Common Structural Rules for Double Hull Oil Tankers, January 2006

Rule Change Notice No. 1
September 2006

Notes: (1) Rule Changes introduced in Rule Change Notice No.1 are to be applied to ships contracted for construction on or after 1 April 2007. However, application to ships contracted for construction prior to 1 April 2007 is acceptable where agreed by builder and prospective owner.

(2) The Rule changes are not to be partially applied.

(3) This document contains a copy of the affected rule along with the proposed change.

SECTION 6 – MATERIALS AND WELDING

3 CORROSION ADDITIONS

3.2 Local Corrosion Additions

3.2.1 General

Table 6.3.1
Corrosion Addition, t_{corr}, for Typical Structural Elements Within the Cargo Tank Region

Category of contents			Corrosion Addition t_{corr}, in mm
Internal members and plate boundary between spaces with the same category of contents			
In and between ballast water tanks	Face plate of PSM	Within 3m below top of tank (1)	4.5
		Elsewhere	3.5
	Other members	Within 3m below top of tank (1)	4.0
		Elsewhere	3.0
	Stiffeners on boundaries to heated cargo tanks	Within 3m below top of tank (1)	4.5
		Elsewhere	3.5
In and between cargo oil tanks	Face plate of PSM	Within 3m below top of tank (1)	4.0
		Elsewhere	3.5
	Other members	Within 3m below top of tank (1)	4.0
		Elsewhere	2.5
~~In and between heated cargo oil tanks~~	~~Face plate of PSM~~	~~Within 3m below top of tank (1)~~	~~4.5~~
		~~Elsewhere~~	~~4.0~~
	~~Other members~~	~~Within 3m below top of tank (1)~~	~~4.5~~
		~~Elsewhere~~	~~3.5~~
Exposed to atmosphere on both sides	Support members on deck		2.5
In and between void spaces	Spaces not normally accessed, e.g. access only via bolted manhole openings, pipe tunnels, etc.		2.0
In and between dry spaces	Internals of deckhouses, machinery spaces, pump room, store rooms, steering gear space, etc.		1.5
Plate boundary between spaces having a different category			
Boundary between ballast tank and cargo oil tank	Unheated cargo ~~oil~~tank	Within 3m below top of tank (1)	4.0
		Inner bottom plating	4.0
		Elsewhere	3.0
	Heated cargo ~~oil~~tank	Within 3m below top of tank (1)	4.5
		Inner bottom plating	4.5
		Elsewhere	3.5 ~~3.0~~
Boundary between ballast tank and atmosphere or sea	Weather deck plating		4.0
	Other members(2)	Within 3m below top of tank (1)	3.5
		Elsewhere	3.0
Boundary between ballast tank and void or dry space	Within 3m below top of tank(1)		3.0
	Elsewhere		2.5
Boundary between cargo tank and atmosphere	~~Unheated cargo oil~~	Weather deck plating	4.0
	~~Heated cargo oil~~	~~Weather deck plating~~	~~4.5~~
Boundary between cargo tank and void spaces	~~Unheated cargo oil~~	Within 3m below top of tank (1)	3.0
		~~Elsewhere~~	~~2.5~~
	~~Heated cargo oil~~	~~Within 3m below top of tank (1)~~	~~3.5~~
		Elsewhere	2.5
Boundary between cargo tank and dry spaces	~~Unheated cargo oil~~	Within 3m below top of tank (1)	3.0
		Elsewhere	2.0
	~~Heated cargo oil~~	~~Within 3m below top of tank (1)~~	~~3.0~~
		~~Elsewhere~~	~~2.5~~

Note
1. Only applicable to cargo and ballast tanks with weather deck as the tank top
2. 0.5mm to be added for side plating in the quay contact region defined in *Section 8/Figure 8.2.2*
3. Heated cargo oil tanks ~~is~~are defined as cargo tanks arranged with any form of heating capability

Reason for the Rule Change:

Clarification of the corrosion addition for heated cargo tanks, corresponds with the corrections made in *Section 12, Table 12.1.1*. A key correction is the wrong interpretation of the additional margin due to heated cargo. Whereas the statistics show that the corrosion rates increase in ballast tanks subject to increased temperature there is no data showing the same effect in the cargo tanks.

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
  - all segregated ballast tanks in the cargo tank region or aft of the cargo tank region may be are full, or partially full or empty. Where the partially full options are exercised, the conditions in *1.1.2.5* are to be complied with
  - the lower fore peak water ballast tank is to be full. If upper and lower fore peak tanks are fitted, the lower is required to be full. The upper fore peak tank may be full, partially full or empty. (if fitted)
  - any ballast tank 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
  - 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 immersion I/D_{prop} is to be at least 60% where

    I = the distance from the propeller centreline to the waterline, in m

    D_{prop} = propeller diameter, in m
  - 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

(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.

Reason for the Rule Change:

A significant number of questions have been raised with respect to the normal and heavy ballast conditions. When the conditions where set they were based on URS25 and the immersion for the heavy ballast was set to 60%. In this process the point that 60% is more than full immersion was missed. The 60% immersion requirement will in many cases also lead to a reduced draught fwd as compared to the normal ballast condition which is not the intent.

Considering that the URS25 heavy ballast condition is more an emergency condition with filling of a cargo hold it is not relevant to require more than full immersion for the CSR Tanker "heavy ballast condition". A corresponding correction to the Rules is proposed above . To avoid misunderstanding of whether the heavy ballast condition as specified in the CSR is an operational condition it is further suggested to add the trim requirement.

1.4 Hull Girder Buckling Strength

1.4.2 Buckling assessment

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

$$\eta \le \eta_{allow}$$

Where:

η buckling utilisation factor

$$\frac{\sigma_{hg-net50}}{\sigma_{cr}}$$

$\sigma_{hg-net50}$ hull girder compressive stress based on net hull girder sectional properties, in N/mm² as defined in *1.4.2.3*

σ_{cr} critical compressive buckling stress, σ_{xcr} or σ_{ycr} as appropriate, in N/mm², as specified in *Section 10/3.2.1.3*. The critical compressive buckling stress is to be calculated for the effects of hull girder compressive stress only. The effects of other membrane stresses and lateral pressure are to be ignored. The net thickness given as $t_{grs} - t_{corr}$ as described in *Section 6/3.3.2.2* is to be used for the calculation of σ_{cr}

η_{allow} allowable buckling utilisation factor:

= 1.0 for plate panels above 0.5*D*

= ~~0.85~~0.90 for plate panels below 0.5*D*

t_{grs} gross plate thickness, in mm

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

Reason for the Rule Change:

Application of the Rules to standard designs indicates that the buckling requirements are somewhat conservative. The calculations give significant increases to bottom longitudinals due to torsional buckling.

Comparison has been made with IACS URS11, CSR Tankers advanced buckling method as incorporated in the 2nd draft of the CSR and based on these results the buckling utilisation factor is proposed increased to 0.9. For reference please note that allowable utilisation factor in CSR for Bulk carriers where pressure is also incorporated is 1.0.

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

$\eta \leq \eta_{allow}$

Where:

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

η_{allow} allowable buckling utilisation factor:

= 1.0 for stiffeners above 0.5*D*

= ~~0.85~~0.90 for stiffeners below 0.5*D*

Reason for the Rule Change:

Application of the Rules to standard designs indicates that the buckling requirements are somewhat conservative. The calculations give significant increases to bottom longitudinals due to torsional buckling.

Comparison has been made with IACS URS11, CSR Tankers advanced buckling method as incorporated in the 2nd draft of the CSR and based on these results the buckling utilisation factor is proposed increased to 0.9. For reference please note that allowable utilisation factor in CSR for Bulk carriers where pressure is also incorporated is 1.0.

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. ~~Tight floors, girders and webs~~	$\lambda_y \leq 0.8$ (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*.	

Reason for the Rule Change:

The allowable yield utilisation for tight floors, girders, webs is proposed changed to 0.9/0.72. The latter is found acceptable as the majority of stresses in these members are hull girder stress and shear stress and consequently the amount of stress "missing" is not significant and the 0.9 value is more appropriate. Calculations on existing designs and using the 0.8 allowable typically shows and increase of up to 7mm for the CL double bottom girder of a VLCC.

SECTION 10 – BUCKLING AND ULTIMATE STRENGTH

2 STIFFNESS AND PROPORTIONS

2.2 Plates and Local Support Members

2.2.1 Proportions of plate panels and local support members

Table 10.2.1
Slenderness Coefficients

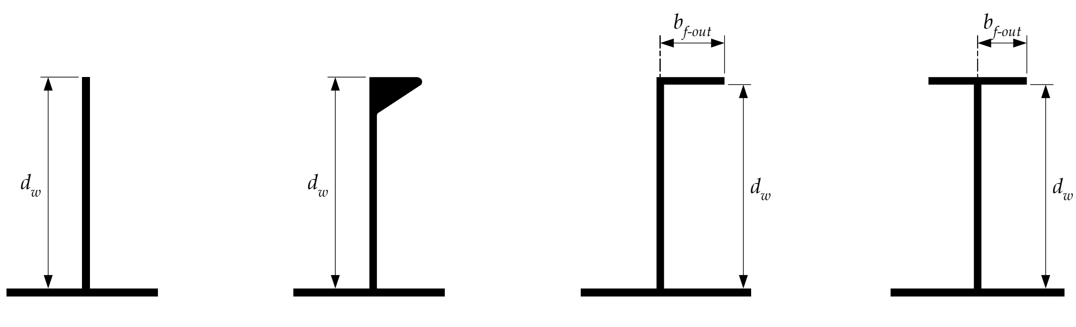
Item		Coefficient
plate panel, C	hull envelope and tank boundaries	100
	other structure	125
stiffener web plate, C_w	angle and T profiles	75
	bulb profiles	~~37~~ 41
	flat bars	22
flange/face plate(1), C_f	angle and T profiles	12

Note

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

Where:

t_{net}	Net thickness of plate, in mm
d_w	depth of web plate, in mm
$t_{w\text{-}net}$	Net web thickness, in mm
$b_{f\text{-}out}$	breadth of flange outstands, in mm
$t_{f\text{-}net}$	Net flange thickness, in mm



Flat bars   Bulb flats   Angles   T bars

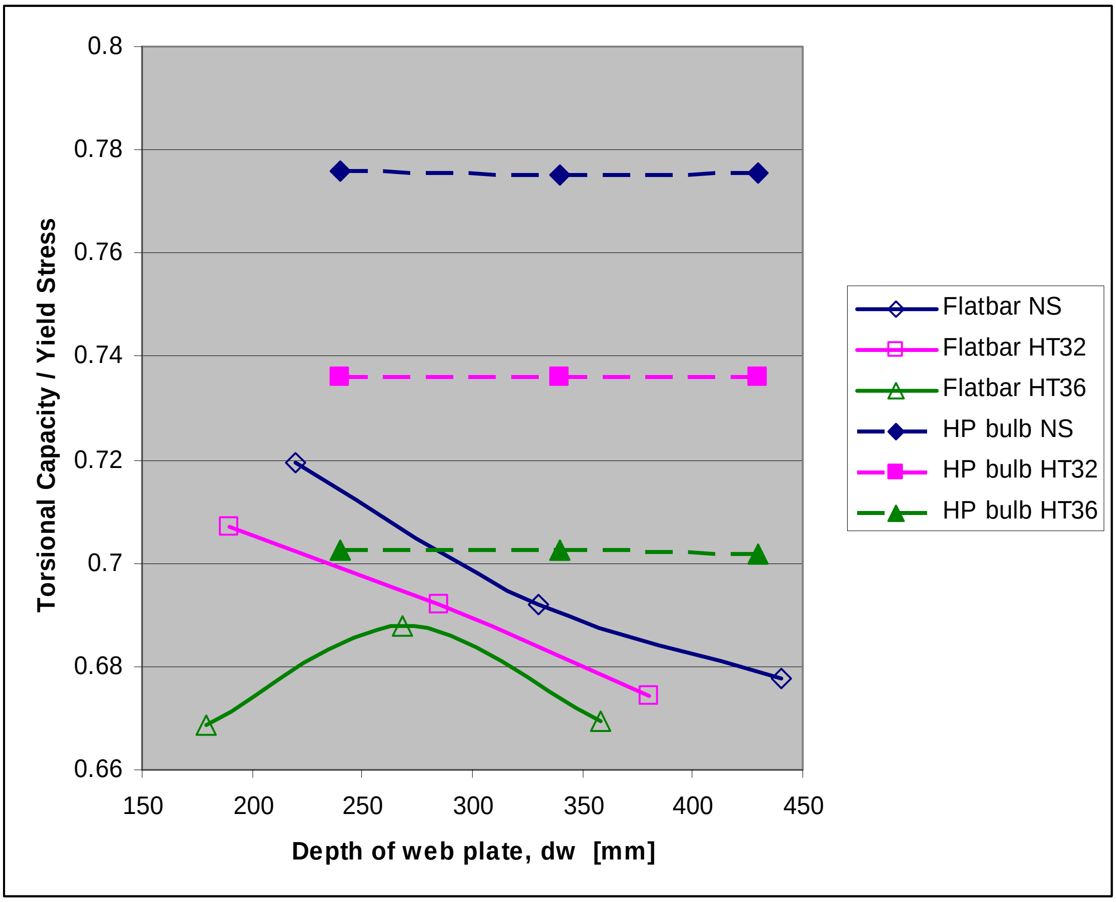
Reason for the Rule Change:
When used as deck longitudinals, most of the standard bulb profiles of HT32 and HT36 with height exceeding 200 mm will not meet the slenderness criteria for C= 37. In the background, the slenderness coefficient C is based on an assumed buckling coefficient F = 1.0 and a buckling strength of approx. 60% of yield. Corresponding values for flat bar stiffeners are slenderness coefficient C = 22 and elastic buckling factor F = 0.43.

By assuming an elastic buckling coefficient F=1.25 for bulb profiles the slenderness coefficient will be 10% higher (C=41) with the same target buckling strength. To test this assumption, torsional capacity calculations, according to *Section 10/3.3.3,* have been done for the following cases:

- Flatbar stiffeners of height 180-440 mm, with C=22 and σ_{yd} = 235, 315 and 355 N/mm²
- Bulb flats of height between 220-430 mm with the proposed C = 41. σ_{yd} = 235, 315 and 355 N/mm²

The figure below shows torsional capacity of bulb flats, based on the 10% increase of the slenderness coefficient (C=41 shown with dotted lines), is approx. 5-10% higher (comparing NS flatbar with NS bulb and HT flatbar with HT bulb) than the torsional capacity of the bulb flats, with C=22.

The proposed elastic buckling factor of F=1.25 and the corresponding slenderness coefficient C=41 for bulb flats are still on the conservative side as compared with the acceptance criteria for flatbars.



SECTION 11 – GENERAL REQUIREMENTS

3 SUPPORT STRUCTURE AND STRUCTURAL APPENDAGES

3.1 Support Structure for Deck Equipment

3.1.4 Supporting structure for cranes, derricks and lifting masts

3.1.4.14 Depending on the arrangement of the deck connection in way of crane pedestals, the following additional requirements are to be complied with:

(a) where the pedestal is directly connected to the deck, without above deck brackets, adequate under deck structure directly in line with the crane pedestal is to be provided. Where the crane pedestal is attached to the deck without bracketing or where the crane pedestal is not continuous through the deck, welding to the deck of the crane pedestal and its under deck support structure is to be made by suitable full penetration welding. This could include a deep penetration welding procedure with a maximum root face of 3mm provided this results in full penetration and consequently enables ultrasonic lamination testing after welding has been completed. The design of the weld connection is to be adequate for the calculated stress in the welded connection, in accordance with *3.1.4.21*

(b) where the pedestal is directly connected to the deck with brackets, under deck support structure is to be fitted to ensure a satisfactory transmission of the load, and to avoid structural hard spots. Above deck brackets may be fitted inside or outside of the pedestal and are to be aligned with deck girders and webs. The design is to avoid stress concentrations caused by an abrupt change of section. Brackets and other direct load carrying structure and under deck support structure are to be welded to the deck by suitable full penetration welding. This could include a deep penetration welding procedure with a maximum root face of 3mm provided this results in full penetration and consequently enables ultrasonic lamination testing after welding has been completed. The design of the connection is to be adequate for the calculated stress, in accordance with *3.1.4.21*.

Reason for the Rule Change:
Some yards have the capability to obtain full penetration welds using a small root face of 3mm and deep penetration welding procedures. The rule has been revised to accept this process for this application.

SECTION 12 – SHIP IN OPERATION RENEWAL CRITERIA

1 ALLOWABLE THICKNESS DIMINUTION FOR HULL STRUCTURE

1.4 Renewal Criteria of Local Structure for General Corrosion

Table 12.1.2 Local Wastage Allowance for One Side of Structural Elements			
Compartment Type	**Structural Member**		**Ship in Operation Component Wastage Allowance, t_{was-1} or t_{was-2} (mm)**
Ballast water tank and chain locker~~[3]~~	Face plate of PSM	Within 3m below top of tank [1]	2.0
		Elsewhere	1.5
	Other members[3]	Within 3m below top of tank [1]	1.7
		Elsewhere	1.2
Cargo oil tank ~~[3]~~	Face plate of PSM	Within 3m below top of tank [1]	1.7
		Elsewhere	1.4
	Inner-bottom plating/bottom of tank		2.1
	Other members	Within 3m below top of tank [1]	1.7
		Elsewhere	1.0
Exposed to atmosphere	Weather deck plating		1.7
	Other members		1.0
Exposed to sea water	Shell plating[2]		1.0
Fuel and lube oil tank [~~3~~4],	Top of tank and attached internal stiffeners		1.0
	Elsewhere		0.7
Fresh water tank	Top of tank and attached internal stiffeners		1.0
	Elsewhere		0.7
Void spaces	Spaces not normally accessed, e.g. access only via bolted manhole openings, pipe tunnels, etc.		0.7
Dry spaces	Internals of deckhouses, machinery spaces, pump room, store rooms, steering gear space, etc.		0.5

Notes

1. Only applicable to cargo and ballast tanks with weather deck as the tank top.
2. 0.5mm to be added for side plating in the quay contact region as defined in *Section 8/Figure 8.2.2.*
3. 0.5mm to be added to the plate surface exposed to ballast for plate boundary between water ballast and heated cargo oil tanks. 0.3mm to be added to each surfaces of the web and face plate~~side~~ of a stiffener ~~exposed to~~ in a ballast tank and attached to ~~of the longitudinal stiffeners on~~ the boundary between water ballast and heated cargo oil tanks ~~(0.6mm total)~~. Heated cargo oil tanks are defined as tank arranged with any form of heating capability (most common type is heating coils).
4. 0.7mm to be added for plate boundary between water ballast and heated fuel oil tanks

Reason for the Rule Change:

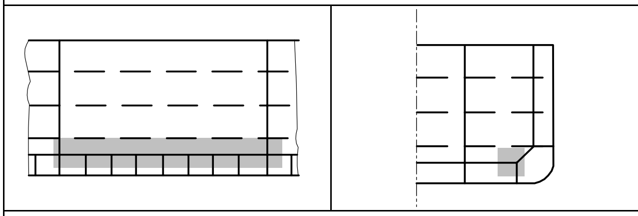
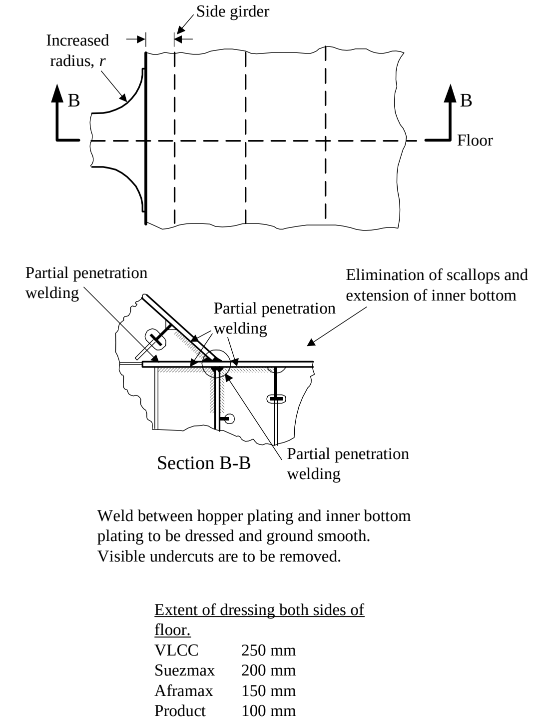
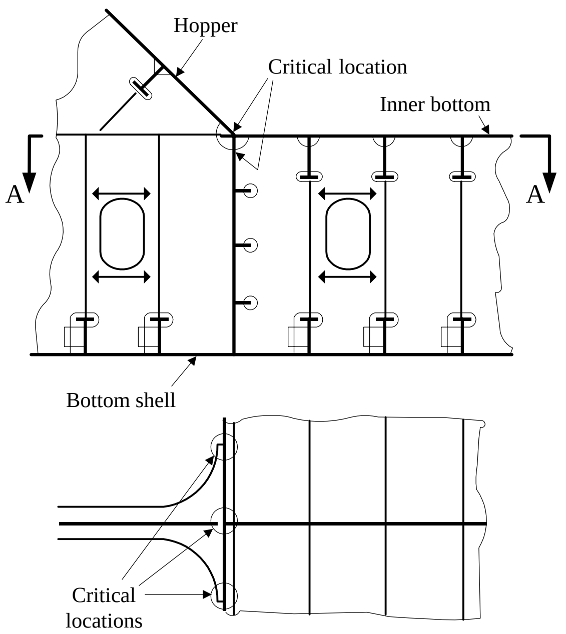
Clarification that the additional corrosion addition for heated cargo tanks only applies to boundaries between heated cargo oil tanks and ballast tanks. Clarify that the heated cargo addition applies to plates (0.5mm on surface on exposed to ballast) and to the stiffeners (0.3mm for each surface in contact with ballast water i.e. 0.6 mm in total for stiffeners) located within the ballast tanks. Correction of omission of corrosion addition for heated fuel oil tanks to ensure consistency with CSR for Bulk.

Appendix C – Fatigue Strength Assessment

2 HOT SPOT STRESS (FE BASED) APPROACH

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	DETAIL DESIGN STANDARD A
	 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.
CRITICAL LOCATIONS	
 Section A-A	

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, ~~0.15*t*~~ 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).

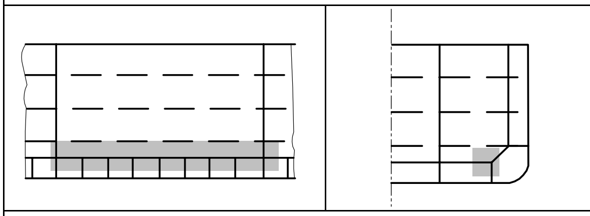
Reason for the Rule Change:

The building tolerance is updated to be in line with acceptable ship building tolerances specified in IACS Recommendation 47. The 0.15t criteria is related to alignment of face plates of primary support members and not applicable to the alignment of the hopper area. It should also be noted that IACS Recommendation will be subject to a general review and that any changes there will be reflected in future updates of the CSR

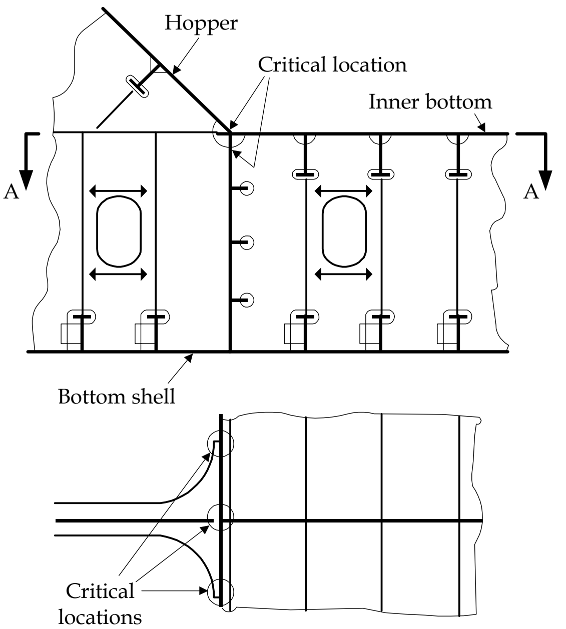
Figure C.2.3
Option: Hopper Knuckle Connection Detail, With Bracket

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

CRITICAL AREAS

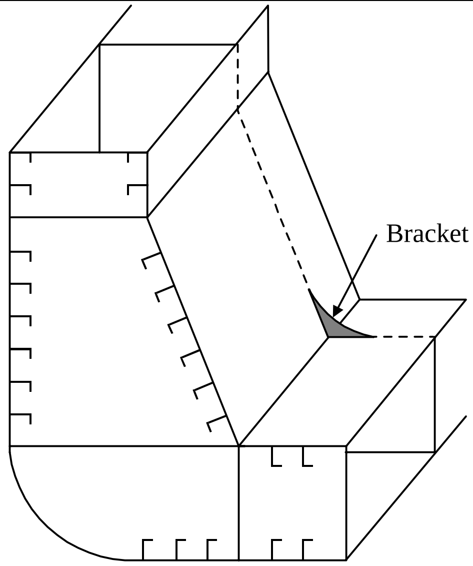


CRITICAL LOCATIONS



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:

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

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, ~~0.15*t*~~ 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).

Reason for the Rule Change:

The building tolerance is updated to be in line with acceptable ship building tolerances specified in IACS Recommendation 47. The 0.15t criteria is related to alignment of face plates of primary support members and not applicable to the alignment of the hopper area. It should also be noted that IACS Recommendation will be subject to a general review and that any changes there will be reflected in future updates of the CSR.