Common Structural Rules for Double Hull Oil Tankers, July 2008

Rule Change Notice No. 2
April 2010

Notes:

(1) These Rule Changes enter into force on 1st July 2010.

(2) The Rule amendments contained in this document are to the Common Structural Rules for Double Hull Oil Tankers, July 2008.

COMMON STRUCTURAL RULES FOR DOUBLE HULL OIL TANKERS, JULY 2008

RULE CHANGE NOTICE NO. 2

This document contains amendments within the following Sections of the Common Structural Rules for Double Hull Oil Tankers, July 2008. The amendments are effective on the dates shown:

Section	Paragraph/Figure/Table	Effective Date
Section 2	2.1.2.1	1 July 2010
Section 2	2.1.3.1(b)	1 July 2010
Section 2	3.1.7.4	1 July 2010
Section 4	Table 4.1.1	1 July 2010
Section 4	3.2.3.4 bis	1 July 2010
Section 4	Figure 4.3.4	1 July 2010
Section 4	3.4.2.1	1 July 2010
Section 6	1.2.3.1	1 July 2010
Section 6	Table 6.1.3	1 July 2010
Section 6	2.1.2.2	1 July 2010
Section 6	3.3.4.3	1 July 2010
Section 6	5.4.1.3	1 July 2010
Section 6	5.7.4.1	1 July 2010
Section 6	Table 6.5.4	1 July 2010
Section 8	1.1.2.2(a)	1 July 2010
Section 8	1.4.2.5	1 July 2010
Section 8	2.5.7.6	1 July 2010
Section 8	Table 8.2.3	1 July 2010
Section 8	2.5.7.9	1 July 2010
Section 8	2.6.1.1	1 July 2010
Section 8	2.6.1.2	1 July 2010
Section 8	2.6.1.8	1 July 2010
Section 8	6.2.2.5	1 July 2010
Section 8	6.2.3 & 6.2.3.1	1 July 2010
Section 8	6.2.4 & 6.2.4.1	1 July 2010
Section 8	6.2.5.4 bis	1 July 2010
Section 8	Table 8.6.2	1 July 2010
Section 8	6.4.7.5	1 July 2010
Section 9	Table 9.2.1	1 July 2010
Section 11	1.1.6.15	1 July 2010

Section	Paragraph/Figure/Table	Effective Date
Section 11	Table 11.1.5	1 July 2010
Section 11	3.1.2.15	1 July 2010
Section 11	3.1.2.18	1 July 2010
Section 11	3.1.3.7	1 July 2010
Section 11	3.1.4.21	1 July 2010
Section 11	3.1.5.12	1 July 2010
Section 11	3.1.6.13	1 July 2010
Section 11	Table 11.5.1	1 July 2010
Appendix A	2.1.1.1	1 July 2010
Appendix B	2.3.1.7	1 July 2010
Appendix B	Table B.2.4	1 July 2010
Appendix B	Table B.3.1	1 July 2010
Appendix B	4.3.1.2	1 July 2010
Appendix C	1.4.4.6	1 July 2010
Appendix C	1.4.4.8	1 July 2010
Appendix C	1.4.5.11	1 July 2010
Appendix C	2.4.2.6	1 July 2010
Appendix C	Figure C.2.2	1 July 2010
Appendix C	Figure C.2.3	1 July 2010

For technical background for Rule Changes in this present document, reference is made to separate document Technical Background for Rule Change Notice No. 2.

SECTION 2 – RULE PRINCIPLES

2 GENERAL ASSUMPTIONS

2.1 General

2.1.2 Classification Societies

2.1.2.1 ~~Classification Societies develop and publish the standards for the hull structure and essential engineering systems. Classification Societies undertake an audit during design, construction and operation of a ship to confirm compliance with the classification requirements and the applicable international regulations when authorised by a National Administration.~~ Classification Societies develop and publish the standards for the hull structure and essential engineering systems. Classification Societies verify compliance with the classification requirements and the applicable international regulations when authorised by a National Administration during design, construction and operation of a ship.

2.1.3 Responsibilities of Classification Societies, builders and owners

2.1.3.1

(part only shown)

(b) design aspects:

- ~~the classification society is responsible for a technical review of the design plans and related documents for a ship to verify compliance with the appropriate classification rules.~~ the classification society is responsible for a technical appraisal of the design plans and related documents for a ship to verify compliance with the appropriate classification rules.

3 DESIGN BASIS

3.1 General

3.1.7 External environment

3.1.7.1 To cover worldwide trading operations and also to deal with the uncertainty in the future trading pattern of the ship and the corresponding wave conditions that will be encountered, a severe wave environment is used for the design assessment. The rule requirements are based on a ship trading in the North Atlantic wave environment for its entire design life.

3.1.7.2 The effects of wind and current on the structure are considered to be negligible and hence are not explicitly included.

3.1.7.3 The Rules do not include the effects of ice.

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

(a) lowest daily mean temperature in air is ~~-15 ˚C~~ -10 ˚C

(b) 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.

SECTION 4 – BASIC INFORMATION

1 DEFINITIONS

1.8 Glossary

1.8.1 Definitions of terms

1.8.1.1 The terms in *Table 4.1.1* are used within these Rules to describe the items which their respective definitions describe.

(part only shown)

Table 4.1.1
Definitions of Terms

Terms	**Definition**
Deck house	~~A structure on the freeboard or superstructure deck not extending from side to side of the ship~~ A decked structure other than a superstructure, located on the freeboard deck or above.
Superstructure	~~A decked structure on the freeboard deck extending for at least 92 percent of the breadth of the ship~~ A decked structure on the freeboard deck, extending from side to side of the ship or with the side plating not being inboard of the shell plating more than 0.04B.

3 STRUCTURE DESIGN DETAILS

3.2 Termination of Local Support Members

3.2.3 Bracketed connections

3.2.3.1 At bracketed end connections, continuity of strength is to be maintained at the stiffener connection to the bracket and at the connection of the bracket to the supporting member. The brackets are to have scantlings sufficient to compensate for the non-continuous stiffener flange or non-continuous stiffener.

3.2.3.2 The arrangement of the connection between the stiffener and the bracket is to be such that at no point in the connection, the section modulus is less than that required for the stiffener.

3.2.3.3 Minimum net bracket thickness, $t_{bkt-net}$, is to be taken as:

$$t_{bkt-net} = \left(2 + f_{bkt}\sqrt{Z_{rl-net}}\right)\left(\sqrt{\frac{\sigma_{yd-stf}}{\sigma_{yd-bkt}}}\right)$$

mm, but is not to be less than 6mm and need not be greater than 13.5mm

Where:

f_{bkt} 0.2 for brackets with flange or edge stiffener
0.3 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

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

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

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 or with offset necessary to enable welding, 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*

3.2.3.4bis In case of different arm lengths the lengths of the arms, measured from the plating to the toe of the bracket, are to be such that the sum of them is greater than $2l_{bkt}$ and each arm not to be less than $0.8l_{bkt}$, where l_{bkt} is as defined in 3.2.3.4.

3.2.3.5 The proportions and edge stiffening of brackets are to be in accordance with the requirements of *Section 10/2.4*. Where an edge stiffener is required, the depth of stiffener web, d_w, is not to be less than:

$$d_w = 45\left(1 + \frac{Z_{rl-net}}{2000}\right)$$ mm, but is not to be less than 50mm

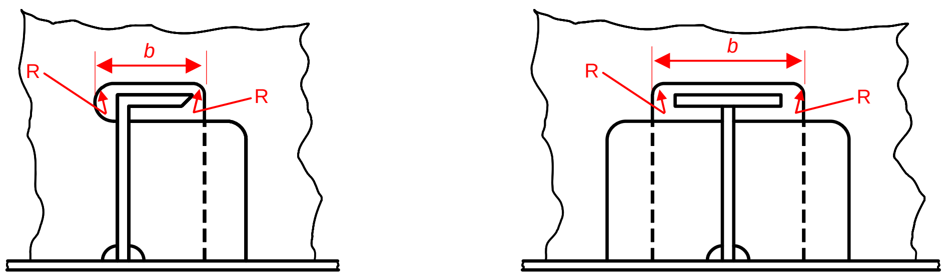
Where:

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

3.4 Intersections of Continuous Local Support Members and Primary Support Members

3.4.1 General

Figure 4.3.4
Collars for Cut-outs in Areas of High Stress



R=0,2*b*
(min. 25 mm)

3.4.2 Details of cut-outs

3.4.2.1 ~~Cut-outs~~ In general, cut-outs are to have rounded corners and the corner radii, *R*, are to be as large as practicable, with a minimum of 20 percent of the breadth, *b*, of the cut-out or 25mm, whichever is greater, but need not be greater than 50mm, see *Figure 4.3.4*. Consideration will be given to other shapes on the basis of maintaining equivalent strength and minimizing stress concentration.

SECTION 6 – MATERIALS AND WELDING

1 STEEL GRADES

1.2 Application of Steel Materials

1.2.3 Operation in areas with low air temperature

1.2.3.1 For ships intended to operate for long periods in areas with a lowest daily mean air temperature below ~~–15 degrees C~~ –10 degrees C (i.e. regular service during winter to Arctic or Antarctic waters) the materials in exposed structures will be specially considered.

Table 6.1.3
Material Class or Grade of Structural Members

Structural member category	**Material Class or Grade**	
	Within 0.4*L* Amidships	**Outside 0.4*L***
Secondary Longitudinal bulkhead strakes, other than those belonging to primary category Deck plating exposed to weather other than that belonging to primary or special category Side plating	Class I	Grade A(8)/AH
Primary Bottom plating including keel plate Strength deck plating, excluding that belonging to the special category (10)(11) Continuous longitudinal members above strength deck, excluding longitudinal hatch coamings (11) Uppermost strake in longitudinal bulkheads (10) Vertical strake (hatch side girder) and upper sloped strake in top wing tank	Class II	Grade A(8) /AH
Special Sheer strake at strength deck (1)(2)(3)(10)(11) Stringer plate in strength deck (1)(2)(3)(10)(11) Deck strake at longitudinal bulkhead (2)(4)(10)(11) Strength deck plating at outboard corners of cargo hatch openings (11) Bilge strake (2)~~(5)~~(6) Continuous longitudinal hatch coamings (11)	Class III	Class II (Class I outside 0.6*L* amidships)
Other Categories Plating for stern frames, rudder horns~~, rudders~~ and shaft brackets ~~(7)~~	–	Class II
Longitudinal strength members of strength deck plating for ships with single strength deck (11)	Grade B/AH	-
Strength members not referred to in above categories (9)	Grade A(8) /AH	Grade A(8) /AH

Note
1. Not to be less than E/EH within 0.4*L* amidships in vessels with length, *L*, exceeding 250m.
2. Single strakes required to be of material class III or E/EH are, within 0.4*L* amidships, to have breadths not less than 800 + 5*L* mm, but need not be greater than 1800mm.
3. A radius gunwale plate may be considered to meet the requirements for both the stringer plate and the sheer strake, provided it extends generally 600mm inboard and vertically.
4. For tankers having a breadth, *B*, exceeding 70m, the centreline strake and the strakes in way of the longitudinal bulkheads port and starboard, are to be class III.
5. ~~May be class II in vessels with a double bottom over the full breadth, *B*, and with a length, *L*, less than 150m.~~ (void)
6. To be not lower than D/DH within 0.6*L* amidships of vessels with length, *L*, exceeding 250m.
7. ~~For rudder and rudder body plates subjected to stress concentrations (e.g. in way of lower support of semi-spade rudders or at upper part of spade rudders) class III is to be applied.~~ (void)
8. Grade B/AH to be used for plate thickness more than 40mm. However, engine foundation heavy plates outside 0.6*L* amidships may be of Grade A/AH.
9. The material class used for reinforcement and the quality of material (i.e. whether normal or higher strength steel) used for welded attachments, such as spill protection bars and bilge keel, is to be similar to that of the hull envelope plating in way. Where attachments are made to round gunwale plates, special consideration will be given to the required grade of steel, taking account of the intended structural arrangements and attachment details.
10. The material class for deck plating, sheer strake and upper strake of longitudinal bulkhead within 0.4*L* amidships is also to be applied at structural breaks of the superstructure, irrespective of position.
11. To be not lower than B/AH within 0.4*L* amidships for ships with single strength deck.

2 CORROSION PROTECTION INCLUDING COATINGS

2.1 Hull Protection

2.1.2 Internal cathodic protection systems

2.1.2.1 When a cathodic protection system is to be fitted to steel structures in tanks used for liquid cargo with flash point below 60°C, a plan of the fitting arrangement is to be submitted for approval. The arrangements will be considered for safety against fire and explosion. This approval also applies to adjacent tanks.

2.1.2.2 Permanent anodes in tanks made of, or alloyed with magnesium are not acceptable, except in tanks solely intended for water ballast that are not adjacent to cargo tanks. Impressed current systems are not to be used in cargo tanks due to the development of chlorine and hydrogen that can result in an explosion. Aluminium anodes are accepted, however, in tanks with liquid cargo with flash point below 60°C and in adjacent ballast tanks, aluminium anodes are to be located so a kinetic energy of not more than 275J is developed in the event of their loosening and becoming detached.

2.1.2.3 Aluminium anodes are to be located in such a way that they are protected from falling objects. They are not to be located under tank hatches or Butterworth openings unless protected by adjacent structure.

2.1.2.4 All anodes are to be attached to the structure in such a way that they will remain securely fastened both initially and during service. The following methods are acceptable:

(a) steel core connected to the structure by continuous fillet welds of sufficient cross section

(b) attachment by properly secured through-bolts or other positive locking devices.
Attachment by clamps fixed with setscrews is to be by approved means.

2.1.2.5 Anode steel cores bent and directly welded to the steel structure are to be of a material complying with the requirements for grade A of the Rules for Materials of the individual Classification Society.

2.1.2.6 Anodes are to be attached to stiffeners or aligned in way of stiffeners on plane bulkhead plating, but they are not to be attached to the shell. The two ends are not to be attached to separate members which are capable of relative movement.

2.1.2.7 Where cores or supports are welded to local support members or primary support members, they are to be kept clear of end supports, toes of brackets and similar stress raisers. Where they are welded to asymmetrical members, the welding is to be at least 25mm away from the edge of the web. In the case of stiffeners or girders with symmetrical face plates, the connection may be made to the web or to the centreline of the face plate, but well clear of the free edges. Generally, anodes are not to be fitted to a face plate of higher strength steel.

2.1.2.8 Tanks in which anodes are installed, are to have sufficient holes for the circulation of air to prevent gas from collecting in pockets.

3 CORROSION ADDITIONS

3.3 Application of Corrosion Additions

3.3.4 Application of corrosion additions for scantling strength assessment of primary support members

3.3.4.1 The required gross thickness of primary support members is calculated by adding half the corrosion addition, i.e. $+0.5t_{corr}$, to the net thickness required in accordance with the strength requirements in *Section 8/2.6* and *8/3* to *8/7*.

3.3.4.2 The net sectional properties of primary support members are to be calculated by deducting half the corrosion addition, i.e. $-0.5t_{corr}$, from the web and flange gross thicknesses, and are to comply with the required section modulus, moment of inertia and area as given in *Section 8/2.6* and *8/3* to *8/7*.

3.3.4.3 The required minimum gross thickness of primary support members is calculated by adding the full corrosion addition, i.e. $+1.0t_{corr}$, to the minimum net thickness requirement given in *Section 8/2.1.6.1, 8/3.1.4.1, 8/4.1.5.1, 8/5.1.4.1, 8/6.3.7.5, 8/6.4.5.4* and *10/2.3*.

5 WELD DESIGN AND DIMENSIONS

5.4 Lapped Joints

5.4.1 General

5.4.1.1 Overlaps may be adopted for end connections where the connection is not subject to high tensile or compressive loading.

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 gross thickness of the lug but need not be greater than 50mm. The joints are to be positioned to allow adequate access for completion of sound welds.

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

5.7 Determination of the Size of Welds

5.7.4 Welding of end connections of primary support members

5.7.4.1 Welding of end connections of primary support members (i.e. transverse frames and girders) is to be such that the weld area, A_{weld}, is to be equivalent to the Rule gross cross-sectional area of the member. In terms of weld leg length, l_{leg}, this is to be taken as by:

$$l_{leg} = 1.41 f_{yd} \frac{h_w t_{p-grs}}{l_{dep}} \quad \text{mm}$$

Where:

h_w web height of primary support member, in mm, see *Figure 6.5.10*

t_{p-grs} rule gross thickness of the primary support member, in mm

l_{dep} total length of deposit of weld metal, in mm. Generally this can be taken as twice l_{weld} shown in *Figure 6.5.10* for a double continuous fillet weld

f_{yd} correction factor taking into account the yield strength of the weld deposit, as defined in *5.7.1.2*

In no case is the size of weld to be less than that calculated in accordance with *5.7.1.2*, using a minimum weld factor, ~~f_1~~ f_{weld}, of 0.48 in tanks or 0.38 elsewhere.

Table 6.5.4
Connection of Primary Support Members

Primary Support Member gross face area, in cm^2		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 Remainder	0.20 0.12	0.26 0.20	0.20 0.12	0.20 0.15
30.0	65.0	At ends Remainder	0.20 0.12	0.38 0.26	0.20 0.12	0.20 0.15
65.0	95.0	At ends Remainder	0.42 0.30 (2)	0.59 (3) 0.42	0.20 0.15	0.30 0.20
95.0	130.0	At ends Remainder	0.42 0.30 (2)	0.59 (3) 0.42	0.30 0.20	0.42 0.30
130.0		At ends Remainder	0.59 (3) 0.42	0.59 (3) 0.42	0.42 0.30	0.59 (3) 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*.

SECTION 8 – SCANTLING REQUIREMENTS

1 LONGITUDINAL STRENGTH

1.1 Loading Guidance

1.1.2 Loading Manual

1.1.2.2 The following loading conditions and design loading and ballast conditions upon which the approval of the hull scantlings is based are, as a minimum, to be included in the Loading Manual:

(a) Seagoing conditions including both departure and arrival conditions

- homogeneous loading conditions including a condition at the scantling draft (homogeneous loading conditions shall not include filling of dry and clean ballast tanks)
- a normal ballast condition where:
  - the ballast tanks may be full, partially full or empty. Where partially full options are exercised, the conditions in *1.1.2.5* are to be complied with
  - all cargo tanks are to be empty including cargo tanks suitable for the carriage of water ballast at sea
  - the propeller is to be fully immersed, and
  - the trim is to be by the stern and is not to exceed 0.015*L*, where *L* is as defined in *Section 4/1.1.1*
- a heavy ballast condition where:
  - the draught at the forward perpendicular is not to be less than that for the normal ballast condition
  - ballast tanks in the cargo tank region or aft of the cargo tank region may be full, partially full or empty. Where the partially full options are exercised, the conditions in 1.1.2.5 are to be complied with
  - the fore peak water ballast tank is to be full. If upper and lower fore peak water ballast tanks are fitted, the lower is required to be full. The upper fore peak tank may be full, partially full or empty.
    If upper and lower fore peak tanks are fitted and only one of them is designated as water ballast tank, the other may be empty.
  - all cargo tanks are to be empty including cargo tanks suitable for the carriage of water ballast at sea
  - the propeller is to be fully immersed
  - the trim is to be by the stern and is not to exceed 0.015*L*, where *L* is as defined in *Section 4/1.1.1*
- any specified non-uniform distribution of loading
- conditions with high density cargo including the maximum design cargo density, when applicable
- mid-voyage conditions relating to tank cleaning or other operations where these differ significantly from the ballast conditions
- conditions covering ballast water exchange procedures with the calculations of the intermediate conditions just before and just after ballasting and/or deballasting any ballast tank

(b) Harbour/sheltered water conditions

- conditions representing typical complete loading and unloading operations
- docking condition afloat

- propeller inspection afloat condition, in which the propeller shaft centre line is at least $D_{prop}/4$ above the waterline in way of the propeller, where D_{prop} is the propeller diameter

(c) Additional design conditions

- a design ballast condition in which all segregated ballast tanks in the cargo tank region are full and all other tanks are empty including fuel oil and fresh water tanks.

Guidance Note

The design condition specified in (c) is for assessment of hull strength and is not intended for ship operation. This condition will also be covered by the *IMO 73/78 SBT* condition provided the corresponding condition in the Loading Manual only includes ballast in segregated ballast tanks in the cargo tank region.

1.4 Hull Girder Buckling Strength

1.4.2 Buckling assessment

1.4.2.5 The design hull girder shear stress for the buckling assessment, $\tau_{hg-net50}$, is to be calculated based on net hull girder sectional properties and is to be taken as:

$$\tau_{hg-net50} = \left| \left(Q_{sw-perm-sea} + Q_{wv}\right)\left(\frac{1000 q_v}{t_{ij-net50}}\right) \right| \quad \text{N/mm}^2$$

Where:

$Q_{sw-perm-sea}$ positive and negative still water permissible shear force for seagoing operation, in kN, as defined in *Section 7/2.1.3*

Q_{wv} positive or negative vertical wave shear, in kN, as defined in *Section 7/3.4.3.*

Q_{vw} is to be taken as:

Q_{wv-pos} for assessment with the positive permissible still water shear force

Q_{wv-neg} for assessment with the negative permissible still water shear force

$t_{ij-net50}$ net thickness for the plate ij, in mm

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

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

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

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

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

q_v unit shear per mm for the plate being considered as defined in *1.3.2.2*

Note

1. Maximum of the positive shear (still water + wave) and negative shear (still water + wave) is to be used as the basis for calculation of design shear stress
2. All plate elements ij that contribute to the hull girder shear capacity are to be assessed. See also *Table 8.1.4* and *Figure 8.1.2*
3. The gross rule required thicknesses is to be calculated considering shear force correction.
4. For longitudinal bulkheads between cargo tanks, $t_{ij-net50}$ is to be taken as $t_{sfc-net50}$ and t_{str-k} as appropriate.

2 CARGO TANK REGION

2.5 Bulkheads

2.5.7 Vertically corrugated bulkheads

2.5.7.6 The net section modulus at the lower and upper ends and at the mid length of the corrugation ($l_{cg}/2$) of a unit corrugation, $Z_{cg\text{-}net}$, are to be taken as the greatest value calculated for all applicable design load sets, as given in *Table 8.2.7*, and given by the following. ~~This requirement is not applicable to corrugated bulkheads without a lower stool, see 2.5.7.9.~~

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

Where:

M_{cg} $= \dfrac{C_i |P| s_{cg}\, l_o^{\,2}}{12000}$ kNm

P $= \dfrac{P_u + P_l}{2}$ kN/m²

P_l, P_u design pressure for the design load set being considered, calculated at the lower and upper ends of the corrugation, respectively, in kN/m²:

(a) for transverse corrugated bulkheads, the pressures are to be calculated at a section located at $b_{tk}/2$ from the longitudinal bulkheads of each tank

(b) for longitudinal corrugated bulkheads, the pressures are to be calculated at the ends of the tank, i.e., the intersection of the forward and aft transverse bulkheads and the longitudinal bulkhead

b_{tk} maximum breadth of tank under consideration measured at the bulkhead, in m

s_{cg} spacing of corrugation, in mm. See *Figure 8.2.3*

l_o effective bending span of the corrugation, measured from the mid depth of the lower stool to the mid depth of the upper stool, or upper end where no upper stool is fitted, in m, see *Figure 8.2.3*

l_{cg} length of corrugation, which is defined as the distance between the lower stool and the upper stool or the upper end where no upper stool is fitted, in m, see *Figure 8.2.3*

C_i the relevant bending moment coefficients as given in *Table 8.2.3*

$C_{s\text{-}cg}$ permissible bending stress coefficient

at the mid length of the corrugation length, l_{cg}:

= c_e, but not to be taken as greater than 0.75 for acceptance criteria set AC1

= c_e, but not to be taken as greater than 0.90 for acceptance criteria set AC2

at the lower and upper ends of corrugation length, l_{cg}:

= 0.75 for acceptance criteria set AC1

= 0.90 for acceptance criteria set AC2

c_e $= \frac{2.25}{\beta} - \frac{1.25}{\beta^2}$ for ® ≥ 1.25

$= 1.0$ for ® < 1.25

β $= \frac{b_f}{t_{f-net}} \sqrt{\frac{\sigma_{yd}}{E}}$

b_f breadth of flange plating, in mm, see *Figure 8.2.3*

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

E modulus of elasticity, in N/mm²

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

Table 8.2.3
Values of C_i

Bulkhead	At lower end of l_{cg}	At mid length of l_{cg}	At upper end of l_{cg}
Transverse Bulkhead	C_1	C_{m1}	$0.80C_{m1}$
Longitudinal Bulkhead	C_3	C_{m3}	$0.65C_{m3}$

Where:

C_1 $= a_1 + b_1 \sqrt{\frac{A_{dt}}{b_{dk}}}$ but is not to be taken as less than 0.60

$= a_1 - b_1 \sqrt{\frac{A_{dt}}{b_{dk}}}$ for transverse bulkhead with no lower stool, but is not to be taken as less than 0.55

a_1 $= 0.95 - \frac{0.41}{R_{bt}}$

$= 0.6$ for transverse bulkhead with no lower stool

b_1 $= -0.20 + \frac{0.078}{R_{bt}}$

$= 0.13$ for transverse bulkhead with no lower stool

C_{m1} $= a_{m1} + b_{m1} \sqrt{\frac{A_{dt}}{b_{dk}}}$ but is not to be taken as less than 0.55

$= a_{m1} - b_{m1} \sqrt{\frac{A_{dt}}{b_{dk}}}$ for transverse bulkhead with no lower stool, but is not to be taken as less than 0.60

a_{m1} $= 0.63 + \frac{0.25}{R_{bt}}$

$= 0.96$ for transverse bulkhead with no lower stool

b_{m1} $= -0.25 - \frac{0.11}{R_{bt}}$

$= 0.34$ for transverse bulkhead with no lower stool

C_3 $= a_3 + b_3 \sqrt{\frac{A_{dl}}{l_{dk}}}$ but is not to be taken as less than 0.60

$= a_3 - b_3 \sqrt{\frac{A_{dl}}{l_{dk}}}$ for longitudinal bulkhead with no lower stool, but is not to be taken as less than 0.55

a_3 $= 0.86 - \frac{0.35}{R_{bl}}$

$= 0.6$ for longitudinal bulkhead with no lower stool

Table 8.2.3 (Continued)
Values of C_i

b_3	$= -0.17 + \frac{0.10}{R_{bl}}$	
	$= 0.13$	for longitudinal bulkhead with no lower stool
C_{m3}	$= a_{m3} + b_{m3}\sqrt{\frac{A_{dl}}{l_{dk}}}$	but is not to be taken as less than 0.55
	$= a_{m3} - b_{m3}\sqrt{\frac{A_{dl}}{l_{dk}}}$	for longitudinal bulkhead with no lower stool, but is not to be taken as less than 0.60
a_{m3}	$= 0.32 + \frac{0.24}{R_{bl}}$	
	$= 0.9$	for longitudinal bulkhead with no lower stool
b_{m3}	$= -0.12 - \frac{0.10}{R_{bl}}$	
	$= 0.19$	for longitudinal bulkhead with no lower stool
R_{bt}	$= \frac{A_{bt}}{b_{ib}}\left(1+\frac{l_{ib}}{b_{ib}}\right)\left(1+\frac{b_{av-t}}{h_{st}}\right)$	for transverse bulkheads
R_{bl}	$= \frac{A_{bl}}{l_{ib}}\left(1+\frac{l_{ib}}{b_{ib}}\right)\left(1+\frac{b_{av-l}}{h_{sl}}\right)$	for longitudinal bulkheads
A_{dt}	cross sectional area enclosed by the moulded lines of the transverse bulkhead upper stool, in m^2 = 0 if no upper stool is fitted	
A_{dl}	cross sectional area enclosed by the moulded lines of the longitudinal bulkhead upper stool, in m^2 = 0 if no upper stool is fitted	
A_{bt}	cross sectional area enclosed by the moulded lines of the transverse bulkhead lower stool, in m^2	
A_{bl}	cross sectional area enclosed by the moulded lines of the longitudinal bulkhead lower stool, in m^2	
b_{av-t}	average width of transverse bulkhead lower stool, in m. See *Figure 8.2.3*	
b_{av-l}	average width of longitudinal bulkhead lower stool, in m. See *Figure 8.2.3*	
h_{st}	height of transverse bulkhead lower stool, in m. See *Figure 8.2.3*	
h_{sl}	height of longitudinal bulkhead lower stool, in m. See *Figure 8.2.3*	
b_{ib}	breadth of cargo tank at the inner bottom level between hopper tanks, or between the hopper tank and centreline lower stool, in m. See *Figure 8.2.3*	
b_{dk}	breadth of cargo tank at the deck level between upper wing tanks, or between the upper wing tank and centreline deck box or between the corrugation flanges if no upper stool is fitted, in m. See *Figure 8.2.3*	
l_{ib}	length of cargo tank at the inner bottom level between transverse lower stools, in m. See *Figure 8.2.3*	
l_{dk}	length of cargo tank at the deck level between transverse upper stools or between the corrugation flanges if no upper stool is fitted, in m. See *Figure 8.2.3*	

2.5.7.9 For ships with a moulded depth, see *Section 4/1.1.4*, less than 16m, the lower stool may be eliminated provided the following requirements, in addition to the requirements of 2.5.7.6, are complied with:

(a) general:

- double bottom floors or girders are to be fitted in line with the corrugation flanges for transverse or longitudinal bulkheads, respectively

- brackets/carlings are to be fitted below the inner bottom and hopper tank in line with corrugation webs. Where this is not practicable gusset plates with shedder plates are to be fitted, see item (c) below and *Figure 8.2.3*
- the corrugated bulkhead and its supporting structure is to be assessed by Finite Element (FE) analysis in accordance with *Section 9/2*. In addition the local scantlings requirements of *2.5.6.4* and *2.5.6.5* and the minimum corrugation depth requirement of *2.5.7.4* are to be applied.

(b) inner bottom and hopper tank plating:

- the inner bottom and hopper tank in way of the corrugation is to be of at least the same material yield strength as the attached corrugation

(c) supporting structure:

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

2.6 Primary Support Members

2.6.1 General

2.6.1.1 The ~~following requirements relate to the determination of~~ scantlings of the primary support members in the cargo tank region for the extents shown in *Figure 8.2.4* <u>are to be in accordance with the requirements of *2.6.1.2* to *2.6.1.7*</u>.

2.6.1.2 The section modulus and shear area criteria for primary support members contained in *2.6* apply to structural configurations shown in *Figure 2.3.1* and are applicable to the following structural elements:

(a) floors and girders within the double bottom;

(b) deck transverses fitted below the upper deck;

(c) side transverses within double side structure;

(d) vertical web frames on longitudinal bulkheads with or without cross ties;

(e) horizontal stringers on transverse bulkheads, except those fitted with buttresses or other intermediate supports; and

(f) cross ties in wing cargo and centre cargo tanks.

~~The section modulus and shear area criteria for primary support members of structural configurations other than those listed above are to be obtained by calculation methods as described in *Section 8/7*.~~

2.6.1.3 The scantlings of primary support members are to be verified by the Finite Element (FE) cargo tank structural analysis defined in *Section 9/2*.

2.6.1.4 The section modulus and/or shear area of a primary support member and/or the cross sectional area of a primary support member cross tie may be reduced to 85% of the prescriptive requirements provided that the reduced scantlings comply with the FE cargo tank structural analysis and with *2.1.6*.

2.6.1.5 In general, primary support members are to be arranged in one plane to form continuous transverse rings. Brackets forming connections between primary support members of the ring are to be designed in accordance with *Section 4/3.3.3*.

2.6.1.6 Webs of the primary support members are to be stiffened in accordance with *Section 10/2.3*.

2.6.1.7 Webs of the primary support members are to have a depth of not less than given by the requirements of *2.6.4.1*, *2.6.6.1* and *2.6.7.1*, as applicable. Lesser depths may be accepted where equivalent stiffness is demonstrated. See *3/5.3.3.4*. Primary support members that have open slots for stiffeners are to have a depth not less than 2.5 times the depth of the slots.

2.6.1.8 The scantlings of the first primary support members from the transverse bulkhead are to be in accordance with *Section 8/7, 2.6.1.3, 2.6.1.4, 2.6.1.5, 2.6.1.6, 2.6.4.3* and *2.6.4.4*. In the application of 2.6.4.3 and 2.6.4.4 only the design green sea pressure is to be considered.

6 EVALUATION OF STRUCTURE FOR SLOSHING AND IMPACT LOADS

6.2 Sloshing in Tanks

6.2.2 Application of sloshing pressure

6.2.2.1 The following tanks are to be assessed for the design sloshing pressures $P_{slh-lng}$ and P_{slh-t} in accordance with *6.2.2.2* to *6.2.2.5*:

(a) cargo and slop tanks

(b) fore peak and aft peak ballast tanks

(c) other tanks which allow free movement of liquid, except as follows:

- where the effective sloshing length is less than $0.03L$, calculations involving $P_{slh-lng}$ are not required and
- where the effective sloshing breadth is less than $0.32B$, calculations involving P_{slh-t} are not required.

The design sloshing pressure for other tanks mentioned in *6.2.1.2* is to be taken as the minimum sloshing pressure, $P_{slh-min}$, as defined in *Section 7/4.2.4.*

6.2.2.2 The design sloshing pressure due to longitudinal liquid motion, $P_{slh-lng}$, as defined in *Section 7/4.2.2.1* is to be applied to the following members as shown in *Figure 8.6.1*:

(a) transverse tight bulkheads

(b) transverse wash bulkheads

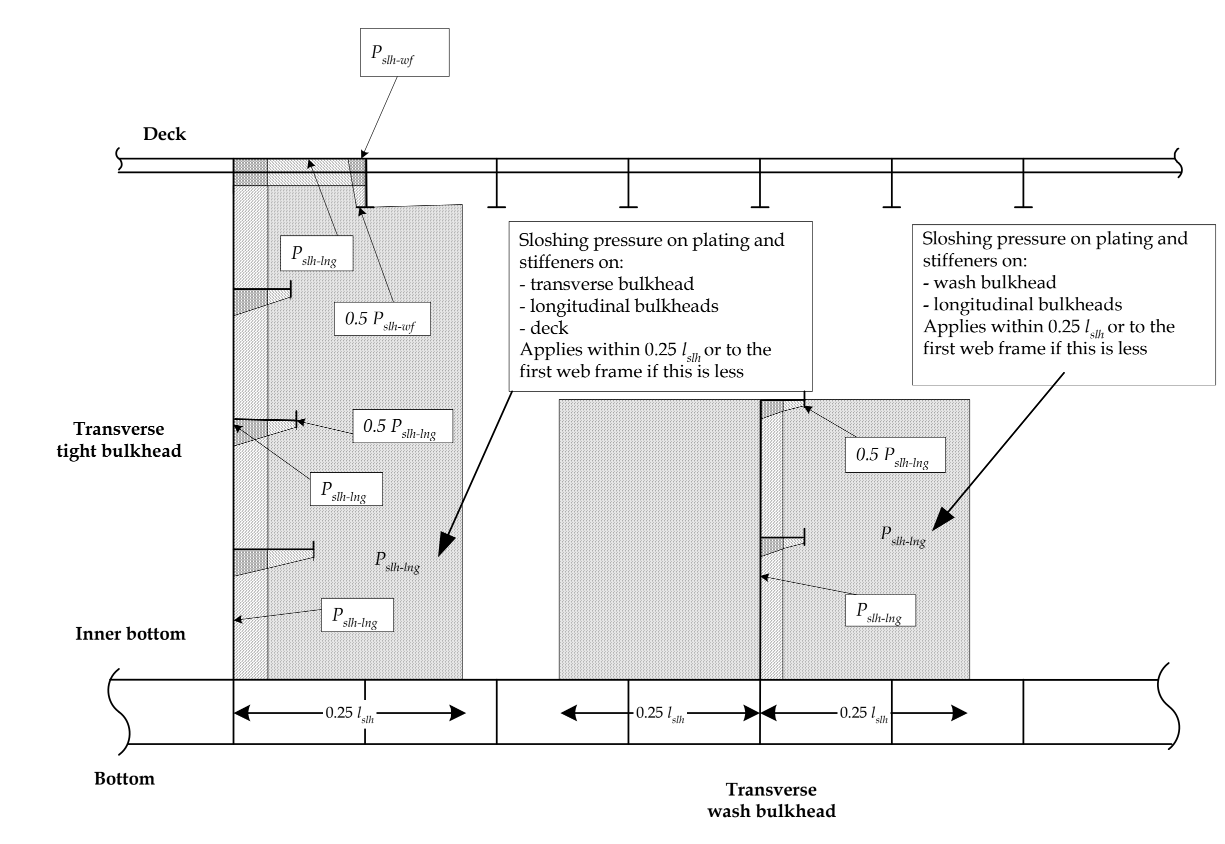
(c) stringers on transverse tight and wash bulkheads

(d) plating and stiffeners on the longitudinal bulkheads, deck and inner hull which are between the transverse bulkhead and the first web frame from the bulkhead or the bulkhead and $0.25l_{slh}$, whichever is lesser.

6.2.2.3 In addition to *6.2.2.2*, the first web frame next to a transverse tight or wash bulkhead if the web frame is located within $0.25l_{slh}$ from the bulkhead, as shown in *Figure 8.6.1*, is to be assessed for the web frame reflected sloshing pressure, P_{slh-wf}, as defined in *Section 7/4.2.2.5*.

6.2.2.4 The minimum sloshing pressure, $P_{slh-min}$, as defined in *Section 7/4.2.4* is to be applied to all other members.

Figure 8.6.1
Application of Sloshing Loads due to Longitudinal Liquid Motion



6.2.2.5 The design sloshing pressure due to transverse liquid motion, P_{shl-t}, as defined in *Section 7/4.2.3.1*, is to be applied to the following members as shown in *Figure 8.6.2*:

(a) longitudinal tight bulkhead

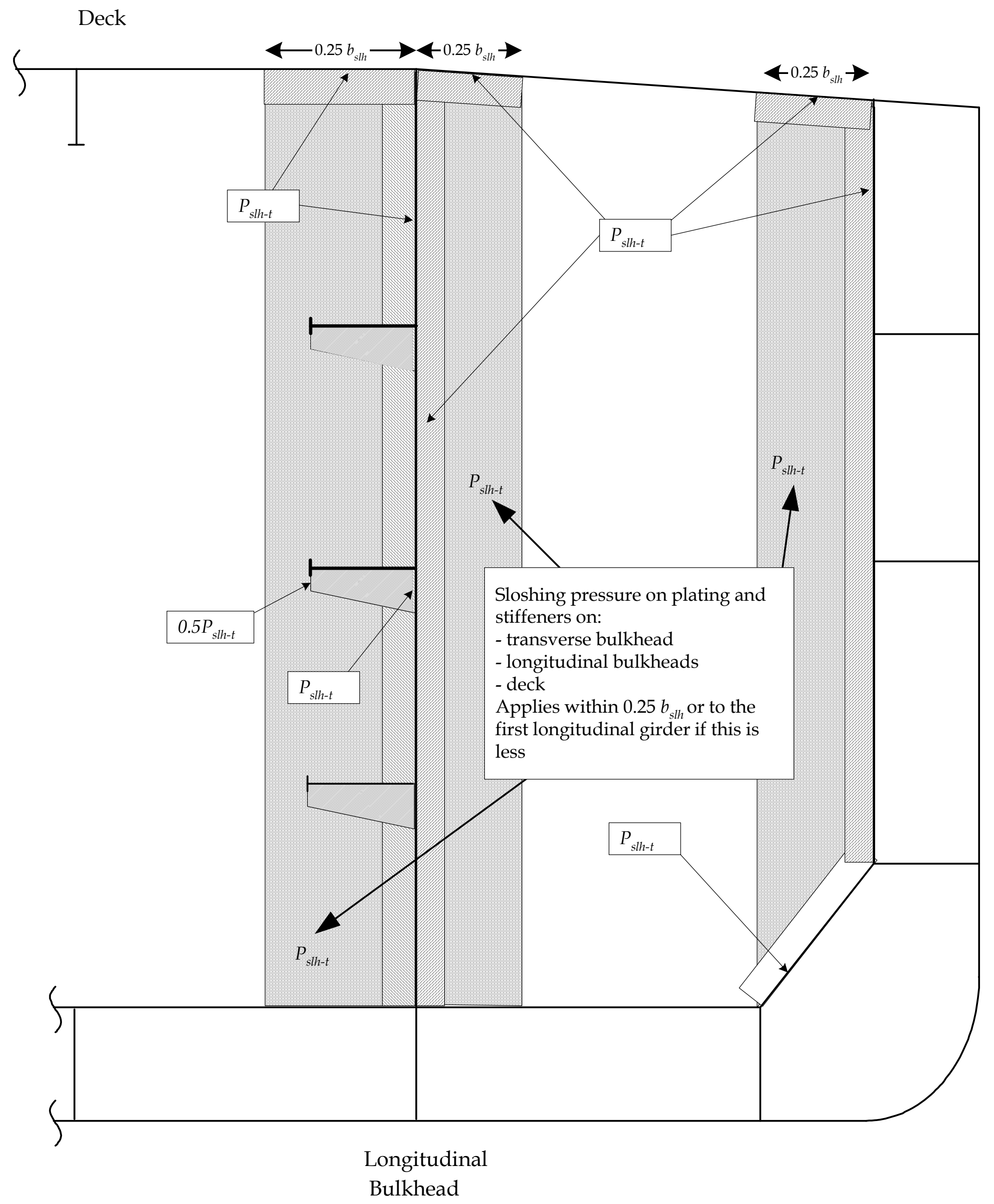
(b) longitudinal wash bulkhead

(c) horizontal stringers ~~and vertical webs~~ on longitudinal tight and wash bulkheads

(d) plating and stiffeners on the transverse tight bulkheads including stringers and deck which are between the longitudinal bulkhead and the first girder from the bulkhead or the bulkhead and $0.25b_{slh}$ whichever is lesser.

6.2.2.6 In addition to *6.2.2.5*, the first girder next to longitudinal tight or wash bulkhead if the girder is located within $0.25b_{slh}$ from the longitudinal bulkhead, as shown in *Figure 8.6.2*, is to be assessed for the reflected sloshing pressure, $P_{slh-grd}$ as defined in *Section 7/4.2.3.5*.

Figure 8.6.2
Application of Sloshing Loads due to Transverse Liquid Motion



6.2.2.7 The minimum sloshing pressure, $P_{slh-min}$, as defined in *Section 7/4.2.4*, is to be applied to all other members.

6.2.2.8 The sloshing pressures due to transverse and longitudinal fluid motion are assumed to act independently. Structural members are therefore to be evaluated based on the greatest sloshing pressure due to longitudinal and transverse fluid motion.

6.2.3 Sloshing assessment of plating forming tank boundaries and wash bulkheads

6.2.3.1 The net thickness of plating forming tank boundaries and wash bulkheads, t_{net}, subjected to sloshing pressures is not to be less than:

$$t_{net} = 0.0158\alpha_p s\sqrt{\frac{P_{slh}}{C_a \sigma_{yd}}} \quad \text{mm}$$

Where:

α_p correction factor for the panel aspect ratio

$$= 1.2 - \frac{s}{2100\, l_p}$$ but not to be taken as greater than 1.0

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

l_p length of plate panel, to be taken as the spacing of primary support members, S, unless carlings are fitted, in m

P_{slh} the greater of $P_{slh-lng}$, P_{slh-t} or $P_{slh-min}$ as specified in *6.2.2*

C_a permissible plate bending stress coefficient as given in *Table 8.6.1*

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

6.2.4 Sloshing assessment of stiffeners on tank boundaries and wash bulkheads

6.2.4.1 The net section modulus, Z_{net}, of stiffeners on tank boundaries and wash bulkheads subjected to sloshing pressures is not to be less than:

$$Z_{net} = \frac{P_{slh}\, s\, l_{bdg}^{\,2}}{f_{bdg}\, C_s\, \sigma_{yd}} \quad \text{cm}^3$$

Where:

l_{bdg} effective bending span, of stiffener, as defined in *Section 4/2.1*, in m

C_s permissible bending stress coefficient as given in *Table 8.6.2*

P_{slh} the greater of $P_{slh-lng}$, P_{slh-t} or $P_{slh-min}$ as specified in *6.2.2*

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

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

f_{bdg} bending moment factor:

= 12 for stiffeners fixed against rotation at each end. This is generally to be applied for scantlings of all continuous stiffeners

= 8 for stiffeners with one or both ends not fixed against rotation. This is generally to be applied to discontinuous stiffeners

for other configurations the bending moment factor may be taken as given in *Table 8.3.5*

6.2.5 Sloshing assessment of primary support members

6.2.5.1 Web plating, web stiffeners and tripping brackets on stringers, girders and web frames in cargo and ballast tanks are to be assessed based on sloshing pressures as given in *6.2.2*.

6.2.5.2 The web plating net thickness of primary support members, t_{net}, is not to be less than:

$$t_{net} = 0.0158\, \alpha_p\, s \sqrt{\frac{P_{slh}}{C_a \sigma_{yd}}} \quad \text{mm}$$

Where:

α_p correction factor for the panel aspect ratio

$$= 1.2 - \frac{s}{2100\, l_p}$$ but not to be taken as greater than 1.0

s	stiffener spacing, in mm, as defined in *Section 4/2.2*
l_p	length of plate panel, mean spacing between local support members on the long edges of the panel, typically between tripping brackets, in m
P_{slh}	the greater of $P_{slh-lng}$, P_{slh-t}, P_{slh-wf}, $P_{slh-grd}$ or $P_{slh-min}$ as specified in *6.2.2*. The pressure is to be calculated at the load application point, defined in *Section 3/5.1.2*, taking into account the distribution over the height of the member, as shown in *Figure 8.6.1*
C_a	permissible plate bending stress coefficient as given in *Table 8.6.1*
σ_{yd}	specified minimum yield stress of the material, in N/mm^2

6.2.5.3 The net section modulus, Z_{net}, of each individual stiffener on the web plating of primary support members subjected to sloshing pressures is not to be less than:

$$Z_{net} = \frac{P_{slh}\ s\ l_{bdg}^{\ 2}}{f_{bdg}\ C_s\ \sigma_{yd}} \quad \text{cm}^3$$

Where:

P_{slh}	the greater of $P_{slh-lng}$, P_{slh-t}, P_{slh-wf}, $P_{slh-grd}$ or $P_{slh-min}$ as specified in *6.2.2*. The pressure is to be calculated at the load application point taking into account the distribution over the height of the member, as shown in *Figure 8.6.1* and *8.6.2.*
s	stiffener spacing, in mm, as defined in *Section 4/2.2*
l_{bdg}	effective bending span, in m, of web stiffener as defined in *Section 4/2.1*
C_s	permissible bending stress coefficient as given in *Table 8.6.2*
f_{bdg}	bending moment factor = 12 for stiffeners fixed against rotation at each end. This is generally to be applied for scantlings of all continuous stiffeners = 8 for stiffeners with one or both ends not fixed against rotation. This is generally to be applied to discontinuous stiffeners for other configurations the bending moment factor may be taken as given in *Table 8.3.5*
σ_{yd}	specified minimum yield stress of the material, in N/mm^2

6.2.5.4 The net section modulus, Z_{net}, in way of the base of tripping brackets supporting primary support members in cargo and ballast tanks is not to be less than:

$$Z_{net} = \frac{1000\,P_{slh}\ s_{trip}\ l_{trip}^2}{2\,C_s\,\sigma_{yd}} \quad \text{cm}^3$$

Where:

P_{slh}	the greater of $P_{slh-lng}$, P_{slh-t}, P_{slh-wf}, $P_{slh-grd}$ and $P_{slh-min}$ as defined in *6.2.2*. The average pressure may be calculated at mid point of the tripping bracket taking into account the distribution as shown in *Figure 8.6.1* and *8.6.2*
s_{trip}	mean spacing, between tripping brackets or other primary support members or bulkheads, in m
l_{trip}	length of tripping bracket, see *Figure 8.6.3,* in m
C_s	permissible bending stress coefficient for tripping brackets = 0.75

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

6.2.5.4 bis The effective breadth of the attached plate to be used for calculating the section modulus of the tripping bracket supporting primary support members is to be taken as 1/3 the length of the tripping bracket, l_{trip}, as given in *8/6.2.5.4*.

6.2.5.5 The net shear area, $A_{shr-net}$, after deduction of cut-outs and slots, of tripping brackets supporting primary support members in cargo and ballast tanks is not to be less than:

$$A_{shr-net} = 10\frac{P_{slh}\, s_{trip}\, l_{trip}}{C_t \tau_{yd}} \quad \text{cm}^2$$

Where:

P_{slh} the greater of $P_{slh\text{-}lng}$, $P_{slh\text{-}t}$, $P_{slh\text{-}wf}$, $P_{slh\text{-}grd}$ and $P_{slh\text{-}min}$ as defined in *6.2.2*. The average pressure may be calculated at mid point of the tripping bracket taking into account the distribution as shown in *Figure 8.6.1* and *8.6.2*

s_{trip} mean spacing, between tripping brackets or other primary support members or bulkheads, in m

l_{trip} length of tripping bracket, see *Figure 8.6.3*, in m

C_t permissible shear stress coefficient, as given in *Table 8.6.3*

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

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

Figure 8.6.3
Effective Length of Tripping Bracket

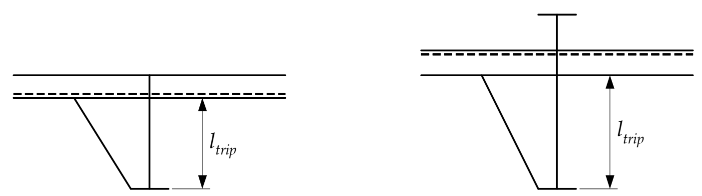


Table 8.6.2
Allowable Bending Stress Coefficient, C_s, for Assessment of Sloshing on Stiffeners

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 $C_{s\text{-}max}$

Where:

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

Acceptance Criteria Set	Structural Member		β_s	α_s	$C_{s\text{-}max}$
AC1	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	Longitudinal stiffeners	0.85	1.0	0.75
		Transverse or vertical stiffeners	0.7	0	0.7
	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		0.75	0	0.75

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

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

$M_{sw\text{-}perm\text{-}sea}$ 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*.~~

Stiffener Location	$M_{sw\text{-}perm\text{-}sea}$	
	Pressure acting on Plate Side	**Pressure acting on Stiffener Side**
Above Neutral Axis	Sagging SWBM	Hogging SWBM
Below Neutral Axis	Hogging SWBM	Sagging SWBM

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

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

6.4 Bow Impact

6.4.7 Primary support members

6.4.7.1 Primary support members in the bow impact region are to be configured to ensure effective continuity of strength and the avoidance of hard spots.

6.4.7.2 To limit the deflections under extreme bow impact loads and ensure boundary constraint for plate panels, the spacing, S, measured along the shell girth of web frames supporting longitudinal framing or stringers supporting transverse framing is not to be greater than:

$S = 3+0.008L_2$ m

Where:

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

6.4.7.3 End brackets of primary support members are to be suitably stiffened along their edge. Consideration is to be given to the design of bracket toes to minimise abrupt changes of cross-section.

6.4.7.4 Tripping arrangements are to comply with *Section 10/2.3.3*. In addition, tripping brackets are to be fitted at the toes of end brackets and at locations where the primary support member flange is knuckled or curved.

6.4.7.5 The net section modulus of each primary support member, Z_{net50}, is not to be less than:

$$Z_{net50} = 1000 \frac{f_{bdg-pt} P_{im}\, b_{slm} f_{slm}\, l_{bdg}^{\;2}}{f_{bdg} C_s \sigma_{yd}} \quad \text{cm}^3$$

Where:

f_{bdg-pt} correction factor for the bending moment at the ends and considering the patch load

$= 3 f_{slm}^{\;3} - 8 f_{slm}^{\;2} + 6 f_{slm}$

f_{slm} patch load modification factor

$= \frac{l_{slm}}{l_{bdg}}$

l_{slm} extent of bow impact load area along the span

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

A_{slm} bow impact load area, in m^2, as defined in *6.4.6.1*

l_{bdg} effective bending span, as defined in *Section 4/2.1.4*, in m

P_{im} bow impact pressure as given in *Section 7/4.4* and calculated at the load calculation point defined in *Section 3/5.3.3*, in kN/m^2

b_{slm} breadth of impact load area supported by the primary support member, to be taken as the spacing between primary support members as defined in *Section 4/2.2.2*, but not to be taken as greater than l_{slm}, in m

f_{bdg} bending moment factor

= 12 for primary support members with end fixed continuous face plates, stiffeners or where stiffeners are bracketed in accordance with *Section 4/3.3* at both ends

C_s permissible bending stress coefficient

= 0.8 ~~for acceptance criteria set AC3~~

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

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

$$A_{w-net50} = \frac{5 f_{pt} P_{im} b_{slm} l_{shr}}{C_t \tau_{yd}} \quad \text{cm}^2$$

Where:

f_{pt} patch load modification factor

$$= \frac{l_{slm}}{l_{shr}}$$

l_{slm} extent of bow impact load area along the span

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

l_{shr} effective shear span, as defined in *Section 4/2.1.2*, in m

P_{im} bow impact pressure as given in *Section 7/4.4* and calculated at the load calculation point defined in *Section 3/5.3.2*, in kN/m^2

b_{slm} breadth of impact load area supported by the primary support member, to be taken as the spacing between primary support members as defined in *Section 4/2.2.2*, but not to be taken as greater than l_{slm}, in m

C_t permissible shear stress coefficient

= 0.75 for acceptance criteria set AC3

τ_{yd} $= \frac{\sigma_{yd}}{\sqrt{3}}$ N/mm^2

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

6.4.7.7 The net web thickness of each primary support member, t_{w-net}, including decks/bulkheads in way of the side shell is not to be less than:

$$t_{w-net} = \frac{P_{im}\, b_{slm}}{\sin\varphi_w\, \sigma_{crb}} \quad \text{mm}$$

Where:

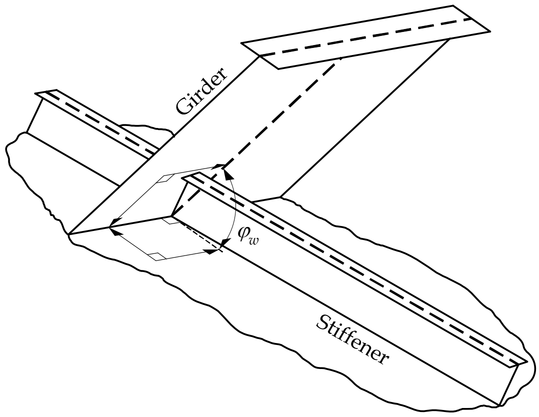
P_{im} bow impact pressure as given in *Section 7/4.4* and calculated at the load calculation point defined in *Section 3/5.3.*2 or at the intersection of the side shell with the deck/bulkhead, in kN/m^2

b_{slm} breadth of impact load area supported by the primary support member, to be taken as spacing between primary support members as defined in *Section 4/2.2.2*, but not to be taken as greater than l_{slm}, in m

φ_w angle, in degrees, between the primary support member web and the shell plate, see *Figure 8.6.7*

σ_{crb} critical buckling stress in compression of the web of the primary support member or deck/bulkhead panel in way of the applied load given by *Section 10/3.2.1*, in N/mm^2

Figure 8.6.7
Angle between Shell Primary Member and Shell Plate



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	$\lambda_y \leq 1.0$ (load combination S + D) $\lambda_y \leq 0.8$ (load combination S)
Structure on tank boundaries	
Plating of deck, sides, inner sides, hopper plate, bilge plate, plane and corrugated cargo tank longitudinal bulkheads. Tight floors, girders and webs	$\lambda_y \leq 0.9$ (load combination S + D) $\lambda_y \leq 0.72$ (load combination S)
Plating of inner bottom, bottom, plane transverse bulkheads and corrugated bulkheads.	$\lambda_y \leq 0.8$ (load combination S + D) $\lambda_y \leq 0.64$ (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. The yield utilisation factor for plane and corrugated 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. The water-tight bottom girder under the longitudinal bulkhead is to be treated as a tight structural member.

SECTION 11 – GENERAL REQUIREMENTS

1 HULL OPENINGS AND CLOSING ARRANGEMENTS

1.1 Shell and Deck Openings

1.1.6 Small hatches on the exposed fore deck

1.1.6.1 Openings to forward spaces as defined in *1.1.6.2* are to comply with the requirements of *1.1.6.3* to *1.1.6.14*.

1.1.6.2 These requirements apply to small hatches (generally openings 2.5m² or less) on the exposed deck within 0.25*L* from the F.P. and at a height less than 0.1*L* or 22m, whichever is less, from the summer load water line at the location of the hatch.

1.1.6.3 Hatches designed for emergency escape need not comply with *1.1.6.9(a), 1.1.6.9(b), 1.1.6.13* and *1 1.6.14*.

1.1.6.4 For small rectangular steel hatch covers, the plate thickness, stiffener arrangement and scantlings are to be in accordance with *Table 11.1.1* and *Figure 11.1.1*.

1.1.6.5 Stiffeners, where fitted, are to be aligned with the metal to metal contact points required by *1.1.6.10* and *1.1.6.11*. See also *Figure 11.1.1*. Primary stiffeners are to be continuous. All stiffeners are to be welded to the inner edge stiffener. See *Figure 11.1.2*.

1.1.6.6 The upper edge of the hatchway coaming is to be suitably reinforced by a horizontal member, normally not more than 190mm from the upper edge of the coaming.

1.1.6.7 For small hatch covers of circular or similar shape, the cover plate thickness and reinforcement is to provide strength and stiffness equivalent to the requirements for small rectangular hatches.

1.1.6.8 For small hatch covers constructed of materials other than normal strength steel, the required scantlings are to provide equivalent strength and stiffness.

1.1.6.9 The primary securing devices are to be such that the hatch cover can be secured in place and be made weathertight by means of a closing mechanism employing any one of the following methods:

(a) butterfly nuts tightening onto forks (clamps)
(b) quick acting cleats, or
(c) a central locking device.

Dogs (twist tightening handles) with wedges are not acceptable.

1.1.6.10 The hatch cover is to be fitted with a gasket of elastic material. This is to be designed to allow a metal to metal contact at a designed compression and to prevent over compression of the gasket by green sea forces that may cause the securing devices to be loosened or dislodged.

1.1.6.11 The metal to metal contacts are to be arranged close to each securing device as shown in *Figure 11.1.1*, and are to be of sufficient capacity to withstand the bearing force.

1.1.6.12 The primary securing method is to be designed and manufactured such that the designed compression pressure can be achieved by one person without the need for any tools.

1.1.6.13 For a primary securing method using butterfly nuts, the forks (clamps) are to be of robust design. They are to be designed to minimize the risk of butterfly nuts being dislodged while in use, by means of curving the forks upward and raising the surface on the free end, or a similar method. The gross plate thickness of unstiffened steel forks is not to be less than 16mm. An example arrangement is shown in *Figure 11.1.2*.

1.1.6.14 Small hatches on the exposed fore deck are to be fitted with an independent secondary securing device, e.g. by means of a sliding bolt, a hasp or a backing bar of slack fit, which is capable of keeping the hatch cover in place, even in the event that the primary securing device becomes loosened or dislodged. It is to be fitted on the side opposite to the hatch cover hinges.

1.1.6.15 For small hatch covers located on the exposed deck within the forward 0.25*L* from the F.P., the hinges are to be fitted such that the predominant direction of green sea will cause the cover to close, which means that the hinges are normally to be located on the fore edge.

1.3 Air Pipes

1.3.3 Details, arrangement and scantlings for air pipes

1.3.3.1 The wall thicknesses of air pipes, where exposed to weather, are not to be taken less than that given in *Table 11.1.4*.

Table 11.1.4
Minimum wall Thickness for Air Pipes

External diameter, in mm	Gross minimum wall thickness, in mm
$d_{air} \leq 80$	6.0
$d_{air} \geq 165$	8.5

Where:
d_{air} external diameter of pipe, in mm

Note
1. Intermediate values are to be obtained by linear interpolations.
2. See also *1.3.4* and *1.3.5* for ventilators in forward part of the ship.

1.3.3.2 For standard air pipes of 760mm in height, closed by heads of not more than the tabulated projected area, the minimum pipe thickness and bracket heights are to be as specified in *Table 11.1.5*. Where brackets are required, three or more radial brackets are to be fitted. In addition, the relevant requirements of *1.3.4* are to be applied.

1.3.3.3 Brackets are to have a gross thickness of 8mm or more, minimum length of 100mm, and height according to *Table 11.1.5*, but need not extend over the joint flange for the head. Bracket toes at the deck are to be suitably supported. In addition, loads according to *1.3.4* are to be applied. Brackets, where fitted, are to be of suitable thickness and length according to their height.

1.3.3.4 Gross pipe thickness is to be in accordance with the relevant requirements for machinery of the individual Classification Societies.

1.3.4 Applied loading on air pipes

Table 11.1.5
Thickness and Bracket Standards for 760mm High Air Pipes

Nominal pipe size	Minimum fitted gross thickness, in mm	Maximum projected area of head, in cm^2	Height (1) of brackets, in mm
65A	6.0	-	480
80A	6.3	-	~~480~~ 460
100A	7.0	-	~~460~~ 380
125A	7.8	-	~~380~~ 300
150A	8.5	-	300
175A	8.5	-	300
200A	8.5(2)	1900	300 (2)
250A	8.5(2)	2500	300 (2)
300A	8.5(2)	3200	300 (2)
350A	8.5(2)	3800	300 (2)
400A	8.5(2)	4500	300 (2)

Note
1. Brackets (see *1.3.3.2*) need not extend over the joint flange for the head.
2. Brackets are required where the gross thickness of the pipe section is less than 10.5mm, or where the tabulated projected head area is exceeded.

3 SUPPORT STRUCTURE AND STRUCTURAL APPENDAGES

3.1 Support Structure for Deck Equipment

3.1.2 Supporting structures for anchoring windlass and chain stopper

3.1.2.15 The stresses resulting from anchoring design loads induced in the supporting structure are not to be greater than the permissible values given below, based on the gross thickness of the structure:

~~Direct~~ Normal stress 1.00 σ_{yd}

Shear stress 0.58 σ_{yd}

Where:

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

Normal stress is the sum of bending stress and axial stress with the corresponding shearing stress acting perpendicular to the normal stress.

3.1.2.18 The stresses resulting from green sea design loads induced in the supporting structure are not to be greater than the permissible values given below, based on the gross thickness of the structure:

~~Direct~~ Normal stress 1.00 σ_{yd}

Shear stress 0.58 σ_{yd}

Where:

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

Normal stress is the sum of bending stress and axial stress with the corresponding shearing stress acting perpendicular to the normal stress.

3.1.3 Supporting structure for mooring winches

3.1.3.1 Mooring winches are to be efficiently bedded and secured to the deck. The deck thickness in way of mooring winches is to be compatible with the deck attachment design.

3.1.3.2 In addition to complying with the requirements of *3.1.3.6*, the shipbuilder and mooring winch manufacturer are to satisfy themselves that the foundation is suitable for the safe operation and maintenance of the mooring winch equipment.

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.

3.1.3.5 The following plans and information are to be submitted for approval:

(a) details of the supporting structure for mooring winches

(b) details of the mooring winch foundation design, including material specifications for hold down bolts and the connection of the foundation to the deck

(c) design loads as specified in *3.1.3.8* and *3.1.3.9* and associated reaction forces applied to the foundation and supporting structure.

3.1.3.6 The scantlings of the support structure are to be dimensioned to ensure that, for each of the load cases specified in *3.1.3.8* and *3.1.3.9*, the calculated stresses in the support structure do not exceed the permissible stress levels specified in *3.1.3.13* and *3.1.3.14*, respectively.

3.1.3.7 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.

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.

3.1.3.9 For mooring winches situated within the forward 0.25*L*, the load cases for green seas are to be applied as indicated in *3.1.2.9*.

3.1.3.10 For mooring winches situated within the forward 0.25*L,* the resultant forces in the bolts obtained from green sea design loads are to be calculated in accordance with *3.1.2.10* to *3.1.2.12*.

3.1.3.11 The resultant forces from the application of the loads specified in *3.1.3.8* and *3.1.3.9* are to be considered in the design of the supporting structure.

3.1.3.12 Where a separate foundation is provided for the mooring winch brake, the distribution of resultant forces is to take account of the different load path. The brake is only to be considered in relation to the forces in *3.1.3.8*, load case *(b)*.

3.1.3.13 The stresses resulting from mooring operation design loads, induced in the supporting structure, are not to exceed those given in *3.1.2.15*.

3.1.3.14 For mooring winches situated within the forward 0.25*L,* the stresses resulting from green sea design loads, induced in the bolts and supporting structure, are not to exceed values indicated in *3.1.2.16* through *3.1.2.18*.

3.1.4 Supporting structure for cranes, derricks and lifting masts

3.1.4.21 The stresses induced in the supporting structure are not to exceed the permissible values given below, based on the gross thickness of the structure:

~~Direct~~ Normal stress $0.67\ \sigma_{yd}$

Shear stress $0.39\ \sigma_{yd}$

Where:

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

Normal stress is the sum of bending stress and axial stress with the corresponding shearing stress acting perpendicular to the normal stress.

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

3.1.5.12 For the design load specified in *3.1.5.10* and *3.1.5.11* the stresses induced in the supporting structure and welds, in way of strong-points and fairleads, are not to exceed the permissible values given below based on the gross thickness of the structure:

~~Direct~~ Normal stress 1.00 σ_{yd}

Shear stress 0.58 σ_{yd}

Where:

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

Normal stress is the sum of bending stress and axial stress with the corresponding shearing stress acting perpendicular to the normal stress.

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

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 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~~ Normal stress 1.00 σ_{yd}

Shear stress 0.60 σ_{yd}

Where:

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

Normal stress is the sum of bending stress and axial stress with the corresponding shearing stress acting perpendicular to the normal stress.

5 TESTING PROCEDURES

5.1 Tank Testing

Table 11.5.1
Testing Requirements for Tanks and Boundaries

	Structures to be tested	Type of testing	Hydrostatic testing head or pressure	Remarks
1	Double Bottom Tanks	Structural(1)	The greater of - to the top of overflow, or - to the bulkhead deck	Tank boundaries tested from at least one side
2	Double Side Tanks	Structural(1)	The greater of - to the top of overflow, or - to 2.4m above top of tank(2)	Tank boundaries tested from at least one side
3	Cargo Tanks	Structural(1)	The greatest of - to the top of overflow, - to 2.4m above top of tank(2), or - to the top of tank(2) plus setting of any pressure relief valve	Tank boundaries tested from at least one side
	Fuel Oil Bunkers	Structural		
4	Cofferdams	Structural(3)	The greater of - to the top of overflow, or - to 2.4m above top of cofferdam	
5a	Peak Tanks	Structural	The greater of - to the top of overflow, or - to 2.4m above top of tank(2)	Aft peak tank test to be carried out after installation of stern tube.
5b	Fore Peak not used as a tank	Refer to *SOLAS II.1 Reg.14*		
5c	Aft Peak not used as a tank	Leak		
6	Watertight Bulkheads in way of dry space	Hose(4)		Including steps and recesses
7	Watertight Doors below freeboard or bulkhead deck	Hose		For testing before installation(5)
8	~~Double Plate Rudder~~ (void)	~~Structural(1), (6)~~	~~2.4m head of water. Rudder is to be tested while laid on its side~~	
9	Watertight hatch covers of tanks on combination carriers	Structural testing	The greater of: - to 2.4m above the top of hatch cover, or - setting pressure of the pressure relief valve	At least every second hatch cover is to be tested
10	Weathertight Hatch Covers, Doors and other Closing Appliances	Hose(4)		
11	Shell plating in way of pump room	Visual examination		To be carefully examined with the vessel afloat

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 4/2.6.1.1*, 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. In the case of the stiffener and plate having different specified minimum yield stress, σ_{yd}, is to be taken as the lesser of the two.

$z_{dk-mean}$ 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

Appendix B – Structural Strength Assessment

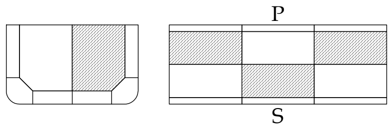
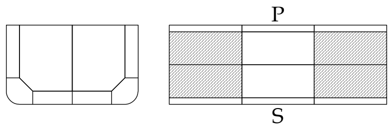
2 CARGO TANK STRUCTURAL STRENGTH ANALYSIS

2.3 Loading Conditions

2.3.1 Finite element load cases

2.3.1.7 Where a ballast condition is specified in the ship loading manual with ballast water filled in one or more cargo tanks, loading patterns A8 and B7 in *Tables B.2.3* and *B.2.4* are to be examined. If this loading is un-symmetrical then additional strength assessment is to be carried out according to the requirements of the individual Classification Society.

Table B.2.4 (Continued)
Load Cases for Tankers with One Centreline Oil-tight Longitudinal Bulkhead

Loading Pattern	Figure	Still Water Loads			Dynamic load cases		
		Draught	Perm. SWBM[(2)]	Perm. SWSF[(2)]	Strength assessment [(1a)]	Strength assessment against hull girder shear loads [(1b)]	
					Midship region	Forward region	Midship and aft regions
B10 [(6, 8)]		$1/3T_{sc}$	100% (sag)	75% (+ve fwd) See note 4	Only applicable to strength assessment of midship region (see note 1(a))		
B11[(8)]		T_{sc}	100% (Hog)	100% (-ve fwd) See note 5	Applicable to strength assessment of midship region (see 1(a)) and strength assessment against hull girder shear loads (see 1(b))		

<u>Note</u>

1.
   (a) For the assessment of scantlings of longitudinal hull girder structural members, primary supporting structural members and transverse bulkheads within midship region, see *1.1.1.5*.
   (b) For the assessment of strengthening of longitudinal hull girder shear structural members in way of transverse bulkheads for hull girder vertical shear loads, see *1.1.1.6, 1.1.1.7* and *1.1.1.8*.
2. The selection of permissible SWBM and SWSF for the assessment of different cargo regions of the ship is to be in accordance with *Table B.2.6*. The percentage of the permissible SWBM and SWSF to be applied are to be accordance with this table.
3. The actual shear force that results from the application of static and dynamic local loads to the FE model are to be used.
4. The actual shear force that results from the application of static and dynamic local loads are to be used. Where this shear force exceeds the target SWSF (design load combination S) or target combined SWSF and VWSF, calculated in accordance with *2.4.5.2,* (design load combination S+D) as specified in the table, correction vertical loads are to be applied to adjust the shear force down to the required value.
5. Correction vertical loads are to be applied to adjust the shear force to the required value specified.
6. Load cases B2, B5 and B10 are only required if the structure is not symmetrical about the ship's centreline.
7. Ballast loading pattern B7 with ballast filled in cargo tanks (i.e. gale ballast/emergency ballast conditions etc.) is only required to be analysed if the condition is specified in the ship's loading manual. The actual loading pattern and draught from the loading manual for the condition is to be used in the analysis, see *Table B.2.5*. <u>If the actual loading pattern is different from load case B7 then:</u>
   (a) <u>An operational restriction corresponding to the analysed condition is to be added in the Loading Manual.</u>
   (b) <u>100% of the permissible SWBM is to be applied when analyzing loading pattern with ballast in cargo tanks.</u>
8. No dynamic loads are to be applied to Design Load Combination S (harbour and tank testing load cases).

3 LOCAL FINE MESH STRUCTURAL STRENGTH ANALYSIS

3.1 General

Table B.3.1
Fine Mesh Analysis Screening Criteria for Openings in Primary Support Members

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

$\lambda_y > 1.7$ (load combination S + D)

$\lambda_y > 1.36$ (load combination S)

Where:

λ_y yield utilisation factor

$$= 0.85C_h\left(\left|\sigma_x + \sigma_y\right| + \left(2 + \left(\frac{l_0}{2r}\right)^{0.74} + \left(\frac{h_0}{2r}\right)^{0.74}\right)\left|\tau_{xy}\right|\right)\frac{k}{235}$$

C_h $= 1.0 - 0.23\left(\frac{h_0}{h}\right) + 2.12\left(\frac{h_0}{h}\right)^2$ for openings in vertical web and horizontal girder of wing ballast tank, double bottom floor and girder and horizontal stringer of transverse bulkhead

$= 1.0$ for opening in web of main bracket and buttress (see figures below)

r radius of opening, in mm

h_0 height of opening parallel to depth of web, in mm

l_0 length of opening parallel to girder web direction, in mm

h height of web of girder in way of opening, in mm

σ_x axial stress in element x direction determined from cargo tank FE analysis according to the coordinate system shown, in N/mm^2

σ_y axial stress in element y direction determined from cargo tank FE analysis according to the coordinate system shown, in N/mm^2

τ_{xy} element shear stress determined from cargo tank FE analysis, in N/mm^2, (2)

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

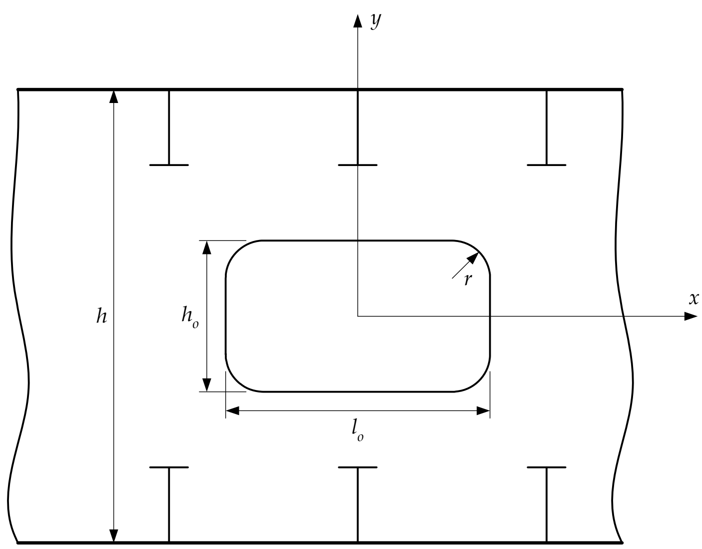
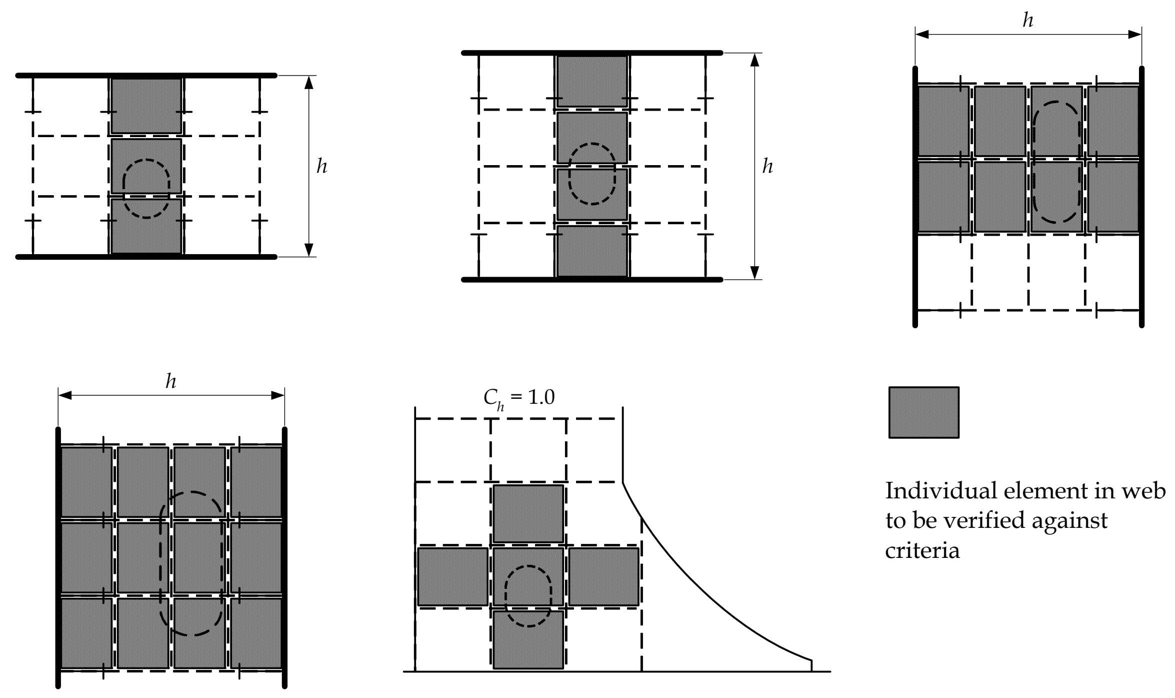


Table B.3.1 (Continued)
Fine Mesh Analysis Screening Criteria for Openings in Primary Support Members



Notes

1. ~~Screening criteria only applicable to opening where its geometry is not required to be represented in the cargo tank FE model in accordance with *Table B.2.2*. Where the geometry of the opening is required to be modelled in accordance with *Table B.2.2*, fine mesh FE analysis is to be carried out to determine the stress level.~~
   For opening where the modelled shear area in way of the opening is different from the actual net shear area the element shear stress is to be adjusted using the formula given in *B.2.7.2.4* prior to the evaluation of yield utilisation factor for verification against the screening criteria.
2. ~~Where the modelled thickness of the web in way of the opening is reduced in accordance with *Table B.2.2*, the element shear stress is to be adjusted by the ratio of the actual net web thickness (i.e. calculated by deducting 0.5t_{corr} from the gross thickness) to the modelled reduced mean thickness (i.e. $t_{1-net50}$ or $t_{2-net50}$ defined in *Table B.2.2*) prior to the evaluation of yield utilisation factor for verification against the screening criteria.~~
   Where the geometry of the opening is required to be modelled in accordance with *Table B.2.2*, fine mesh FE analysis is to be carried out to determine the stress level. The screening criteria given in this table are not applicable.
3. 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*.

4 EVALUATION OF HOT SPOT STRESS FOR FATIGUE ANALYSIS

4.3 Loading Conditions

4.3.1 General

4.3.1.2 The cargo density to be used for the fatigue assessment is to be taken as the greater of the cargo density specified for the homogeneous scantling draught condition and $0.9t/m^3$.:

(a) longitudinal end connections - the greater of the cargo density specified for the homogeneous scantling draught condition and $0.9t/m^3$

(b) connection between inner bottom and hopper plate – $0.9t/m^3$.

Appendix C – Fatigue Strength Assessment

1 NOMINAL STRESS APPROACH

1.4 Fatigue Damage Calculation

1.4.4 Definition of stress components

1.4.4.6 For the calculation of stress components, the vertical wave hull girder stress, σ_v, is given by:

$$\sigma_v = \frac{M_{wv-v-amp}}{Z_{v-net75}} 10^{-3} \quad \text{N/mm}^2$$

Where:

$M_{wv\text{-}v\text{-}amp}$ pseudo amplitude (half range), in kNm, as defined in *1.3.4*

$Z_{v\text{-}net75}$ $= \dfrac{I_{v-net75}}{|z - z_{NA-net75}|}$ m³ see *Section 4/2.6.1*

$I_{v\text{-}net75}$ net vertical hull girder moment of inertia, of hull cross-section about transverse neutral axis ~~(openings deducted)~~, in m⁴

$I_{v\text{-}net75}$ is to be calculated based on gross thickness, minus the corrosion addition $0.25t_{corr}$ of all effective structural elements, see *Section* ~~4/2.6.1.3~~ 4/2.6.1

z distance from baseline to the critical location of the considered member, i.e. top of flange of longitudinal stiffener, in m

$z_{NA\text{-}net75}$ distance from baseline to horizontal neutral axis consistent with $I_{v\text{-}net75}$, in m

1.4.4.8 The horizontal wave hull girder stress, σ_h, is to be taken as:

$$\sigma_h = \frac{M_{wv-h-amp}}{Z_{h-net75}} 10^{-3} \quad \text{N/mm}^2$$

Where:

$M_{wv\text{-}h\text{-}amp}$ in kNm, as defined in *1.3.5*

$Z_{h\text{-}net75}$ $\dfrac{I_{h-net75}}{|y|}$ m³ see *Section 4/2.6.2*

y distance from vertical neutral axis of hull cross section to the critical location of the considered member, in m. i.e. top of face plate of longitudinal stiffener

$I_{h\text{-}net75}$ net horizontal hull girder moment of inertia, of the hull cross-section about the vertical neutral axis ~~(openings deducted)~~, in m⁴.
$I_{h\text{-}net75}$ is to be calculated based on gross thickness, minus the corrosion addition $0.25t_{corr}$ for all effective structural elements, see *Section* 4/2.6.2

1.4.5 Selection of S-N curves

1.4.5.11 The total stress range considering the mean stress effect is to be taken as follows:

$S_{Ri} = \sigma_{tensile} - 0.6\,\sigma_{compressive}$ if $\sigma_{compressive} < 0$ and $\sigma_{tensile} > 0$
$S_{Ri} = S$ if $\sigma_{compressive} \geq 0$

$S_{Ri} = 0.6S$ if $\sigma_{tensile} \le 0$

Where:

$\sigma_{tensile}$ mean stress plus half stress range, in N/mm^2
$= \sigma_{mean} + S/2$

$\sigma_{compressive}$ mean stress minus half stress range, in N/mm^2
$= \sigma_{mean} - S/2$

σ_{mean} mean stress due to static load components in the full load condition or ballast condition as appropriate, in N/mm^2, see *1.3.2*

For the nominal stress approach, S and σ_{mean} are to be calculated as follows:

S total combined stress range, in N/mm^2, as defined in *1.4.4.19*

$= \sigma_{tensile} - \sigma_{compressive}$

σ_{mean} $= \sigma_{hg} + \sigma_{ex} + \sigma_{in}$

σ_{hg} mean stress due to hull girder bending, to be derived using σ_v from *1.4.4.6* with $M_{wv\text{-}v\text{-}amp}$ taken as the actual SWBM for the full load condition or ballast condition as appropriate, see *1.3.2*.

σ_{ex} mean local bending stress due to external static sea pressure, if applicable. σ_{ex} is to be derived using σ_{2A} from *1.4.4.11* with P calculated based on the actual draught for the full load condition or ballast condition as appropriate, see *1.3.2*, where $P = P_{hys}$, see *Section 7/2.2.2.1*.

σ_{in} mean local bending stress due to internal static tank pressure, if applicable. σ_{in} is to be derived using σ_{2A} from *1.4.4.11* with P calculated based on the head to the top of tank and the tank contents for the full load condition or ballast condition as appropriate, see *1.3.2*, where $P = P_{in\text{-}tk}$, see *Section 7/2.2.3.1*.

Notes

1 P is to be taken as negative when the pressure is acting on the plate side and positive when acting on the stiffener side. This gives compressive stress with a negative sign

2 Where the stiffener is on the boundary between two cargo tanks, then the mean stress is to be taken as the net stress acting on the stiffener.

3 It is to be assumed that water ballast and cargo tanks are 100% full. The fluid density is to be taken in accordance with *Section 7/2.2.3.1*, where cargo density is not to be less than 0.9 tonnes/m^3

For the hot spot stress approach in *Sub Section 2*, the mean stress, σ_{mean}, is to be calculated by applying the applicable static loads to the FE model for the full load condition or ballast condition as appropriate. Alternatively, in lieu of applying the static loads to the FE model, the total stress range is to be calculated in accordance with *2.4.2.8*.

2 HOT SPOT STRESS (FE BASED) APPROACH

2.4 Fatigue Damage Calculation

2.4.2 Stresses to be used

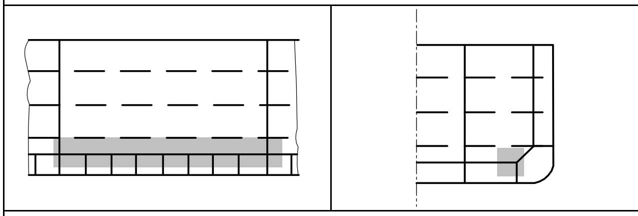
2.4.2.6 The hot spot stress is defined as the surface stress at 0.5*t* away from the weld toe location, as shown in *Figure C.2.1*. This stress may be obtained by linear interpolation in the ship's transverse direction using the respective stress at the 1st and 2nd element from the structure intersection.

2.5 Detail Design Standard

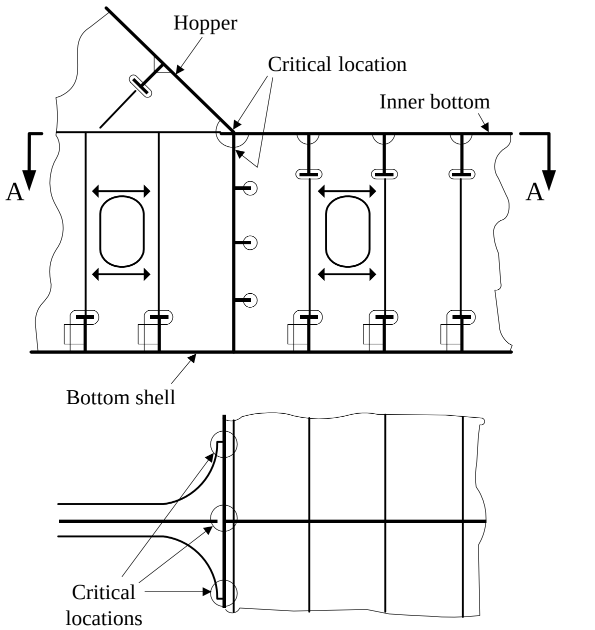
Figure C.2.2
Hopper Knuckle Connection Detail, Without Bracket

Connections of floors in double bottom tanks to hopper tanks
Hopper corner connections employing welded inner bottom and hopper sloping plating

CRITICAL AREAS

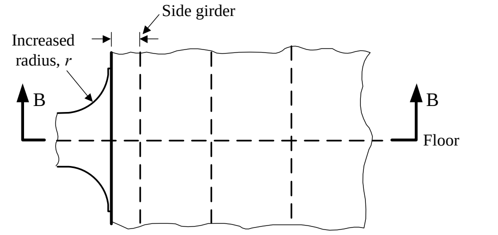


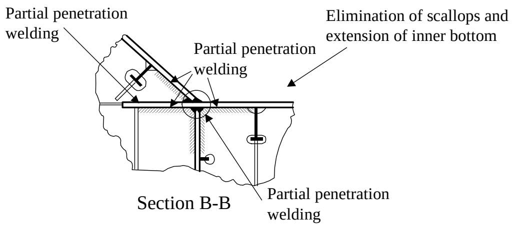
CRITICAL LOCATIONS



Section A-A

DETAIL DESIGN STANDARD A





Section B-B

Weld between hopper plating and inner bottom plating to be ~~dressed~~ extended and ground smooth.
Visible undercuts are to be removed.
Weld extension and grinding to be applied 200 mm either side of the floor.

~~Extent of dressing both sides of floor.~~
~~VLCC 250 mm~~
~~Suezmax 200 mm~~
~~Aframax 150 mm~~
~~Product 100 mm~~

Note:

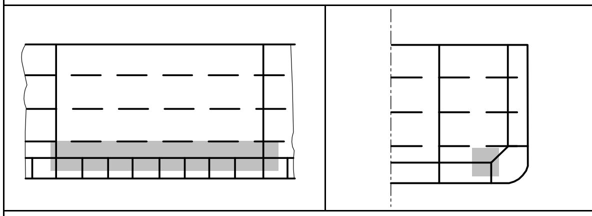
1. A root face with a maximum of 1/3 of the abutting plate thickness is acceptable for the partial penetration welding, see *Section 6/5.3.4*.
2. Grinding need not be applied in the No.1 tank in which floor spans are reduced due to shape.
3. Grinding need not be applied for the knuckle joints at transverse bulkhead positions, or at the floor adjacent to the transverse bulkhead.

Minimum Requirement	As a minimum, detail design standard A or B is to be fitted. Further consideration will be given where the hopper angle exceeds 50 degrees. The ground surface is to be protected by a stripe coat, of suitable paint composition, where the lower hopper knuckle region of cargo tanks is not coated.
Critical Location	Hopper sloping plating connections to inner bottom plating in way of floors. Floor connections to inner bottom plating and side girders in way of hopper corners.
Detail Design Standard	Elimination of scallops in way of hopper corners, extension of inner bottom plating to reduce level of resultant stresses arising from cyclic external hydrodynamic pressure, cargo inertia pressure and hull girder loads. Scarfing bracket thickness is to be close to that of the inner bottom in way of knuckle.
Building Tolerances	Median line of hopper sloping plate is to be in line with the median line of the girder with an allowable tolerance of t/3 or 5mm, whichever is less, ~~towards centreline in way of the floor,~~ where *t* is the inner bottom thickness. The allowable tolerance is to be measured parallel to the inner bottom.
Welding Requirements	Partial penetration welding (hopper sloping plating to inner bottom plating). Partial penetration weld (connection of floors to inner bottom plating and to side girders, connection of hopper transverse webs to sloping plating, to inner bottom plating, and to side girders in way of hopper corners).

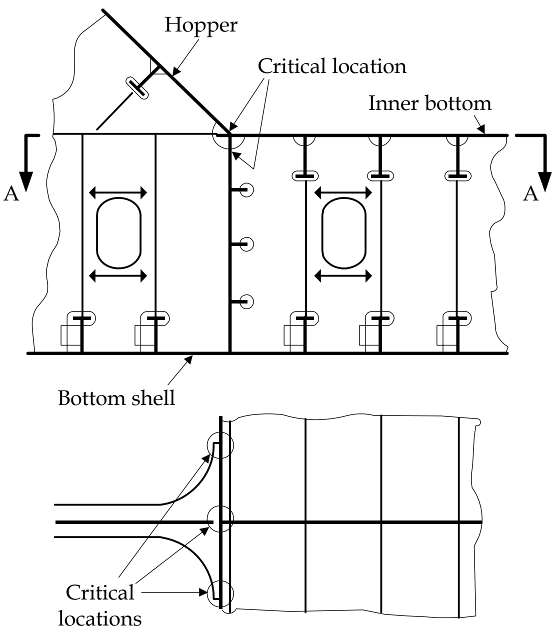
Figure C.2.3
Option: Hopper Knuckle Connection Detail, With Bracket

Connections of floors in double bottom tanks to hopper tanks
Hopper corner connections employing welded inner bottom and hopper sloping plating

CRITICAL AREAS	DETAIL DESIGN STANDARD B

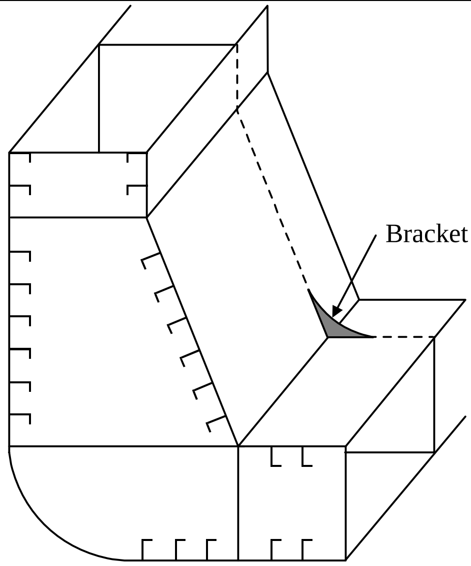


CRITICAL LOCATIONS



Section A-A

DETAIL DESIGN STANDARD B



Note:

1. Bracket to be fitted inside cargo tank
2. Bracket to extend approximately to the first longitudinal
3. The bracket toes are to have a soft nose design
4. Full penetration welding at bracket toes
5. Bracket material to be same as that of inner bottom
6. Buckling of bracket to be checked:

$$\frac{d}{t_{bkt}} < 21\sqrt{\frac{235}{\sigma_{yd}}}$$

where:

d = bracket max depth, as defined in *Table 10.2.3*
t_{bkt} = bracket thickness
σ_{yd} = specified minimum yield stress of material

Minimum Requirement	As a minimum, detail design standard A or B is to be fitted. Further consideration will be given where hopper angle exceeds 50degrees. ~~The ground surface is to be protected by a stripe coat, of suitable paint composition, where the lower hopper knuckle region of cargo tanks is not coated.~~
Critical Location	Hopper sloping plating connections to inner bottom plating in way of floors. Floor connections to inner bottom plating and side girders in way of hopper corners.
Detail Design Standard	Elimination of scallops in way of hopper corners, extension of inner bottom plating to reduce level of resultant stresses arising from cyclic external hydrodynamic pressure, cargo inertia pressure and hull girder loads. Scarfing bracket thickness to be close to that of the inner bottom in way of knuckle.
Building Tolerances	Median line of hopper sloping plate is to be in line with the median line of girder with an allowable tolerance of t/3 or 5mm, whichever is less, ~~towards centreline in way of the floor,~~ where *t* is the inner bottom thickness.
Welding Requirements	Partial penetration welding (hopper sloping plating to inner bottom plating). Partial penetration weld (connection of floors to inner bottom plating and to side girders, connection of hopper transverse webs to sloping plating, to inner bottom plating, and to side girders in way of hopper corners).

------------ 00000 ------------

Common Structural Rules for Double Hull Oil Tankers, July 2008

Technical Background for Rule Change Notice No. 2 April 2010

SECTION 2 – RULE PRINCIPLES

Section 2/2.1.2.1 and 2.1.3.1(b)

1. Background

The proposed amendment is to clarify the role and responsibilities of Classification societies.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 512:

RCP #512:

We propose the following modification as audit in sense of Quality control is not actually performed as requested in the Rules: - Replace "undertake and audit" in para 2.1.2.1 below with "ensure compliance".

2.1.2.1 Classification Societies develop and publish the standards for the hull structure and essential engineering systems. Classification Societies undertake and audit during design, construction and applicable international regulations when authorised by a National Administration.

Answer #512:

The following changes will be made:

2.1.2 Classification Societies

2.1.2.1 Classification Societies develop and publish the standards for the hull structure and essential engineering systems. Classification Societies undertake an audit during design, construction and operation of a ship to confirm compliance with the classification requirements and the applicable international regulations when authorised by a National Administration.

will be replaced by:

2.1.2.1 Classification Societies develop and publish the standards for the hull structure and essential engineering systems. Classification Societies ensure* compliance with the classification requirements and the applicable international regulations when authorised by a National Administration during design, construction and operation of a ship.

** Note: in the approved version of RCN 2 'ensure' was replaced with 'verify'.*

2.1.3 Responsibilities of Classification Societies, builders and owners

2.1.3.1

(b) design aspects:

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.

will be replaced by:

the classification society is responsible for a technical appraisal of the design plans and related documents for a ship to verify compliance with the appropriate classification rules.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Section 2/3.1.7.4

1. Background

See Background for Section 6/1.2.3.1.

2. Impact on scantlings

There is no impact on scantlings due to this change.

SECTION 4 – BASIC INFORMATION

Section 4/Table 4.1.1

1. Background

The definitions of “superstructure” and “deck house” in Table 4.1.1 of CSR Tanker not in accordance with the definitions in 1966 ICLL. The Rule text is proposed amended in line with ICLL.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 754:

Question #754:

The following definitions of “superstructure” and “deck house” in Table 4.1.1 of CSR Tanker seem to be incorrect in light of the definitions in 1966 ICLL:

Superstructure: A decked structure on the freeboard deck extending for at least 92 percent of the breadth of the ship

Deck house: A structure on the freeboard or superstructure deck not extending from side to side of the ship

Please revise the definition.

For your reference, the following definitions in CSR Bulk Carriers are in line with 1966 ICLL:

A superstructure is a decked structure on the free-board deck, extending from side to side of the ship or with the side plating not being inboard of the shell plating more than 0.04B.

A deckhouse is a decked structure other than a superstructure, located on the freeboard deck or above.

Answer #754:

The definitions of "superstructure" and "deck house" will be updated in accordance with ICLL definitions.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Section 4/3.2.3.5

1. Background

The Rules do not have any provisions for brackets with different arm lengths. The Rule text is proposed amended to cover this.

(The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre ID: 599:

Question #599:

Understand that the requirement of CSR 4/3.2.3.4 is coming from DNV Rules Pt.3 Ch.1 Sec.3 C200 and LR Rules Pt.3 Ch.10 3.4.1. Both DNV and LR source Rules have similar requirements such as:

DNV Rules: “In case of different arm lengths a1 and a2, the sum is not to be less than 2a and each arm not less than 0.75a”

LR Rules: “a+b>=2.0L, a>=0.8L, b>=0.8L”

In view of the above, could you consider similar provision also for CSR 4/3.2.3.4?

Answer #599:

Your proposal is noted and will be considered in connection with next revision of the rules.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Section 4/3.4.2.1, Figure 4.3.4

1. Background

The Rule text is proposed amended to clarify the requirements for cut-outs.

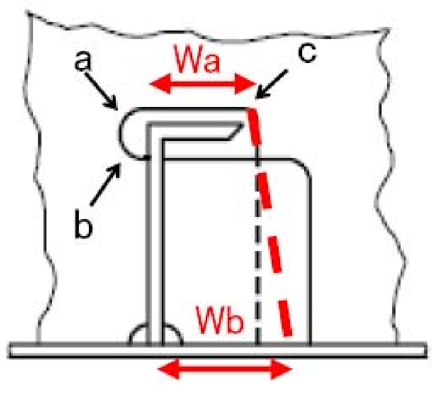
The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 731:

Question #731:

1. Sec4/ 3.4.2.1 states that "Cut-outs are to have rounded corners and the corner radii are to be as large as practicable, with a minimum of 20 percent of the breadth of the cut-out or 25mm … ".

When the breadth of the actual cut-out differs from that of the standard cut-out as shown the attached sketch, how should the breadth of the actual cut-out be defined? (Wa, Wb or (Wa+Wb)/2)

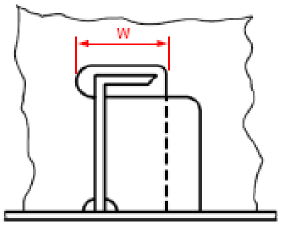
2. Does the requirement for corner radii apply to all of parts "a","b","c" or only to "a" and "c" in the attached sketch?

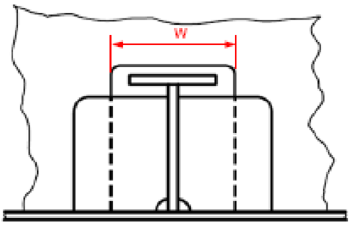


Answer #731:

1. For definition of 'breadth', see attachment.

2. The requirement apply to 'a' and 'c' only.





2. Impact on scantlings

There is no impact on scantlings due to this change.

SECTION 6 – MATERIALS AND WELDING

Section 6/1.2.3.1

1. Background

The technical background document to the latest revision of IACS UR S6, September 2007 confirms that the definition for normal worldwide service is based on a lowest mean daily average design air temperature of -10 degrees Celsius. Since this has been reduced from the previously assumed -15 degrees Celsius, there is a need for aligning the text with IACS UR S6.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Section 6/Table 6.1.3

1. Background

IACS UR S6 on the use of steel grades for various hull members on ships of 90 m in length and above has been updated (Rev.5 Sept 2007). The Rules are proposed amended to include this latest revision (excluding those related to operation in ice and rudders).

Since rudder is not part of the scope of CSR Tankers the Rule text is proposed amended to delete rudder provisions from the Rules.

The proposed amendment, on rudders, is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 810:

Interpretation request #810:

Material class lll to be required for rudder and rudder body plates subject ot stress concentrations in way of lower support of semi-spade rudder or at upper part of spade rudder. Should it be required since rudder is not part of scope?

Answer #810:

Rudder is not part of the scope of CSR Tanker. We will amend the Rules to remove this requirement.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Section 6/2.1.2.2

1. Background

The proposal is to clarify the requirements and to align in accordance with IACS UR F1.2.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 593:

Question #593:

1) The 1st sentence of Section 6/2.1.2.2 indicates that permanent anodes in tanks made of, or alloyed with magnesium are not acceptable except in tanks solely intended for water ballast. From this sentence, it appears that the "tanks solely intended for water ballast" include ballast tanks adjacent to cargo tanks. If so, this requirement conflicts with IACS UR F1.2 and the existing ABS Rules 5C-1-1/5.9.2 as follows:

- IACS UR F1.2 indicates "Magnesium or magnesium alloy anodes are not permitted in oil cargo tanks and tanks adjacent to cargo tanks".

- ABS Rules 5C-1-1/5.9.2 indicates "Magnesium and magnesium alloy anodes are not to be used".

Please advise.

2) The 2nd sentence of Section 6/2.1.2.2 indicates that impressed current systems are not to be used in tanks due to the development of chlorine and hydrogen that can result in an explosion.

From this sentence, it appears that the "tanks" mean "any tank including ballast tanks not adjacent to cargo tanks"? If so, this requirement conflicts with IACS UR F1.1 and the existing ABS Rules 5C-1-7/31.13 as follows.

- IACS UR F1.1 indicates "Impressed current systems are not permitted in oil cargo tanks".

- ABS Rules 5C-1-7/31.13 indicates "hull fittings….containing terminals for anodes or electrodes of impressed current cathodic protection system are not to be installed in cargo tanks. However, they may be installed in harzardous areas, such as cofferdams adjacent to cargo tanks….provided all of the following are complied with:……."

Please advise.

Answer #593:

1)The 1st sentence of Section 6/2.1.2.2 is to read "Permanent anodes in tanks made of, or alloyed with magnesium are not acceptable except in tanks solely intended for water ballast that are not adjacent to cargo tanks."

2)The 2nd sentence of Section 6/2.1.2.2 is to read "Impressed current systems are not to be used in cargo tanks due to the development of chlorine and hydrogen that can result in an explosion."

We intend to fix the Rule text accordingly at the next chance of corrigenda.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Section 6/3.3.4.3

1. Background

The application of corrosion additions for the proportion (slenderness) requirements in Section 10/2 is missing in Section 6/3.3 while this Section covers all other criteria (e.g. hull girder, local scantlings, minimum thickness, hull girder ultimate strength, FE, buckling, fatigue, etc.). The proposal is to include proportion (slenderness) requirements in this Section.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 606:

Question #606:

1) Presume that the net web thickness “tw-net” used in Sections 8/6.3.7.5 and 8/6.4.5.4 are of FULL corrosion addition (not of HALF corrosion addition). Please confirm.

2) It seems that application of corrosion additions for the proportion (slenderness) requirements in Section 10/2 is missing in Section 6/3.3 while this Section covers all other criteria (e.g. hull girder, local scantlings, minimum thickness, hull girder ultimate strength, FE, buckling, fatigue, etc.). Please include proportion (slenderness) requirements in this Section.

Answer #606:

1. tw_net is based of full corrosion.

2. Full corrosion addition is to be used for slenderness requirement for primary supporting members.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Section 6/5.4.1.3

1. Background

The current text does not clarify whether to calculate the overlap on the basis of the net thickness or gross thickness. The proposal clarifies that “thickness” is to be taken as the “gross” thickness.

2. Impact on scantlings

No significant impact on scantlings is expected.

Section 6/5.7.4.1

1. Background

The proposed amendment is to clarify the weld factor.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 505:

Question #505:

Welding requirements:

a) Please clarify if Table 6.5.2 apply only to fillet weld or also to partial penetration welding?

b) The reference to weld factor f_1 in Section 6/5.7.4.1 seems wrong. We assume it should be weld factor f_weld.

Answer #505:

We respond to the question in the same order as they appear:

a)Table 6.5.2 is applicable to all type of welding

b)Yes we agree the factor should be fweld, not f1. The rules will be corrected at first opportunity.

2. Impact on scantlings

No significant impact on scantlings is expected.

Section 6/Table 6.5.4

1. Background

The proposed amendment is to clarify that "Note 3" is also applicable to the weld factor for "primary support member of gross face area greater than 130.0 at ends" to "face plate in tanks" of "0.59".

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 608:

Question #608:

From the welding factors indicated in Table 6.5.4, it seems that the welding factor for "To face plate" is not greater than that for "To plating". If so, presume that "Note 3" is also applicable to the weld factor for "primary support member of gross face area greater than 130.0 at ends" to "face plate in tanks" of "0.59". Please confirm and edit the Table as appropriate.

Answer #608:

"Note 3" should apply also to the weld factor for "primary support member of gross face area greater than 130.0 at ends" to "face plate in tanks" of "0.59". We intend to correct the Table 6.5.4 at the next chance.

2. Impact on scantlings

No significant impact on scantlings is expected.

SECTION 8 – SCANTLING REQUIREMENTS

Section 8/1.1.2.2(a)

1. Background

The requirements in Section 8/1.1.2.2(a) are specifically towards fore peak tanks designated as ballast tanks. If upper and lower spaces are ballast tanks, the lower is required to be full.

If the design has the lower tank designated as void space and the upper is designated as ballast tank then only the upper tank is required to be full and lower void space is empty and vice versa.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 829:

Interpretation request #829:

Regarding to the arrangement of F.P.T. and heavy ballast condition required in CSR section 8.1.1.2.2, We would like ask whether it is acceptable that upper part of fore peak is used as fore peak tank and the lower part of fore peak space is designated as void space under CSR for double hull tankers.

It is common to divide fore peak space into upper and lower compartment and to utilize the lower compartment as water ballast tank so as to prevent partial filling in fore peak tank and reduce the excessive hogging moment when fore peak tank is full under IACS UR S11.

But, some ship owners seem to prefer upper fore peak tank to lower peak tank if the fore peak space should be divided into two spaces due to the nature of ship design.

Answer #829:

The requirements in Section 8/1.1.2.2(a) is specifically towards fore peak tanks designated as ballast tanks. If upper and lower spaces are ballast tanks, the lower is required to be full.

If the design has the lower tank designated as void space and the upper is designated as ballast tank then only the upper tank is required to be full and lower void space is empty and vice versa.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Section 8/1.4.2.5

1. Background

The thickness is to be calculated considering shear force correction; the proposed amendment clarifies this intent.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 556:

Question #556:

Please confirm whether buckling assessment (Section 8/1.4.2) is to be carried out using a thickness (tij-net50), using shear force correction.

In the assessment of hull girder shear strength (Section 8/1.3.2), tij-net50 is calculated using shear force correction.

Answer #556:

The hull girder shear stress to be used for buckling shall be calculated using equivalent thickness of plate tij-net50 as given in 8/1.3.2.2 and including shear force correction.

However the buckling capacity shall be calculated with as built thickness minus 0.5tcorr.

The rules text will be amended to clarify this.

2. Impact on scantlings

No significant impact on scantlings is expected as the proposal is to clarify the original intent.

Section 8/2.5.7.6, Table 8.2.3, 2.5.7.9

1. Background

Corrugated bulkheads with lower stool

The requirements are based on the ABS Rules Pt.5 Ch.1 Sec.4/17.5.2. The formula for required section modulus is based on simple beam theory and the basic understanding that the vertically corrugated bulkhead can be considered as consisting of separate vertically oriented beam-columns (i.e. corrugations) working independently. The loading on the corrugated bulkhead consists of the following three major components – (1) lateral pressure, (2) "carry over" bending moments due to bending of the double bottom, and (3) vertical axial force in the corrugation due to lateral loads on the double bottom and loads on deck. The formulae explicitly consider the boundary conditions for the two corrugation ends, which are addressed in the formulations provided in Table 8.2.3. The requirements were calibrated against FEM calculations. The requirements in this Sub-section are not applicable to corrugated bulkheads without a lower stool.

Corrugated bulkheads without a lower stool

For ships with a moulded depth less than 16m, omission of lower stool is allowed in accordance with Section 8/2.5.7.9. This paragraph was introduced in the rules just before the final CSR was published (in October 2005 after the third CSR draft) reflecting the industry comments.

Since the prescriptive requirements for corrugation web shear, flange buckling and section modulus requirements as given in Sections 8/2.5.7.3, 8/2.5.7.5 and 8/2.5.7.6 were calibrated with corrugated bulkheads having lower stool, those requirements are not applicable for the corrugated bulkheads without lower stool.

An additional factor of safety in Finite Element Analysis (10% reduction in the stress and buckling acceptance utilisation factors) was introduced in the absence of applicable prescriptive requirements for those bulkheads.

The new formulae for corrugated bulkheads without bottom stools were derived from the formulae for corrugated bulkheads with bottom stools and deck boxes. After the coefficients C_i (for the lower end and mid-span of transverse and longitudinal bulkheads) were calculated for numerous values of the parameter R_b (bottom stool parameter) within the wide range of the selected A_d/b_d ratio, analytical equations for the coefficients C_i as a function of the parameter R_b have been developed. Now, a corresponding value of C_i using the analytical equations can be obtained when R_b is 0 (i.e. no bottom stool exists). Then from the derived values of C_i for case when R_b=0, the corresponding curves for C_1, C_{m1}, C_3 and C_{m3}

as a function of the ratio A_d/b_d were built for transverse and longitudinal bulkheads. The proposed equations correspond to those curves in a smooth form.

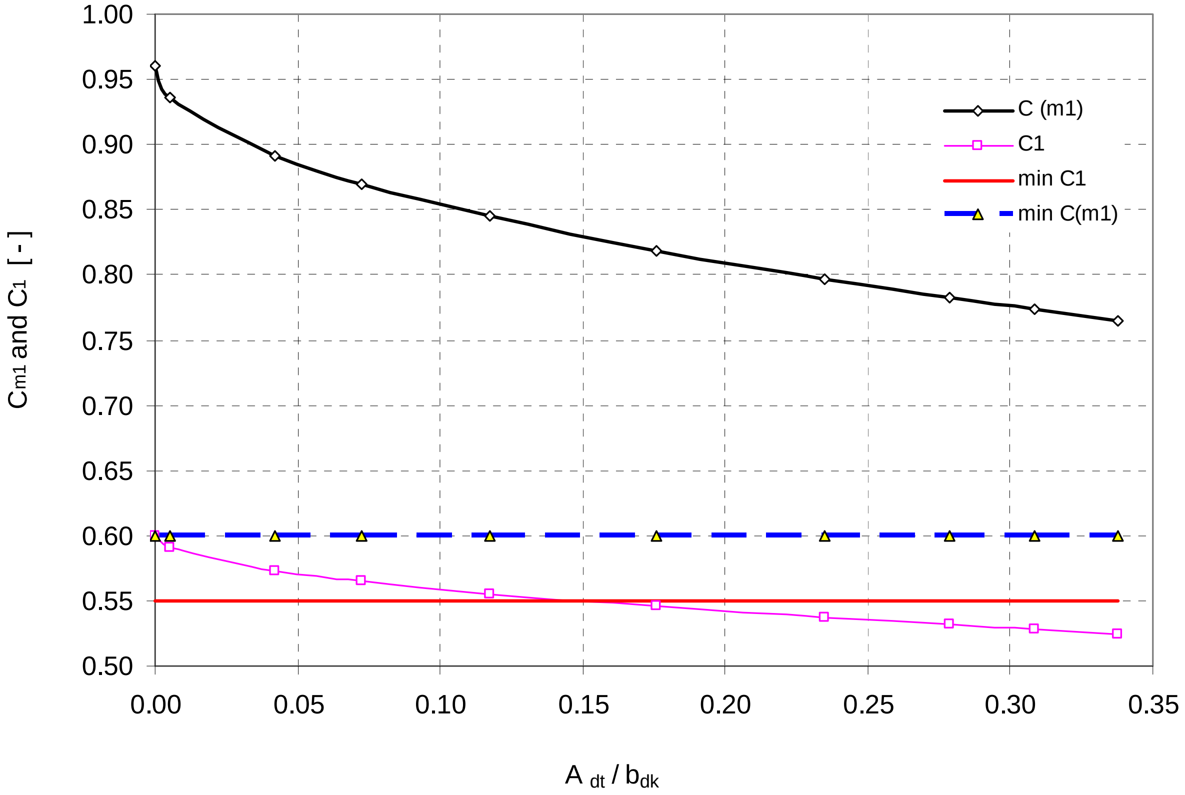


Figure 1: Coefficients C_1 and C_{m1} for corrugated transverse bulkheads without bottom stools

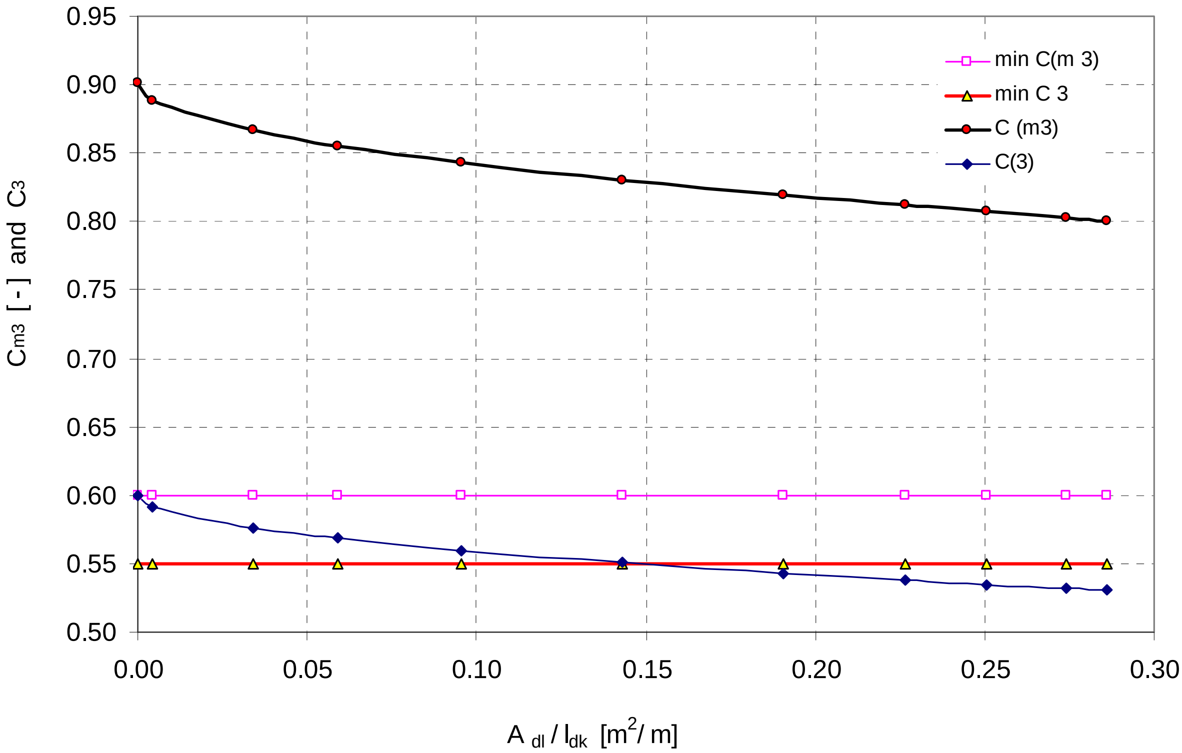


Figure 2: Coefficients C_3 and C_{M3} for corrugated longitudinal bulkheads without bottom stools

The proposal is to amend the Rules to have prescriptive requirements for bulkheads without lower stools.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 407:

Question #407:

The section in reference requests to apply a permissible stress which is reduced by 10% if no stool is arranged underneath a corrugated bulkhead.

Comparing with already existing designs this leads to increased plate thickness. We would like to know the techical background for this requirement.

Answer #407:

For ships with a moulded depth less than 16m, omission of lower stool is allowed in accordance with Section 8/2.5.7.9. This paragraph was introduced in the rules just before the final CSR was published (in October 2005 after the third CSR draft) reflecting the industry comments.

Since the prescriptive requirements for corrugation web shear, flange buckling and section modulus requirements as given in Sections 8/2.5.7.3, 8/2.5.7.5 and 8/2.5.7.6 were calibrated with corrugated bulkheads having lower stool, those requirements are not applicable for the corrugated bulkheads without lower stool.

An additional factor of safety in Finite Element Analysis (10% reduction in the stress and buckling acceptance utilisation factors) was introduced in the absence of applicable prescriptive requirements for those bulkheads.

Also, service experience indicates that corrugated bulkhead designs without a lower stool are more critical (e.g. prone to local fracture) than those fitted with a lower bulkhead stool due to higher stress level and alignment problems with the supporting structure in the double bottom.

Having said the above, however, we see a need for future development/re-calibration of the prescriptive requirements for those without lower stool in association with possible adjustment of utilization factors in Finite Element Analysis.

2. Impact on scantlings

A consequence assessment has been carried, for the ship detailed in Table 1, and results shown in the tables below:

Transverse vertically corrugated bulkhead without lower and upper stools.

- Table 2: Input data
- Table 3: Results

Longitudinal vertically corrugated bulkhead without lower and upper stools

- Table 4: Input data
- Table 5: Results

Table 1 Ship Data

Ship length	150	m
Ship depth	15000	mm
Corrugation flange a	1200	mm
Corrugation depth d	1250	mm
Double bottom height at ship's side	1950	mm
Double bottom height at C.L.	1800	mm
Camber at ship C.L.	550	mm

Table 2 Input data – Transverse vertically corrugated bulkhead without lower and upper stools

t_{gross}	24	mm	
Corrosion allowance	2.5	mm	
Projection of the web	500	mm	
Corrugation length at ship's side	13.05	m	
Corrugation length at C.L.	13.75	m	
Corrugation length used in the calculation	13.75	m	corrugation length at ship's side
Pressure at lower end p_l	383.54	MPa	the cargo density is 1.85 t/m^3
Pressure at upper end p_u	26.33	Mpa	the cargo density is 1.85 t/m^3
Mean pressure p	204.94	MPa	the cargo density is 1.85 t/m^3
Yield stress s_y	315	MPa	
Modulus of Elasticity E	206000	MPa	
$C_{s\text{-}cg}$	0.90	-	for lower end
$C_{s\text{-}cg}$	0.77	-	for midspan
A_{dt}	0		
b_{dk}	0		

Table 3 Results – Transverse vertically corrugated bulkhead without lower and upper stools

$t_{offered\ net}$	21.5	mm
spacing s	1700	mm
web c	1346.29	mm
offered net SM	22155	cm^3
Coefficient β	2.18	-
Coefficient C_e	0.7685	-
Coefficient for lower end C_1	0.60	-
Coefficient for midspan C_{m1}	0.96	-
B.M. at lower end M_{cg}	3293	kNm
B.M. at midspan M_{cg}	5269	kNm
$SM_{required\ at\ lower\ end}$	11617	cm^3
$SM_{required\ at\ midspan}$	21768	cm^3
$SM_{offered\ net}$ / $SM_{required}$	1.0178	-
required t	21.12	mm

NOTES:

- C_l calculated by the equation $C_l = a_1 - b_1(A_{dt}/b_{dk})^{0.5}$
- C_{m1} Calculated by the equation $C_{m1} = a_{m1} - b_{m1}(A_{dt}/B_{dk})^{0.5}$
- Offered net SM calculated by the formula SM = d $(3at_f + ct_w)/6$
- min $C_{m1} = 0.60$
- min $C_l = 0.55$
- In this case $A_{dt} = 0$ because there is no deck box
- If $t_f = t_w = t$, the required t is calculated by the formula:
- t = 6SM / [d (3a+c)]

Table 4 Input data – Longitudinal vertically corrugated bulkhead without lower and upper stools

t_{gross}	24	mm	
Corrosion allowance	2.5	mm	
Projection of the web	500	mm	
Corrugation length at C.L.	13.75	m	
Corrugation length used in the calculation	13.75	m	corrugation length at ship's side
Pressure at lower end p_l	377.45	MPa	the cargo density is 1.85 t/m^3
Pressure at upper end p_u	41.77	Mpa	the cargo density is 1.85 t/m^3
Mean pressure p	209.61	MPa	the cargo density is 1.85 t/m^3
Yield stress s_y	315	MPa	
Modulus of Elasticity E	206000	MPa	
$C_{s\text{-}cg}$	0.90	-	for lower end
$C_{s\text{-}cg}$	0.73	-	for midspan
A_{dl}	0		
I_{dk}	0		

Table 5 Results – Longitudinal vertically corrugated bulkhead without lower and upper stools

$t_{offered\ net}$	21.5	mm
spacing s	1800	mm
web c	1346.29	mm
offered net SM	23499	cm^3
Coefficient β	2.36	-
Coefficient C_e	0.728	-
Coefficient for lower end C_3	0.60	-
Coefficient for midspan C_{m3}	0.90	-
B.M. at lower end M_{cg}	3567	kNm
B.M. at midspan M_{cg}	5355	kNm
$SM_{required\ at\ lower\ end}$	12681	cm^3
$SM_{required\ at\ midspan}$	23353	cm^3
$SM_{offered\ net}$ / $SM_{required}$	1.0063	-
required t	21.37	mm

NOTES:
- C_3 calculated by the equation $C_3 = a_3 - b_3(A_{dl}/I_{dk})^{0.5}$
- C_{m3} calculated by the equation $C_{m3} = a_{m3} - b_{m3}(A_{dl}/I_{dk})^{0.5}$
- Offered net SM calculated by the formula $SM = d(3at_f + ct_w)/6$
- min $C_{m3} = 0.60$
- min $C_3 = 0.55$
- In this case $A_{dl} = 0$ because there is no deck box
- If $t_f = t_w = t$, the required t is calculated by the formula: $t = 6SM / [d(3a+c)]$

Section 8/2.6.1.1, 2.6.1.2, 2.6.1.8

1. Background

The proposal clarifies the requirements applicable to the 1st primary support member adjacent to the transverse bulkhead.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 733:

Question #733:

Figure 8.2.4 shows the depiction of applicable extents of Primary Support Members. According to this Figure, Primary Support Members which are adjacent to Transverse Bulkhead are excluded from the target.

Our understanding is that Section 8.2.6 does not apply to Primary Support Members adjacent to Transverse Bulkhead. Please confirm.

Answer #733:

1st PSM adjacent to the transverse bulkhead in the cargo tank region

Requirements to be applied: Section 8/7, 8/2.6.4.3, 2.6.4.4

The other PSMs in the cargo tank region

Requirements to be applied: Section 8/2.6.1.2 to 2.6.1.7

Green sea load is to be applied to the entire cargo tank.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Section 8/6.2.2.5

1. Background

Deletion of a misprint in the Rules. Transverse sloshing pressure need not be applied on a vertical web frame. The vertical web is parallel to the direction of the liquid movement in case of the transverse sloshing and no significant net pressure will occur on the web.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 705:

Question #705:

Please clarify how to apply transverse sloshing pressure to vertical webs on longBHDs. According to Sec 8 / 6.2.2.5 (c) transverse sloshing pressure shall be applied, but sloshing pressure due to transverse motion will be on both sides of the web so net pressure is 0.

Answer #705:

This is a misprint and transverse sloshing pressure need not be applied on a vertical web frame. The vertical web is parallel to the direction of the liquid movement in case of the transverse sloshing and no significant net pressure will occur on the web.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Section 8/6.2.3 and 6.2.4

1. Background

Clarification of requirements. These requirements are also applicable to wash bulkhead. Therefore, it is proposed that the wording “wash bulkheads” is included.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 607:

Question #607:

8/6.2.3 and 8/6.2.3.1 indicate the wording “forming tank boundaries”. Similarly, 8/6.2.4 and 8/6.2.4.1 indicate the wording “on tank boundaries”.

However, understand that these requirements are also applicable to wash bulkhead. Therefore, the wording “tank boundaries” is not appropriate, and to be removed. Please confirm.

Answer #607:

We confirm that these requirements are also applicable to wash bulkhead and the wording should be modified.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Section 8/6.2.5.4 bis

1. Background

The Rules specify "s_trip" (mean spacing between tripping brackets) for the calculation of the required section modulus of tripping bracket in way of its base. However, the Rules do not specify the effective breadth of the attached plate (web of the primary support member) for the calculation of the actual section modulus. The Rule text is proposed amended to clarify this.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 554:

Question #554:

The Rules specify "s_trip" (mean spacing between tripping brackets) for the calculation of the REQUIRED section modulus of tripping bracket in way of its base. However, the Rules do not specify the effective breadth of the attached plate (web of the primary support member) for the calculation of the ACTUAL section modulus. Please clarify.

Answer #554:

It is suggested that the associated plate breadth be a fraction of ltrip. The difference in the section modulus of the tripping bracket will not be significant. It is proposed that that fraction is 1/3.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Section 8/Table 8.6.2

1. Background

The sagging or hogging Msw-perm-sea is to be used so that the hull girder stress direction agrees with the local stress direction at the stiffener flange. The current text "The greatest of the sagging and hogging bending moment is to be used" in the definition of Msw-perm-sea in Table 8.6.2 was inadvertently copied from the same definition in Table 8.6.1, and is not appropriate for stiffeners. The table is proposed to be updated in accordance with the definition as similar to Mv-total in Table 8.2.5.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 433:

Question #433:

Please confirm whether, in the calculation of Msw-perm-sea, sagging or hogging bending moment is to be used according to direction of sloshing pressure. In case of compressive stress at stiffener flange, hull girder bending moment, which induces compressive stress at same, is to be used.

Answer #433:

We confirm that sagging or hogging Msw-perm-sea is to be used so that the hull girder stress direction agrees with the local stress direction at the stiffener flange. We found that the current text "The greatest of the sagging and hogging bending moment is to be used" in the definition of Msw-perm-sea in Table 8.6.2 was inadvertently copied from the same definition in Table 8.6.1, and is not appropriate for stiffeners. We will update the definition as similar to Mv-total in Table 8.2.5 at the next chance of rule change. Until this Rule change, the Msw-perm-sea can be defined as "permissible hull girder hogging and sagging still water bending moment for seagoing operation at the location being considered, in kNm. The sagging or hogging bending moment leading to the maximum combined stress in absolute value at the level of the flange is to be used.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Section 8/6.4.7.5

1. Background

The parameter, Cs, "permissible bending stress coefficient" as defined in 8/6.4.7.5 refers to the acceptance criteria set AC3 in Section 2/Table 2.5.2, in which the applicable reference for PSM is written as "Plastic criteria".

The Z_{net50} equation in 8/6.4.7.5, the requirement for member properties of the PSM, is an elastic section modulus.

Z_{net50} equation in 8/6.4.7.5 is an elastic section modulus and for these reasons we propose to delete "for acceptance criteria set AC3".

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 591:

Question #591:

The parameter, "C sub s: permissible bending stress coefficient" as defined in 8/6.4.7.5 refers to the acceptance criteria set AC3 in 2/Table 2.5.2, in which the applicable reference for PSM is written as "Plastic criteria".

From the appearance of the "Z sub net50" equation in 8/6.4.7.5 and our commonly used engineering assessments, the requirement for member properties of the PSM is to be of an elastic SM.

Kindly advise if "Plastic criteria" in the 4th column of 4th entry of 2/Table 2.5.2 is to read "(XX%) yield stress "or"C sub s"in 8/6.4.7.5 is simply to read, "permissible bending stress coefficient=0.8 (without "for acceptance criteria set AC3").

Question #591:

We confirm that "Z sub net50" in 8/6.4.7.5 is to be elastic SM. We intend to fix the Rule text at the next chance of corrigenda.

2. Impact on scantlings

There is no impact on scantlings due to this change.

SECTION 9 – DESIGN VERIFICATION

Section 9/Table 9.2.1

1. Background

For the centreline bulkhead in case of Load Case B6 in Appendix B, the yield utilisation factor is taken as 1.0 for non-tight structural members in accordance with Rule Clarification of Corrigenda 1. This interpretation is not applicable to water-tight bottom girder under centreline bulkhead at the same load case.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 539:

Question #539:

For the centreline bulkhead in case of Load Case B6 in Appendix B, the yield utilisation factor is taken as 1.0 for non-tight structural members in accordance with Rule Clarification of Corrigenda 1. Is this interpretation also applicable to water-tight bottom girder under centreline bulkhead at the same load case? According to Rule Change Notice 1, tight girders are now in the same category as centreline longitudinal cargo tank bulkheads.

Answer #539:

In order to obtain max shear force on the longitudinal bulkhead the cargo tanks need to be full abreast, and in this condition (B6-head-sea) there is marginal net pressure on the longitudinal bulkhead between cargo tanks. We may therefore disregard the in plane stresses on the bulkhead due to lateral pressure for this particular condition and apply the criteria for non-tight structure.

The same does not apply to watertight girder in double bottom under the centre line bulkhead because the size of the tanks may allow for a combination of high hull girder shear force and lateral pressure on the centre line girder.

2. Impact on scantlings

There is no impact on scantlings due to this change.

SECTION 11 – GENERAL REQUIREMENTS

Section 11/1.1.6.15

1. Background

Missing requirement from IACS UR S26.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 712:

Question #712:

It seems that the following requirements of IACS UR S26.6.4 regarding hinge location has not been incorporated in CSR Tanker. There is no explanation in TB in this connection. Is there any reason for this?

IACS UR S26

"6.4 For small hatch covers located on the exposed deck forward of the fore-most cargo hatch, the hinges are to be fitted such that the predominant direction of green sea will cause the cover to close, which means that the hinges are normally to be located on the fore edge."

Answer #712:

UR S26 should be fully implemented in CSR Tank and we will include this missing requirement to hinges location at first opportunity.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Section 11/Table 11.1.5

1. Background

Amendment to be in line with IACS UR S27.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 746:

Question #746:

Table 11.1.5 of Section 11 of CSR OT (Thickness and Bracket Standards for 760mm High Air Pipes) is based on Table 1 (760 mm Air Pipe Thickness and Bracket Standards) of UR S27. However, the last column is different from the one of the UR (see attached file). Is there a misprint in Table 11.1.5?

Answer #746:

We agree there CSR Tank Table 11.1.5 should be in line with UR S27 and there are misprints in the last column. We will correct CSR Tank.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Section 11/3.1.2.15, 3.1.2.18

1. Background

Amendment is proposed to clarify the allowable stress.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Section 11/3.1.3.7

1. Background

Amendment to be in line with IACS UR A2.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 683:

RCP #683:

Contradiction between "UR A2 and CSR Double hull tanker"

- In UR A2, "Shipboard fittings and supporting hull structures associated with towing and mooring on conventional vessels", the net minimum scantlings of the supporting hull structure are to comply with the requirements given in A 2.1.5 and A 2.2.5.

However, 3.1.3 "Supporting structure for mooring winches" in Section 11 General Requirements of the Tanker CSR requires to be assessed using a simplified engineering analysis based on elastic beam theory, two-dimensional grillage or finite-element analysis using gross scantlings.

- Therefore, the term of Tanker CSR, "gross scantlings" is to be changed with "net scantlings".

- Please refer to the attachment.

Attachment:

Contradiction between "UR A2 and CSR Double hull tanker"

CSR Double hull tanker	UR A2 : Shipboard fittings and supporting hull structures associated with towing and mooring on conventional vessels	Remark
Section 11 General Requirements **3.1.3 Supporting structure for mooring winches** 3.1.3.7 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 scantlings. ….. **3.1.6 Supporting structure for bollards and bitts, fairleads, stand rollers,**	**A 2.0. Application and Definitions** The net minimum scantlings of the supporting hull structure are to comply with the requirements given in A 2.1.5 and A 2.2.5. The net thicknesses, t_{net}, are the member thicknesses necessary to obtain the above required minimum net scantlings. The required gross thicknesses are obtained by adding the total corrosion additions, t_c, given in A 2.4, to t_{net}. ….. **A 2.4. Corrosion Addition** The total corrosion addition, tc, in mm, for both sides of the hull	1. CSR for Double hull tanker rules apply to the vessel contracted for construction on or after 1 April 2006. 2. UR A2 requirements is to be implemented to ships contracted for construction from 1 January 2007. 3. CSR for tanker has to be revised for review of shipboard fittings supporting hull structures of ships contracted for construction from 1 January 2007.

chocks and capstans 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 scantlings. ….	supporting structure is not to be less than the following values: • Ships covered by CSR for bulk carriers and CSR for double hull oil tankers : Total corrosion additions defined in these rules • Other ships : 2.0	

Answer #683:

Ref. your attachment:
11/3.1.6.9 is corrected in Corrigenda 3.
11/3.1.3.7 will be considered updated at first opportunity.

2. Impact on scantlings

No significant impact on scantlings is expected.

Section 11/3.1.4.21

1. Background

Amendment is proposed to clarify the allowable stress.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Section 11/3.1.5.12

1. Background

Amendment is proposed to clarify the allowable stress.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 667:

RCP #667:

1. In CSR for Tankers Section11/3.1.5.12 two stress criteria was addressed,

Direct stress - 1.0 Sigma_yd

Shear stress - 0.58 Sigma_yd

However, there is no clear definition regarding the term 'direct stress', which would lead to inharmoniousness situation. Some designers use the maximum normal stress, while others use the von mises tress.

2. Recalling Section11/3.1.5.9, where both finite-element analysis and beam theory are applicable for assessing the supporting structure's stress, we therefore would suggest the permissible stress criteria as below:

"Beam theory or two-dimensional grillage analysis,

Normal stress - 1.0 Sigma_yd

Shear stress - 0.58 Sigma_yd

Finite-element analysis by shell element,

Von Mises stress - 1.0 Sigma_yd".

Answer #667:

Your item 1:

"direct stress" is equivalent to "Normal stress" in UR A2, where these requirements are taken from, and defined as follows:

"Normal stress is the sum of bending stress and axial stress with the corresponding shearing stress acting perpendicular to the normal stress." This definition will be included at the next available opportunity.

Your item 2:

UR A2 stipulates that the same criteria is applied regardless of the assessment method (simplified or FE). The CSR Rules should be consistent with URs, hence no further change will be adopted.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Section 11/3.1.6.13

1. Background

Amendment is proposed to clarify the allowable stress.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Section 11/Table 11.5.1

1. Background

Rudder is not part of the scope of CSR Tankers.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 811:

Interpretation request #811:

Strength test is required for double plate rudder in Table 11.5.1 Is it necessary to be kept in this table even though rudder is not part of scope?

Answer #811:

Rudder is not part of the scope of CSR Tanker. We will amend the Rules to remove this requirement.

2. Impact on scantlings

There is no impact on scantlings due to this change.

APPENDIX A – HULL GIRDER ULTIMATE STRENGTH

Appendix A/2.1.1.1

1. Background

Where the material properties of deck plate and deck longitudinals are different, in general, the lower material property is used for the determination of the hull girder section modulus on tankers. Therefore, the wording "that is used to determine the hull girder section modulus" in the definition of sigma-yd in Appendix A/2.1.1.1 was put with the intention to use the lower material property of deck plate and deck longitudinals.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 449:

Question #449:

Sigma_yd is defined as specified minimum yield stress of material that is used to determine the hull girder section modulus. When material of deck plate and deck longitudinal are different or higher than the design yield stress for longitudinal strength, which yield stress should be used? Please clarify.

Case-1: Deck plate is of HT36 and deck longitudinal is of HT40. The hull girder section modulus is determined for HT36. Yield stress for HT36 should be used?

Case-2: Deck plate is of HT36 and deck longitudinal is of HT40. But the hull girder section modulus is determined for HT32. Yield stress for HT32 should be used?

Answer #449:

Where the material properties of deck plate and deck longitudinals are different, in general, the lower material property is used for the determination of the hull girder section modulus on tankers. Therefore, the wording "that is used to determine the hull girder section modulus" in the definition of sigma-yd in Appendix A/2.1.1.1 was put with the intention to use the lower material property of deck plate and deck longitudinals. Consequently, for both Case-1 and Case-2, HT36 should be used. Please note that Case-2 is very unusual case on tankers and, therefore, the current rule wording does not fit. We intend to update the definition to make this clear.

2. Impact on scantlings

No significant impact on scantlings is expected.

APPENDIX B – STRUCTURAL STRENGTH ASSESSMENT

Appendix B/2.3.1.7 & Table B.2.4

1. Background

For un-symmetrical loading additional assessment is to be carried out. The amendment clarifies this provision.

The proposal furthermore makes clarification for the gale ballast/emergency ballast condition loading pattern B7.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 707:

Question #707:

Table B.2.4 load case B7 describe an emergency/gale ballast condition with ballast filled in cargo tanks.

- The figure shows full double bottom and side tanks in way of the full cargo tanks. May operational restrictions be applied so that ballast tanks adjacent to ballasted cargo tanks are empty in emergency/gale ballast condition?

- load case B7 require strength to be calculated using 100% of SWBM (sag.) which is considered realistic when filling ballast in cargo tanks across. Gale/emergency ballast may also be arranged by unsymmetrical filling of cargo tanks e.g. ballast in Cargo Tank No.2 port and No.4 starboard. Should strength also be calculated with 100% of SWBM for this condition? Are additional strength evaluation needed for unsymmetrical filling?

Answer #707:

- If ballast tanks adjacent to ballasted cargo tanks are empty in emergency/gale ballast condition, operational restriction is to be added in the loading manual.

- If the actual loading pattern from the Loading Manual is different to Load Case B7 then the actual is to be used (see Table B.2.4, Note 7).

- 100% of the SWBM is to be applied be applied when analyzing heavy weather ballast conditions with ballast in cargo tanks including the case with unsymmetrical filling.

- Additional strength assessment needed for unsymmetrical filling will be evaluated by the individual class societies.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Appendix B/Table B.3.1

1. Background

Note 3 of Table B.3.1 is intended to clarify the point that the criteria given in the table is only valid if the finite element model is according with the Rules, This includes the reduction of area in way of opening is according to Table B.2.2. In another word, if the modelled thickness of the web in way of the opening is NOT reduced in accordance with Table B.2.2, then the criteria cannot be used.

To make this clear, the proposal amends Notes 1 and 2 as shown and Note 3 remains unchanged.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 715:

RCP #715:

In the screening criteria for openings in PSM, shear stress is to be adjusted according to Note 2 of App.B/Table B.3.1. In order to get the adjusted shear stress, I think that the shear stress is to be adjusted by "t_actual (in FE model according to Table B.2.2)/Actual net thickness (scantling in the drawing deduct the corrosion)".

Answer #715:

Note 3 of Table B.3.1 is intended to clarify the point that the criteria given in the table is only valid if the finite element model is according with the Rules, This includes the reduction of area in way of opening is according to Table B.2.2. In another word, if the modelled thickness of the web in way of the opening is NOT reduced in accordance with Table B.2.2, then the criteria cannot be used.

To make this clear, we suggest rewriting Notes 1 and 2 as follows. Note 3 remains unchanged.

1. Screening criteria given in this table are only applicable to opening where the modelled thickness of the web in way of the opening is reduced in accordance with Table B.2.2. The element shear stress is to be adjusted using the formula given in B.2.7.2.4 prior to the evaluation of yield utilisation factor for verification against the screening criteria.

2. Where the geometry of the opening is required to be modelled in accordance with Table B.2.2, fine mesh FE analysis is to be carried out to determine the stress level. The screening criteria given in this table are not applicable.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Appendix B/4.3.1.2

1. Background

It is found that the formulation in Appendix C/2.4.2.7 for fatigue strength of hopper connection yields lesser requirements if a higher cargo density than $0.9t/m^3$ is used. However, the formulation has been developed and calibrated for the cargo density of $0.9t/m^3$, and it is not the original rule intention to reduce the requirements for higher cargo densities. The above revised text fixes the rule flaw. It does not change the originally intended scantling requirements or background.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 396:

Question #396:

We carried out a fatigue strength assessment on a lower hopper knuckle of VLCC in accordance with CSR. In the assessment, we intended to increase the cargo density from 0.9t/m^3 specified as a minimum one. We generally understood that higher cargo density or accelerations acting on cargo tanks decrease fatigue life of the lower hopper knuckle. However, we obtained longer fatigue life by increasing the cargo density. It differs from our understanding and knowledge. The cause is in the combination formula prescribed in

App.C.2.4.2.7: S=f_model|0.85(S_e1 + 0.25S_e2) - 0.3S_i| for full load condition, where S_e=stress range caused by external pressures; and S_i = stress range caused by internal pressures. We would like to ask you to reconsider the formula technically.

Answer #396:

In general, the stress range caused by dynamic external pressure is higher in way of hopper knuckle than that caused by internal pressure. The formulation in Appendix C2.4.2.7 has been derived based on this premise and calibrated with a cargo density of 0.9t/m3.

Also considering that the actual cargo densities used in the ordinary oil tanker operation are even smaller than the specified maximum cargo density as per Section 2/3.1.8.2, it is our intention to limit the cargo density to 0.9t/m3 only for fatigue assessment of hopper knuckle connection even if a higher cargo density is used for fatigue assessment of ordinary longitudinal stiffener end connections.

Consequently, cargo density of 0.9t/m3 is to be always used for fatigue assessment of hopper knuckle connection. We will update the applicable rule text to clarify this.

2. Impact on scantlings

There is no impact on scantlings due to this change.

APPENDIX C – FATIGUE STRENGTH ASSESSMENT

Appendix C/1.4.4.6 & 1.4.4.8

1. Background

The rule provisions "(openings deducted)" in Appendix C/1.4.4.6 and 1.4.4.8 is to be read as "Large openings and small openings that are not isolated" indicated in Section 4/2.6.3.4 provided that the conditions for "isolated small openings" in Section 4/2.6.3.7 are met. As such, isolated small openings need not be deducted for fatigue analysis provided that the conditions in Section 4/2.6.3.7 are met.

The wording "(openings deducted)" is not necessary and has caused confusion. It is proposed removed since all other CSR/Tanker requirements using the hull girder properties do not specifically indicate it.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 828:

Interpretation request #828:

"With regard to the rule wording "(openings deducted)" in Appendix C/1.4.4.6 and 1.4.4.8, presume that this "opening" is "Large openings and small openings that are not isolated" indicated in 4/2.6.3.4 provided that the conditions for "isolated small openings" in 4/2.6.3.7 are met. As such, isolated small openings need not be deducted for fatigue analysis provided that the conditions in 4/2.6.3.7 are met. Please confirm."

Answer #828:

Your interpretation is confirmed; to avoid any confusion "(openings deducted)" will be deleted from C/1.4.4.6 and C/1.4.4.8 at the next Rule change.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Appendix C/1.4.5.11

1. Background

For clarification.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Appendix C/2.4.2.6

1. Background

For clarification.

2. Impact on scantlings

There is no impact on scantlings due to this change.

Appendix C/Figure C.2.2 & Figure C.2.3

1. Background

The theoretical optimum alignment is for the hopper median line to be outboard of the girder median line, which appears opposite of the rule stipulation “towards centreline in way of the floor”. In that case, not only is the current rule stipulation impractical for some builders, it could also lead to incorrect alignment.

Stripe coating is stipulated where weld toe grinding is applied in order to protect the ground surface from corrosion. This is not relevant to Fig.C.2.3 where a bracket is fitted in lieu of weld toe grinding. The sentence was retained by accident when copying from one figure to another during rule development.

Weld dressing is a general term that applies to different methods of weld treatment to improve fatigue strength. In the context of CSR for Tankers dressing is to be read as weld extension. Furthermore the text has been clarified to show that the extent of grinding is the same as the extent of dressing.

The proposed amendment is in line with the answer provided in the IACS CSR Knowledge Centre KC ID: 156:

Question #156:

(1) It is requested to clarify the “dressed” and “ground smooth” which are stated in Figure C2.2 of Appendix C and to specify in the detailed procedure of such improvement measure.

(2) In the Figure C2.2 of Appendix C, extent of dressing both side of floor.

VLCC: 250mm, Suezmax: 200mm, Aframax: 150mm, Product: 100mm

Is value able to be applied to grinding of the weld toe, too?

(3) We would like to know the reasons why the recommended value of the extent of dressing is different corresponding to the vessel size. It is seemed to be little difference the structural arrangement of such hopper parts regardless the ship size.

Answer #156:

1) Dressing to read as bead dressing i.e. as per attached figure. "Grinding smooth" means smooth concave profile and small weld flank angle. The rules need update to clarify this.

2) That is correct, extent of "grinding smooth" is the same as the extent of dressing

3) We will consider future update of the rules e.g. apply one limit of 200mm for all size of tankers.

2. Impact on scantlings

There is no impact on scantlings due to this change.

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