z_{v-net50}$, see *Section 4/2.6.1*

Step 4 For each element (index j), calculate the strain $\varepsilon_{ij} = \kappa_i\ (z_j - z_{NA-i})$ corresponding to κ_i, the corresponding stress σ_j, see *2.2.1.9*, and hence the force in the element $\sigma_j A_j$.

Step 5 Determine the new neutral axis position z_{NA-i} by checking the longitudinal force equilibrium over the whole transverse section. Hence adjust z_{NA_i} until

$F_i = 0.1\Sigma A_j \sigma_j$ kN = 0

Note σ_j is positive for elements under compression and negative for elements under tension. Repeat from step 4 until equilibrium is satisfied. Equilibrium is satisfied when the change in neutral axis position is less than 0.0001m.

Step 6 Calculate the corresponding moment by summating the force contributions of all elements as follows:

~~$M_i = 0.1\sum \sigma_j A_j \left|\left(z_j - z_{NA-i}\right)\right|$~~ $M_i = 0.1\sum \left|\sigma_j A_j \left(z_j - z_{NA-i}\right)\right|$ kNm

Step 7 Increase the curvature by $\Delta\kappa$, use the current neutral axis position as the initial value for the next curvature increment and repeat from step 4 until the maximum required curvature is reached. The ultimate capacity is the peak value M_u from the M-κ curve. If the peak does not occur in the curve, then κ_F is to be increased until the peak is reached

<u>*Rule Editorial:*</u>

Editorial correction. Absolute sign was not correctly placed.

2.3 Stress-strain Curves σ-ε (or Load-end Shortening Curves)

2.3.6 Web local buckling of stiffeners with flanged profiles

2.3.6.1 The equation describing the shortening portion of the stress strain curve σ_{CR3}-ε for the web local buckling of flanged stiffeners is to be obtained from the following formula:

$$\sigma_{CR3} = \Phi\sigma_{yd}\left(\frac{b_{eff-s}t_{net50} + d_{w-eff}t_{w-net50} + b_f t_{f-net50}}{st_{net50} + d_w t_{w-net50} + b_f t_{f-net50}}\right)$$

$$\sigma_{CR3} = \Phi\sigma_{yd}\left(\frac{b_{eff-p}t_{net50} + d_{w-eff}t_{w-net50} + b_f t_{f-net50}}{st_{net50} + d_w t_{w-net50} + b_f t_{f-net50}}\right) \quad \text{N/mm}^2$$

Where:

Φ edge function defined in *2.3.3.1*

b_{eff-sp} effective width, in mm, of the attached plating, defined in *2.3.4*

t_{net50} net thickness of plate, in mm

d_w depth of the web, in mm

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

b_f breadth of the flange, in mm

$t_{f-net50}$ net thickness of flange, in mm

s plate breadth, in mm, taken as the spacing between the stiffeners, as defined in *Section 4/2.2.1*

d_{w-eff} effective depth of the web, in mm:

$$d_{w-eff} = \left(\frac{2.25}{\beta_w} - \frac{1.25}{\beta_w^2}\right)d_w \quad \text{for} \quad \beta_w > 1.25$$

$$d_{w-eff} = d_w \quad \text{for} \quad \beta_w \le 1.25$$

β_w $$\frac{d_w}{t_{w-net50}}\sqrt{\frac{\varepsilon\sigma_{yd}}{E}}$$

ε relative strain defined in *2.3.3.1*

E modulus of elasticity, 2.06×10^5 N/mm²

<u>*Rule Editorial:*</u>
Correction of symbols and wording to ensure consistency.

APPENDIX B –STRUCTURAL STRENGTH ASSESSMENT

2 CARGO TANK STRUCTURAL STRENGTH ANALYSIS

2.2 Structural Modelling

2.2.1 General

2.2.1.11 All local stiffeners are to be modelled. These stiffeners may be modelled using line elements positioned in the plane of the plating. Beam elements are to be used in areas under the action of lateral loads whilst rod (truss) elements may be used to represent local stiffeners on internal structural members under no lateral loads. The line elements are to have the following properties:

(a) for beam elements, out of plane bending properties are to represent the inertia of the combined plating and stiffener. The width of the attached plate is to be taken as ½ + ½ stiffener spacing on each side of the stiffener. The eccentricity of the neutral axis is not required to be modelled.

(b) for beam and rod elements, other sectional properties are to be based on a cross sectional area representing the stiffener area, excluding the area of the attached plating.

Rule Editorial:
Editorial correction.

Table B.2.2
Representation of Openings in Girder Webs

$h_o/h < 0.35$ 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 $t_{1\text{-}net50}$
$h_o/h < 0.35$ 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:

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

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

$t_{2\text{-}net50} =$ ~~$\dfrac{h - h_o}{hr_o} t_{w-net50}$~~ $\dfrac{h - h_o}{hg_o} t_{w-net50}$

$t_{w\text{-}net50}$ net web thickness
l_o length of opening parallel to girder 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 in way of opening, see *Figure B.2.8*
t_{corr} corrosion addition, as defined in *Table 6.3.1*

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.

Rule Editorial:
Editorial correction.

2.3 Loading Conditions

2.3.1 Finite element load cases

Table B.2.3
FE Load Cases for Tankers with Two Oil-tight Longitudinal Bulkheads

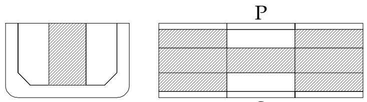
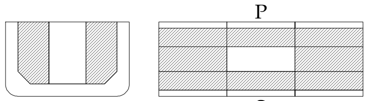
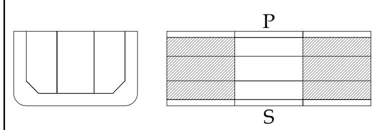
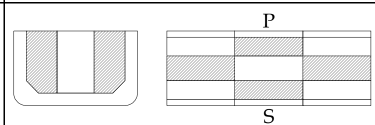
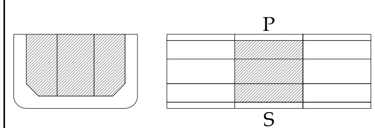
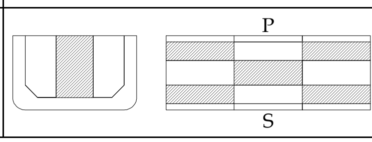
Loading Pattern	Figure	Still Water Loads			Dynamic load cases		
		Draught	% of Perm. SWBM(2)	% of Perm. SWSF(2)	Strength assessment (1a)	Strength assessment against hull girder shear loads (1b)	
					Midship region	Forward region	Midship and aft regions
Design load combination S + D (Sea-going load cases)							
A1		$0.9\ T_{sc}$	100% (sag)	See note 3	1	\	\
			100% (hog)	100% (-ve fwd) See note 4	2, 5a	\	\
A2		$0.9\ T_{sc}$	100% (sag)	See note 3	1	\	\
			100% (hog)	100% (-ve fwd) See note 4	2, 5a	\	\

Table B.2.3
FE Load Cases for Tankers with Two Oil-tight Longitudinal Bulkheads

Loading Pattern	Figure	Still Water Loads			Dynamic load cases		
		Draught	% of Perm. SWBM[(2)]	% of Perm. SWSF[(2)]	Strength assessment [(1a)]	Strength assessment against hull girder shear loads [(1b)]	
					Midship region	Forward region	Midship and aft regions
A3~~(6)~~		0.55 T_{sc} see note ~~5~~6	100% (hog)	100% (-ve fwd) See note 5	2	4	2
				100% (-ve fwd) See note ~~5~~4	5a	\	\
A4		0.6 T_{sc}	100% (sag)	100% (+ve fwd) See note 4	1, 5a	\	\
A5~~(7)~~		0.8 T_{sc} See note ~~6~~7	100% (sag)	100% (+ve fwd) See note 5	1	3	1
				100% (+ve fwd) See note 4	5a	\	\
A6		0.6 T_{sc}	100% (hog)	100% (-ve fwd) See note 4	5a	\	\

Rule Editorial:
Editorial correction to correct wrong references.

4 EVALUATION OF HOT SPOT STRESS FOR FATIGUE ANALYSIS

4.3 Loading Conditions

4.3.2 Finite element load cases for hopper knuckle connection

Table B.4.1
Load Cases for the Evaluation of Component Stress Range for Hopper Knuckle Joint

Load case	Component Stress ~~range~~	Applied Load	Parameters for calculation of loads
Full load condition			
L1	s_{e1}	Dynamic wave pressure (full range) applies only to the side of the hull where the hopper knuckle is analysed.	Ship draught = midship draught from departure homogeneous full load condition in the ship loading manual, see *Appendix C/1.3.2.* GM: see *Section 7/3.1.3.4* $r_{roll-gyr}$: see *Section 7/3.1.3.4* Cargo density = 0.9t/m^3 (minimum, see *4.3.1.2*)
L2	s_{e2}	Dynamic wave pressure (full range) applies only to the side of the hull where the hopper knuckle is not analysed.	
L3	s_{ix}	Dynamic tank pressure (full range) due to longitudinal acceleration.	
L4	s_{iy}	Dynamic tank pressure (full range) due to transverse accelerations.	
L5	s_{iz}	Dynamic tank pressure (full range) due to vertical acceleration.	
Ballast condition			
L6	s_{e1}	Dynamic wave pressure (full range) applies only to the side of the hull where the hopper knuckle is analysed.	Ship draught = midship draught from departure normal ballast condition in the ship loading manual. If normal ballast condition is not defined, then the midship draught from light ballast condition is to be used, see *Appendix C/1.3.2*
L7	s_{e2}	Dynamic wave pressure (full range) applies only to the side of the hull where the hopper knuckle is not analysed.	
Load cases for bending moment correction			
C1	s_{VBM}	Unit vertical bending moment applies to ends of cargo tank model	No other loads are to be applied
C2	s_{HBM}	Unit horizontal bending moment applies to ends of cargo tank model	

Table B.4.1 (Continued) Load Cases for the Evaluation of Component Stress Range for Hopper Knuckle Joint	
Where:	
s_{e1}, s_{e2}, s_{ix}, s_{iy}, s_{iz}	component stresses (with proper sign convention used)~~ranges~~ before correction for bending moment effect (5)
s_{VBM}	stress response due to the application of unit vertical bending moment at ends of cargo tank model
s_{HBM}	stress response due to the application of unit horizontal bending moment at ends of cargo tank models
Notes 1. For dynamic wave pressure load cases, the pressure distribution is to be calculated at midship and this distribution is to be applied along the full length of the cargo tank FE model. 2. For dynamic tank pressure load cases, vertical, transverse and longitudinal accelerations are calculated at the centre of gravity position of the midship cargo tanks. The accelerations calculated for each tank are to be applied to all corresponding cargo tanks along the length of the FE model. 3. Longitudinal, transverse and vertical accelerations at tank centre of gravity position are to be calculated in accordance with *Section 7/3.3.* The dynamic tank pressure amplitudes due to accelerations are to be calculated in accordance with *Section 7/3.5.4.7*. The dynamic tank pressure (full range) is to be obtained as two times the dynamic tank pressure amplitude and distributed in accordance with *Figure 7.3.9*. Note that these pressure distributions are different from those used for strength analysis. 4. The dynamic wave pressure amplitude is to be calculated according to *Section 7/3.5.2.3*. The dynamic wave pressure (full range) is to be obtained as two times the dynamic wave pressure amplitude. Note that the dynamic wave pressure and distribution is different from that used for strength analysis. *5.* Component ~~Stress~~ stresses (with proper sign convention used)~~ranges~~ calculated from load cases L1 to L7 are to be corrected to deduct the component due to vertical and horizontal bending moment effect, see *4.5.2.2.*	

Rule Editorial:

Editorial correction to clarify that the sign is to be included in the component stress.

4.5 Result Evaluation

4.5.2 Hopper knuckle connection

4.5.2.2 The component ~~hot spot~~ stress ranges are to be obtained by eliminating ~~calculated from load cases L1 to L7 in *Table B.4.1* are to be corrected as follows to eliminate~~ the stress induced by hull girder vertical and horizontal bending moments from the component stress determined from load cases L1 to L7 in *Table B.4.1* as follows:

$$S_{c\_i} = s_{c\_i} - M_{V\_i}\, s_{VBM} - M_{H\_i}\, s_{HBM}$$

Where:

S_{c_i}	S_{e1}, S_{e2}, S_{ix}, S_{iy} or S_{iz}, component stress range after correction for bending moment effects
s_{c_i}	s_{e1}, s_{e2}, s_{ix}, s_{iy} or s_{iz}, component stress (with proper sign convention used)~~range~~ including vertical and horizontal bending moment effects obtained from load cases L1 to L7, see *Table B.4.1*

M_{V_i} is the vertical hull girder bending moment due to loads applied to the cargo tank FE model obtained from load case L1, L2, L3, L4, L5, L6 or L7. The bending moment is to be calculated at the longitudinal position where the centroid of shell element under evaluation is located

M_{H_i} is the horizontal hull girder bending moment due to loads applied to the cargo tank FE model obtained from load case L1, L2, L3, L4, L5, L6 or L7. The bending moment is to be calculated at the longitudinal position where the centroid of shell element under evaluation is located

s_{VBM} stress due to unit vertical bending moment obtained from load case C1, see *Table B.4.1*

s_{HBM} stress due to unit horizontal bending moment obtained from load case C2, see *Table B.4.1*

Rule Editorial:

Correction to clarify that component stress ranges are to be taken as absolute values. Signs are to be included in the component stresses for the calculation of stress ranges.

APPENDIX C – FATIGUE STRENGTH ASSESSMENT

1 NOMINAL STRESS APPROACH

1.5 Classification of Structural Details

1.5.1 General

1.5.1.2 In case where pillar-less connections are adopted in way of bottom, side and inner hull, see note 6 of *Table C.1.7*.~~the cut out designs shown in *Figure C.1.11* are recommended.~~

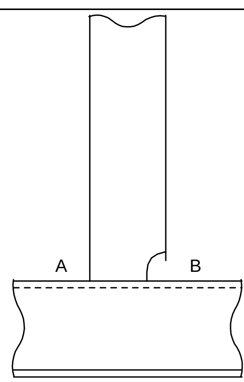
Rule Editorial:

Wording corrected to ensure consistency with respect to requirement given in note 6 of Table C.1.7.

Table C.1.7
Classification of Structural Details

Notes

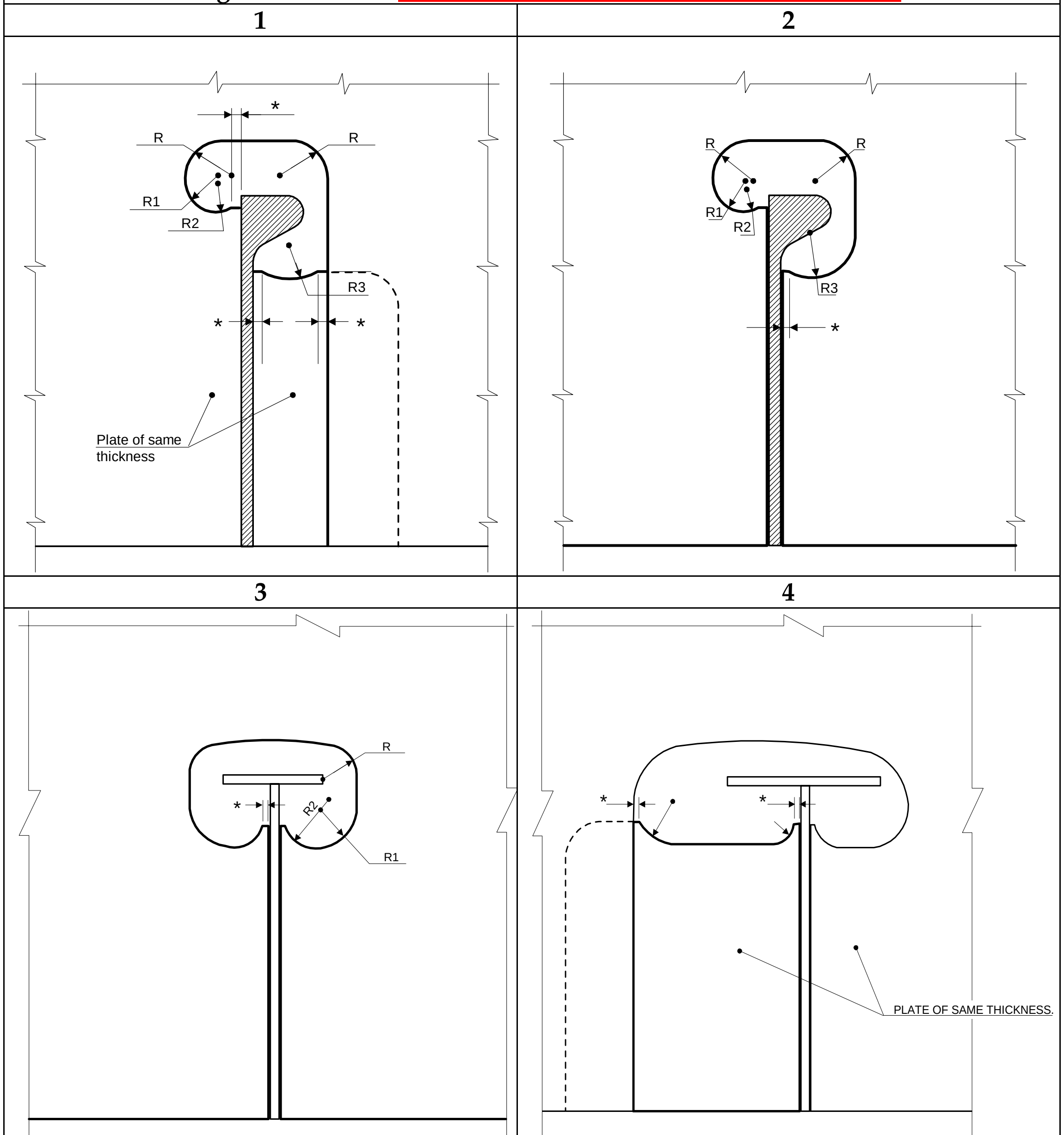
1. Where the attachment length is less than or equal to 150mm, the S-N curve is to be upgraded one class from those specified in the table. For example, if the class shown in the table is F2, upgrade to F. Attachment length is defined as the length of the weld attachment on the longitudinal stiffener face plate without deduction of scallop.
2. Where there is less than 10mm minimum clearance between the edge of the stiffener flange and the face of the attachment e.g. where the longitudinal stiffener is a flat bar, the S-N curve is to be downgraded by one class from those specified in the table. For example, if the class shown in the table is F, downgrade to F2; if the class shown in the table is F2, downgrade to G. This also applies to unsymmetrical profiles, e.g. bulb or angle profiles where the stated clearance cannot be achieved.
3. Lapped connections (attachments welded to the web of the longitudinals) should not be adopted and therefore these are not covered by the table.
4. For connections fitted with a soft heel, class F may be used if it is predominantly subjected to axial loading. Stiffeners fitted on deck and within 0.1D below deck edge are considered to satisfy this condition.
5. For connections fitted with a tight collar around the face plate, class F may be used if subjected to axial loading. Stiffeners fitted on deck and within 0.1D below deck edge are considered to satisfy this condition
6. ID32 is applicable in cases where web stiffeners are omitted or are not connected to the longitudinal stiffener face plate. In the dynamic wave wetted zone at side and below, in way of bottom and in way of inner hull below 0.1D from the deck edge, a water-tight collar or alternatively a detail design for cut-outs as shown in *Figure C.1.11* or equivalent is to be adopted. Other designs are subject to a satisfactory fatigue assessment by using comparative FEM based hot spot stress. For detail design of cut-outs as shown in *Figure C.1.11* or equivalent, the S-N curve may be upgraded to E for the dynamic wave wetted zone at side and below, in way of bottom and in way of inner hull below 0.1D from the deck edge.
7. In way of other areas besides what is mentioned in Note 6, i.e. side above wave wetted zone, deck, inner hull areas within 0.1D from the deck edge, in cases where web stiffeners are omitted or not connected to the longitudinal stiffener face plate, conventional slot configurations are permitted and an F class is to be applied, as described in ID 32.

ID	Connection type	Critical Locations Notes (1), (2), (3)	
		A	B
1		F2	F2

Rule Editorial:

Clarification of Note 6 was necessary in order to clarify applicability.

Figure C.1.11
Design for Cut Outs in cases where Web Stiffeners are Omitted



Notes

1. Soft toes marked "*" are to be dimensioned to suit the weld leg length such that smooth transition from the weld to the radiused part can be achieved. Max. 15 mm.
2. ~~In way of side and bottom, configurations 2 or 3 are recommended.~~ Configurations 1 and 4 indicate acceptable lapped lug plate connections, a~~A~~lternatively, butted lug plates with similar shape may be ~~considered~~adopted.
3. Designs that are different than shown in the above sketches are acceptable subject to a satisfactory fatigue assessment by using comparative FEM based hot spot stress.

Rule Editorial:

Rule clarification needed to avoid confusion with Note 6 in Table C.1.7.

2 HOT SPOT STRESS (FE BASED) APPROACH

2.5 Detail Design Standard

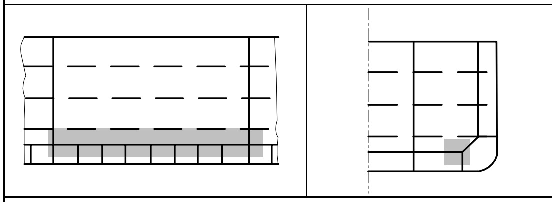
2.5.1 Hopper knuckles

Figure C.2.4
Hopper Knuckle Connection Detail, Bent Type

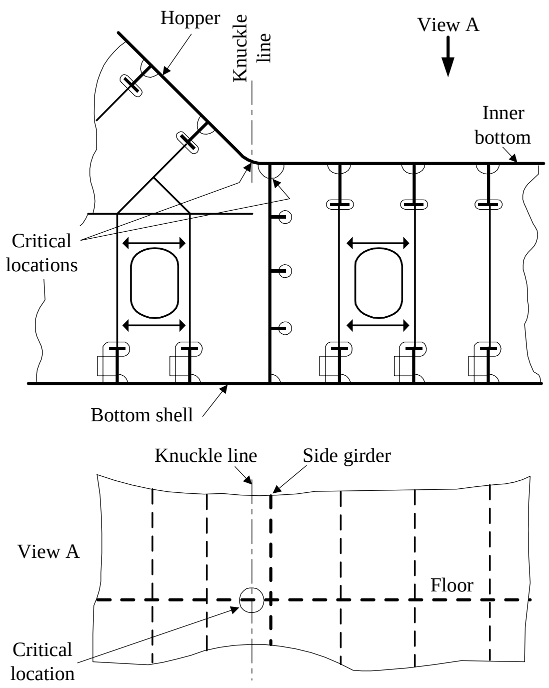
Connections of floors in double bottom tanks to hopper tanks

Hopper corner connections employing bent knuckle inner bottom and hopper sloping plating

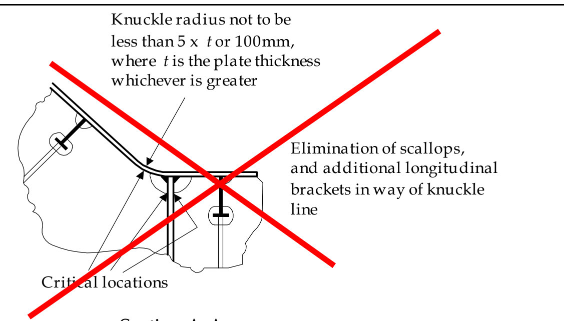
CRITICAL AREAS

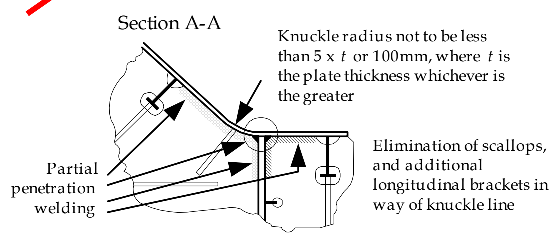


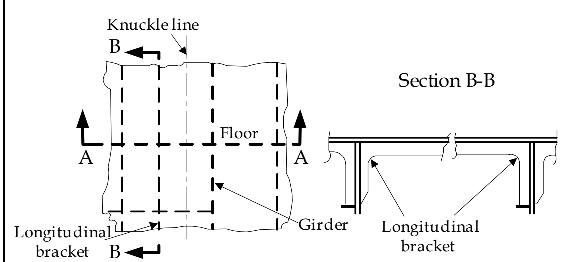
CRITICAL LOCATIONS



DETAIL DESIGN STANDARD







Note: Longitudinal brackets may be omitted if it can be demonstrated that the girder provides sufficient support at the knuckle line.

Minimum Requirement	As a minimum, the detail design standard C is to be fitted.
Critical Location	Side girder connections to inner bottom plating in way of floors. Floor and hopper transverse web connections to inner bottom plating and to side girders in way of hopper corners.
Detail Design Standard	Elimination of scallops in way of hopper corners and additional longitudinal brackets to reduce peak and range of resultant stresses arising from cyclic external hydrodynamic pressure, cargo inertia pressure, and hull girder global loading.
Building Tolerances	Enhanced alignment standard. The nominal distance between the centres of thickness of the two abutting members (e.g. floor and hopper web plate and additional supporting brackets) should not exceed 1/3 of the table member thickness.
Welding Requirements	Partial penetration welding with a maximum root face of 1/3 of the abutting plate thickness (Connection of side girders to inner bottom plating. Connection of floors to inner bottom plating and to side girders. Connection of hopper transverse webs to sloped inner bottom plating and to side girders in way of hopper corners).

<u>Rule Editorial:</u>

Changed to indicate the preferred design rather than an unacceptable design.

APPENDIX D – BUCKLING STRENGTH ASSESSMENT

1 ADVANCED BUCKLING ANALYSIS

1.1 General

1.1.3 Definitions

1.1.3.2 Buckling capacity accepting local elastic plate buckling with load redistribution is referred to as Method 1. The buckling capacity is the load that results in the first occurrence of membrane yield stress anywhere in the stiffened panel. Buckling capacity based on this principle gives a lower bound estimate of ultimate capacity, or the maximum load the panel can carry without suffering major permanent set. Method 1 buckling capacity assessment utilizes the positive elastic post-buckling effect for plates and accounts for load redistribution between the structural components, such as between plating and stiffeners. For slender structures the capacity calculated using this method is typically higher than the ideal elastic buckling stress (minimum Eigen-value). Accepting elastic buckling of structural components in slender stiffened panels implies that large elastic deflections and reduced in-plane stiffness will occur at higher buckling utilization levels.

~~Buckling capacity with allowance for redistribution of load (Method 1). This defines the upper bound value of the buckling capacity and represents the maximum load the panel can carry without suffering major permanent set and is effectively the ultimate load carrying capacity of a panel. The buckling capacity is taken as the load that results in the first occurrence of membrane yield stress anywhere in the stiffened panel. In calculating this, load redistribution within the structure is taken into account. This redistribution of load is a result of elastic buckling of component plates, such as the plating between the stiffeners. For slender structures the capacity calculated using this method is typically higher than the ideal elastic buckling stress (minimum Eigen-value). For stocky panels, the first occurrence of membrane yield stress will occur before any load redistribution can occur, see below.~~

1.1.3.3 Method 2 buckling capacity does not accept load redistribution between structural components and refers to the minimum of value of the ideal elastic buckling stress and the Method 1 buckling capacity. Method 2 buckling capacity normally equals the same strength as Method 1 for stocky panels, while it is the ideal elastic buckling stress (minimum Eigen-value cut-off) for slender panels. By applying the ideal elastic buckling stress limitation, large elastic deflections and reduced in-plane stiffness will be avoided at higher buckling utilization levels.

~~Buckling capacity with no allowance for redistribution of load (Method 2). This defines the lower bound value of the buckling capacity. For slender structures, this is defined as the ideal elastic buckling stress. For more stocky structures, for which the ideal elastic buckling strength is high, the first occurrence of membrane yield stress will occur before any load redistribution can occur and hence gives the same buckling strength as the upper bound method, see above. In calculating the buckling strength, no internal redistribution of load is to be taken into account. Hence this is more conservative than the upper bound value given by Method 1 and ensures that the panel does not suffer large elastic deflections with consequent reduced in plane stiffness.~~

Rule Editorial:

Clean up of wording to avoid ambiguity.

5 STRENGTH ASSESSMENT (FEM) – BUCKLING PROCEDURE

5.2 Structural Modelling and Capacity Assessment Method

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.*

Rule Editorial:

Clarification that weighted average for plate thickness in capacity model is allowed also for S3 elements.

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

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

Note

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

Rule Clarification:

The idealisation given in Table D.5.1 is the default for the structures listed. The stiffened panel is however only applicable for stiffeners that are welded at the ends. For webframes the stiffened panel idealistaion is only to be used for configurations where the webstiffener is welded to the longitudinals. In case of sniped and or offset stiffeners the webframe is to be assessed using the un-stiffened panel option. Hence only plating between stiffeners is assessed.

Girders and stringers in the double bottom/double side are to be assessed as stiffened panels if the longitudinals are welded at the ends/are continuous. For other configurations e.g. sniped stiffeners the member is to be assessed as an un-stiffened panel.

The stiffened panel option is only applicable in case of regular stiffening. If openings are modelled the area around these are to be idealised using the un-stiffened panel option.

Transverse bulkheads are in general to be assessed as stiffened panels. Areas strengthened with buckling stiffeners are however assumed to be non-regular and to be assessed as a number of un-stiffened panels. Hence only plating between stiffeners is assessed.

Where the structural configuration of tight members such as tight floors, webframes and transverse bulkheads requires the use of un-stiffened panels as described above the assessment is to be performed with in-plane stresses and shear only, e.g. excluding pressure.