RUSSIAN MARITIME REGISTER OF SHIPPING

GUIDELINES
ON FATIGUE ASSESSMENT OF SHIPS

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GUIDELINES ON FATIGUE ASSESSMENT OF SHIPS

Guidelines on Fatigue Assessment of Ships of Russian Maritime Register of Shipping have been approved in accordance with the established approval procedure and come into force on 1 December 2020.

The recommendations of the International Association of Classification Societies (IACS) have been considered in the Guidelines.

In case of discrepancies between the Russian and English versions, the Russian version shall prevail.

REVISION HISTORY

(purely editorial amendments are not included in the Revision History)

For this version, there are no amendments to be included in the Revision History.

1 GENERAL

1.1 SYMBOLS

1.1.1 For the purpose of these Guidelines, the following symbols have been adopted:

L — length of the ship, in m, in accordance with 1.1.3, Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships;

B — moulded breadth of the ship, in m, in accordance with 1.1.3, Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships;

d — summer draught, in m, in accordance with 1.1.3, Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships;

d_1 — load draught, in m, corresponding to the loading condition under consideration in accordance with the Stability Booklet;

d_B — minimum draught amidships, in m, in accordance with 2.1.2 of these Guidelines;

d_F — maximum draught amidships, in m, in accordance with 2.1.2 of these Guidelines;

C_b — block coefficient in accordance with 1.1.3, Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships;

B_w — moulded breadth of the hull transverse section under consideration measured at the waterline at draught d_1, in m;

p_{st} — static sea pressure, in kPa;

p_w — wave pressure, in kPa;

$p_{c.st}$ — static internal pressure induced by cargo, fuel oil or ballast, in kPa;

$p_{c.in}$ — inertial pressure induced by cargo, fuel oil or ballast, in kPa;

v_0 — specified speed of ship, in knots;

x — longitudinal co-ordinate, in m, measured from the after perpendicular;

y — transverse co-ordinate, in m, measured from the centreline;

z — height co-ordinate, in m, measured from the baseline;

z_0 — height co-ordinate, in m, measured from the waterline at draught d;

z_1 — height co-ordinate, in m, measured from the waterline at draught d_1, therewith, z_1 is positive for the points above the waterline;

I_z — moment of inertia of the hull transverse section, in m^4, about the vertical neutral axis, to be calculated taking into account 1.3.3 of these Guidelines;

I_y — moment of inertia of the hull transverse section, in m^4, about the horizontal neutral axis, to be calculated taking into account 1.3.3 of these Guidelines;

e — distance, in m, measured from the baseline to horizontal neutral axis of the hull transverse section;

ρ_c — cargo density, in t/m^3;

ρ_l — liquid cargo, ballast or fuel oil density, in t/m^3, whichever is appropriate;

φ_r — reduction factor in accordance with 1.3.1.5, Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships;

i — index which denotes the load case "*a*", "*b*", "*c*" or "*d*";

j — index which denotes the loading condition *B* or *F* consistent with 2.1.2 of these Guidelines;

H — height, in m, of a tank, to be taken as the vertical distance from the bottom to the top of the tank, excluding any small hatchways.

1.2 SCOPE OF APPLICATION

1.2.1 These Guidelines are intended for the assessment of fatigue capacity of steel welded ships, from 150 to 350 m in length at design stage.

1.2.2 The recommendations of these Guidelines apply to welded structural details of steel ships.

1.2.3 The aim of fatigue assessment at design stage is to ensure the required fatigue life of critical details. The associated methodology is based on S-N curves, linear damage accumulation approach and several stress assessment methods.

1.2.4 The associated fatigue assessment is performed in order to prevent the following types of fatigue failure:

fatigue cracks initiating from the weld toe;

fatigue cracks initiating from the weld root.

1.3 ASSUMPTIONS

1.3.1 These Guidelines apply for calculation of steel structures with the yield stress not greater than 390 N/mm^2.

1.3.2 **Temperature.**

1.3.2.1 For design temperatures up to 100 ºC, steel material properties at 20 ºC may be considered.

1.3.2.2 For design temperatures higher than 100 ºC, the decrease of fatigue capacity with the temperature increase is to be regarded. IIW Fatigue Recommendations (IIW-XIII-1823-07, 2008) contain the reduction factors for steel at temperatures higher than 100 ºC and lower than 600 ºC.

1.3.3 Scantlings without corrosion allowances are to be considered throughout the Guidelines.

1.3.4 The methodology specifies fatigue assessment of hull structures subject to wave loads causing elastic deformations. Plastic deformations caused by other loads (e.g. loading/unloading, local ice loads etc.) are not considered.

1.4 LIST OF DETAILS

1.4.1 Fatigue assessment is carried out for the details given in Appendix 1. The details are divided into several groups depending of the calculation method:

details located at ends of primary longitudinal members in area of intersection with transverse bulkheads, floors and other transverse deep members;

details, where the stresses are calculated through the finite element method.

1.4.2 When details other than those in 1.4.1 with specific geometry and/or high stress values are used, the Register reserves the right to require fatigue assessment for the ones.

1.5 SIGN CONVENTIONS

1.5.1 **Sign conventions for bending moments:**

.1 vertical bending moment is positive when it induces tensile stresses in the strength deck (hogging bending moment), it is negative in the opposite case (sagging bending moment);

.2 horizontal bending moment is positive.

1.5.2 Tensile stresses are positive, compressive stresses are negative.

1.6 DEFINITIONS

1.6.1 For the purpose of these Guidelines, the following definitions and explanations have been adopted.

Hot spots are the locations where fatigue cracking may occur due to the combined effect of nominal stress fluctuation and stress raising effects due to connection geometry and weld notches (see Fig.1.6.1).

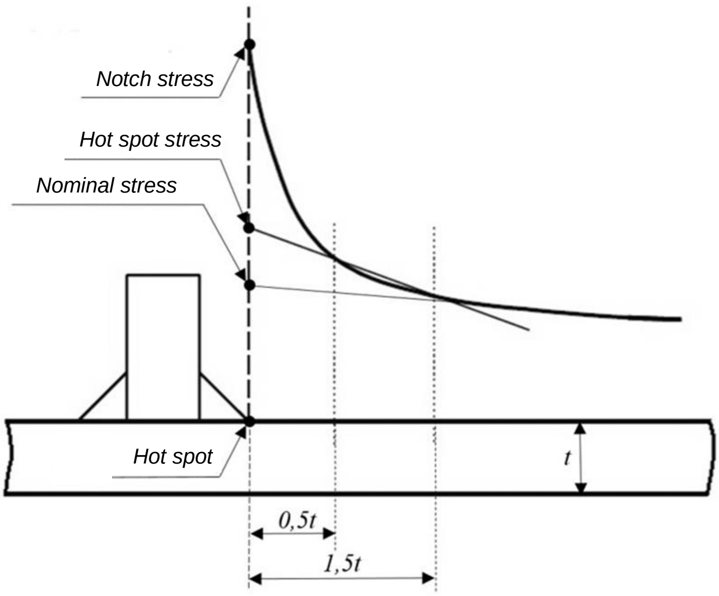


Fig. 1.6.1

Nominal stress is the stress in a structural component taking into account only macro-geometric effects. The stress concentration due to structural discontinuities and the presence of welded attachments is disregarded.

Hot spot stress is a stress at the end point of weld taking into account the stress concentration due to structural discontinuities and the presence of welded attachments, but excluding nonlinear stress peak caused by notches.

Notch stress is a peak stress in a notch such as the root of a weld taking into account the nonlinear stress peak due to the presence of notches.

Stress range is the difference between the maximum and minimum stresses, to be determined for each combination of load cases and loading conditions specified in accordance with 2.1.2.

1.7 PARTIAL SAFETY FACTORS

1.7.1 Partial safety factors are to be determined in accordance with Table 1.7.1.

Table 1.7.1

Uncertainties regarding:	Symbol	Value	
		General	For details located at ends of primary longitudinal members
Still water hull girder loads	γ_{s1}	1,00	1,00
Wave hull girder loads	γ_{w1}	1,05	1,15
Static pressure	γ_{s2}	1,00	1,00
Wave pressure	γ_{w2}	1,10	1,20
Resistance	γ_R	1,02	1,10

2 LOADS

2.1 GENERAL

2.1.1 The load points are specified in accordance with 1.3.1.3, Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships.

Where stress range is determined through the finite element method, distributed loads are to be applied.

2.1.2 Loads for fatigue assessment consist of hull girder loads and local pressure induced by the sea, cargo, fuel oil and ballast. The loads are to be determined for each load case "*a*", "*b*", "*c*" and "*d*" at two loading conditions accepted based on the Stability Booklet, corresponding to the minimum and maximum draught amidships (the values related to these loading conditions are specified by indexes *B* and *F* respectively).

2.1.3 Each load case "*a*", "*b*", "*c*" and "*d*" is divided into two cases "max" and "min", for which pressure induced by the sea, cargo, fuel oil and ballast, as well as the relevant hull girder loads are specified according to 2.2 and 2.3 respectively.

2.1.4 When the distinguishing mark **FTL (years) Spectral North Atlantic** is applied in the class notation, the loads required for calculation by spectral method are determined by means of hydrodynamic calculations with due regard to main characteristics of the ship. Information on model, calculation methodology and intermediate results of calculations, such as Response Amplitude Operators at various headings is to be submitted to the Register for approval.

2.1.5 Design wave height h, in m, is calculated as follows:

$$h = 5{,}5 - 0{,}5\left(\frac{275-L}{100}\right)^{3/2} \quad \text{at } 150 < L \le 275 \text{ m;} \qquad (2.1.5\text{-}1)$$

$$h = 5{,}5 \quad \text{at } L > 275 \text{ m.} \qquad (2.1.5\text{-}2)$$

2.2 PRESSURE INDUCED BY THE SEA, CARGO, FUEL OIL AND BALLAST

2.2.1 The pressures are to be determined for the load draught corresponding to the loading condition under consideration in accordance with 2.1.2.

2.2.2 Pressures are divided into static and wave, induced by the sea (p_{st}, p_w) and various cargo, fuel oil and ballast types ($p_{c.st}$, $p_{c.in}$) determined in accordance with 2.2.3 — 2.2.7. Combined sea pressure p, and combined internal pressure p_c are:

$$p = \gamma_{s2} p_{st} + \gamma_{w2} p_w; \qquad (2.2.2\text{-}1)$$

$$p_c = \gamma_{s2} p_{c.st} + \gamma_{w2} p_{c.in}. \qquad (2.2.2\text{-}2)$$

2.2.3 Static pressure induced by cargo, fuel oil and ballast (static internal pressure).

.1 static internal pressure $p_{c.st}$, in kPa, on the grillages of cargo decks, platforms and double bottom from package cargo is determined from the formula:

$$p_{c.st} = \rho_c g h_c \qquad (2.2.3.1)$$

where h_c – design stowage height, in m.

.2 static internal pressure $p_{c.st}$, in kPa, on the structures forming boundaries of the compartments intended for the carriage of liquid cargoes, ballast and fuel oil is determined as the greater of the values obtained from the following formulae:

$$p_{c.st} = 0{,}75 \rho_l g (z_i + \Delta z); \qquad (2.2.3.2\text{-}1)$$

$$p_{c.st} = \rho_l g z_i + p_v \qquad (2.2.3.2\text{-}2)$$

where z_i – distance, in m, from the member concerned to the deck level (tank top) as measured at the centreline;
Δz – height, in m, of air pipe above deck (tank top), but shall not be less than 1,5 m for the ballast tanks of dry cargo ships and for fresh water tanks, 2,5 m for the tanks of tankers and for fuel oil and lubricating oil tanks; for small expansion tanks and for lubricating oil tanks of less than 3 m^3 capacity, the minimum values of Δz are not stipulated;
p_v – pressure, in kPa, for which the safety valve is set, if fitted, but shall not be less than 15 kPa for the ballast tanks of dry cargo ships and fresh water tanks, 25 kPa for the tanks of tankers and for fuel oil and lubricating oil tanks; for small expansion tanks and for lubricating oil tanks of less than 3 m^3 capacity, the minimum values of p_v are not stipulated.

.3 static internal pressure $p_{c.st}$, in kPa, on structures bounding the bulk cargo hold is determined from the following formula:

$$p_{c.st} = \rho_c g k_c z_i \qquad (2.2.3.3\text{-}1)$$

where $k_c = \sin^2\alpha \cdot \tan^2(45° - \varphi_{i.f}/2) + \cos^2\alpha$ (2.2.3.3-2)

or

$k_c = \cos\alpha,$ (2.2.3.3-3)

whichever is the greater;
α – angle of web inclination to the base line, in deg.;
$\varphi_{i.f}$ – internal friction angle of bulk cargo, in deg.;
z_i – vertical distance from the load application point to the free surface level of cargo, in m.

2.2.4 Determination of load values for different load cases.

2.2.4.1 *Load case "a".*

.1 the static sea pressure is determined in accordance with 1.3.2.1, Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships;
.2 the wave pressure is determined in Table 2.2.4.1.2-1;
.3 the static internal pressure is determined in accordance with 2.2.3**;**
.4 no inertial pressures are considered.

Table 2.2.4.1.2-1

Location	Wave pressure p_w, in kPa	
	"*a*-max"	"*a*-min"
Bottom and sides below the load waterline $z_1 \le 0$	$\alpha^{1/4}\rho g h_1\left(1 + \frac{z_1}{2d_1}\right)$	$-\alpha^{1/4}\rho g h_1\left(1 + \frac{z_1}{2d_1}\right)$, but not less $-\frac{\gamma_s}{\gamma_w}\rho g z_1$
Sides above the load waterline $z_1 > 0$	$\rho g(\alpha^{1/4}h_1 - z_1)$	0
$\alpha = d_1/d$, but not greater than 1; h_1 – relative motion of the ship's hull in "*a*" load case in accordance with Table 2.2.4.1.2-2		

2.2.4.2 *Load case "b".*

.1 the static sea pressure is determined in accordance with 1.3.2.1, Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships;
.2 no wave pressures are considered;
.3 the static internal pressure is determined in accordance with 2.2.3**;**
.4 the inertial pressure is determined in Table 2.2.4.2.4-1. The highest point *H* of the tank in the direction of the total acceleration vector is to be determined as a point of the tank boundary, the projection of which to the direction of the total acceleration vector is located at the greatest distance from the tank's centre of gravity.

Components of the total acceleration vector are to be determined in accordance with Table 2.2.4.2.4-2. The total acceleration vector a_T is shown in Fig. 2.2.4.2.4.

Table 2.2.4.1.2-2

Position of section along the ship's length	h_1
$x = 0$	$0{,}7\left(\frac{4{,}35}{\sqrt{C_b}} - 3{,}25\right)h_{1M}$ at $C_b < 0{,}875$ h_{1M} at $C_b < 0{,}875$
$0 < x/L < 0{,}3$	$h_{1AE} - \frac{h_{1AE} - h_{1M}}{0{,}3}\frac{x}{L}$
$0{,}3 \le x/L \le 0{,}7$	$0{,}42\,\varphi_r c_w\,(C_b + 0{,}7)$, but not greater than the lesser of two values d_1 and $(D - 0{,}9d)$
$0 < x/L$	$h_{1AE} + \frac{h_{1FE} - h_{1M}}{0{,}3}\left(\frac{x}{L} - 0{,}7\right)$
$x = L$	$\left(\frac{4{,}35}{\sqrt{C_b}} - 3{,}25\right)h_{1M}$

c_w – wave factor to be taken depending on the ship's length in accordance with 1.3.1.4, Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships;
h_{1AE} – value h_1, calculated for $x = 0$;
h_{1M} – value h_1, calculated for $x/L = 0{,}5$;
h_{1FE} – value h_1, calculated for $x = L$

Table 2.2.4.2.4-1

Cargo type	Design case	Inertial pressure, in kPa
Liquid	"*b*-max"	$p_{c.in} = \rho_l[-0{,}5a_x l - a_z z_i]$
	"*b*-min"	$p_{c.in} = \rho_l[0{,}5a_x l + a_z z_i]$
	"*c*-max" "*d*-max"	$p_{c.in} = \rho_l[0{,}7C_{FI}\sqrt{a_{cy}{}^2 + (a_{ry} + g\sin\theta)^2}(y - y_H)$ $+(-0{,}7C_{FA}a_z - g)(z - z_H) - gz_i]$
	"*c*-min" "*d*-min"	$p_{c.in} = \rho_l[-0{,}7C_{FI}\sqrt{a_{cy}{}^2 + (a_{ry} + g\sin\theta)^2}(y - y_H)$ $+(0{,}7C_{FI}a_z - g)(z - z_H) - gz_i]$
Dry	"*b*-max"	$p_{c.in} = -\rho_c a_z z_i\{\sin^2\alpha\tan^2(45° - \varphi_{i.f}/2) + \cos^2\alpha\}$
	"*b*-min"	$p_{c.in} = \rho_c a_z z_i\{\sin^2\alpha\tan^2(45° - \varphi_{i.f}/2) + \cos^2\alpha\}$
	"*c*-max" "*c*-min" "*d*-max" "*d*-min"	Inertial pressure may not be considered. In specific cases, determination of the pressure is subject to special consideration by the Register

α – angle of web inclination to the base line, in deg.;
$\varphi_{i.f}$ – internal friction angle of bulk cargo, in deg.;
a_x, a_y, a_z – design accelerations, in m/s², in accordance with 1.3.3.1, Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships;
a_{cy}, a_{ry} – design accelerations, in m/s², in accordance with 1.3.3.1, Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships;
C_{FI} – combination factor, to be taken equal to:
$C_{FI} = 0{,}7$ for "*c*" case;
$C_{FI} = 1$ for "*d*" case;
l – length of a compartment measured at mid-height, in m;
θ – rolling angle, in rad, to be determined from formula (1.3.3.1-5), Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships;
y_H, z_H – co-ordinates of the highest point *H* of the tank in the direction of the total acceleration vector defined in accordance with Table 2.2.4.2.4-2 and Fig. 2.2.4.2.4;
z_i – vertical distance to the load point, in m:
for dry cargo — from the free surface level of cargo;
for liquid cargo, fuel oil or ballast — from the deck level (tank top) as measured at the centreline

Table 2.2.4.2.4-2

Acceleration components (at negative rolling angle)		Angle Θ, in rad, between the total acceleration vector and the vertical
a_{Ty}, m/s²	a_{Tz}, m/s²	$\operatorname{arctg}\dfrac{a_{Ty}}{a_{Tz}}$
$0{,}7C_{FI}\sqrt{{a_{cy}}^2 + (a_{ry} + g\sin\theta)^2}$	$-0{,}7C_{FI}a_z - g$	

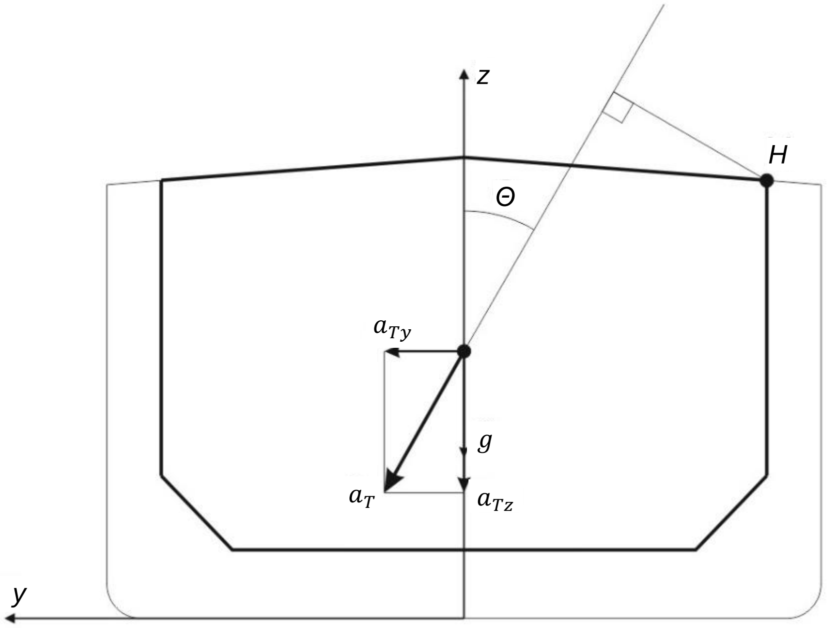


Fig. 2.2.4.2.4

2.2.4.3 *Load case "c".*

.1 the static sea pressure is determined in accordance with 1.3.2.1, Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships;

.2 the wave pressure is determined in accordance with Table 2.2.4.3.2;

.3 the static internal pressure is determined in accordance with 2.2.3**;**

.4 the inertial pressure is determined in Table 2.2.4.2.4-1.

2.2.4.4 *Load case "d".*

.1 the static sea pressure is determined in accordance with 1.3.2.1, Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships;

.2 the wave pressure is determined in Table 2.2.4.3.2;

.3 the static internal pressure is determined in accordance with 2.2.3**;**

.4 the inertial pressure is determined in Table 2.2.4.2.4-1.

Table 2.2.4.3.2

Location		Wave pressure p_w, in kPa	
		"*c*-max"/"*d*-max"	"*c*-min"/"*d*-min"
Bottom and sides below the load waterline $z_1 \le 0$	$y \ge 0$	$C_{FW}\alpha^{1/4}\rho g h_2 \frac{\lvert y\rvert}{B_w}\left(2+\frac{z_1}{d_1}\right)$	$-C_{FW}\alpha^{1/4}\rho g h_2 \frac{\lvert y\rvert}{B_w}\left(2+\frac{z_1}{d_1}\right)$, but not less than $-\frac{\gamma_s}{\gamma_w}\rho g z_1$
	$y < 0$	$-C_{FW}\alpha^{1/4}\rho g h_2 \frac{\lvert y\rvert}{B_w}\left(2+\frac{z_1}{d_1}\right)$, but not less than $-\frac{\gamma_s}{\gamma_w}\rho g z_1$	$C_{FW}\alpha^{1/4}\rho g h_2 \frac{\lvert y\rvert}{B_w}\left(2+\frac{z_1}{d_1}\right)$
Sides above the load waterline $z_1 > 0$	$y \ge 0$	$\rho g\left[2C_{FW}\alpha^{1/4}h_2\frac{\lvert y\rvert}{B_w}-z_1\right]$	0
	$y < 0$	0	$\rho g\left[2C_{FW}\alpha^{1/4}h_2\frac{\lvert y\rvert}{B_w}-z_1\right]$

$\alpha = d_1/d$, but not greater than 1;
$\frac{|y|}{B_w}$ is to be taken not greater than 0,5;
C_{FW} – combination factor equal to:
$C_{FW} = 1$ for "*c*" *case*;
$C_{FW} = 0{,}5$ for "*d*" *case*;
h_2 – relative motion of the ship's hull in "*c*" and "*d*" load cases is obtained from the following formula:

$$h_2 = 0{,}5h_1 + \theta\frac{B_w}{2}$$

where θ – rolling angle, in rad, to be determined from formula (1.3.3.1-5), Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships;
h_1 – relative motion of the ship's hull in "*a*" load case in accordance with Table 2.2.4.1.2-2,
therewith, h_2 is not to be taken greater than the lesser of d_1 and $(D - 0{,}9d)$

2.3 HULL GIRDER LOADS

2.3.1 The vertical still water bending moment M_{sw}, in kN/m, is to be determined in accordance with the Stability Booklet for the loading condition under consideration.

2.3.2 The vertical wave bending moments causing sagging $M_{w,s}$, in kN/m, and hogging $M_{w,h}$, in kN/m, are to be determined in accordance with 1.4.4), Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships.

2.3.3 The horizontal wave bending moment M_h, in kN/m, is to be calculated as follows:

$$M_h = \psi_0\varphi_r h_0 k_0 B L^2 \varphi_{xh} \quad (2.3.3\text{-}1)$$

where $k_0 = 0{,}9C_b\left(1-\frac{4d_1}{L}\right)d_1/B;$ (2.3.3-2)

$\varphi_{xh} = \sin^2(\pi x/L);$ (2.3.3-3)

$\psi_0 = (0{,}895 - 0{,}5L\cdot 10^{-3})(1/2\cos\left(\frac{2\pi x}{L}\right) + 3/2);$ (2.3.3-4)

$h_0 = 0{,}5\left(1+\frac{0{,}15L}{100}\right)h$ (2.3.3-5)

where h – design wave height in accordance with 2.1.5.

3 STRESSES

3.1 STRESSES INDUCED BY LOCAL PRESSURE

3.1.1 Normal stresses induced by local pressure, in N/mm^2, are to be determined for each load case "*a*-max", "*a*-min", "*b*-max", "*b*-min", "*c*-max", "*c*-min", "*d*-max" and "*d*-min" and each loading condition *B* and *F*, from the following formula:

$$\sigma_l = \frac{|p - p_c| a l^2 10^3}{12W'} \tag{3.1.1}$$

where W' – section modulus of the considered member with an effective flange and without corrosion allowance, in cm^3;
a – the width of the effective flange, in m, in accordance with 1.6.3.3, Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships;
l – span of the member considered, in m, in accordance with 1.6.3.1, Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships.

3.2 HULL GIRDER STRESSES

3.2.1 Still water hull girder normal stresses, in N/mm^2, are to be taken equal to:

$$\sigma_{sw} = \frac{M_{sw}}{I_y}(z - e)10^{-3} \tag{3.2.1}$$

where M_{sw} – vertical still water bending moment according to 2.3.1, in kN/m.

3.2.2 Total hull girder normal stresses for the structural members contributing to the longitudinal strength is determined from the following formula:

$$\sigma_h = \gamma_{s1}\sigma_{sw} + \gamma_{w1}(C_{FV}\sigma_{wv} + C_{FH}\sigma_{wh}) \tag{3.2.2}$$

where σ_{sw} – still water hull girder normal stresses, in accordance with 3.2.1;
σ_{wv}, σ_{wh} – stresses due to vertical and horizontal wave bending moments respectively, in accordance with Table 3.2.2-1;
C_{FV}, C_{FH} – combination factors depending on the load case in accordance with Table 3.2.2-2.

For structural members not contributing to the longitudinal strength $\sigma_h = 0$.

Table 3.2.2-1

Load case	σ_{wv}, in N/mm^2	σ_{wh}, in N/mm^2
"*a*-max"	$0{,}625\frac{M_{w,h}}{I_y}(z - e)10^{-3}$	0
"*a*-min"	$0{,}625\frac{M_{w,s}}{I_y}(z - e)10^{-3}$	0
"*b*-max" "*b*-min"	0	0
"*c*-max" "*d*-max"	0	$-\frac{M_h}{I_z}y10^{-3}$
"*c*-min" "*d*-min"	0	$\frac{M_h}{I_z}y10^{-3}$

Table 3.2.2-2

Load case	C_{FV}	C_{FH}
"*a*"	1	0
"*b*"	1	0
"*c*"	0,4	1
"*d*"	0,4	1

3.3 DETERMINATION OF STRESS RANGE

3.3.1 Hot spot stress range.

3.3.1.1 Hot spot stress range for details located at ends of primary longitudinal members in area of intersection with transverse bulkheads, floors and other transverse deep members is to be determined for each load case "*a*", "*b*", "*c*" and "*d*".

.1 hot spot stress range $\Delta\sigma_{G,ij}$, in N/mm^2, for details located at ends of primary longitudinal members in area of intersection with transverse bulkheads and with floors in way of stool is defined from the following formula:

$$\Delta\sigma_{G,ij} = \left|\sigma_{G,i-\max} - \sigma_{G,i-\min}\right| + K_L \Delta\sigma_{DEF,ij} \quad (3.3.1.1\text{-}1)$$

where $\sigma_{G,i-\max} = K_N(K_H\sigma_h + K_L K_S \sigma_l)_{i-\max}$; (3.3.1.1-2)

$\sigma_{G,i-\min} = K_N(K_H\sigma_h + K_L K_S \sigma_l)_{i-\min}$; (3.3.1.1-3)

$\Delta\sigma_{DEF,ij}$ – stresses, in N/mm^2, due to relative displacement, in accordance with the following formula:

$$\Delta\sigma_{DEF,ij} = \frac{4(\Delta\delta)EI}{W' l^2} 10^{-5} \quad (3.3.1.1\text{-}4)$$

where $\Delta\delta$ – local displacement range, in mm, is to be determined by means of finite element method for the load cases $i-\max$ and $i-\min$;

σ_h – normal hull girder stress, in N/mm^2, in accordance with 3.2.2;

σ_l – normal local stress, in N/mm^2, in accordance with 3.1.1;

I – moment of inertia, in cm^4, about the neutral axis parallel to the effective flange, to be determined with an effective flange which width specified in 1.6.3.3, Part II "Hull" of the Rules for the Classification and Construction of Sea-Going Ships;

K_N – coefficient considering North Atlantic navigation, taken as $K_N = 1$;

K_S – coefficient considering the member section geometry as follows without being taken less than 1:

$$K_S = 1 + \left[\frac{t_f(a^2-b^2)}{2W_B}\right]\left[1 - \frac{b}{a+b}(1 + \frac{W_B}{W_A})\right] 10^{-3} \quad (3.3.1.1\text{-}5)$$

where a, b – eccentricities of the member, in mm, fined in Fig. 3.3.1.1, therewith, bulb sections are to be taken as equivalent to an angle profile, as defined below with $a = 0{,}75b_f$, $b = 0{,}25b_f$;

when using bulbs of the European standards HP (DIN), web height h_w, frame web thickness t_w, face plate width b_f and face plate thickness t_f of the equivalent angle section are to be taken as follows:

$$h_w = h'_w - \frac{h'_w}{9{,}2} + 2;$$
$$b_f = \varphi_1(t'_w + \frac{h'_w}{6{,}7} - 2);$$
$$t_f = \frac{h'_w}{9{,}2} - 2;$$
$$t_w = t'_w,$$

where $\varphi_1 = 1{,}1 + \frac{(120-h'_w)^2}{3000}$ at $h'_w \le 120$;

$\varphi_1 = 1$ at $h'_w > 120$;

when using bulbs of GOST 21937-76:

$$h_w = h'_w - t_f;$$
$$t_f = \frac{h'_w \alpha_1}{9{,}8} + 3{,}4\beta_1;$$

$b_f = t'_w + \frac{h'_w \alpha_2}{8,1} + 5,6\beta_2;$

$t_w = t'_w$

where factors $\alpha_1, \alpha_2, \beta_1, \beta_2$ to be taken in accordance with Table 3.3.1.1;

W_A, W_B – section modulus without the effective flange, in cm^3, about its neutral axis parallel to the member web calculated for points A and B respectively.

Table 3.3.1.1

Profiles as per GOST 21937-76	α_1	β_1	α_2	β_2
Profiles with $h'_w < 120$	1,23	0,66	1,07	0,77
Profiles of "*a*" type	1,00	1,00	1,00	1,00
Profiles of "*b*" type	0,90	1,66	1,04	0,79

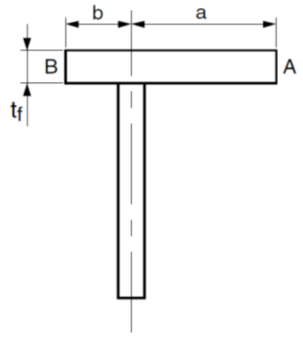


Fig. 3.3.1.1

.2 hot spot stress range $\Delta\sigma_{G,ij}$, in N/mm^2, for details located at ends of primary longitudinal members in area of intersection with transverse deep members other than those in 3.3.1.1.1, is to be determined from the following formula:

$$\Delta\sigma_{G,ij} = \left|\sigma_{G,i-\max} - \sigma_{G,i-\min}\right| \quad (3.3.1.1.2)$$

3.3.1.2 Hot spot stress range for the details, where stresses are calculated through the finite element method, is defined as follows:

.1 nominal stress range in hot spots is determined through the finite element method for load cases $i-\max$ and $i-\min$ of each loading condition *j* individually using the following formula:

$$\Delta\sigma_{n,ij} = \left|\sigma_{n,ij-\max} - \sigma_{n,ij-\min}\right| \quad (3.3.1.2.1)$$

where $\sigma_{n,ij-\max}, \sigma_{n,ij-\min}$ – maximum and minimum values of nominal stresses, in N/mm^2, calculated through the finite element method for load cases $i-\max$ and $i-\min$ respectively. Direction of nominal stresses for the relevant components are shown in Appendix 2;

.2 formulae for determination of stress range in hot spots are given in Appendix 2 in the relevant tables for each structural detail. Where the formula for stress range calculation in hot spots are absent in Appendix 2, the stress range in hot spots is to be determined as follows:

$$\Delta\sigma_{G,ij} = K_S \Delta\sigma_{n,ij} \quad (3.3.1.2.2)$$

where K_S – stress concentration factor is specified for the relevant components in Appendix 2;

$\Delta\sigma_{n,ij}$ – nominal stress range in hot spots, in N/mm^2, to be obtained in accordance with 3.3.1.2.1;

.3 model extension and boundary conditions are to consider hull girder loads. Finite element size and mesh quality shall cover macro-geometric effects and ensure numerical stability. Hot spot stress range may be obtained directly upon the calculations of model enabling to consider stress increase due to the structural discontinuities and the presence of welded attachments;

.4 a document comprising the information on the finite element method shall be submitted to the Register. The document shall contain information on the initial data, loads, boundary conditions, calculation methodology and the results.

3.3.2 Notch stress range $\Delta\sigma_{N,ij}$, in N/mm^2, for each load case "*a*", "*b*", "*c*" and "*d*" is to be obtained from the following formula:

$$\Delta\sigma_{N,ij} = K_{C,ij}\Delta\sigma_{N0,ij} \qquad (3.3.2\text{-}1)$$

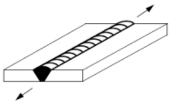
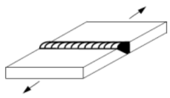
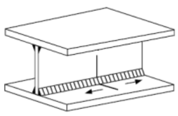
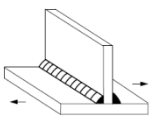
where $\Delta\sigma_{N0,ij} = 0{,}7K_F\Delta\sigma_{G,ij}$ (3.3.2-2)

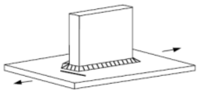
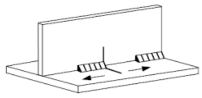
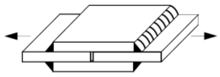
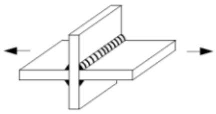
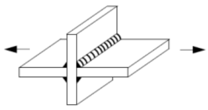
where $\Delta\sigma_{G,ij}$ – hot spot stress range, in N/mm^2, to be obtained:
for details located at ends of primary longitudinal members in area of intersections with transverse bulkheads and deep members in accordance with 3.3.1.1;
for details, where stresses are calculated through the finite element method in accordance with 3.3.1.2;
K_F – factor to be taken equal to:

$$K_F = \lambda\sqrt{\frac{\theta}{30}}, \qquad (3.3.2\text{-}3)$$

for flame-cut edges, K_F may be taken according to Table 3.3.2-2 depending on the cutting quality, post treatment and control of quality;
λ – coefficient depending of the weld configuration in accordance with Table 3.3.2-1;
θ – mean weld toe angle, in deg., without being taken less than 30°. Unless otherwise specified, may be taken equal to:
$\theta = 30°$ – for butt joints;
$\theta = 45°$ – for corner joints, T joints, and cruciform joints;
$K_{C,ij} = \frac{0{,}4\,R_{eH}}{\Delta\sigma_{N0,ij}} + 0{,}6$ with $0{,}8 \le K_{C,ij} \le 1$.

Table 3.3.2-1

Weld configuration				Coefficient λ	Grinding applicable
Type	Description	Stress direction	Figure		
Butt weld		Parallel to the weld		2,10	Yes
		Perpendicular to the weld		2,40	Yes
Fillet weld	Continuous	Parallel to the weld		1,80	Yes
		Perpendicular to the weld[1]		2,15	Yes

Weld configuration				Coefficient λ	Grinding applicable
Type	Description	Stress direction	Figure		
Fillet weld (cont.)	Well contoured end	Perpendicular to the weld		2,15	Yes
	Not continuous	Parallel to the weld		2,90	Yes
	Lap weld	Perpendicular to the weld		4,50	No
Cruciform joint	Full penetration	Perpendicular to weld		2,10	Yes
	Partial penetration	Perpendicular to weld		Toe crack 2,10	Yes
				Root crack 4,50	No

[1] The factor is also applied for fatigue calculation of details located at ends of primary longitudinal members in area of intersection with deep members.

Table 3.3.2-2

Flame-cut edge description	K_F
Machine gas cut edges, with subsequent machining, dressing and grinding	1,4
Machine thermally cut edges, corners removed, no crack by inspection	1,6
Manually thermally cut edges, free from cracks and severe notches	2,0
Manually thermally cut edges, uncontrolled, no notch deeper than 0,5 mm	2,5

4 FATIGUE DAMAGE

4.1 ELEMENTARY FATIGUE DAMAGE RATIO

4.1.1 The elementary fatigue damage ratio is to be obtained from the following formula:

$$D_{ij} = \frac{N_t}{K_p} \frac{(\Delta\sigma_{N,ij})^3}{(-\ln p_R)^{3/\xi}} \mu_{ij} \Gamma_c \left[\frac{3}{\xi} + 1\right] \quad (4.1.1\text{-}1)$$

where $\Delta\sigma_{N,ij}$ – local stress range, in N/mm², to be determined in accordance with 3.3.2;

$$\mu_{ij} = 1 - \frac{\Gamma_N\left[\frac{3}{\xi}+1, v_{ij}\right] - \Gamma_N\left[\frac{5}{\xi}+1, v_{ij}\right] v_{ij}^{-2/\xi}}{\Gamma_C\left[\frac{3}{\xi}+1\right]}; \quad (4.1.1\text{-}2)$$

$$\xi = \xi_0 \left(1{,}04 - 0{,}14 \frac{|z_1|}{D - d_1}\right) \quad (4.1.1\text{-}3)$$ without being less than $0{,}9\xi_0$;

$$\xi_0 = \frac{73 - 0{,}07L}{60} \quad (4.1.1\text{-}4)$$ without being less than 0,85;

$$v_{ij} = -\left(\frac{S_q}{\Delta\sigma_{N0,ij}}\right)^{\xi} \ln p_R; \quad (4.1.1\text{-}5)$$

$$S_q = (K_p 10^{-7})^{1/3}; \quad (4.1.1\text{-}6)$$

$$K_p = 5{,}802 \left(\frac{22}{t}\right)^{0{,}9} 10^{12} \quad (4.1.1\text{-}7)$$

where t – thickness, in mm, of the considered structural member in accordance with 1.3.3, not being taken less than 22 mm;

$N_t = \frac{31{,}55\alpha_0}{4 \log L} 10^6$ – average annual number of cycles;

α_0 – sailing factor to be taken equal to 0,85;

$p_R = 10^{-5}$;

$\Gamma_N[X + 1, v_{ij}]$ – incomplete Gamma function, calculated for $X = 3/\xi$ or $X = 5/\xi$, and equal to:

$\Gamma_N[X + 1, v_{ij}] = \int_0^{v_{ij}} t^X e^{-t} dt$;

$\Gamma_C[X + 1]$ – complete Gamma function, calculated for $X = 3/\xi$ and equal to:

$\Gamma_C[X + 1] = \int_0^{\infty} t^X e^{-t} dt$.

Values of $\Gamma_N[X + 1, v_{ij}]$ are also indicated in Table 4.1.1-1. For intermediate values of X and v_{ij}, Γ_N the may be obtained by linear interpolation.

Values of $\Gamma_C[X + 1]$ are also indicated in Table 4.1.1-2. For intermediate values of X, Γ_C may be obtained by linear interpolation.

Table 4.1.1-1

X	v_{ij}									
	1,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5	6,0
2,5	0,38	0,73	1,13	1,53	1,90	2,22	2,48	2,70	2,86	2,99
2,6	0,38	0,75	1,19	1,63	2,04	2,41	2,71	2,96	3,16	3,31
2,7	0,39	0,78	1,25	1,73	2,20	2,62	2,97	3,26	3,49	3,67
2,8	0,39	0,80	1,31	1,85	2,38	2,85	3,26	3,60	3,87	4,09
2,9	0,39	0,83	1,38	1,98	2,57	3,11	3,58	3,98	4,30	4,56
3,0	0,39	0,86	1,45	2,12	2,78	3,40	3,95	4,41	4,79	5,09
3,1	0,40	0,89	1,54	2,27	3,01	3,72	4,35	4,89	5,34	5,70
3,2	0,40	0,92	1,62	2,43	3,27	4,08	4,81	5,44	5,97	6,40
3,3	0,41	0,95	1,72	2,61	3,56	4,48	5,32	6,06	6,68	7,20
3,4	0,41	0,99	1,82	2,81	3,87	4,92	5,90	6,76	7,50	8,11
3,5	0,42	1,03	1,93	3,03	4,22	5,42	6,55	7,55	8,42	9,15
3,6	0,42	1,07	2,04	3,26	4,60	5,97	7,27	8,45	9,48	10,34

X	v_{ij}									
	1,5	2,0	2,5	3,0	3,5	4,0	4,5	5,0	5,5	6,0
3,7	0,43	1,12	2,17	3,52	5,03	6,59	8,09	9,47	10,68	11,71
3,8	0,43	1,16	2,31	3,80	5,50	7,28	9,02	10,63	12,06	13,28
3,9	0,44	1,21	2,45	4,10	6,02	8,05	10,06	11,94	13,63	15,09
4,0	0,45	1,26	2,61	4,43	6,59	8,91	11,23	13,43	15,42	17,16
4,1	0,45	1,32	2,78	4,80	7,22	9,87	12,55	15,12	17,47	19,54
4,2	0,46	1,38	2,96	5,20	7,93	10,95	14,05	17,05	19,82	22,29
4,3	0,47	1,44	3,16	5,63	8,70	12,15	15,73	19,24	22,51	25,45
4,4	0,48	1,51	3,37	6,11	9,56	13,50	17,64	21,74	25,60	29,10
4,5	0,49	1,57	3,60	6,63	10,52	15,01	19,79	24,58	29,14	33,31
4,6	0,49	1,65	3,85	7,20	11,57	16,70	22,23	27,82	33,20	38,17
4,7	0,50	1,73	4,12	7,82	12,75	18,59	24,98	31,53	37,88	43,49
4,8	0,52	1,81	4,40	8,50	14,04	20,72	28,11	35,75	43,25	50,29
4,9	0,52	1,90	4,71	9,25	15,49	23,11	31,64	40,57	49,42	57,81
5,0	0,53	1,99	5,04	10,07	17,09	25,78	35,65	46,08	56,53	66,52
5,1	0,55	2,09	5,40	10,97	18,86	28,79	40,19	52,39	64,71	76,61
5,2	0,56	2,19	5,79	11,95	20,84	32,17	45,34	59,60	74,15	88,32
5,3	0,57	2,30	6,21	13,03	21,03	35,96	51,19	67,85	85,02	101,9
5,4	0,58	2,41	6,66	14,21	25,46	40,23	57,83	77,29	97,56	117,7
5,5	0,59	2,54	7,14	15,50	28,17	45,03	65,37	88,11	112,0	136,0
5,6	0,61	2,67	7,67	16,92	31,18	50,42	73,93	100,5	128,8	157,3
5,7	0,62	2,80	8,23	18,48	34,53	56,49	83,66	114,7	148,1	182,0
5,8	0,64	2,95	8,84	20,19	32,25	63,33	94,72	131,0	170,4	210,9
5,9	0,65	3,10	9,50	22,07	42,39	71,02	107,3	149,8	196,2	244,4
6,0	0,67	3,26	10,21	41,13	47,00	79,69	121,6	171,2	226,1	283,5
6,1	0,68	3,44	10,98	26,39	52,14	89,45	138,0	195,9	260,6	329,0
6,2	0,70	3,62	11,82	28,87	57,86	100,5	156,5	224,2	300,6	382,1
6,3	0,72	3,81	12,71	31,60	64,24	112,9	177,7	256,8	347,0	444,0
6,4	0,73	4,02	13,68	34,60	71,34	126,9	210,7	294,3	400,7	516,3
6,5	0,75	4,23	14,73	37,90	79,25	142,6	229,2	337,3	463,0	600,6
6,6	0,77	4,46	15,87	41,52	88,07	160,4	260,5	386,9	535,2	699,2

Table 4.1.1-2

X	$\Gamma_C[X+1]$	X	$\Gamma_C[X+1]$
2,5	3,332	3,3	8,855
2,6	3,717	3,4	10,136
2,7	4,171	3,5	11,632
2,8	4,694	3,6	13,381
2,9	5,299	3,7	15,431
3,0	6,000	3,8	17,838
3,1	6,813	3,9	20,667
3,2	7,757	4,0	24,000

4.2 CUMULATIVE DAMAGE RATIO

4.2.1 The cumulative damage ratio in load case corresponding to the maximum draught amidships *F* is to be obtained as:

$$D_F = \frac{1}{6}D_{aF} + \frac{1}{6}D_{bF} + \frac{1}{3}D_{cF} + \frac{1}{3}D_{dF} \qquad (4.2.1)$$

where $D_{aF}, D_{bF}, D_{cF}, D_{dF}$ – elementary fatigue damage ratios for load cases "*a*", "*b*", "*c*" and "*d*" respectively in loading condition corresponding to the maximum draught amidships in accordance with 2.1.2.

4.2.2 The cumulative damage ratio in loading condition corresponding to the minimum draught amidships *B* is to be obtained as:

$$D_B = \frac{1}{3} D_{aB} + \frac{1}{3} D_{bB} + \frac{1}{3} D_{cB} \qquad (4.2.2)$$

where D_{aB}, D_{bB}, D_{cB} – elementary fatigue damage ratios for load cases "*a*", "*b*" and "*c*" respectively, in loading condition corresponding to the minimum draught amidships in accordance with 2.1.2.

5 FATIGUE LIFE

5.1 FATIGUE LIFE

5.1.1 The fatigue life is to be obtained from the following formula:

$$T_{FL} \le \frac{1}{\gamma_R K_C(\alpha D_F + (1-\alpha) D_B)} \quad (5.1.1)$$

where γ_R – partial coefficient of resistance in accordance with 1.7;
K_C – corrosion factor, taken equal to:
$K_C = 1{,}5$ – for cargo oil tanks;
$K_C = 1{,}1$ – for ballast tanks having an effective coating protection;
$K_C = 1$ – otherwise;
α – part of the ship's life in loading condition corresponding to the maximum draught, in accordance with Table. 5.1.1;
D_F – the cumulative damage ratio for the ship in loading condition corresponding to the maximum draught amidships, to be obtained by 4.2.1;
D_B – the cumulative damage ratio for the ship in loading condition corresponding to the minimum draught amidships, to be obtained by 4.2.2.

Table 5.1.1

Descriptive notations in the class notation	α
Oil tanker **Gas carrier** **Oil/bulk carrier** **Oil/bulk/ore carrier** **Ore carrier** **Self-unloading bulk carrier** **Tanker** **Bulk carrier** **Chemical tanker**	0,6
Other	0,75

APPENDIX 1

LIST OF DETAILS

Table 1

All ships with longitudinal side framing

Reference number of area	Area description	Detail description	Reference to details
1	Side area: longitudinally, between the after peak and the collision bulkhead; vertically, between $0{,}7d_B$ and 1,15 d_F	Connections of primary longitudinal members with stiffeners of transverse deep members	Appendix 2, Tables 1 — 7

Table 2

Oil tankers and chemical tankers

Reference number of area	Area description	Detail description	Reference to details
1	Part of side extended: longitudinally, between the after peak and collision bulkheads; vertically, between 0,7 d_B and 1,15 d_F	Connections of primary longitudinal members with stiffeners of transverse deep members	Appendix 2, Tables 1 – 7
2	Part of inner side and longitudinal bulkheads in the cargo area extended vertically above half tank height, where the tank breadth exceeds 0,55 *B*	Connections of inner side or longitudinal bulkhead primary longitudinal members with stiffeners of transverse deep members	Appendix 2, Tables 8 – 14
3	Double bottom in way of transverse bulkhead	Connections of bottom and inner bottom primary longitudinal members with floors	Appendix 2, Tables 15 – 17
		Connections of inner bottom with transverse bulkheads or lower stools	Appendix 2, Table 18
4	Double bottom in way of hopper side tanks	Connections of inner side with hopper side tank sloping plates	Appendix 2, Tables 19 – 22
5	Lower part of transverse bulkheads with lower stools	Connections of lower stools with plane bulkheads	Appendix 2, Tables 23 – 29
		Connections of lower stools with corrugated bulkheads	Appendix 2, Tables 30 – 35
6	Lower part of inner side	Connections of the hopper side tank sloping plates with inner side	Appendix 2, Tables 36 – 42

Table 3

Bulk carriers

Reference number of area	Area description	Detail description	Reference to details
3	Double bottom in way of transverse bulkheads	Connections of bottom and inner bottom primary longitudinal members with floors	Appendix 2, Tables 15 – 17
		Connections of inner bottom with transverse bulkheads or lower stools	Appendix 2, Table 18
4	Double bottom in way of hopper side tanks	Connections of inner bottom with hopper tank sloping plates	Appendix 2, Tables 19 – 22
5	Lower part of transverse bulkheads with lower stools	Connections of lower stools with plane bulkheads	Appendix 2, Tables 23 – 29
		Connections of lower stools with corrugated bulkheads	Appendix 2, Tables 30 – 35
6	Lower part of inner side	Connections of hopper side tank sloping plates with inner side	Appendix 2, Tables 36 – 42

Table 4

Ore carriers and oil/bulk/ore carriers

Reference number of area	Area description	Details description	Reference to details
1	Part of side extended: longitudinally, between the after peak and collision bulkheads; vertically, between 0,7 d_B and 1,15 d_F	Connections of primary longitudinal members with stiffeners of transverse deep members	Appendix 2, Tables 1 – 7
3	Double bottom in way of transverse bulkheads	Connections of bottom and inner bottom primary longitudinal members with floors	Appendix 2, Tables 15 – 17
		Connections of inner bottom with transverse bulkheads or lower stools	Appendix 2, Table 18
4	Double bottom in way of hopper side tanks	Connections of inner bottom with hopper side tank sloping plates	Appendix 2, Tables 19 – 22
5	Lower part of transverse bulkheads with lower stools	Connections of lower stools with plane bulkheads	Appendix 2, Tables 23 – 29
		Connections of lower stools with corrugated bulkheads	Appendix 2, Tables 30 – 35
6	Lower part of inner side	Connections of hopper side tank sloping plates with inner side	Appendix 2, Tables 36 – 42

Table 5

Gas carriers

Reference number of area	Area description	Detail description	Reference to details
1	Part of side extended: longitudinally, between the after peak and collision bulkheads; vertically, between 0,7 d_B and 1,15 d_F	Connections of primary longitudinal members with stiffeners of transverse deep members	Appendix 2, Tables 1 – 7
3	Double bottom in way of transverse bulkhead	Connections of bottom and inner bottom primary longitudinal members with floors	Appendix 2, Tables 15 – 17
		Connections of inner bottom with transverse cofferdam bulkheads	Appendix 2, Table 45
4	Double bottom in way of hopper side tanks	Connections of inner bottom with hopper side tank sloping plates	Appendix 2, Tables 19 – 22
6	Lower part of inner side	Connections of hopper side tank sloping plates with inner side	Appendix 2, Tables 43 – 44

When the particular regions of gas carrier include potentially critical structural details other than those given in Table 5, the fatigue assessment of such details shall be performed on agreement with the Register depending on their structural design.

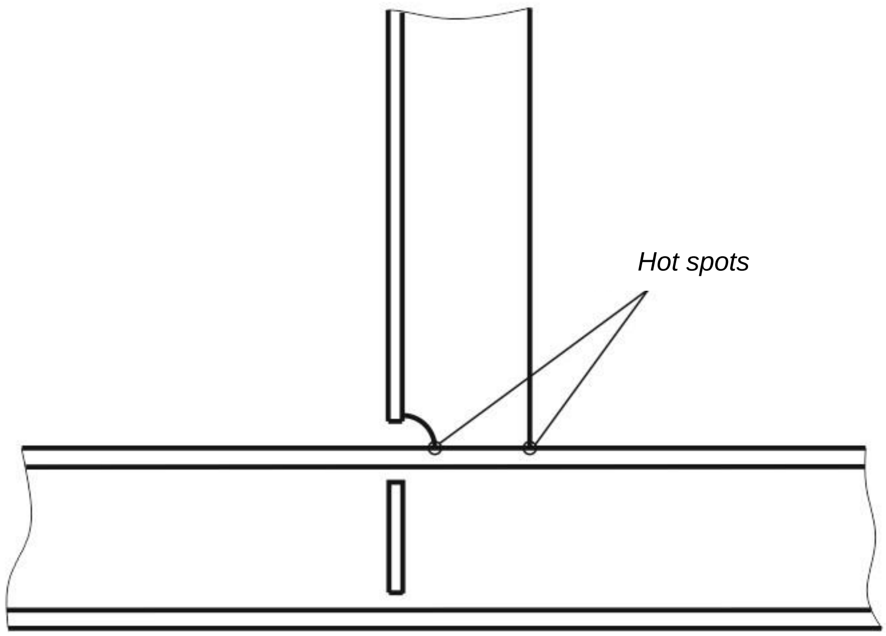
APPENDIX 2

STRESS CONCENTRATION FACTORS

Table 1

All ships with longitudinal side framing

Side between 0,7 d_B and 1,15 d_F	Connection of primary longitudinal members with stiffeners of transverse deep members — no bracket

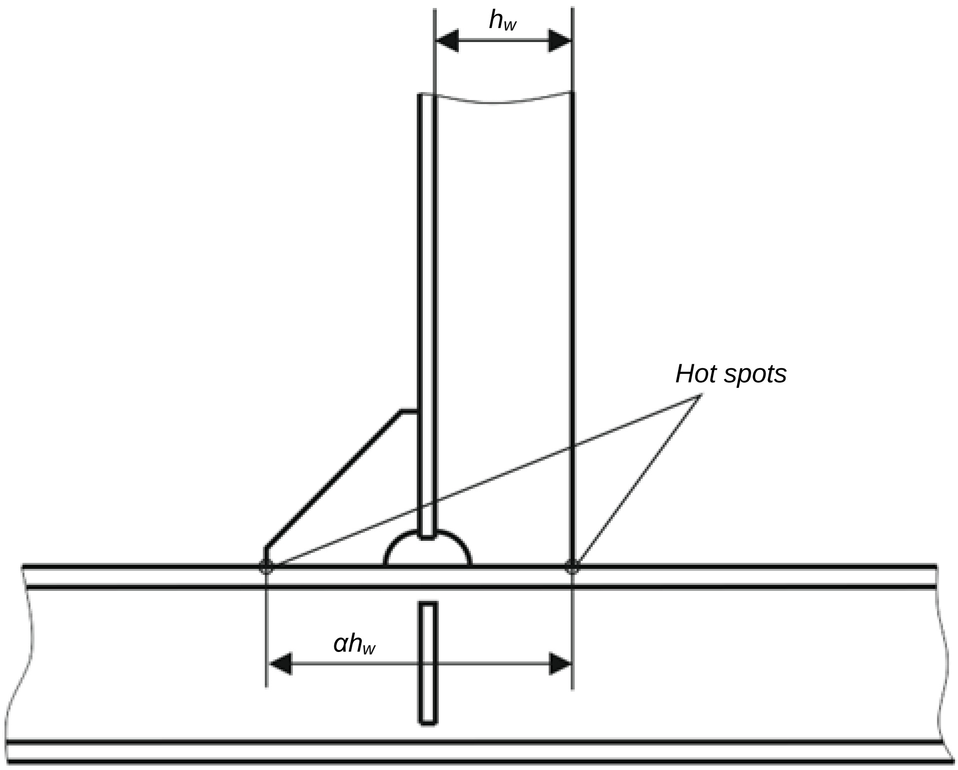


Concentration factors	
Non-watertight collar plate	Watertight collar plate
$K_H = 1,30$ $K_L = 1,65$	$K_H = 1,25$ $K_L = 1,50$

Table 2

All ships with longitudinal side framing

Side between 0,7 d_B and 1,15 d_F	Connection of primary longitudinal members with stiffeners of transverse deep members — one bracket



Concentration facto	
Non-watertight collar plate	Watertight collar plate
At $2 < \alpha < 2{,}5$ $K_H = 1{,}20$ $K_L = 1{,}40$ At $\alpha \geq 2{,}5$ $K_H = 1{,}15$ $K_L = 1{,}40$	At $2 < \alpha < 2{,}5$ $K_H = 1{,}15$ $K_L = 1{,}32$ At $\alpha \geq 2{,}5$ $K_H = 1{,}10$ $K_L = 1{,}32$

Table 3

All ships with longitudinal side framing

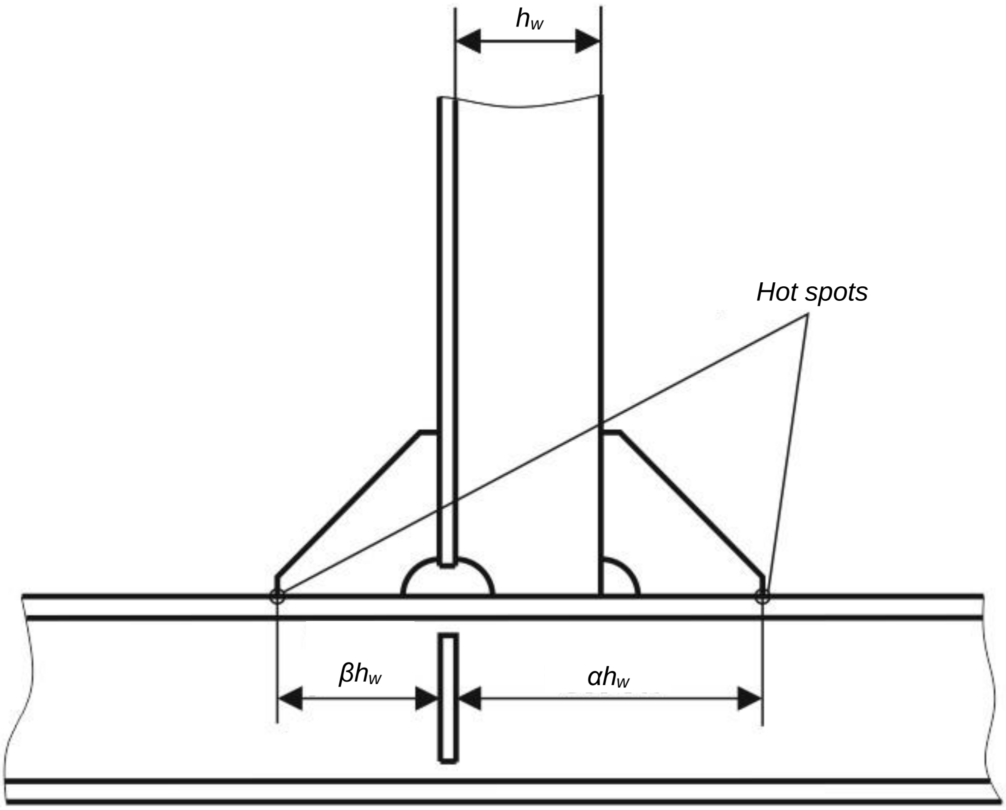
Side between 0,7 d_B and 1,15 d_F	Connection of primary longitudinal members with stiffeners of transverse deep members — two brackets
	
Concentration factors	
Non-watertight collar plate	Watertight collar plate
At $2 < \alpha < 2{,}5$ and $1 < \beta < 1{,}5$ $K_H = K_L = 1{,}15$ At $\alpha \geq 2{,}5$ and $\beta \geq 1{,}5$ $K_H = K_L = 1{,}10$	At $2 < \alpha < 2{,}5$ and $1 < \beta < 1{,}5$ $K_H = K_L = 1{,}10$ At $\alpha \geq 2{,}5$ and $\beta \geq 1{,}5$ $K_H = K_L = 1{,}05$

Table 4

All ships with longitudinal side framing

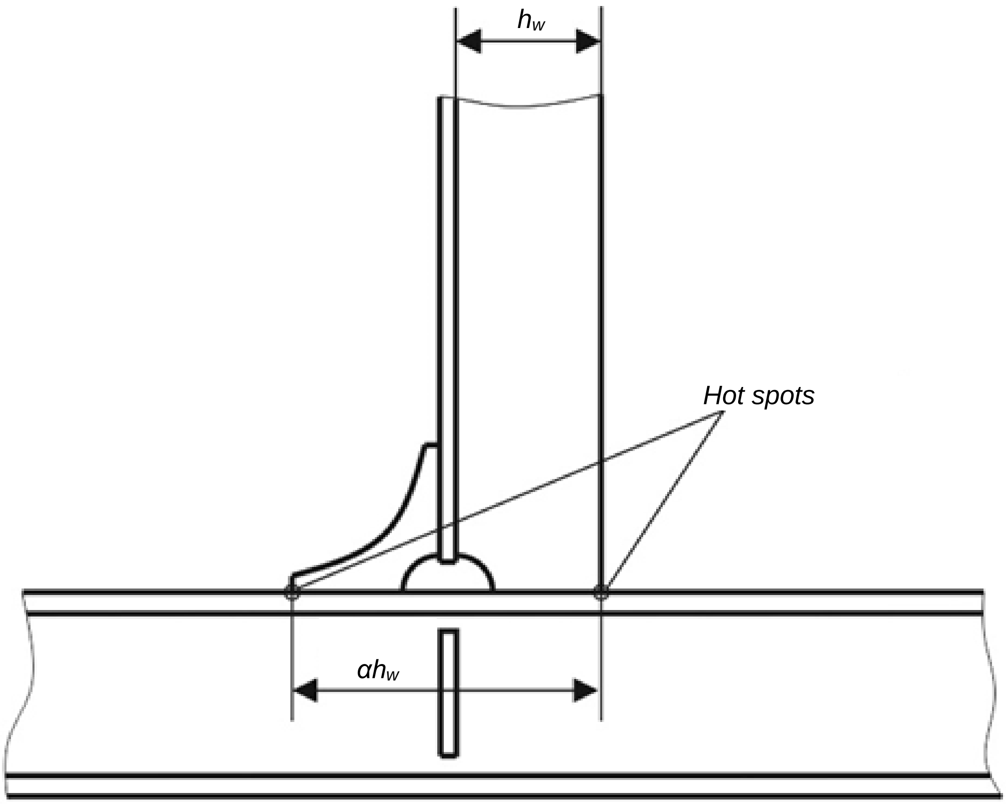
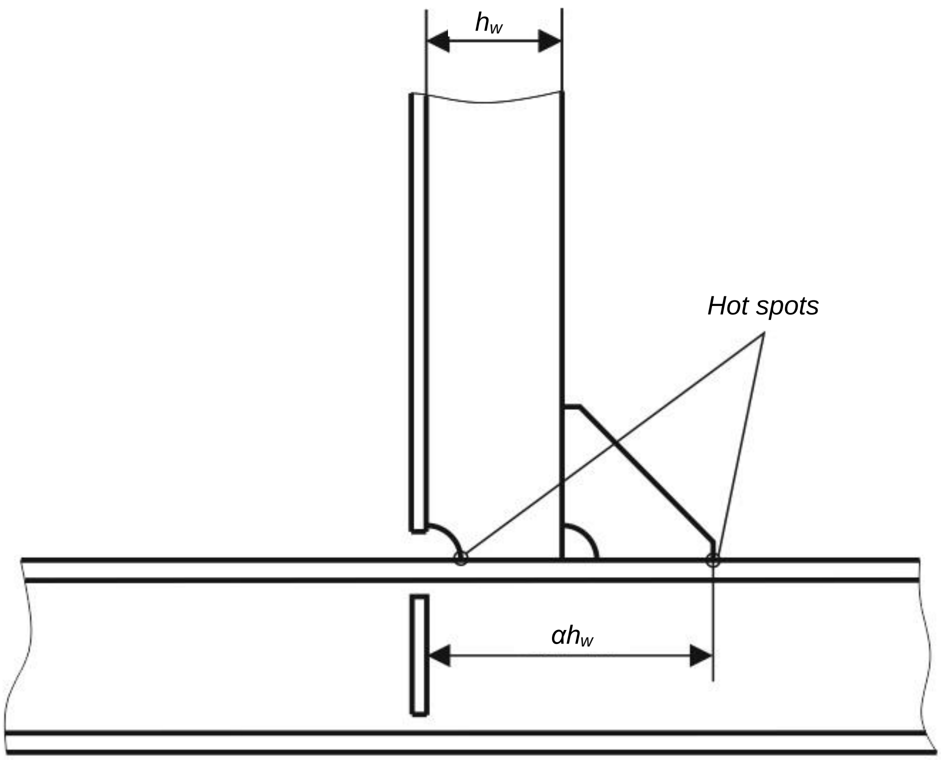
Side between 0,7 d_B and 1,15 d_F	Connection of primary longitudinal members with stiffeners of transverse deep members — one rounded bracket
	
Concentration factors	
Non-watertight collar plate	Watertight collar plate
At $2 < \alpha < 2{,}5$ $K_H = 1{,}15$ $K_L = 1{,}35$ At $\alpha \geq 2{,}5$ $K_H = 1{,}10$ $K_L = 1{,}35$	At $2 < \alpha < 2{,}5$ $K_H = 1{,}13$ $K_L = 1{,}30$ At $\alpha \geq 2{,}5$ $K_H = 1{,}08$ $K_L = 1{,}30$

Table 5

All ships with longitudinal side framing

Side between 0,7 d_B and 1,15 d_F	Connection of primary longitudinal members with stiffeners of transverse deep members — one bracket



Concentration factors	
Non-watertight collar plate	Watertight collar plate
At $2 < \alpha < 2{,}5$ $K_H = 1{,}30$ $K_L = 1{,}55$ At $\alpha \geq 2{,}5$ $K_H = 1{,}25$ $K_L = 1{,}50$	At $2 < \alpha < 2{,}5$ $K_H = 1{,}25$ $K_L = 1{,}46$ At $\alpha \geq 2{,}5$ $K_H = 1{,}20$ $K_L = 1{,}41$

Table 6

All ships with longitudinal side framing

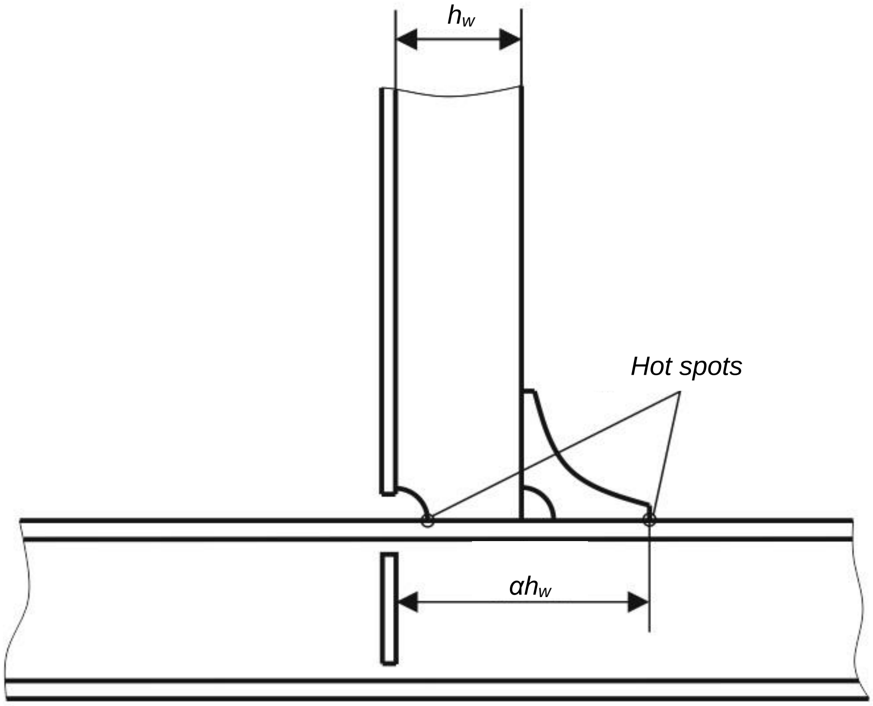
Side between 0,7 d_B and 1,15 d_F	Connection of primary longitudinal members with stiffeners of transverse deep members — one rounded bracket
	
Concentration factors	
Non-watertight collar plate	Watertight collar plate
At $2 < \alpha < 2{,}5$ $K_H = 1{,}25$ $K_L = 1{,}50$ At $\alpha \geq 2{,}5$ $K_H = 1{,}20$ $K_L = 1{,}45$	At $2 < \alpha < 2{,}5$ $K_H = 1{,}22$ $K_L = 1{,}44$ At $\alpha \geq 2{,}5$ $K_H = 1{,}18$ $K_L = 1{,}39$

Table 7

All ships with longitudinal side framing

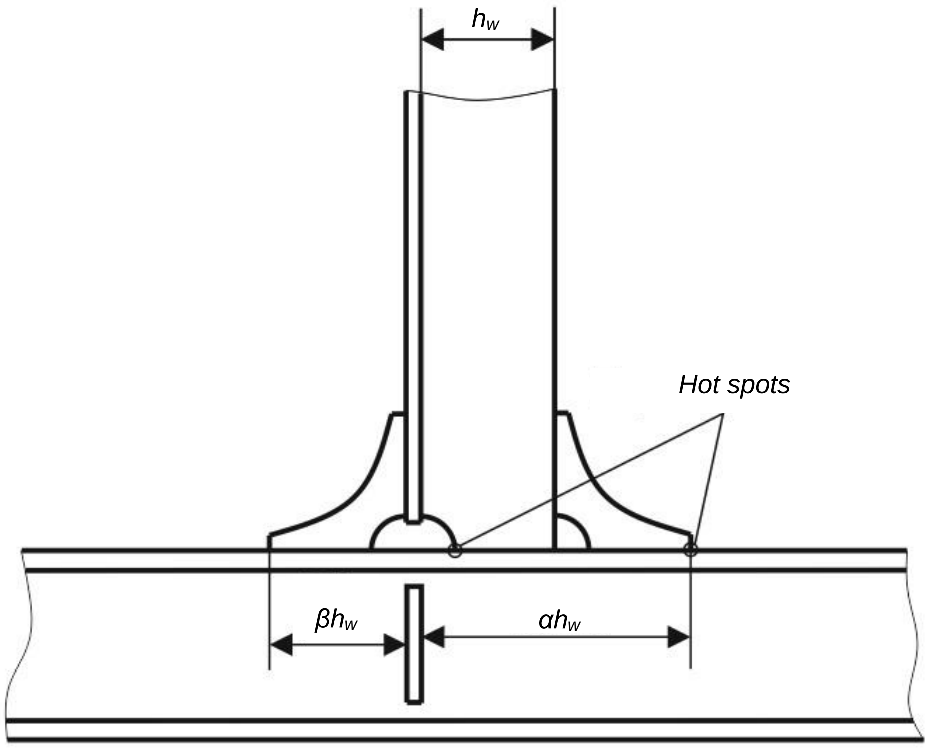
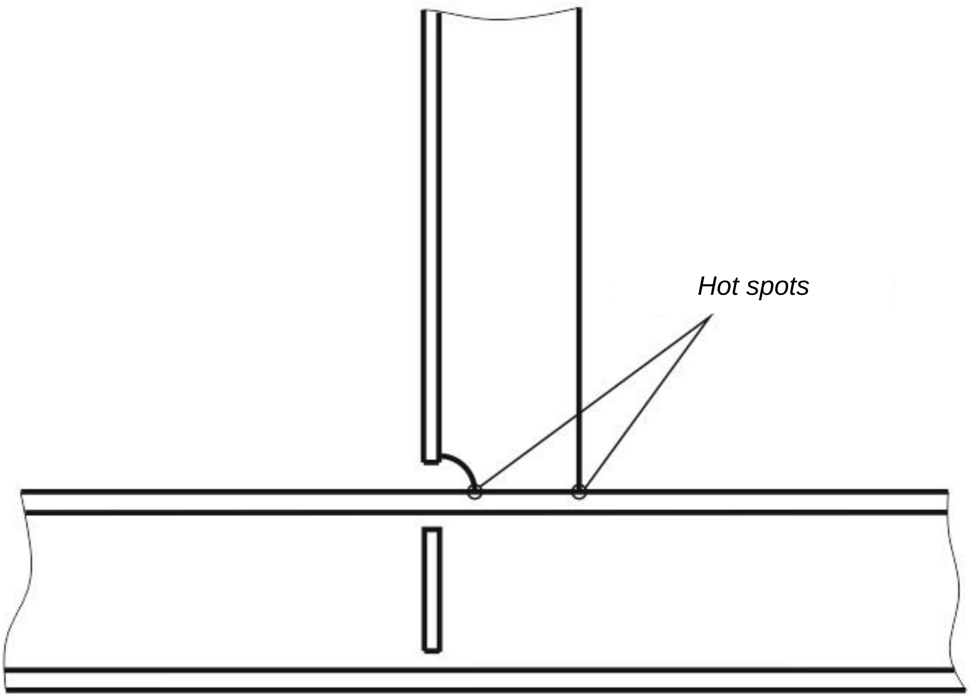
Side between 0,7 d_B and 1,15 d_F	Connection of primary longitudinal members with stiffeners of transverse deep members — two rounded brackets
 	
Concentration factors	
Non-watertight collar plate	Watertight collar plate
At $2 < \alpha < 2{,}5$ and $1 < \beta < 1{,}5$ $K_H = K_L = 1{,}10$ At $\alpha \geq 2{,}5$ and $\beta \geq 1{,}5$ $K_H = K_L = 1{,}15$	At $2 < \alpha < 2{,}5$ and $1 < \beta < 1{,}5$ $K_H = K_L = 1{,}10$ At $\alpha \geq 2{,}5$ and $\beta \geq 1{,}5$ $K_H = K_L = 1{,}05$

Table 8

Oil tankers, chemical tankers

Inner side and longitudinal bulkheads above 0,5 *H*	Connection of inner side or longitudinal bulkhead primary longitudinal members with stiffeners of transverse deep members — no bracket

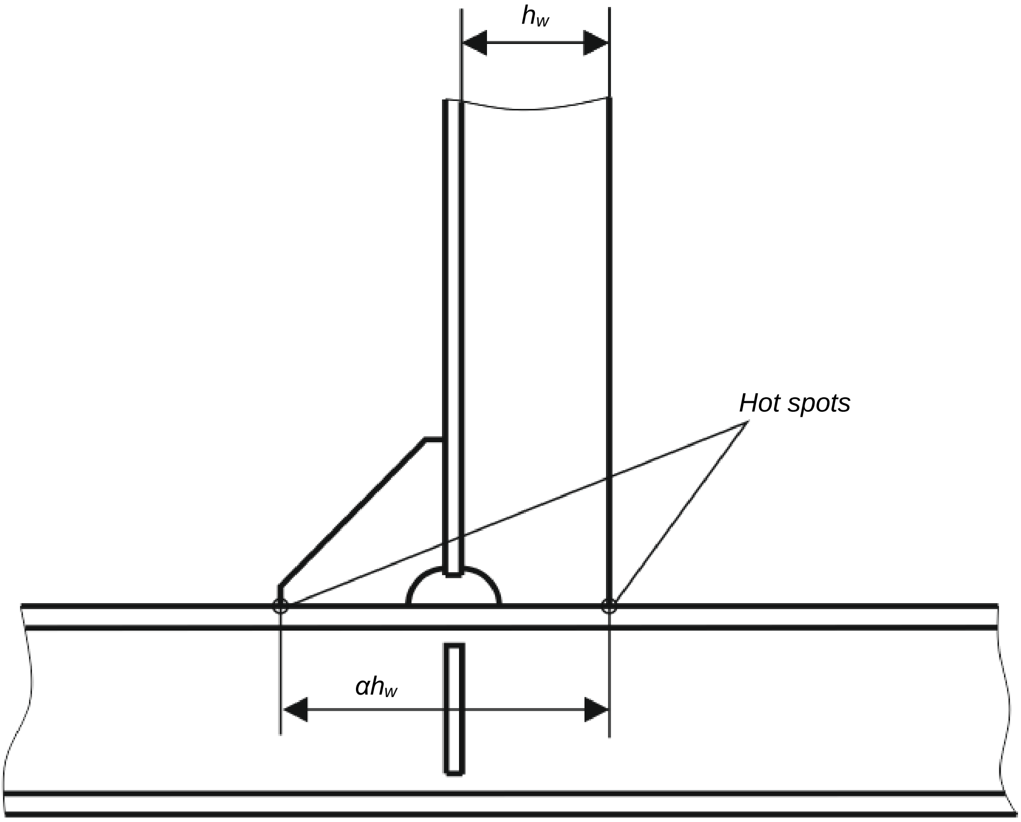


Concentration factors	
Non-watertight collar plate	Watertight collar plate
$K_H = 1{,}30$ $K_L = 1{,}65$	$K_H = 1{,}25$ $K_L = 1{,}50$

Table 9

Oil tankers, chemical tankers

Inner side and longitudinal bulkheads above 0,5 *H*	Connection of inner side or longitudinal bulkhead primary longitudinal members with stiffeners of transverse deep members — one bracket

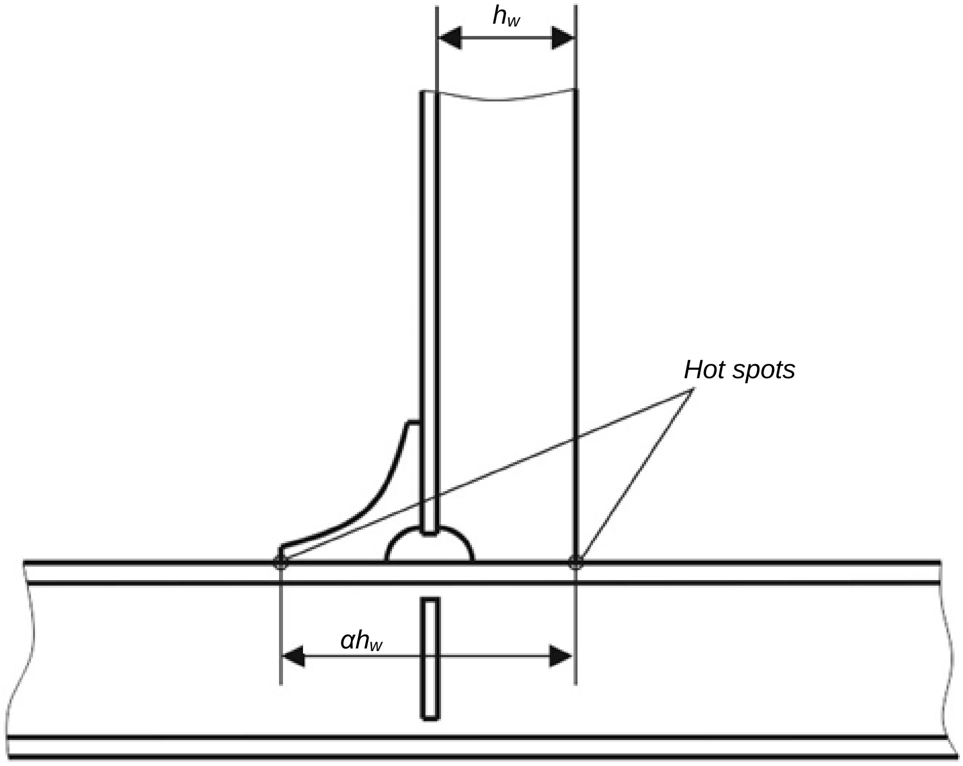


Concentration factors	
Non-watertight collar plate	Watertight collar plate
At $2 < \alpha < 2{,}5$ $K_H = 1{,}20$ $K_L = 1{,}40$ At $\alpha \geq 2{,}5$ $K_H = 1{,}15$ $K_L = 1{,}40$	At $2 < \alpha < 2{,}5$ $K_H = 1{,}15$ $K_L = 1{,}32$ At $\alpha \geq 2{,}5$ $K_H = 1{,}10$ $K_L = 1{,}32$

Table 10

Oil tankers, chemical tankers

Inner side and longitudinal bulkheads above 0,5 *H*	Connection of inner side or longitudinal bulkhead primary longitudinal members with stiffeners of transverse deep members — one rounded bracket



Concentration factors	
Non-watertight collar plate	Watertight collar plate
At $2 < \alpha < 2{,}5$ $K_H = 1{,}15$ $K_L = 1{,}35$ At $\alpha \geq 2{,}5$ $K_H = 1{,}10$ $K_L = 1{,}35$	At $2 < \alpha < 2{,}5$ $K_H = 1{,}13$ $K_L = 1{,}30$ At $\alpha \geq 2{,}5$ $K_H = 1{,}08$ $K_L = 1{,}30$

Table 11

Oil tankers, chemical tankers

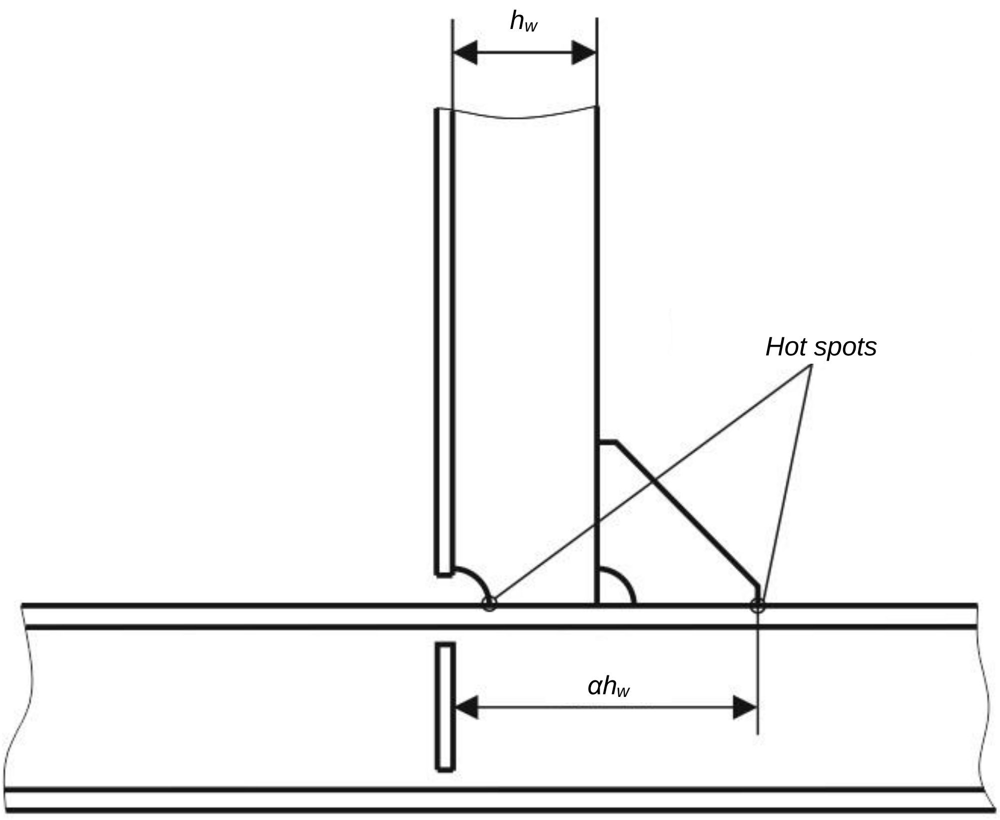
<table>
<tr><td>Inner side and longitudinal bulkheads above 0,5 H</td><td>Connection of inner side or longitudinal bulkhead primary longitudinal members with stiffeners of transverse deep members — one bracket</td></tr>
<tr><td colspan="2">
</td></tr>
<tr><td colspan="2">Concentration factors</td></tr>
<tr><td>Non-watertight collar plate</td><td>Watertight collar plate</td></tr>
<tr><td>At 2 < α < 2,5
$K_H = 1,30$
$K_L = 1,55$
At α ≥ 2,5
$K_H = 1,25$
$K_L = 1,50$</td><td>At 2 < α < 2,5
$K_H = 1,25$
$K_L = 1,46$
At α ≥ 2,5
$K_H = 1,20$
$K_L = 1,41$</td></tr>
</table>

Table 12

Oil tankers, chemical tankers

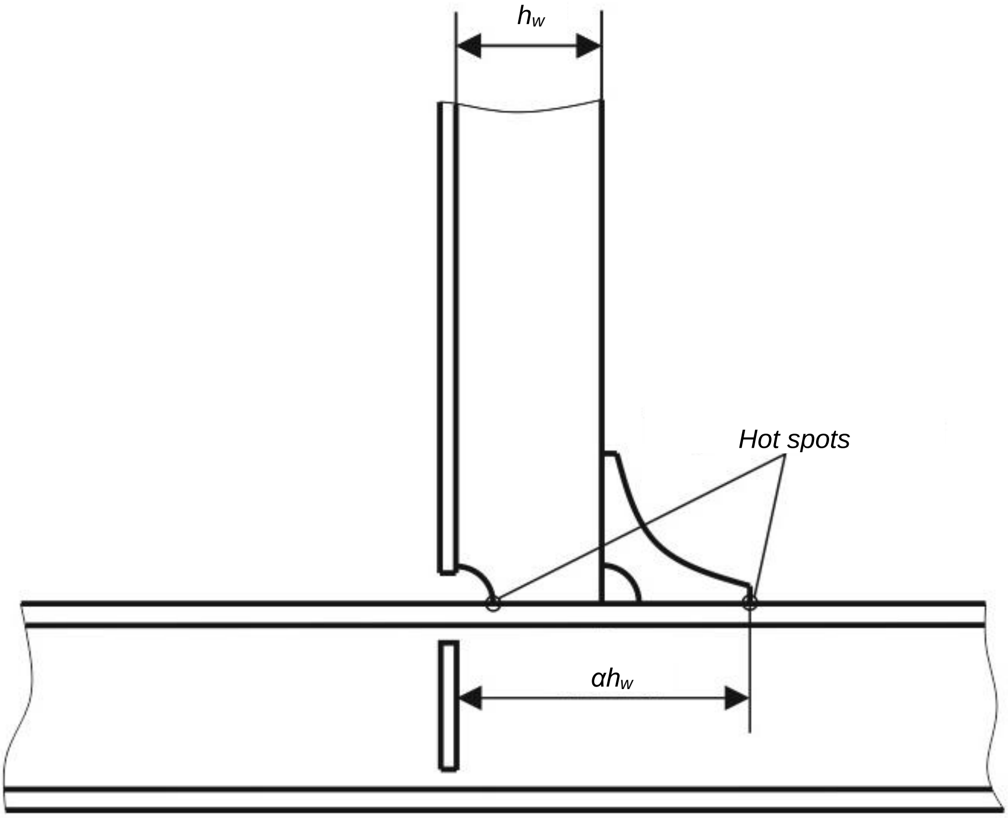
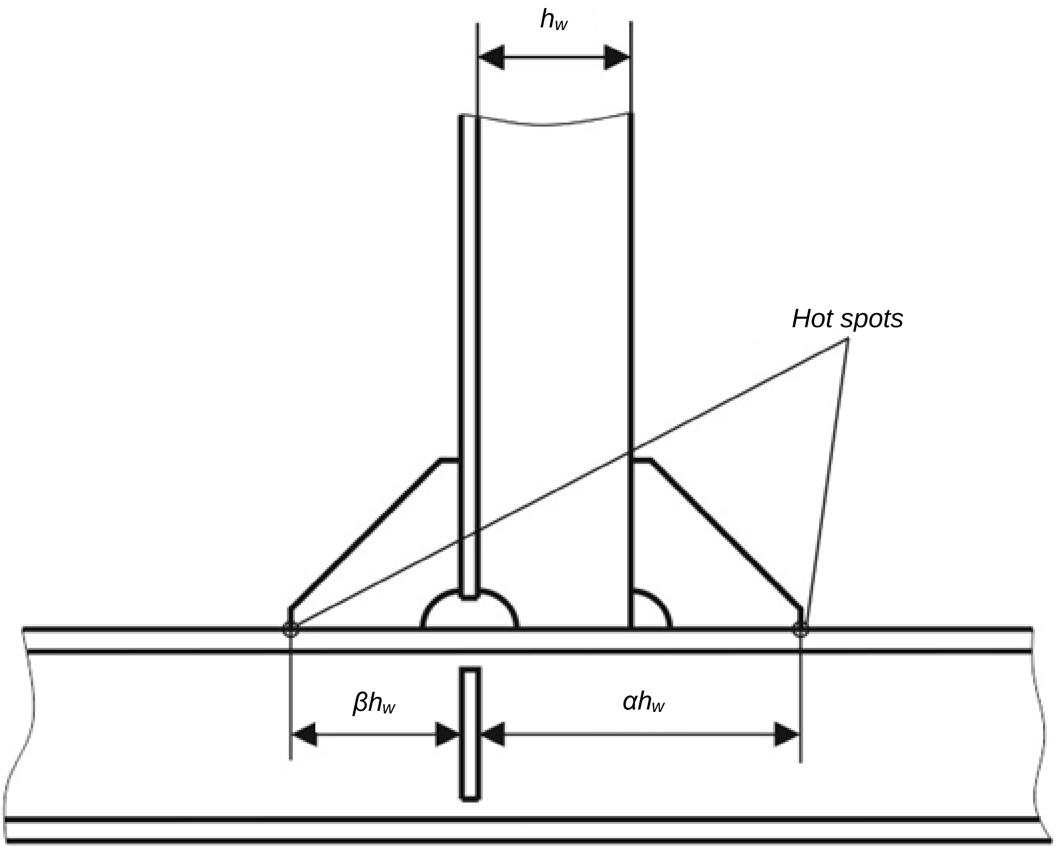
Inner side and longitudinal bulkheads above 0,5 *H*	Connection of inner side or longitudinal bulkhead primary longitudinal members with stiffeners of transverse deep members — one rounded bracket
	
Concentration factors	
Non-watertight collar plate	Watertight collar plate
At $2 < \alpha < 2{,}5$ $K_H = 1{,}25$ $K_L = 1{,}50$ At $\alpha \geq 2{,}5$ $K_H = 1{,}20$ $K_L = 1{,}45$	At $2 < \alpha < 2{,}5$ $K_H = 1{,}22$ $K_L = 1{,}44$ At $\alpha \geq 2{,}5$ $K_H = 1{,}18$ $K_L = 1{,}39$

Table 13

Oil tankers, chemical tankers

Inner side and longitudinal bulkheads above 0,5 *H*	Connection of inner side or longitudinal bulkhead primary longitudinal members with stiffeners of transverse deep members — two brackets



Concentration factors	
Non-watertight collar plate	Watertight collar plate
At $2 < \alpha < 2{,}5$ and $1 < \beta < 1{,}5$ $K_H = K_L = 1{,}15$ At $\alpha \geq 2{,}5$ and $\beta \geq 1{,}5$ $K_H = K_L = 1{,}10$	At $2 < \alpha < 2{,}5$ and $1 < \beta < 1{,}5$ $K_H = K_L = 1{,}10$ At $\alpha \geq 2{,}5$ and $\beta \geq 1{,}5$ $K_H = K_L = 1{,}05$

Table 14

Oil tankers, chemical tankers

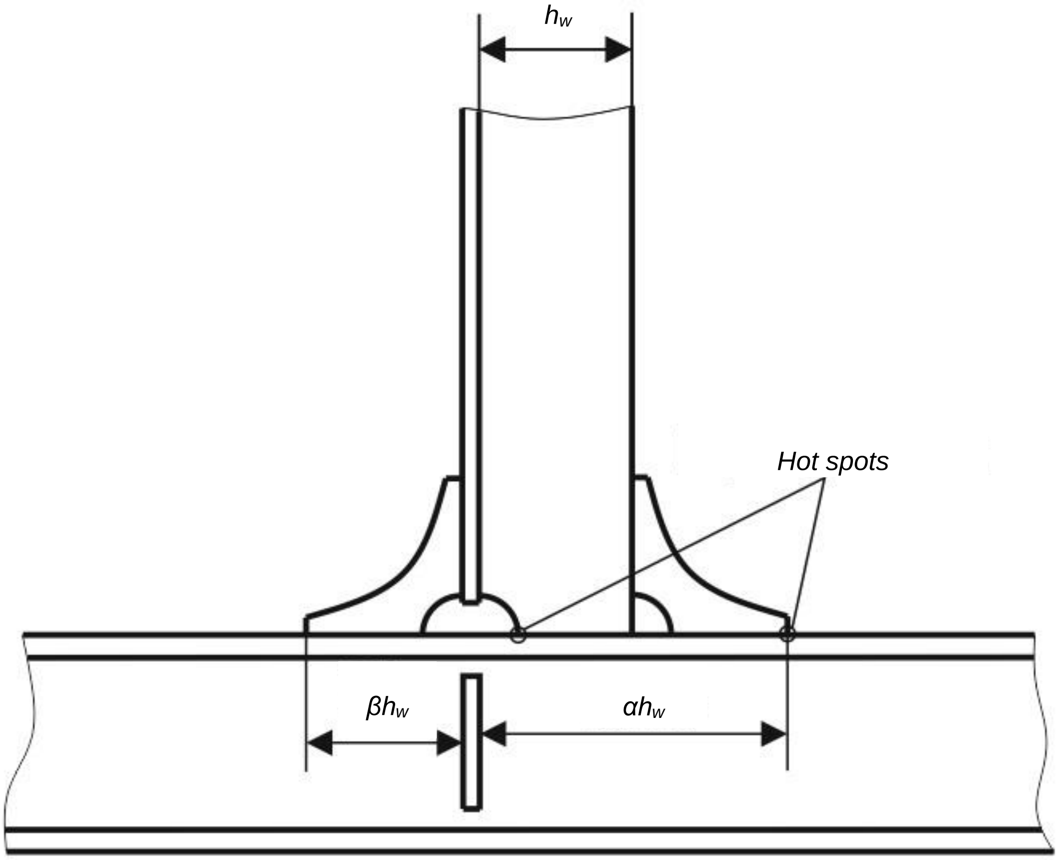
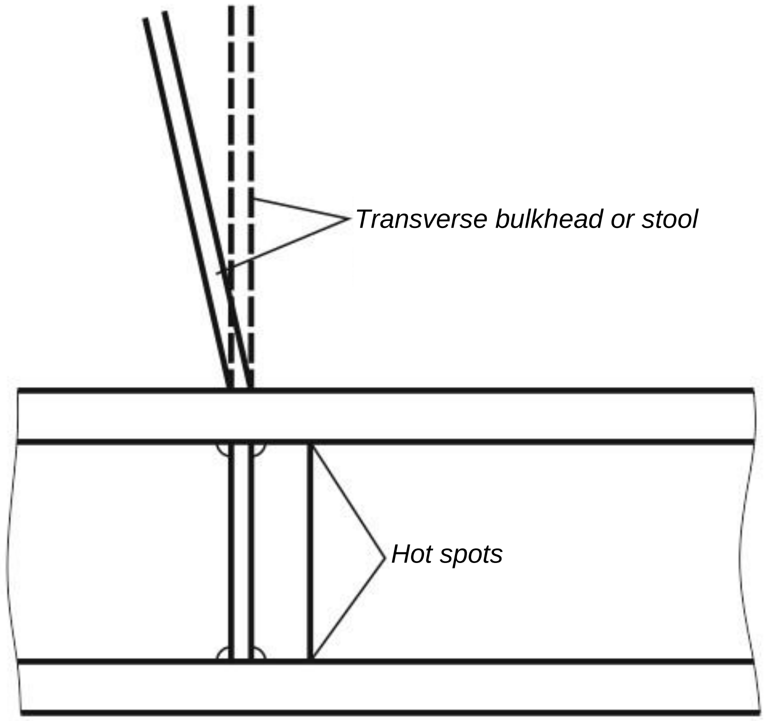
Inner side and longitudinal bulkheads above 0,5 *H*	Connection of inner side or longitudinal bulkhead primary longitudinal members with stiffeners of transverse deep members — two rounded brackets
	
Concentration factors	
Non-watertight collar plate	Watertight collar plate
At $2 < \alpha < 2{,}5$ and $1 < \beta < 1{,}5$ $K_H = K_L = 1{,}10$ At $\alpha \geq 2{,}5$ and $\beta \geq 1{,}5$ $K_H = K_L = 1{,}05$	At $2 < \alpha < 2{,}5$ and $1 < \beta < 1{,}5$ $K_H = K_L = 1{,}10$ At $\alpha \geq 2{,}5$ and $\beta \geq 1{,}5$ $K_H = K_L = 1{,}05$

Table 15

Oil tankers, chemical tankers, gas carriers, bulk carriers, ore carriers, oil/bulk/ore carriers

Double bottom in way of transverse bulkhead	Connection of bottom and inner bottom primary members with floors — no bracket



Concentration factors
$K_H = 1,30$ $K_L = 1,65$

Table 16

Oil tankers, chemical tankers, gas carriers, bulk carriers, ore carriers, oil/bulk/ore carriers

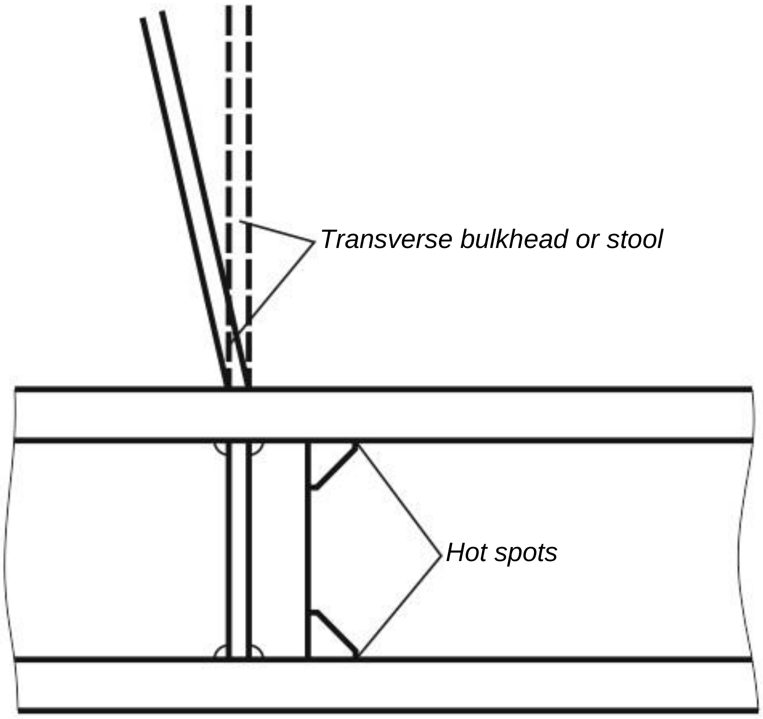
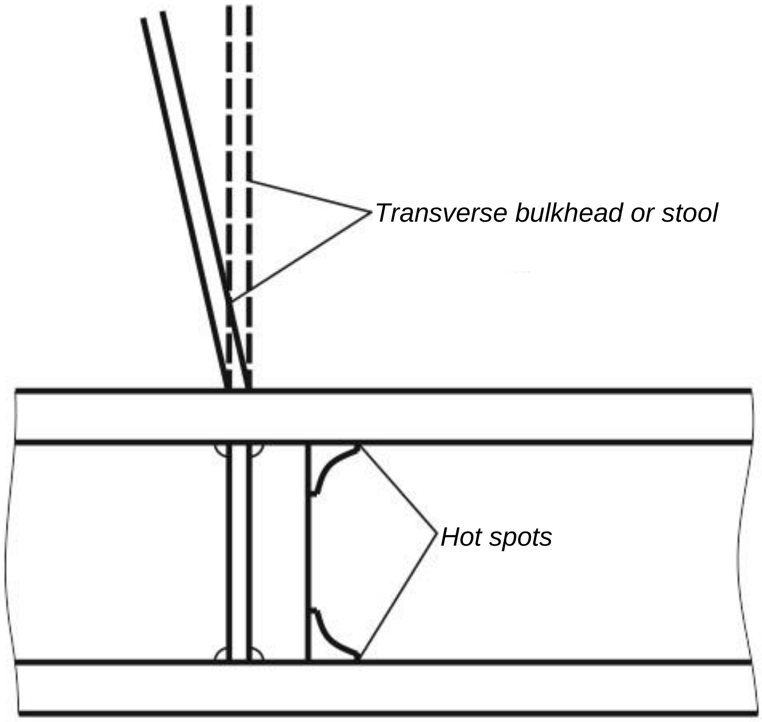
<table>
<tr><td>Double bottom in way of transverse bulkhead</td><td>Connection of bottom and inner bottom primary members with floors — brackets</td></tr>
<tr><td colspan="2">
</td></tr>
<tr><td colspan="2">Concentration factors</td></tr>
<tr><td colspan="2">$K_H = 1{,}30$
$K_L = 1{,}55$</td></tr>
</table>

Table 17

Oil tankers, chemical tankers, gas carriers, bulk carriers, ore carriers, oil/bulk/ore carriers

Double bottom in way of transverse bulkhead	Connection of bottom and inner bottom primary members with floors — rounded brackets



Concentration factors
$K_H = 1{,}25$ $K_L = 1{,}50$

Table 18

Oil tankers, chemical tankers, gas carriers, bulk carriers, ore carriers, oil/bulk/ore carriers

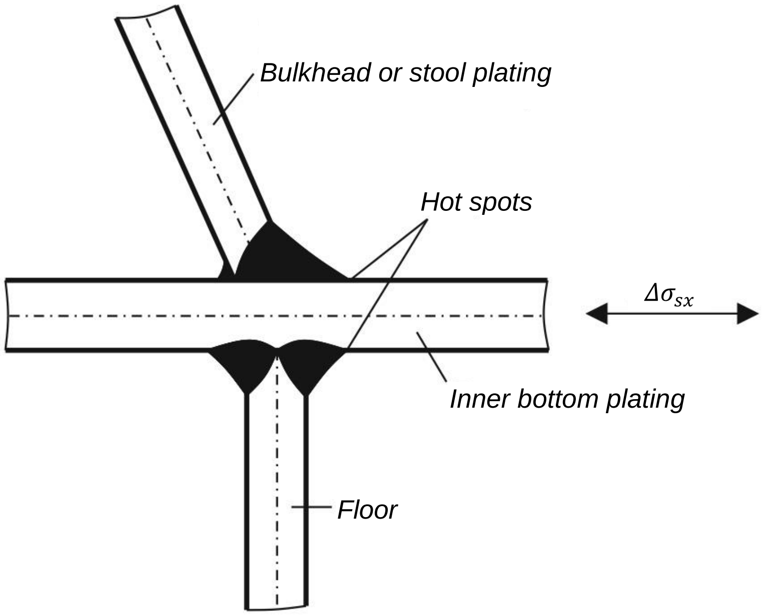
<table>
<tr><td>Double bottom in way of transverse bulkheads</td><td>Connection of inner bottom with transverse bulkheads or lower stools</td></tr>
<tr><td colspan="2">
</td></tr>
<tr><td colspan="2">Concentration factor</td></tr>
<tr><td colspan="2">$K_{SX} = 3{,}85$</td></tr>
</table>

Table 19

Oil tankers, chemical tankers, gas carriers, bulk carriers, ore carriers, oil/bulk/ore carriers

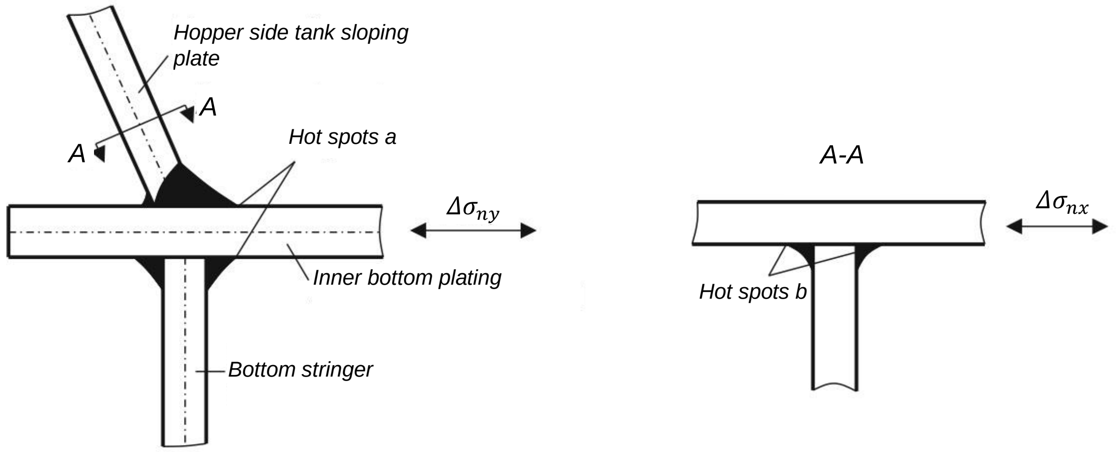
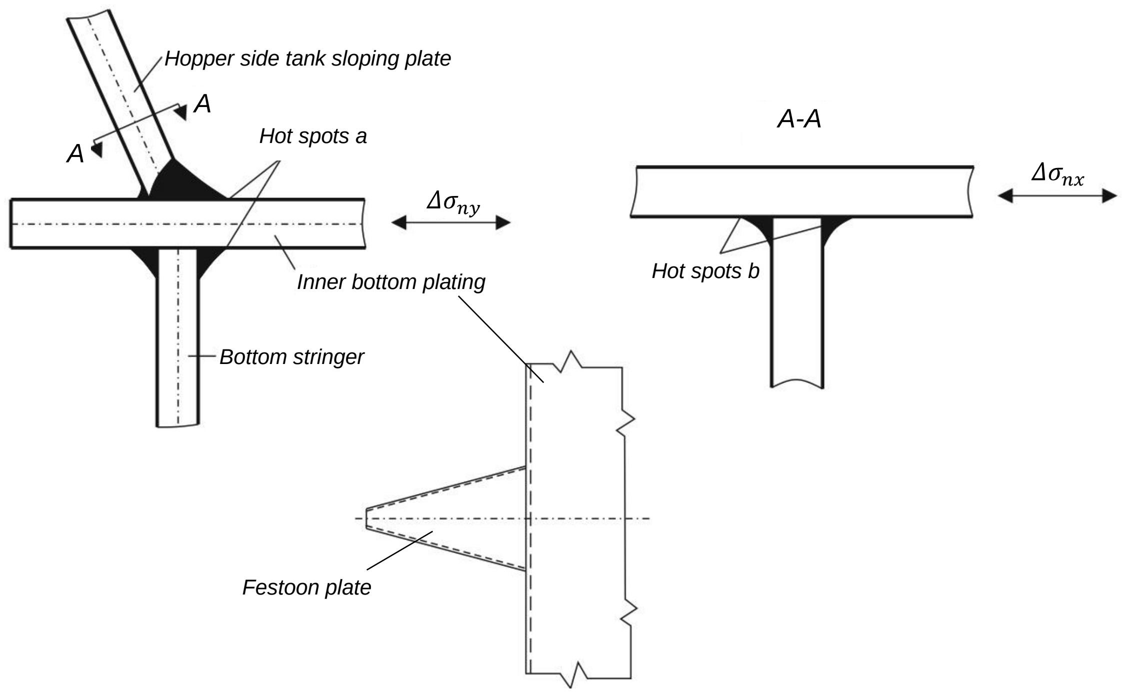
Double bottom in way of hopper side tanks	Connection of inner bottom with hopper side tank sloping plates
	
Concentration factors	
$K_{SY} = 3{,}85$ where closed scallops $K_{SY} = 5{,}40$ where open scallops $K_{SX} = 1{,}30$ $K_{SYX} = 2{,}00$	
Formulae for determination of hot spot stress ranges	
Hot spot *a*	Hot spot *b*
$\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{ny}$	$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nx} + K_{SYX} \cdot \Delta\sigma_{ny}$

Table 20

Oil tankers, chemical tankers, gas carriers, bulk carriers, ore carriers, oil/bulk/ore carriers

Double bottom in way of hopper side tanks	Connection of inner bottom with hopper side tank sloping plates using festoon plates



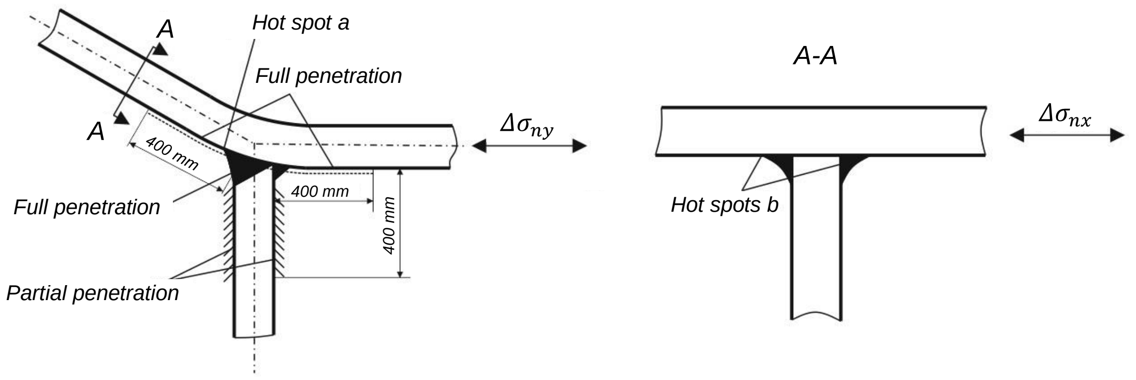
Concentration factors
$K_{SY} = 2{,}40$ where closed scallops $K_{SY} = 3{,}40$ where open scallops $K_{SX} = 1{,}30$ $K_{SYX} = 1{,}50$

Formulae for determination of hot spot stress ranges	
Hot spot *a*	Hot spot *b*
$\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{ny}$	$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nx} + K_{SYX} \cdot \Delta\sigma_{ny}$

Table 21

Oil tankers, chemical tankers, gas carriers, bulk carriers, ore carriers, oil/bulk/ore carriers

Double bottom in way of hoper side tanks	Rounded connection of inner bottom with hoper side tank sloping plates



Concentration factors	
$K_{SY} = 3{,}15$ $K_{SX} = 1{,}30$ $K_{SYX} = 2{,}05$	
Formulae for determination of hot spot stress ranges	
Hot spot *a*	Hot spot *b*
$\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{ny}$	$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nx} + K_{SYX} \cdot \Delta\sigma_{ny}$

Table 22

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

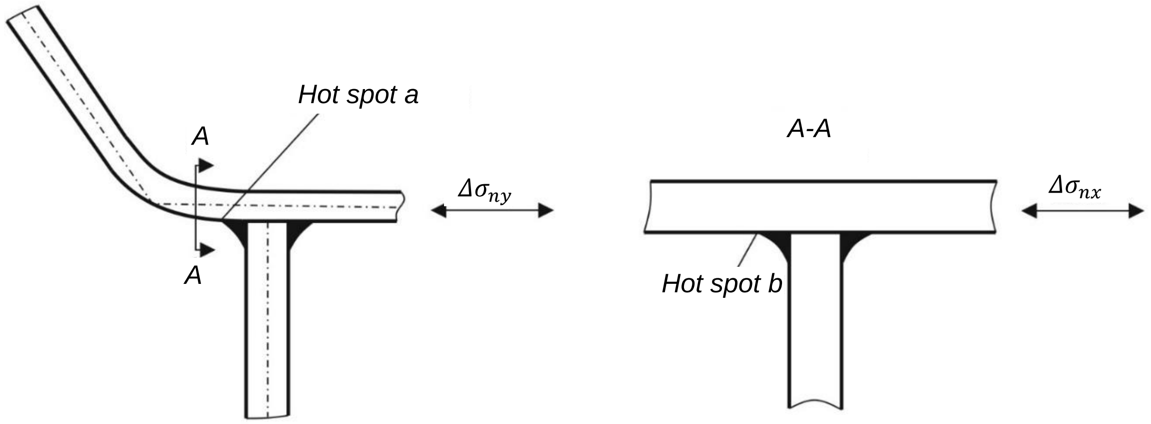
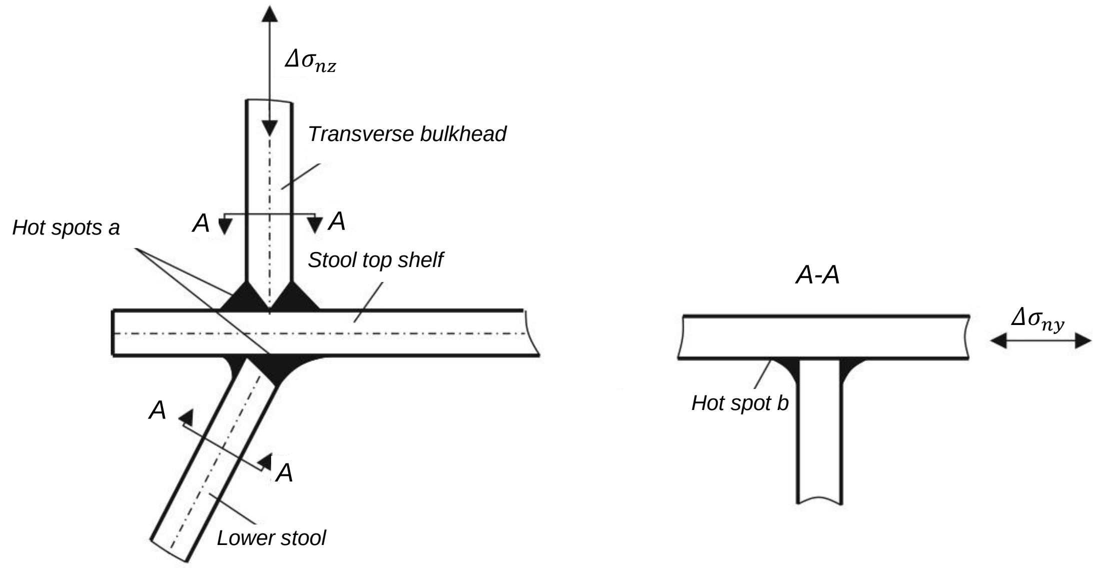
Double bottom in way of hoper side tanks	Rounded connection of inner bottom with hoper side tank sloping plates
	
Concentration factors	
$K_{SY} = 3{,}85$ $K_{SX} = 1{,}30$ $K_{SYX} = 4{,}50$	
Formulae for determination of hot spot stress ranges	
Hot spot *a*	Hot spot *b*
$\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{ny}$	$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nx} + K_{SYX} \cdot \Delta\sigma_{ny}$

Table 23

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

Lower part of transverse bulkhead with lower stool	Connection of lower stool with plane bulkhead

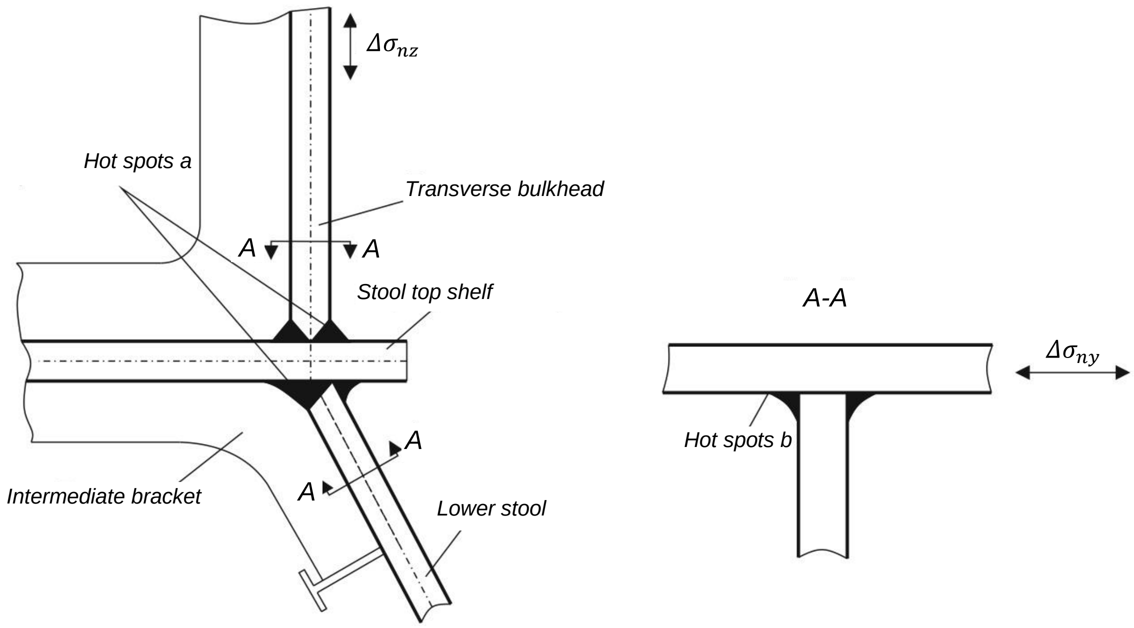


Concentration factors	
$K_{SZ} = 3{,}85$ $K_{SY} = 1{,}30$ $K_{SYZ} = 2{,}00$	
Formulae for determination of hot spot stress ranges	
Hot spot *a*	Hot spot *b*
$\Delta\sigma_{SZ} = K_{SZ} \cdot \Delta\sigma_{nz}$	$\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{ny} + K_{SYZ} \cdot \Delta\sigma_{nz}$

Table 24

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

<table>
<tr><td>Lower part of transverse bulkhead with lower stool</td><td>Connection of lower stool with plane bulkhead in way of intermediate brackets</td></tr>
<tr><td colspan="2">



</td></tr>
<tr><td colspan="2">Concentration factors</td></tr>
<tr><td colspan="2">$K_{SZ} = 3,55$
$K_{SY} = 1,30$
$K_{SYZ} = 1,75$</td></tr>
<tr><td colspan="2">Formulae for determination of hot spot stress ranges</td></tr>
<tr><td>Hot spot *a*</td><td>Hot spot *b*</td></tr>
<tr><td>$\Delta\sigma_{SZ} = K_{SZ} \cdot \Delta\sigma_{nz}$</td><td>$\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{ny} + K_{SYZ} \cdot \Delta\sigma_{nz}$</td></tr>
</table>

Table 25

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

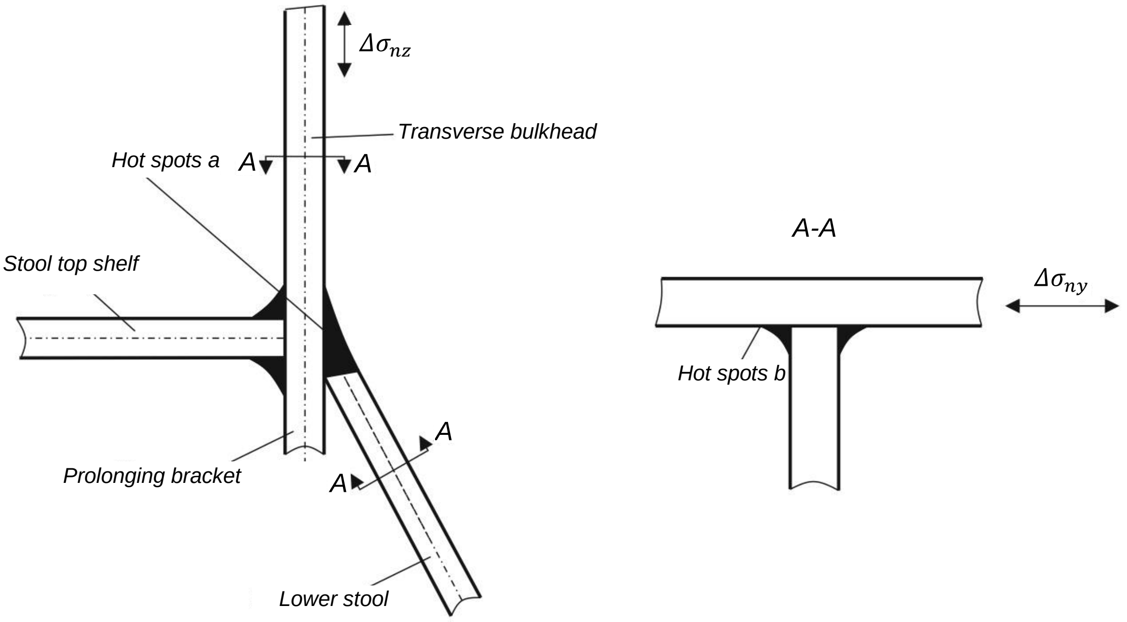
Lower part of transverse bulkhead with lower stool		Connection of lower stool with plane bulkhead using prolonging brackets	
			
Concentration factors			
$K_{SZ} = 2{,}40$ $K_{SY} = 1{,}30$ $K_{SYZ} = 1{,}50$			
Formulae for determination of hot spot stress ranges			
Hot spot *a*		Hot spot *b*	
$\Delta\sigma_{SZ} = K_{SZ} \cdot \Delta\sigma_{nz}$		$\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{ny} + K_{SYZ} \cdot \Delta\sigma_{nz}$	

Table 26

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

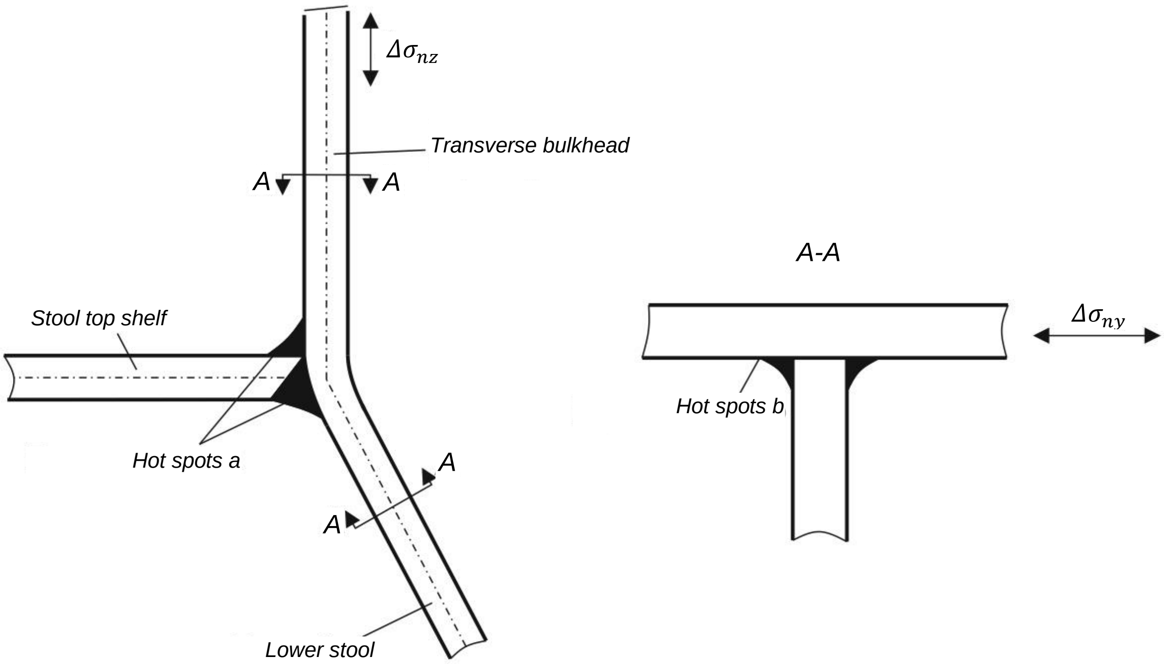
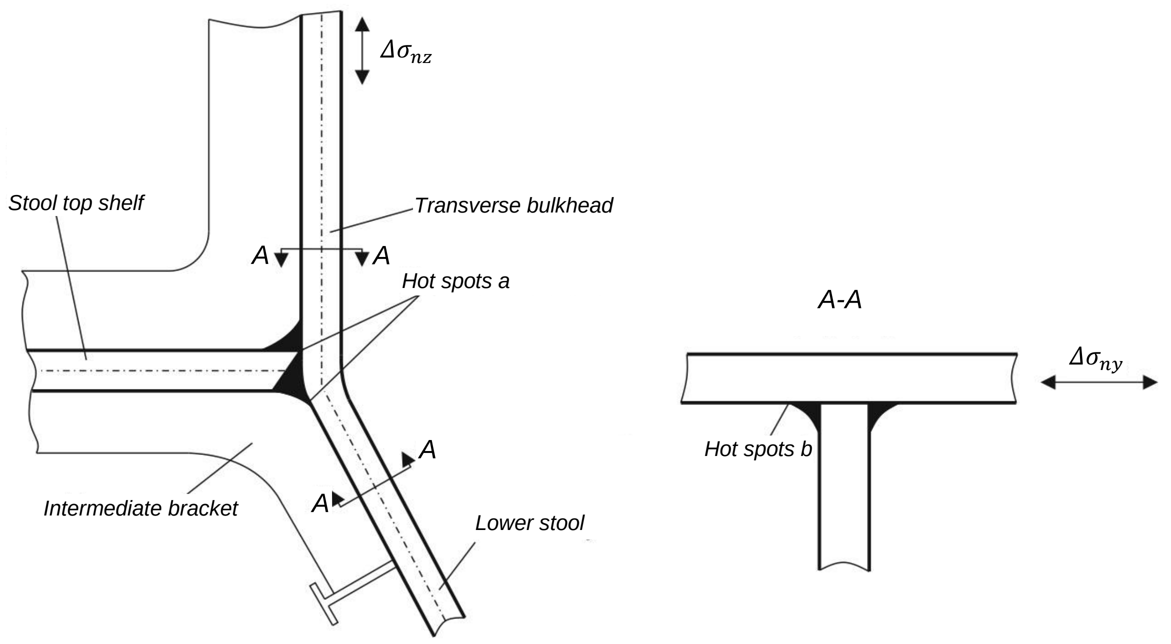
Lower part of transverse bulkhead with lower stool	Rounded connection of lower stool with plane bulkhead
	
Concentration factors	
$K_{SZ} = 3{,}30$ $K_{SY} = 1{,}30$ $K_{SYZ} = 2{,}25$	
Formulae for determination of hot spot stress ranges	
Hot spot *a*	Hot spot *b*
$\Delta\sigma_{SZ} = K_{SZ} \cdot \Delta\sigma_{nz}$	$\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{ny} + K_{SYZ} \cdot \Delta\sigma_{nz}$

Table 27

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

Lower part of transverse bulkhead with lower stool	Rounded connection of lower stool with plane bulkhead using intermediate brackets

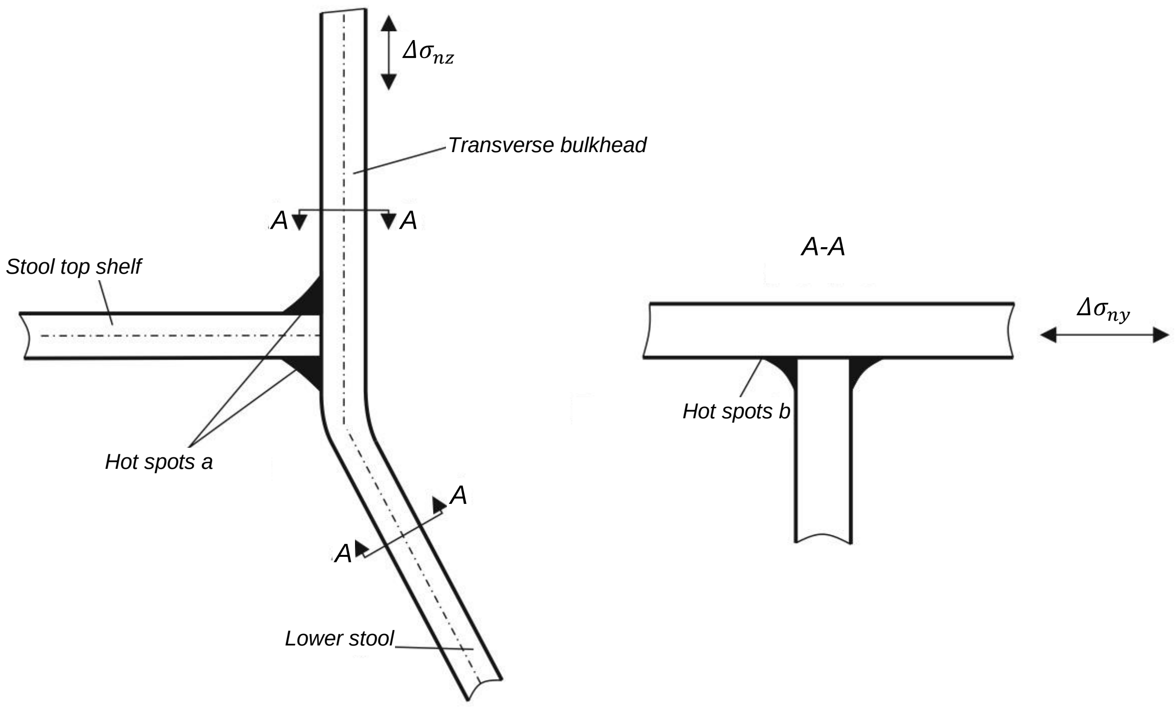


Concentration factors	
$K_{SZ} = 3{,}15$ $K_{SY} = 1{,}30$ $K_{SYZ} = 2{,}05$	
Formulae for determination of hot spot stress ranges	
Hot spot *a*	Hot spot *b*
$\Delta\sigma_{SZ} = K_{SZ} \cdot \Delta\sigma_{nz}$	$\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{ny} + K_{SYZ} \cdot \Delta\sigma_{nz}$

Table 28

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

Lower part of transverse bulkhead with lower stool	Rounded connection of lower stool with plane bulkhead

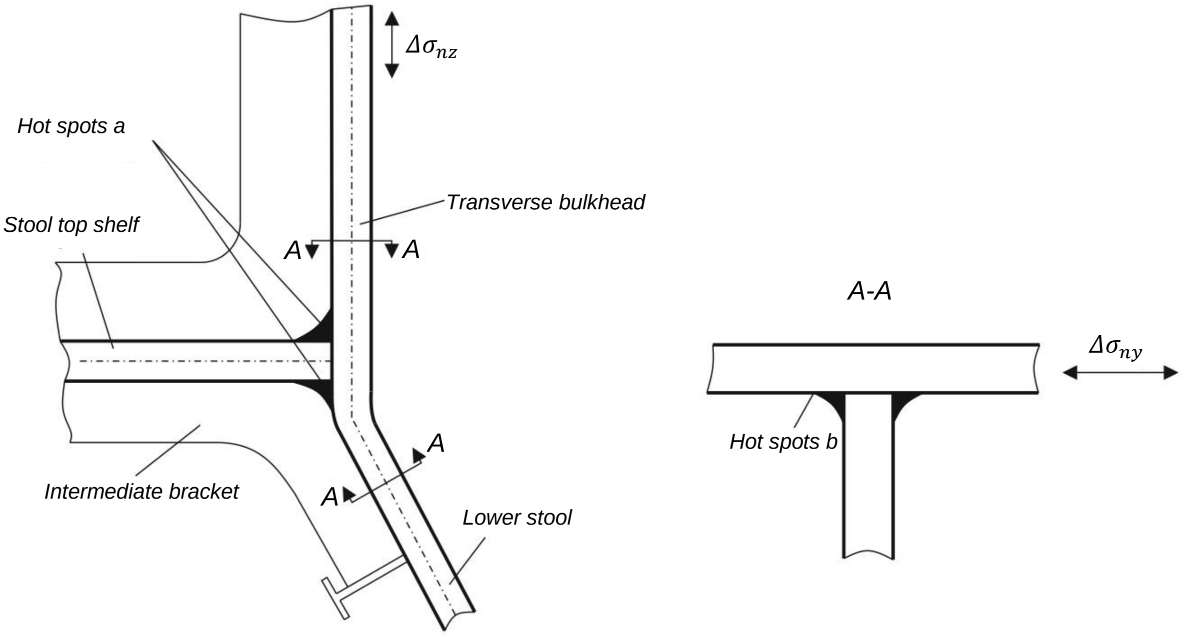


Concentration factors	
$K_{SZ} = 4{,}50$ $K_{SY} = 1{,}30$ $K_{SYZ} = 5{,}60$	
Formulae for determination of hot spot stress ranges	
Hot spot *a*	Hot spot *b*
$\Delta\sigma_{SZ} = K_{SZ} \cdot \Delta\sigma_{nz}$	$\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{ny} + K_{SYZ} \cdot \Delta\sigma_{nz}$

Table 29

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

Lower part of transverse bulkhead with lower stool	Rounded connection of lower stool with plane bulkhead using intermediate bracket



Concentration factors	
$K_{SZ} = 3,85$ $K_{SY} = 1,30$ $K_{SYZ} = 4,50$	
Formulae for determination of hot spot stress ranges	
Hot spot *a*	Hot spot *b*
$\Delta\sigma_{SZ} = K_{SZ} \cdot \Delta\sigma_{nz}$	$\Delta\sigma_{SY} = K_{SY} \cdot \Delta\sigma_{ny} + K_{SYZ} \cdot \Delta\sigma_{nz}$

Table 30

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

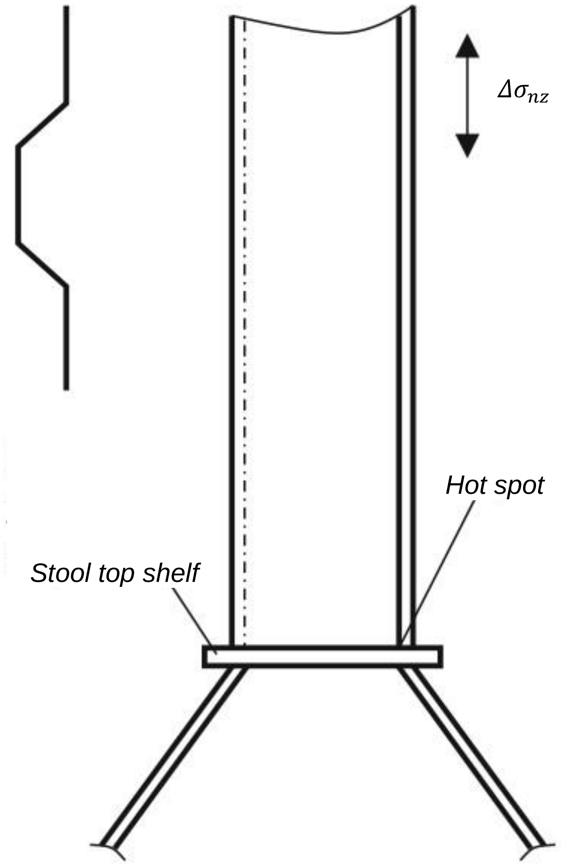
Lower part of transverse bulkhead with lower stool	Connection of lower stool with corrugated bulkhead
	
Concentration factors	
$K_{SZ} = 2{,}35$	

Table 31

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

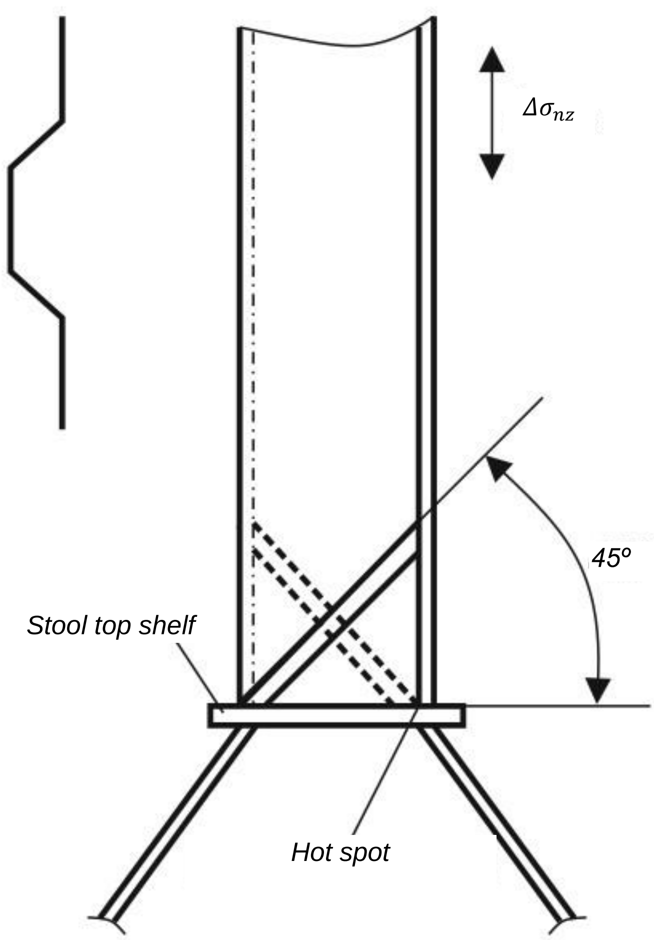
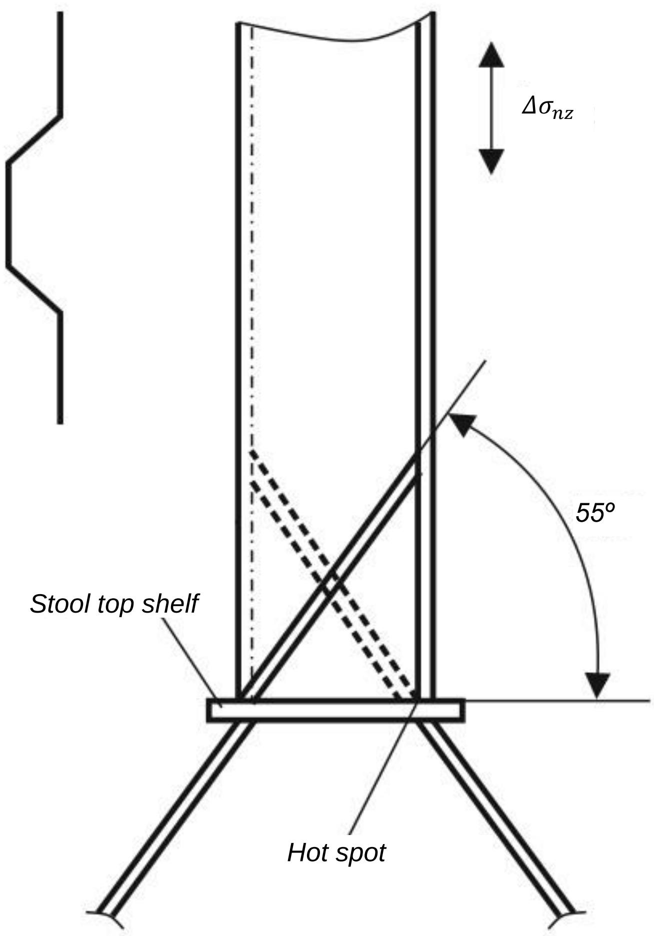
Lower part of transverse bulkhead with lower stool	Connection of lower stool with corrugated bulkhead using shedder plates with slope angle of 45º
	
Concentration factors	
$K_{SZ} = 1{,}35$	

Table 32

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

Lower part of transverse bulkhead with lower stool	Connection of lower stool with corrugated bulkhead using shedder plates with slope angle of 55º



Concentration factors
$K_{SZ} = 1{,}25$

Table 33

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

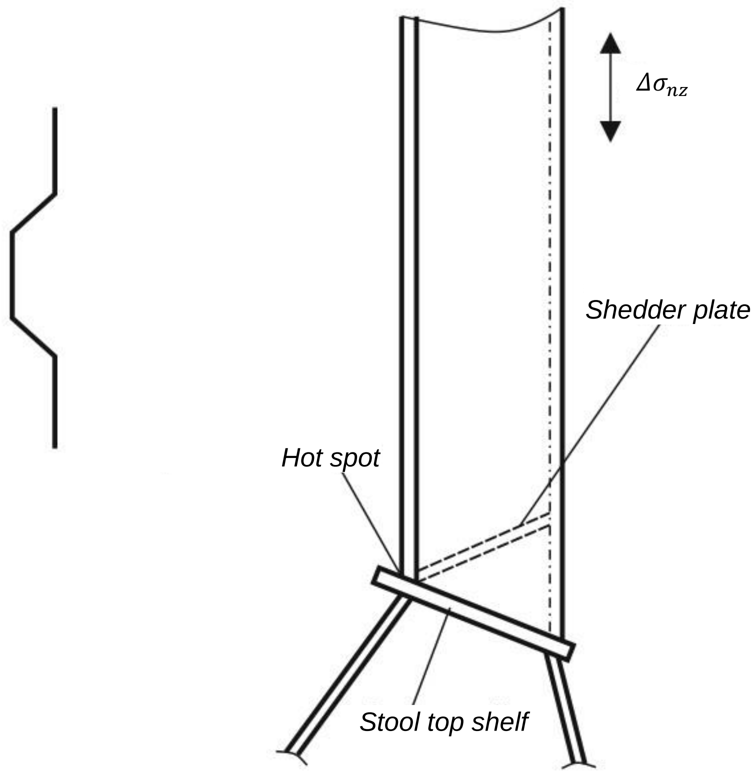
Lower part of transverse bulkhead with lower stool	Connection of lower stool with sloping top shelf and corrugated bulkhead using shedder plates
	
Concentration factors	
$K_{SZ} = 1{,}90$	

Table 34

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

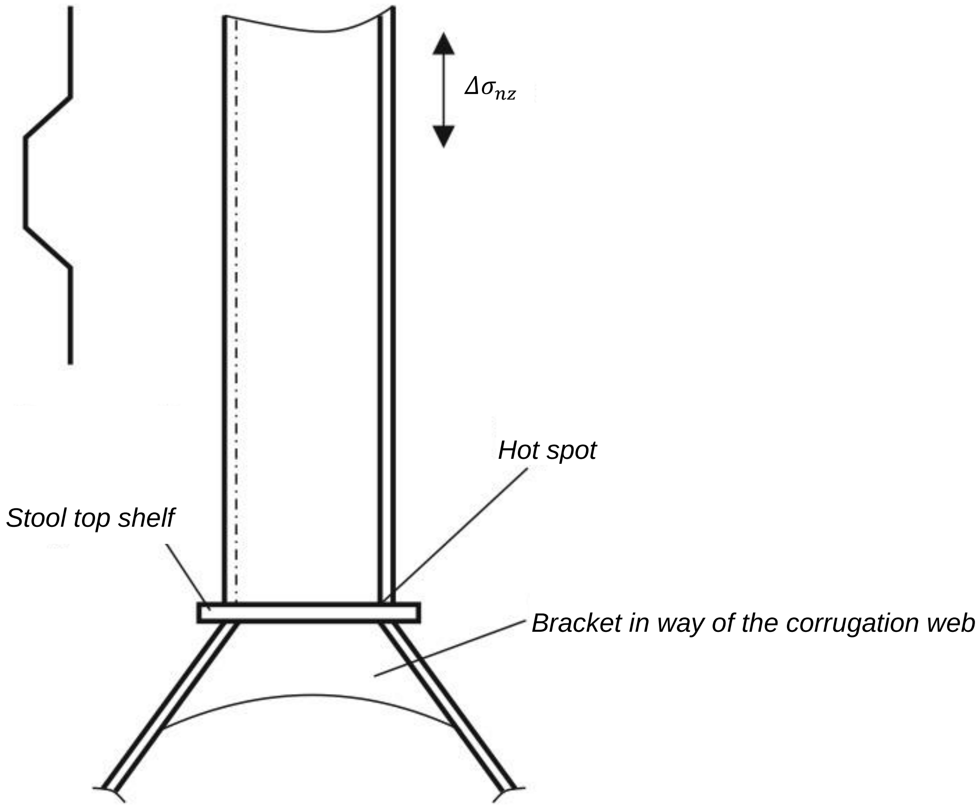
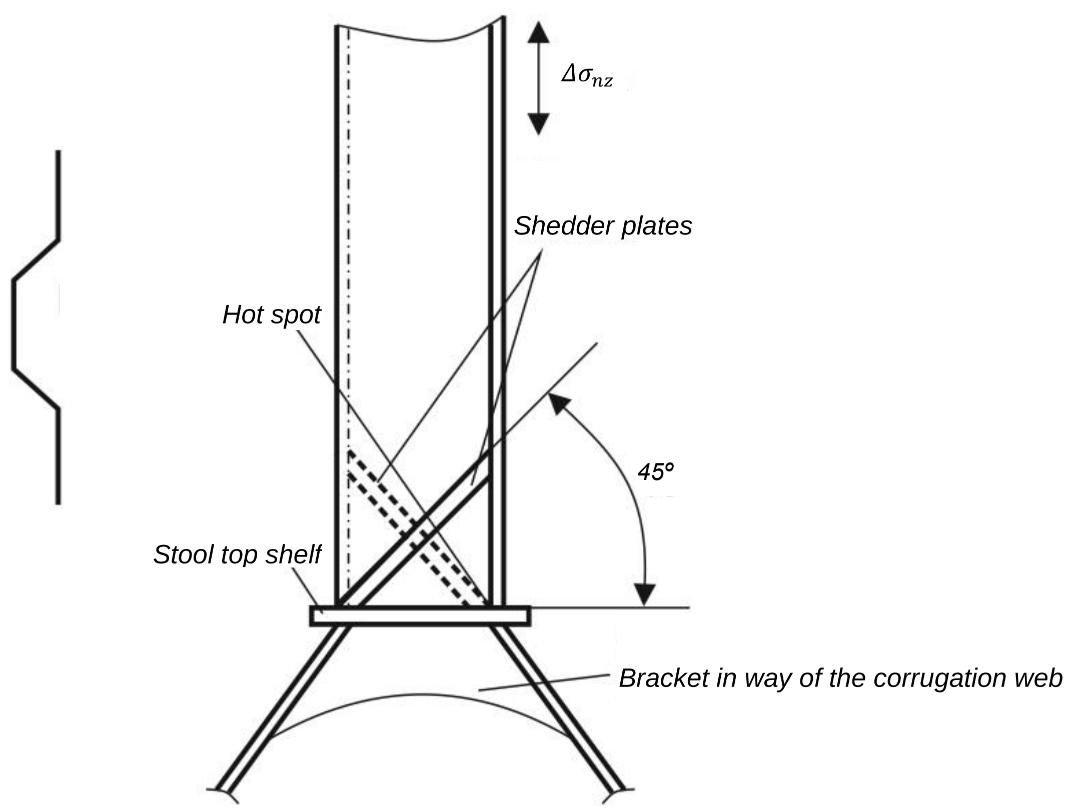
Lower part of transverse bulkhead with lower stool	Connection of lower stool with corrugated bulkhead using bracket below stool top shelf
	
Concentration factors	
$K_{SZ} = 1{,}95$	

Table 35

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

Lower part of transverse bulkhead with lower stool	Connection of lower stool with corrugated bulkhead using shedder plates with brackets below upper stool shelf



Concentration factors
$K_{SZ} = 1{,}25$

Table 36

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

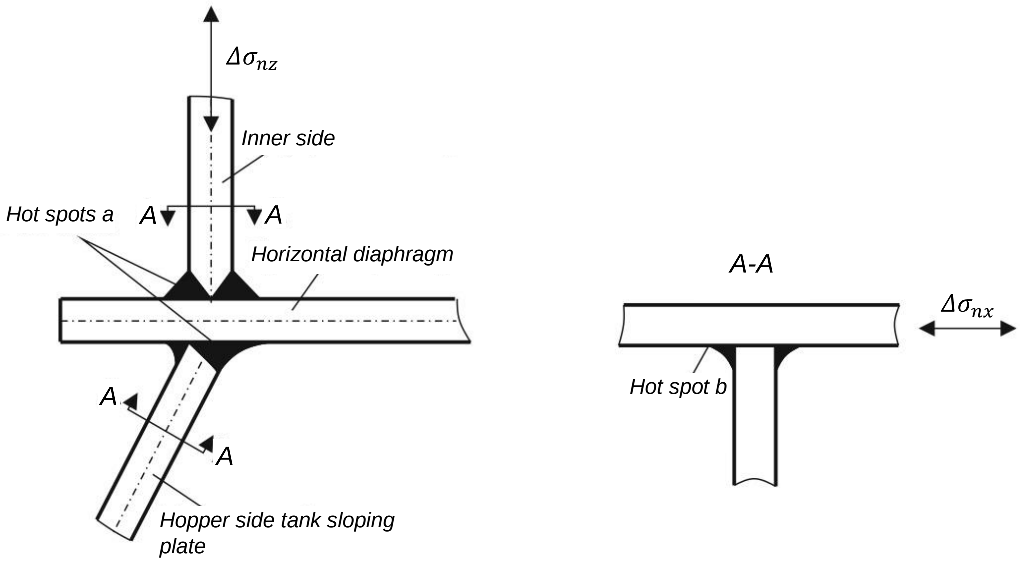
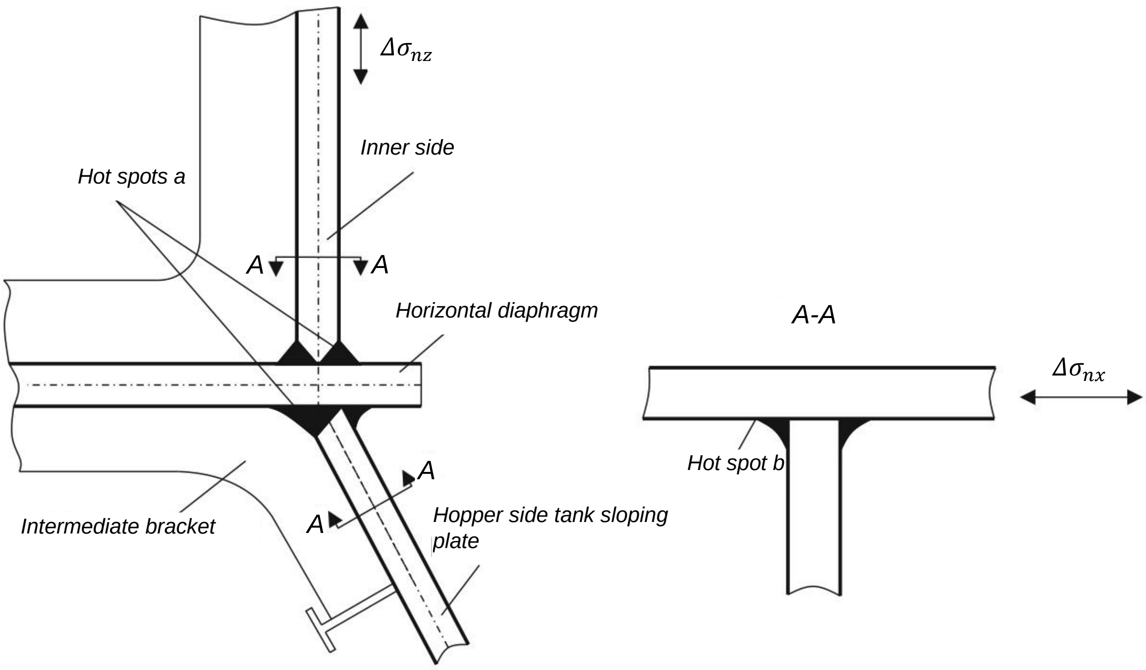
Lower part of inner side	Connection of hopper side tank sloping plate with inner side
	
Concentration factors	
$K_{SZ} = 3,85$ $K_{SX} = 1,30$ $K_{SXZ} = 2,00$	
Formulae for determination of hot spot stress ranges	
Hot spot *a*	Hot spot *b*
$\Delta\sigma_{SZ} = K_{SZ} \cdot \Delta\sigma_{nz}$	$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nx} + K_{SXZ} \cdot \Delta\sigma_{nz}$

Table 37

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

Lower part of inner side	Connection of hopper side tank sloping plate with inner side using intermediate bracket



Concentration factors	
$K_{SZ} = 3{,}55$ $K_{SX} = 1{,}30$ $K_{SXZ} = 1{,}75$	
Formulae for determination of hot spot stress ranges	
Hot spot *a*	Hot spot *b*
$\Delta\sigma_{SZ} = K_{SZ} \cdot \Delta\sigma_{nz}$	$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nx} + K_{SXZ} \cdot \Delta\sigma_{nz}$

Table 38

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

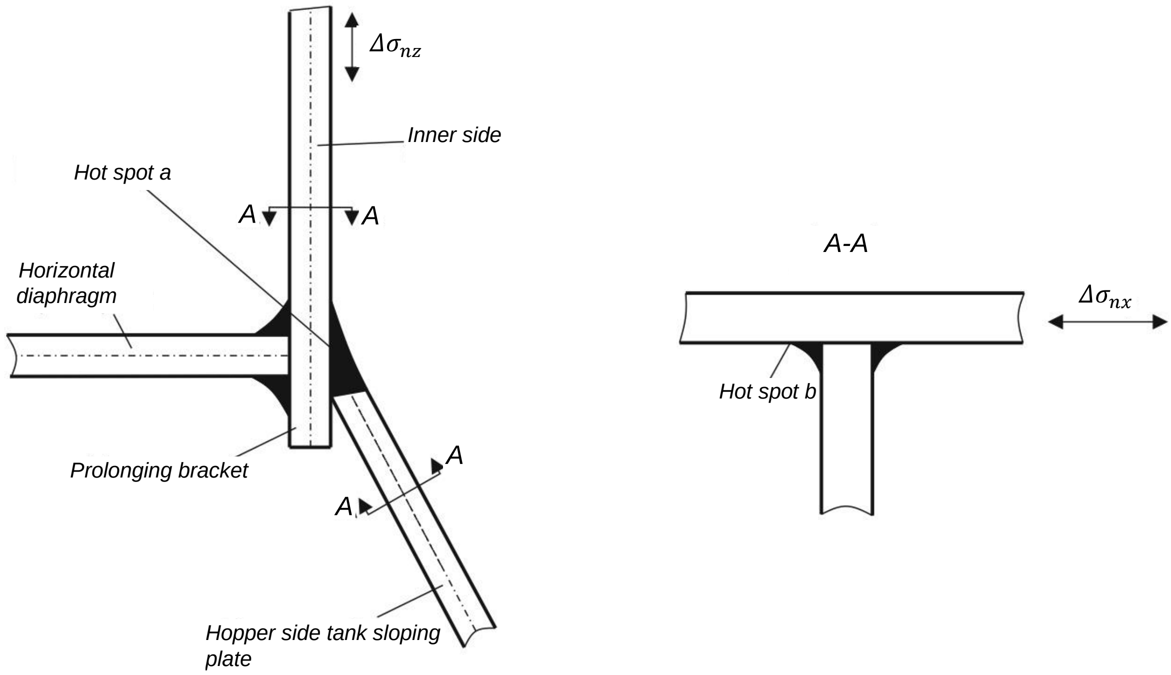
Lower part of inner side	Connection of hopper side tank sloping plate with inner side using prolonging bracket
	
Concentration factors	
$K_{SZ} = 2{,}40$ $K_{SX} = 1{,}30$ $K_{SXZ} = 1{,}50$	
Formulae for determination of hot spot stress ranges	
Hot spot *a*	Hot spot *b*
$\Delta\sigma_{SZ} = K_{SZ} \cdot \Delta\sigma_{nz}$	$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nx} + K_{SXZ} \cdot \Delta\sigma_{nz}$

Table 39

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

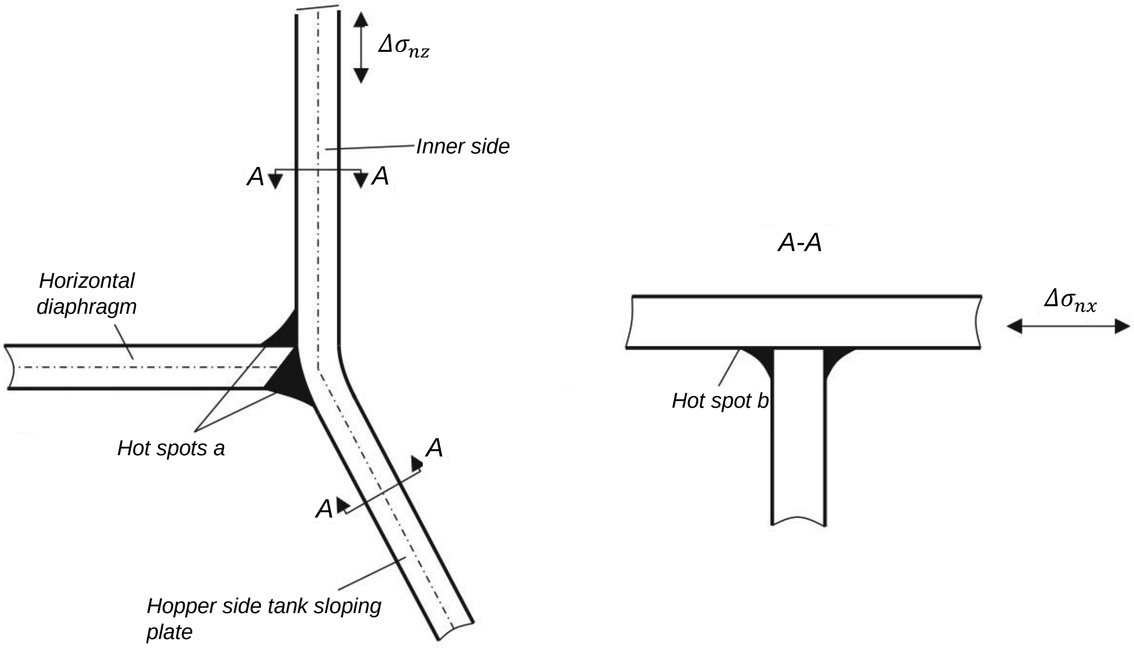
Lower part of inner side	Rounded connection of hopper side tank sloping plate with inner side
	
Concentration factors	
$K_{SZ} = 3{,}30$ $K_{SX} = 1{,}30$ $K_{SXZ} = 2{,}25$	
Formulae for determination of hot spot stress ranges	
Hot spot *a*	Hot spot *b*
$\Delta\sigma_{SZ} = K_{SZ} \cdot \Delta\sigma_{nz}$	$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nx} + K_{SXZ} \cdot \Delta\sigma_{nz}$

Table 40

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

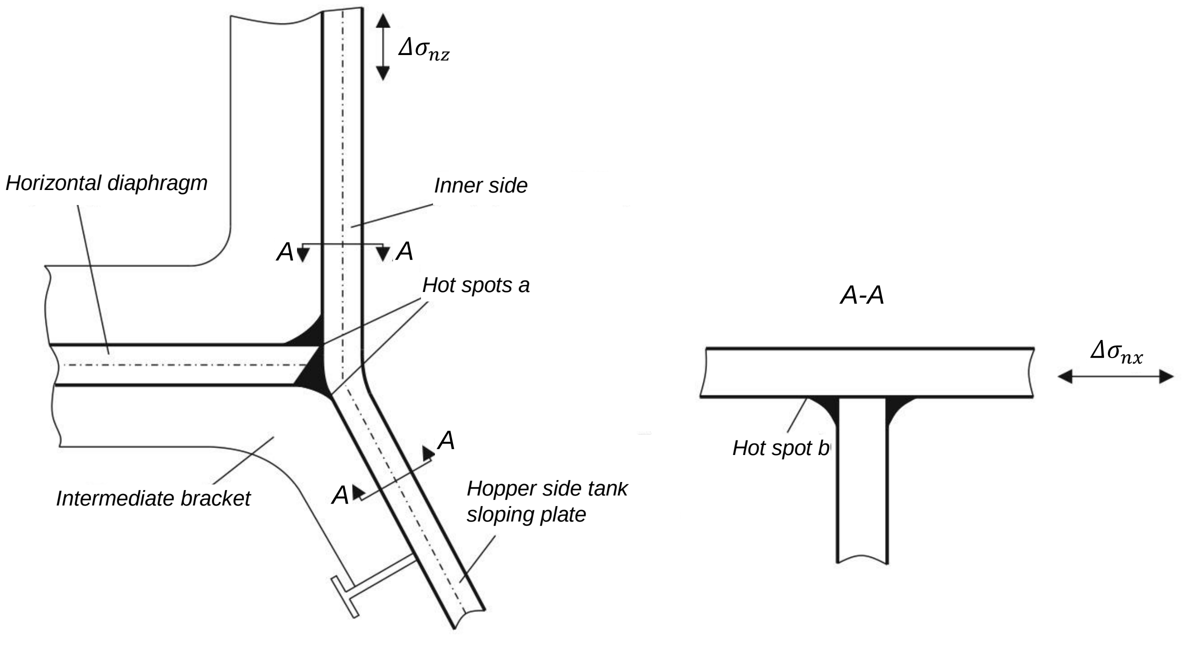
<table>
<tr><td>Lower part of inner side</td><td colspan="2">Rounded connection of hopper side tank sloping plate with inner side using intermediate bracket</td></tr>
<tr><td colspan="3">
</td></tr>
<tr><td colspan="3">Concentration factors</td></tr>
<tr><td colspan="3">$K_{SZ} = 3{,}15$
$K_{SX} = 1{,}30$
$K_{SXZ} = 2{,}05$</td></tr>
<tr><td colspan="3">Formulae for determination of hot spot stress ranges</td></tr>
<tr><td>Hot spot a</td><td colspan="2">Hot spot b</td></tr>
<tr><td>$\Delta\sigma_{SZ} = K_{SZ} \cdot \Delta\sigma_{nz}$</td><td colspan="2">$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nx} + K_{SXZ} \cdot \Delta\sigma_{nz}$</td></tr>
</table>

Table 41

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

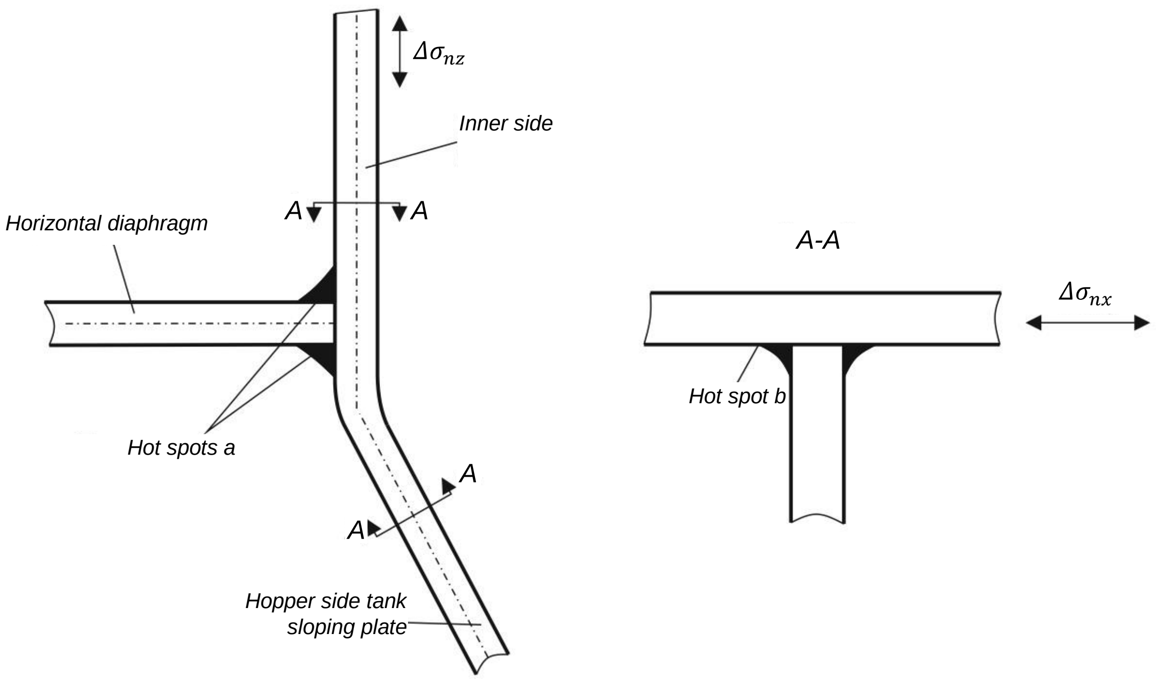
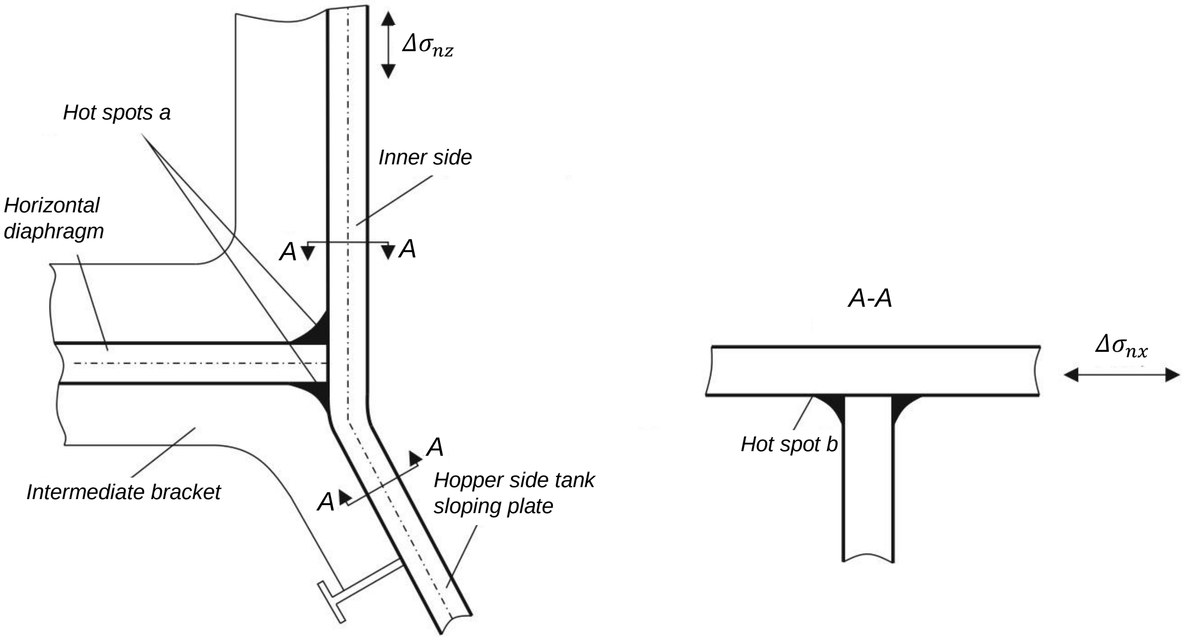
Lower part of inner side	Rounded connection of hopper side tank sloping plate with inner side
	
Concentration factors	
$K_{SZ} = 4{,}50$ $K_{SX} = 1{,}30$ $K_{SXZ} = 5{,}60$	
Formulae for determination of hot spot stress ranges	
Hot spot *a*	Hot spot *b*
$\Delta\sigma_{SZ} = K_{SZ} \cdot \Delta\sigma_{nz}$	$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nx} + K_{SXZ} \cdot \Delta\sigma_{nz}$

Table 42

Oil tankers, chemical tankers, bulk carriers, ore carriers, oil/bulk/ore carriers

Lower part of inner side	Rounded connection of hopper side tank sloping plate with inner side using intermediate bracket



Concentration factors

$K_{SZ} = 3,85$
$K_{SX} = 1,30$
$K_{SXZ} = 4,50$

Formulae for determination of hot spot stress ranges

Hot spot *a*	Hot spot *b*
$\Delta\sigma_{SZ} = K_{SZ} \cdot \Delta\sigma_{nz}$	$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nx} + K_{SXZ} \cdot \Delta\sigma_{nz}$

Table 43

Gas carriers

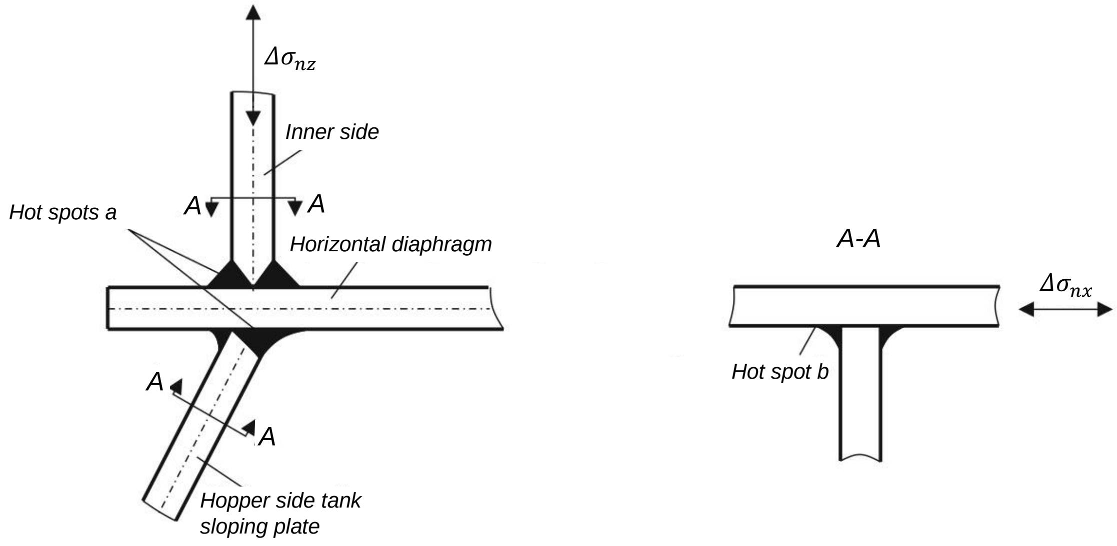
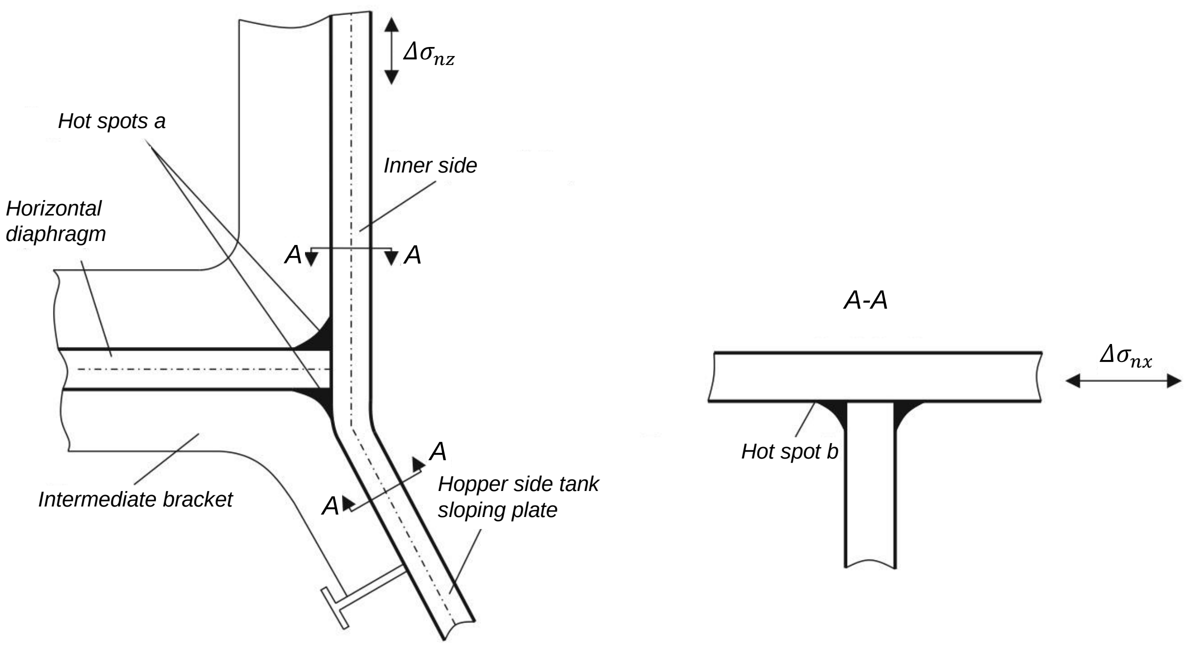
<table>
<tr><td>Lower part of inner side</td><td>Connection of hopper side tank sloping plate with inner side</td></tr>
<tr><td colspan="2">
</td></tr>
<tr><td colspan="2">Concentration factors</td></tr>
<tr><td colspan="2">$K_{SZ} = 3,85$
$K_{SX} = 1,30$
$K_{SXZ} = 2,00$</td></tr>
<tr><td colspan="2">Formulae for determination of hot spot stress ranges</td></tr>
<tr><td>Hot spot a</td><td>Hot spot b</td></tr>
<tr><td>$\Delta\sigma_{SZ} = K_{SZ} \cdot \Delta\sigma_{nz}$</td><td>$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nx} + K_{SXZ} \cdot \Delta\sigma_{nz}$</td></tr>
</table>

Table 44

Gas carriers

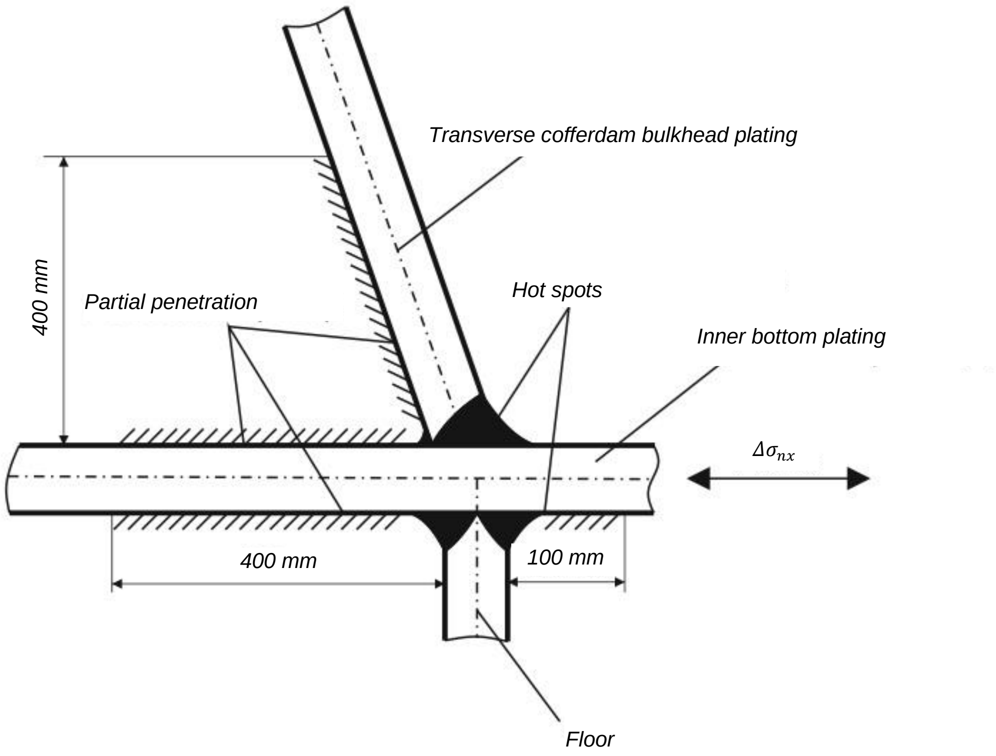
Lower part of inner side	Connection of hopper side tank sloping plate with inner side using intermediate bracket



Concentration factors	
$K_{SZ} = 3{,}55$ $K_{SX} = 1{,}30$ $K_{SXZ} = 1{,}75$	
Formulae for determination of hot spot stress ranges	
Hot spot *a*	Hot spot *b*
$\Delta\sigma_{SZ} = K_{SZ} \cdot \Delta\sigma_{nz}$	$\Delta\sigma_{SX} = K_{SX} \cdot \Delta\sigma_{nx} + K_{SXZ} \cdot \Delta\sigma_{nz}$

Table 45

Gas carriers

Double bottom in way of transverse bulkhead	Connection of inner bottom with transverse cofferdam bulkhead
	
Concentration factor	
$K_{SX} = 3{,}85$	