INTERNATIONAL REGISTER OF SHIPPING

RULES AND REGULATIONS FOR CLASSIFICATION OF INLAND NAVIGATION VESSELS

2021

Part 3

Hull and Equipment

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CHANGES HISTORY

1. Refer Changes history in Part 1

CONTENTS

CHAPTER 1 HULL DESIGN AND CONSTRUCTION, GENERAL

CONTENTS

SECTION 1 GENERAL

Contents

1.1 Symbols and units

1.1.1 Symbols

L = rule length in m, defined in [1.2]
B = breadth in m, defined in [1.2]
D = depth in m, defined in [1.2]
T = draught in m, defined in [1.2]
Δ = displacement in t at draught T
C_B = block coefficient

$$= \frac{\Delta}{L \cdot B \cdot T}$$

1.1.2 Units

Unless otherwise specified, the units used in the rules are as indicated in Table 1.2.1.

1.2 Definitions

1.2.1 Rule length

Rule length, L, is the distance, in meters, on the deepest load waterline from the forward side of the stem or rake plating to the after side of the aftermost rudder post, or to the center of the aftermost rudder stock if there is no rudder post. L is to be not less than 96 per cent, and need not be greater than 97 per cent, of the extreme length on the deepest load waterline. In ships with unusual stern arrangements the Rule length, L, will be specially considered.

1.2.2 Breadth

Breadth, *B*, is the greatest molded breadth, in meters.

1.2.3 Depth

Depth, D, is measured at the middle of the length, L, from top of keel to top of the deck beam at side on the uppermost continuous deck, or as defined in appropriate Chapters. When a rounded gunwale is arranged, the depth, D, is to be measured to the continuation of the molded deck line, in meters.

Table 1.2.1 Symbols and Units

Quantity	Symbol	Units
Dimensions of the vessel	As per 1.1	m
Hull girder section modulus	Z	cm^3
Density	ρ	t/m^3
Concentrated loads	P	kN
Linearly distributed loads	q	kN/m
Surface distributed loads (pressure)	p	kN/m^2
Thickness	t	mm
Span of ordinary stiffeners and primary supporting members	ℓ	m
Spacing of ordinary stiffeners and primary supporting members	s, S	m
Bending moment	M	kNm
Stresses	σ, τ	N/mm^2
Section modulus of ordinary stiffeners and primary supporting members	w	cm^3
Sectional area of ordinary stiffeners and primary supporting members	A	cm^2
Vessel speed	V	km/h

1.2.4 Draught
Draught, *T,* is the maximum draught, measured from top of keel, in meters.

1.2.5 Ends of rule length and midship
The forward and after perpendiculars shall be taken at the forward and after ends of the length (L). Refer Fig 1.2.1. The forward perpendicular shall coincide with the foreside of the stem on the waterline on which the length is measured.
The midship is the perpendicular to the waterline at a distance 0.5 L aft of the fore end.

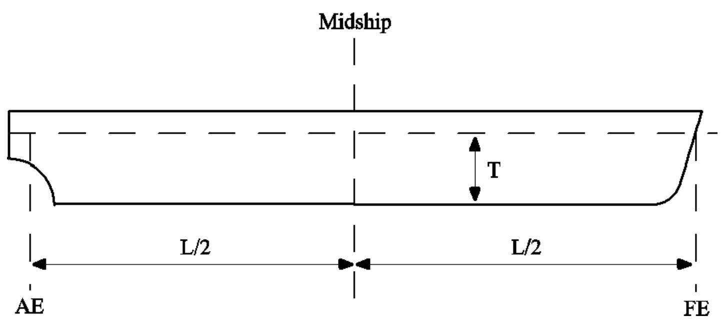


Figure 1.2.1

1.2.6 Superstructure

A superstructure is a decked structure on the freeboard deck, extending from side to side of the ship or with the side plating not being inboard of the shell plating more than 4% of the breadth (B).

1.2.7 Deckhouse

A deckhouse is a decked structure other than a superstructure, located on the strength deck defined in [1.2.8] or above.

1.2.8 Strength deck

The strength deck (usually the main deck) is the uppermost continuous deck taking part in hull girder longitudinal bending. It contributes to hull girder longitudinal strength.

1.2.9 Weather deck

The weather deck is the uppermost continuous deck exposed to weather.

1.2.10 Bulkhead deck

The bulkhead deck is the uppermost deck up to which the transverse watertight bulkheads and the shell are extended.

1.3 Vessel parts

1.3.1 General
The vessel is considered as being divided into the following four parts:
a. fore part
b. Midship region
c. machinery space, where applicable
d. aft part.

1.3.2 Fore part
The fore part includes the structures forward of the midship region

1.3.3 Midship region
The midship region includes the structures within the greater of:
a. the midship 0.5L length,
b. the cargo compartment length which on tankers includes the cofferdams and/or pump-rooms under deck

1.3.4 Aft part
The aft part is considered to include all structure aft of the midship region.

1.4 Reference co-ordinate system

1.4.1 A right hand co-ordinate system is adopted for the Rules. (ref. Figure 1.4.1)

a. Origin: at the intersection among the longitudinal plane of symmetry of vessel, the aft end of L and the baseline
b. X axis: along the centerline of the vessel, positive forwards
c. Y axis: athwartships, positive towards portside
d. Z axis: vertical axis, positive upwards.

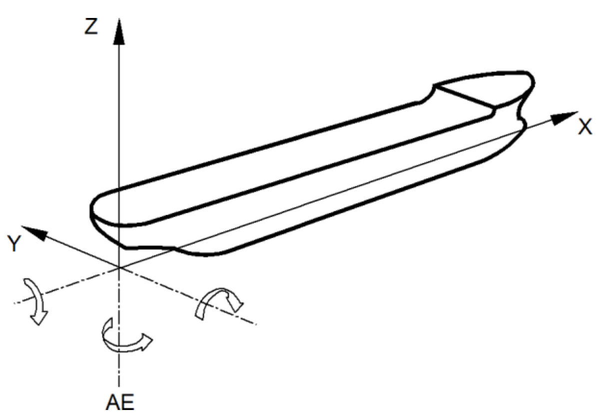


Figure 1.4.1

1.4.2 Positive rotations are oriented in anti-clockwise direction about the X, Y and Z axes.

1.5 Structural requirements

1.5.1 These rules contain the requirements for minimum scantlings, applicable to all types of inland waterway displacement vessels, up to 135 m in length made of welded steel construction.
1.5.2 These rule requirements are also applicable to steel vessels with parts of hull, e.g. superstructure built of aluminum alloys.
1.5.3 For vessels with L>135m and those with hull materials different than those mentioned in [1.5.1] and [1.5.2] shall be considered by INTLREG on case by case basis.
1.5.4 High-speed craft shall comply with IMO HSC Code
1.5.5 Where the vessel speed exceeds 40 km/h, the respective guidelines defined by IMO statutory guidelines shall be considered.

SECTION 2 DOCUMENTATION

Contents

2.1 Documentation requirements

2.1.1 The plans and documents to be submitted to the Society for review/approval are listed in [2.2.2]. Additional documentation may be required depending of type and service notation and additional Class notations. Structural plans shall show connection details, grade of material used and welding details.

2.2 Documentation to be submitted for information

2.2.1 In addition to those in 2.1.1, the following plans and documents shall be submitted to INTLREG for information:

a. general arrangement
b. capacity plan, indicating the volume and position of the center of gravity of all compartments and tanks
c. lines plan
d. hydrostatic curves
e. lightship distribution.

Besides, when direct calculation calculations are carried out as per rule requirements, they shall be submitted to INTLREG.

2.2.2 The following plans with the relevant information shall be furnished to INTLREG during plan approval phase:

a. Details of transverse frames/sections
b. Longitudinal sections
c. Shell expansion
d. Profile and deck plan
e. Midship section drawing with all vessel particulars like Class notation, main dimensions, maximum draught
f. Details of double bottom (as applicable)
g. Details of watertight bulkheads
h. Forepart structure
i. Aft part structure
j. Engine foundation
k. Engine room layout
l. Detail of superstructure and deckhouses
m. Details of hatch covers (as applicable)
n. Details of windows and side scuttles
o. Details of bulwarks and freeing ports
p. Scuppers and sanitary discharges
q. Details of rudder
r. Details of sternframe or sternpost, stern tube, Propeller shaft boss and brackets
s. Detail of watertight and weathertight doors
t. Details of manholes

CHAPTER 2 STRUCTURE DESIGN PRINCIPLES

CONTENTS

SECTION 1 GENERAL

Contents

1.1 Definitions

1.1.1 Local loads
Local loads are pressures and forces that are directly applied to plating panels, ordinary stiffeners, and primary supporting members.

1.1.2 Hull girder loads
Hull girder loads are forces and moments caused by local loads acting on the vessel when approximating it as a girder.

1.1.3 Loading condition
A loading condition is a particular instance of the distribution of cargo in their respective holds.

1.2 AREA of application

1.2.1 The design loads defined in these rules shall be used for the determination of the hull girder strength and structural scantlings in the midship region of the vessels.

SECTION 2 RANGE OF NAVIGATION

Contents

2.1 Range of navigation

2.1.1 General
Each vessel is shall have a range of navigation according to its scantlings and other constructional arrangements.
The ranges of navigation considered in these are defined in Pt 1 Ch 2 Sec [1.3]. The significant wave heights corresponding to ranges of navigation are listed in Table 2.1.1.

2.1.2 Navigation coefficient
The navigation coefficient is defined as:

n = 0.85 · H

H = significant wave height in m (wave height measured from crest to trough).

2.1.3 Length-to-depth ratio
Generally, the length-to-depth ratio of the vessel shall be as per the below:

for **IW (1.2) to IW (2.0)** : $L/D \leq 25$

for **IW (0.6)** : $L/D \leq 35$

Vessels having a ratio beyond these limits shall be considered separately.

2.1.4 Ranges of navigation **IW (1.2)** to **IW (2)**
On vessels assigned the range of navigation **IW (1.2)** to **IW (2.0),** the hatchways shall be fitted with efficient means of closing. The openings of the engine room, if there is an engine room, shall be protected by a superstructure or by a deckhouse.

Table 2.1.1 Values of significant wave height in m

Range of navigation	Wave height (H)
IW (0)	0
IW (0.6)	0.6
IW (1.2) to **IW (2.0)**	1.2 to 2.0

SECTION 3 LOCAL LOADS

Contents

3.1 Symbols

L = rule length in m, defined in Ch 1, Sec [1.1]
B = breadth in m, defined in Ch 1, Sec [1.1]
D = depth in m, defined in Ch 1, Sec [1.1]
T = draught in m, defined in Ch 1, Sec 1.1]
C_B = block coefficient, defined in Ch 1, Sec [1.1]
P = design pressure in kN/m²
x, y, z = x, y and z co-ordinates in m of the calculation point with respect to the reference co-ordinate system defined in Ch1 Sec 1.4

z_L = z co-ordinate in m, of the highest point of the liquid

= $z_{TOP} + d_{AP}$

z_{TOP} = z co-ordinate in m, of the highest point of the tank or compartment

d_{AP} = distance from the top of the air pipe to the top of the tank in m. For minimum distance for the top of the air pipe above deck, refer Pt.4 Ch.2 Sec.1/ [1.13]

p_{PV} = setting pressure in kN/m², of safety valves or maximum pressure in kN/m², in the tank during loading/unloading, whichever is the greater

ρ_L = density in t/m³, of the liquid carried
n = navigation coefficient defined in Ch 2 Sec 2
= 0.85 · H, where H is the significant wave height in m

a_B = motion and acceleration parameter

$$= 0.33 \cdot n \cdot \left(0.04 \cdot \frac{V}{\sqrt{L}} + 1.1 \cdot \frac{h_W}{L}\right)$$

h_W = wave parameter in m

$$= 11.44 - \left|\frac{L-250}{110}\right|^3$$

a_{SU} = surge acceleration in m/s² defined in [3.5.1]

a_{SW} = sway acceleration in m/s² defined in [3.5.2]

a_H = heave acceleration in m/s² defined in [3.5.3]

α_R = roll acceleration in rad/s² defined in [3.5.4]

α_P = pitch acceleration in rad/s² defined in [3.5.5]

α_Y = yaw acceleration in rad/s² defined in [3.5.6]

T_{SW} = sway period in s defined in [3.5.2]

T_R = roll period in s defined in [3.5.4]

T_P = pitch period in s defined in [3.5.5]

A_R = roll amplitude in rad defined in [3.5.4]

A_P = pitch amplitude in rad, defined in [3.5.5]

V = maximum ahead service speed in km/h

3.2 General

3.2.1 Application
The following requirements apply for the definition of local loads to be used for the scantling checks of:

a. plating
b. ordinary stiffeners
c. primary supporting members.

3.2.2 Inertial loads
For a range of navigation higher than **IW (1.2)**, inertial local loads produced by vessel relative motions and accelerations shall be considered.

3.3 Load definition criteria

3.3.1 Cargo and ballast distributions
When calculating the local loads for determining the structural scantling of an element which separates two adjacent compartments, the local loads shall be taken such that the two compartments are considered individually loaded.
For elements of the outer shell, the local loads shall be calculated considering separately:

a. the external pressures considered as acting alone without any interaction from the vessel interior
b. the differential pressures (internal pressure minus external pressure) considering the compartment adjacent to the outer shell as being loaded.

3.3.2 Local loads shall be calculated based on the vessel draught T_1 corresponding to the cargo or lightship distribution considered according to the criteria as mentioned in section [3.3.1]. The vessel draught shall be taken as the distance measured vertically on the hull transverse section at the middle of the length from the base line to the waterline in:

a. full load condition, when:
   i one or more cargo compartments are considered as being loaded and the ballast tanks are considered as being empty
   ii the still water and wave external pressures are considered as acting alone without any counteraction from the vessel's interior
b. light ballast condition, when one or more ballast tanks are considered as being loaded and the cargo compartments are considered as being empty

3.4 Vessel motions and accelerations

3.4.1 Vessels motions and accelerations are defined, with their signs, according to the reference co-ordinate system in Ch 1, Sec [1.4]

3.4.2 Vessel motions and accelerations are assumed to be periodic. The motion amplitudes are half of the crest to through amplitudes.t

3.4.3 INTLREG my accept values of vessels motions and accelerations derived from direct calculations or model tests as an alternative to the values obtained through formulae described in this section.

3.5 Vessel absolute motions and accelerations

3.5.1 Surge

The surge acceleration a_{SU} shall be taken equal to 0.5 m/s^2.

3.5.2 Sway

The sway period and acceleration are obtained from the formulae in Table 3.5.1.

Table 3.5.1 Sway period and acceleration

Period T_{sw} in s	Acceleration a_{sw} in m/s^2
$\dfrac{0.8 \cdot \sqrt{L}}{0.1 \cdot \frac{V}{\sqrt{L}} + 1}$	$7.6 \cdot a_B$

3.5.3 Heave

The heave acceleration is obtained in m/s^2, from the following formula:

$$a_H = 9.81 \cdot a_B$$

3.5.4 Roll

The roll amplitude, period and acceleration are obtained from the formulae in Table 3.6.1.

3.5.5 Pitch

The pitch amplitude, period and acceleration are obtained from the formulae in Table 3.6.2

3.5.6 Yaw

The yaw acceleration is obtained in rad/s^2 from the following formula:

$$\alpha_Y = 15.5 \cdot \frac{a_B}{L}$$

3.6 Vessel relative accelerations

3.6.1 Definition

At any point, the accelerations in X, Y and Z direction are the acceleration components which result from the vessel motions defined from [3.5.1] to [3.5.6]

3.6.2 Vessel conditions

Vessel relative motions and accelerations shall be calculated considering the vessel in the following conditions:

a. upright vessel condition:
In this condition, the vessel encounters waves which produce vessel motions in the X-Z plane, i.e. surge, heave and pitch.

b. inclined vessel condition:
In this condition, the vessel encounters waves which produce vessel motions in the X-Y and Y-Z planes, i.e. sway, roll and yaw.

3.6.3 Accelerations

The reference values of the longitudinal, transverse and vertical accelerations at any point are obtained from the formulae in Table 3.6.3 for upright and inclined vessel conditions.

Table 3.6.1 Roll amplitude, period, and acceleration		
Amplitude A_R in rad	Period T_R in s	Acceleration α_R in rad/s^2
$a_B \cdot \sqrt{E}$ not to be taken greater than 0.35	$0.77 \cdot \frac{B}{\sqrt{GM}}$	$\frac{40 \cdot A_R}{T^2_R}$
$E = 11.34 \cdot \frac{GM}{B} \geq 1.0$ GM = Distance, in m, from the vessel's center of gravity to the transverse metacenter, for the loading considered. When GM is not known, the following values may be, taken: a. full load: GM = 0.07·B b. lightship: GM = 0.18·B		

Table 3.6.2 Pitch amplitude, period, and acceleration		
Amplitude A_P in rad	Period T_P in s	Acceleration α_P in rad/s^2
$0.328 \cdot a_B \cdot \left(1.32 - \frac{h_w}{L}\right) \cdot \left(\frac{0.6}{C_B}\right)^{0.75}$	$0.575 \cdot \sqrt{L}$	$\frac{40 \cdot A_P}{T^2_P}$

Table 3.6.3 Reference values of the accelerations a_X, a_Y and a_Z		
Direction	Upright vessel condition	Inclined vessel condition
X - Longitudinal a_{X1} and a_{X2} in m/s^2	$a_{x1} = \sqrt{a_{SU}^2 + \left(9.81 \cdot A_P + \alpha_P \cdot (z - T_1)\right)^2}$	$a_{X2} = 0$
Y - Transverse a_{Y1} and a_{Y2} in m/s^2	$a_{Y1} = 0$	$a_{Y2} = \left[a_{SW}^2 + \left(9.81 \cdot A_R + \alpha_R \cdot (z - T_1)\right)^2 + \alpha_Y^2 \cdot K_X . L^2\right]^{1/2}$
Z - Vertical a_{Z1} and a_{Z2} in m/s^2	$a_{z1} = \sqrt{a_H^2 + \alpha_P^2 \cdot K_X \cdot L^2}$	$a_{Z2} = \sqrt{0.25 \cdot a_H^2 + \alpha_R^2 \cdot Y^2}$
$K_X = 1.2 \cdot \left(\frac{x}{L}\right)^2 - 1.1 \cdot \frac{x}{L} + 0.2 \geq 0.018$ T_1 = draught in m as defined in 3.3.2		

3.7 Pressure on sides and bottom

3.7.1 The external pressure at any point of the hull, in kN/m2, shall be obtained from the following formulae:

a. for z ≤ T:
$P_E = 9.81\ (T - z + 0.6 \cdot n)$

b. for z > T:

$P_E = MAX\ (5.9 \cdot n;\ 3) + p_{WD}$

p_{WD}= specific wind pressure as defined in Table 3.7.1.

Table 3.7.1 Specific wind pressure	
Navigation Notation	Wind pressure p_{WD} in kN/m^2
IW (1.2), **IW (2)**	0.4·n
IW (0.6), **IW (0)**	0.25

3.8 Pressure on exposed decks

3.8.1 On exposed decks, the pressure due to the load carried shall be considered. This pressure shall be defined by the designer and, in general, it may not be taken less than the values given in Table 3.8.1

Table 3.8.1 Pressure in kN/m^2 on exposed decks	
Exposed deck location	p_E
Weather deck	3.75 · (n + 0.8)
Exposed deck of superstructure or deckhouse:	
– first tier (nonpublic)	2.0
– upper tiers (nonpublic)	1.5
– public	4.0

3.9 Pressure on watertight bulkheads

3.9.1 The still water pressure in kN/m^2 to be considered as acting on platings and stiffeners of watertight bulkheads of compartments not intended to carry liquids is obtained from the following formula:

$$p_{WB} = 9.81 \cdot (z_{TOP} - z)$$

3.10 Internal pressure due to Liquids

3.10.1 General

The pressure transmitted to the hull structure kN/m^2 by liquid cargo (p_C) or ballast (p_B) is the combination of the still water pressure p_S and the inertial pressure p_W.

3.10.2 Still water pressure

a. Liquid cargo

The still water pressure is the greater of the values obtained in kN/m^2 from the following formulae:

$$p_S = 9.81 \cdot \rho_L \cdot (z_L - z)$$

$$p_S = 9.81 \cdot \rho_L \cdot (z_{TOP} - z) + 1.15 \cdot p_{PV}$$

b. Ballast

$$p_S = 9.81 \cdot (z_L - z + 1)$$

3.10.3 Inertial pressure

The inertial pressure is obtained from the formulae in Table 3.10.1 and shall be taken such that:

$$p_S + p_W \geq 0$$

3.11 Internal Pressure Due to Dry Bulk Cargoes

3.11.1 General

The pressure transmitted to the hull structure shall be obtained using the formula

$$p_C = \frac{(D - z)}{D - z_H} p_0$$

p_0 = mean total pressure on the inner bottom (combination of the mean still water pressure p_s defined in 3.11.2 and the mean inertial pressure p_w defined in 3.11.3)
= $p_S + p_W \geq 0$

If $n \leq 1.02$: $p_W = 0$

z_H = Z co-ordinate in m of the inner bottom.

Table 3.10.1 Liquids - inertial pressure	
Vessel condition	Inertial pressure p_W in kN/m^2 1)
Upright	$\rho_L \cdot \left[0.5 \cdot a_{X1} \cdot l_B + a_{Z1} \cdot (Z_{TOP} - Z)\right]$
Inclined	$\rho_L \cdot \left[a_{TY} \cdot (Y - Y_H) - a_{TZ} \cdot (Z - Z_H) + 9.81 \cdot (Z - Z_{TOP})\right]$

1) $p_W = 0$ if $n \leq 1.02$

ℓ_B = longitudinal distance in m between the transverse tank boundaries, without considering small recesses in the lower part of the tank (ref. Fig.3.11.1)

a_{TY}, a_{TZ} = Y and Z components (negative roll angle) in m/s^2 of the total acceleration vector defined as follows:

$a_{TY} = a_{Y2}$

$a_{TZ} = 9.81 + a_{Z2}$

Y_H, Z_H = Y and Z co-ordinates in m of the highest point of the tank in the direction of the total acceleration vector.

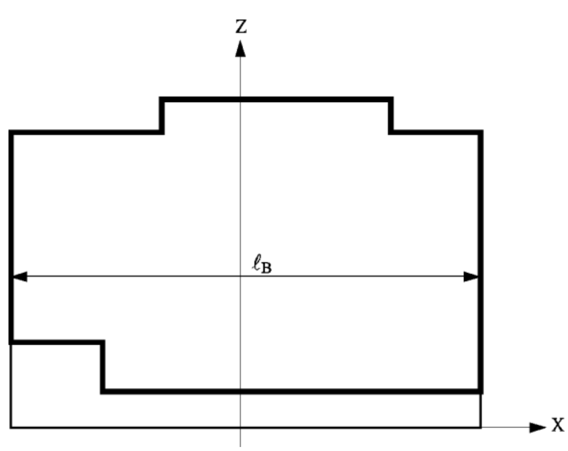


Figure 3.11.1 Distance ℓ_B

3.11.2 Mean still water pressure on the inner bottom

The mean still water pressure on the inner bottom is obtained in kN/m^2 from the following formula:

$$p_S = \frac{9.81 \cdot m_c}{L_H \cdot B_1}$$

L_H = length in m of the hold, to be taken as the longitudinal distance between the transverse bulkheads which form boundaries of the hold considered

B_1 = breadth in m of the hold

m_C = mass of cargo in t inside the hold considered.

3.11.3 Mean inertial pressure on the inner bottom

The mean inertial pressure on the inner bottom is obtained in kN/m^2 from the following formula:

$$p_W = \frac{a_{Z1} \cdot m_C}{L_H \cdot B_1}$$

where m_C, L_H and B_1 are defined in 3.11.2

3.12 Internal Pressure Due to Heavy Dry Bulk Cargoes

3.12.1 Pressure on side and bulkhead structure

The pressure on side and bulkhead structure shall be determined in compliance with [3.11],

3.12.2 Inner bottom design pressure

The inner bottom design pressure, p_{MS} in kN/m^2 is the combination of the still water pressure p_S and the inertial pressure p_W determined in compliance with [3.12.3] and [3.12.4] respectively.

If $n \le 1.02$: $p_W = 0$

3.12.3 Inner bottom still water design pressure

The inner bottom still water design pressure p_S is obtained in kN/m^2 from the following formula:

$$p_S = k_S \cdot \sqrt{\frac{L \cdot B \cdot T}{L_H} \cdot C_B}$$

k_S = coefficient to be determined using the formula:

$$= 9.81 \cdot \sqrt{0.85 \cdot \rho \cdot \tan\phi}$$

L_H = length in m of the hold, to be taken as the longitudinal distance between the transverse bulkheads which form boundaries of the hold considered

ρ = cargo density in t/m^3

$\rho \ge 2.5$

Φ = angle of repose of the bulk cargo considered

$\Phi \ge 35°$

3.12.4 Inner bottom inertial design pressure

The inner bottom inertial design pressure p_W in kN/m^2 is obtained from the formula given in 3.12.3, using the following value of k_S:

$$k_s = a_{z1} \cdot \sqrt{0.85 \cdot \rho \cdot \tan\phi}$$

3.13 Internal Pressure Due to Dry Uniform Cargoes

3.13.1 General

The pressure transmitted to the hull structure, p_C in kN/m² is the combination of the still water pressure p_S and the inertial pressure p_W

3.13.2 Still water pressure

The value of the still water pressure p_S shall be specified by the designer.

3.13.3 Inertial pressure

The inertial pressure p_W in kN/m², is obtained as specified in Table 3.13.1.

3.14 Internal Pressure Due to Dry Unit Cargoes

3.14.1 General

The force transmitted to the hull structure is the combination of the still water force F_S and the inertial force F_W.

Account shall be taken of the elastic characteristics of the lashing arrangement and/or the structure that contains the cargo.

Table 3.13.1 Dry uniform cargoes - Inertial pressures

Vessel condition	Inertial pressure p_W in kN/m² 1)	
Upright (positive heave motion)	$p_{W,Z} = p_S \cdot \frac{a_{Z1}}{9.81}$	in z direction
Inclined (negative roll angle)	$p_{W,y} = p_S \cdot \frac{a_{y2}}{9.81}$	in y direction
	$p_{W,Z} = p_S \cdot \frac{a_{Z2}}{9.81}$	in z direction
1) $p_W = 0$ if $n \le 1.02$		

3.14.2 Still water force

The still water force transmitted to the hull structure shall be determined based on the force obtained in kN from the following formula:

$$F_S = 9.81 \cdot m_c$$

Where m_C is the mass in t of the cargo.

3.14.3 Inertial forces

The inertial forces are obtained in kN/m² as specified in Table 3.14.1.

Table 3.14.1 Dry unit cargoes – Inertial forces

Vessel condition	Inertial force F_W in kN [1)]	
Upright (positive heave motion)	$F_{W,X} = m_C \cdot a_{X1}$	in x direction
	$F_{W,Z} = m_C \cdot a_{Z1}$	in z direction
Inclined (negative roll angle)	$F_{W,Y} = m_C \cdot a_{Y2}$	in y direction
	$F_{W,Z} = m_C \cdot a_{Z2}$	in z direction
1) $F_W = 0$ if $n \leq 1.02$		

3.15 Wheeled cargoes

3.15.1 Vehicles with tires

The forces transmitted through the tires are comparable to pressure uniformly distributed on the tire print, the dimensions of which shall be indicated by the designer together with information concerning the arrangement of wheels on axles, the load per axle and the tire pressures.

Except for dimensioning of plating, such forces may be considered as concentrated in the tire print center.

3.15.2 Vehicles without tires

The requirements of [3.15.3] also apply to tracked vehicles; in this case the print to be considered is that below each wheel or wheelwork.

For vehicles on rails, all the forces transmitted shall be considered as concentrated at the contact area center.

3.15.3 Still water force

The still water force transmitted to the hull structure by one wheel shall be determined based on the force obtained in kN from the formula:

$F_S = 9.81 \cdot m_C$

$m_C = Q_A / n_W$

Q_A = axle load in t.

For forklift trucks, the value of Q_A shall be taken equal to the total mass of the vehicle, including that of the cargo handled, applied to one axle only

n_W = number of wheels for the axle considered

3.15.4 Inertial forces

The inertial forces are obtained in kN as specified in Table 3.15.1.

3.16 Accommodation

3.16.1 The still water pressures transmitted to the deck structures are obtained in kN/m^2 as specified in Table 3.16.1

3.17 Helicopter loads

3.17.1 Landing load

The landing load transmitted through one tire to the deck shall be obtained in kN from the following formula:

$$F_{CR} = 7.36 \cdot W_H$$

W_H = maximum weight of the helicopter in t

Where the upper deck of a superstructure or deckhouse is used as a helicopter deck and the spaces below are quarters, bridge, control room or other normally manned service spaces, the value of F_{CR} shall be multiplied by 1.15.

3.17.2 Emergency landing load

The emergency load resulting from the crash of the helicopter in kN shall be obtained from the following formula:

$$F_{CR} = 29.43 \cdot W_H$$

3.17.3 Helicopter having landing devices other than wheels

In the case of a deck intended for the landing of helicopters having landing devices other than wheels (e.g. skates), the landing load and the emergency landing load shall be examined by the Society on a case-by- case basis.

Table 3.15.1 Wheeled cargoes - inertial forces

Vessel condition	Inertial force F_W in kN 1)	
Upright (positive heave motion)	$F_{W,Z} = m_C \cdot a_{Z1}$	in z direction
Inclined (negative roll angle)	$F_{W,Y} = m_C \cdot a_{Y2}$	in y direction
	$F_{W,Z} = m_C \cdot a_{Z2}$	in z direction

1) $F_W = 0$ if $n \leq 1.02$

3.18 Testing pressures

3.18.1 Still water pressures

The still water pressures to be considered as acting on plates and stiffeners subject to tank testing are specified in Ch 3 Sec [3.5]

Table 3.16.1 Deck pressure in accommodation compartments

Type of accommodation compartment	p in kN/m^2
Large spaces (such as: restaurants, halls, cinemas, lounges, kitchen, service spaces, games and hobbies rooms, hospitals)	4.0
Cabins	3.0
Other compartments	2.5

SECTION 4 HULL GIRDER LOADS

Contents

4.1 Definition and convention

4.1.1 Definition

The hull girder loads are forces and moments caused by local loads acting on the vessel when approximating it as a girder.

4.1.2 Sign convention

Positive: For moment that creates tensile stress in the deck (hogging moment)

Negative: For moment that creates compressive stress in the deck (sagging moment)

4.2 Vertical bending moment calculation

4.2.1 Still water vertical bending moments

The design still water vertical bending moments are the maximum still water bending moments calculated, in hogging and sagging conditions at the midship transverse section for the loading conditions specified in [4.2.2]

4.2.2 Loading conditions

For all vessels, the following loading conditions shall be considered:

a. light ship
b. fully loaded vessel
c. loading and unloading transitory conditions, where applicable

4.2.3 The design still water vertical bending moments shall be obtained from formulae given in Ch 3 Sec 6

4.2.4 Additional bending moments

For vessels assigned the **IW(0.6)** or **IW(1.2)** to **IW(2)** range of navigation defined in Ch 2 Sec [2.1], an additional vertical bending moment, calculated according to Ch 3 Sec [6.14] shall be added to the still water hogging and sagging bending moments. This shall be applied in both loaded and light conditions, for the determination of the hull girder strength and structural scantlings.

CHAPTER 3 HULL GIRDER STRENGTH

CONTENTS

SECTION 1 GENERAL PRINCIPLES

Contents

1.1 Symbols

w = section modulus in cm^3 of an ordinary stiffener or primary supporting member with an attached plating of width b_p

h_W = web height in mm of an ordinary stiffener or a primary supporting member

t_W = web thickness in mm of an ordinary stiffener or a primary supporting member

b_f = face plate width in mm of an ordinary stiffener or a primary supporting member

t_f = face plate thickness in mm of an ordinary stiffener or a primary supporting member

t_p = thickness in mm of the plating attached to an ordinary stiffener or a primary supporting member

s = spacing in m of ordinary stiffeners

S = spacing in m of primary supporting members

ℓ = span in m of an ordinary stiffener or a primary supporting member measured between the supporting members

$ℓ_b$ = length in m of brackets

I = moment of inertia in cm^4 of an ordinary stiffener or a primary supporting member without attached plating, around its neutral axis parallel to the plating

I_B = moment of inertia in cm^4 of an ordinary stiffener or a primary supporting member with bracket and without attached plating, around its neutral axis parallel to the plating, calculated at mid-length of the bracket

k = material factor defined in Ch 4 Sec [1.2]

1.2 Structural continuity

1.2.1 The variation in scantlings between the midship region and the fore and aft parts shall be gradual.

1.2.2 Attention shall be paid to the structural continuity:

a. in way of changes in the framing system
b. at the connections of primary or ordinary stiffeners
c. in way of the ends of the fore and aft parts, and machinery space
d. in way of ends of superstructures.

1.2.3 Where stress concentrations may occur in way of structural discontinuities, adequate compensation and reinforcements shall be provided.

1.2.4 Primary supporting members shall be arranged in such a way that they ensure adequate strength continuity. Abrupt changes in height or in cross-section shall be avoided.

1.3 Rounding of scantlings

1.3.1 Plate thicknesses

The rounding of plate thicknesses shall be obtained from the following procedure:

a) the net thickness (refer Sec [1.22]) is calculated in accordance with the rule requirements
b) corrosion addition t_C (refer sect [1.22.2]) is added to the calculated net thickness, and this gross thickness is rounded to the nearest half-millimeter
c) the rounded net thickness is taken equal to the rounded gross thickness, obtained in b), minus the corrosion addition t_C

1.3.2 Stiffener section moduli

Stiffener section moduli as calculated in accordance with the rule requirements shall be rounded off to the nearest standard value; however, no reduction may exceed 3%.

1.4 Insert plates and doublers

1.4.1 A local increase in plating thickness is generally to be achieved by insert plates. Local doublers, which are normally only allowed for temporary repair, may be accepted by the Society on a case-by- case basis.

In any case, doublers and insert plates shall be made of materials of a quality at least equal to that of the plates on which they are welded.

1.4.2 Doublers having width in mm greater than:

a. 20 times their thickness, for thicknesses equal to or less than 15 mm
b. 25 times their thickness, for thicknesses greater than 15 mm

shall be fitted with slot welds

1.4.3 When doublers fitted on the outer shell and strength deck within 0.5 · L amidships are accepted by the Society, their width and thickness shall be such that slot welds are not necessary according to the requirements in [1.4.2]. Outside this area, the possibility of fitting doublers requiring slot welds will be considered on a case-by-case basis.

1.5 Ordinary Stiffeners Not Perpendicular To The Attached Plating

Where the angle between the section web and the attached plating is less than 70^0, the actual section modulus in cm^3 may be obtained from the following formula:

$w = w_0 \sin \alpha$

w_0 = actual section modulus in cm^3 of the stiffener assumed to be perpendicular to the plating

α = angle between the stiffener web and the attached plating, to be measured at mid-span of the section.

1.6 Span of ordinary stiffeners

1.6.1 The span ℓ of ordinary stiffeners shall be measured as shown in Figure 1.6.1 to Figure 1.6.4 Instead of the true length of curved frames, the length of the chord between the supporting points can be selected.

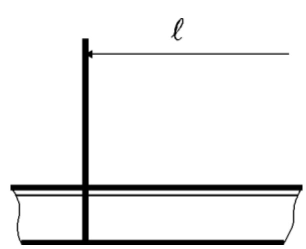


Figure 1.6.1 Ordinary stiffener without brackets

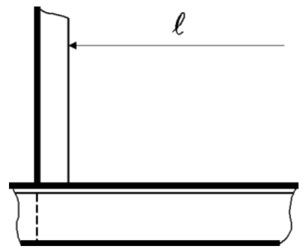


Figure 1.6.2 Ordinary stiffener with a stiffener at one end

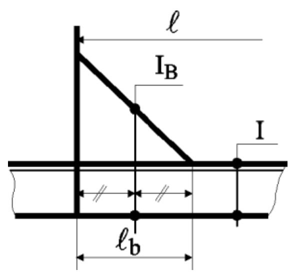


Figure 1.6.3 Ordinary stiffener with end bracket

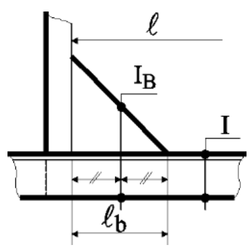


Figure 1.6.4 Ordinary stiffener with a bracket and a stiffener at one end

1.7 Width of attached plating

1.7.1 Yielding check

The width of the attached plating to be considered for the yielding check of ordinary stiffeners shall be obtained in m from the following formulae:

a. where the plating extends on both sides of the ordinary stiffener:
$b_P = s$

b. where the plating extends on one side of the ordinary stiffener (i.e. ordinary stiffeners bounding openings):
$b_P = 0.5 \cdot s$

1.7.2 Buckling check

The attached plating to be considered for the buckling check of ordinary stiffeners is defined in Ch 3 Sec [2.3]

1.8 Built sections

1.8.1 Geometric properties

The geometric properties of built sections as shown in Figure 1.8.1 may be calculated as indicated in the following formulae.

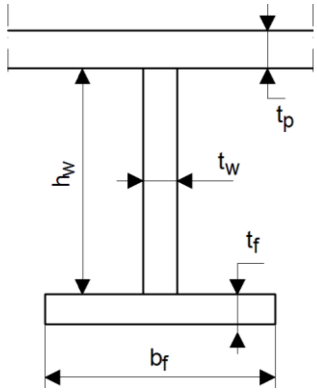


Figure 1.8.1 Dimensions of a built section

The shear sectional area of a built section with attached plating shall be obtained in cm^2 from the following formula:

$$A_{sh} = \frac{h_w \cdot t_w}{100}$$

The section modulus of a built section with attached plating of sectional area A_a in mm^2 shall be obtained in cm^3 from the following formula:

$$w = \frac{h_w \cdot t_f \cdot b_f}{1000} + \frac{t_W \cdot h^2 \cdot w}{6000} \cdot \left(1 + \frac{A_a - t_f \cdot b_f}{A_a + \frac{t_W \cdot h_W}{2}} \right)$$

The distance from mid-plate thickness of face plate to neutral axis shall be obtained in cm from the following formula:

$$v = \frac{h_W \cdot (A_a + 0.5 \cdot t_W \cdot h_W)}{10 \cdot (A_a + t_f \cdot b_f + t_W \cdot h_W)}$$

The moment of inertia of a built section with attached plating shall be obtained in cm^4 from the following formula:

$I = w \cdot v$

These formulae are applicable provided that:

$$A_a \geq t_f \cdot b_f$$

$$\frac{h_w}{t_p} \geq 10$$

$$\frac{h_w}{t_f} \geq 10$$

1.9 End connections

1.9.1 Continuous ordinary stiffeners

Where ordinary stiffeners are continuous through primary supporting members, they shall be connected to the web plating so as to ensure proper transmission of loads, e.g. by means of one of the connection details shown in Figure 1.9.1 to Figure 1.9.4. In the case of high values for the design loads, additional stiffening is required.

Connection details other than those shown in Figure 1.9.1 to Figure 1.9.4 may be considered by the Society on a case-by-case basis. In some cases, the Society may require the details to be supported by direct calculations submitted for review.

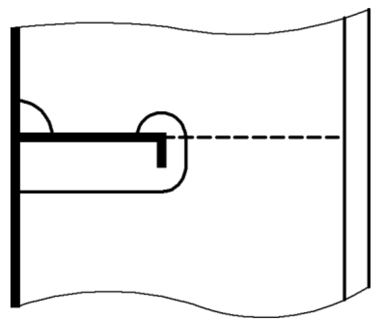


Figure 1.9.1 End connection of ordinary stiffener without collar plate

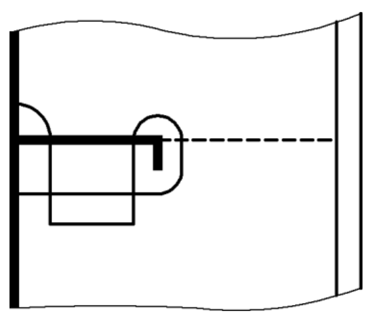


Figure 1.9.2 End connection of ordinary stiffener: Collar plate

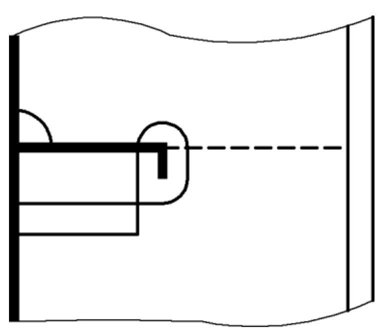


Figure 1.9.3 End connection of ordinary stiffener: One large collar plate

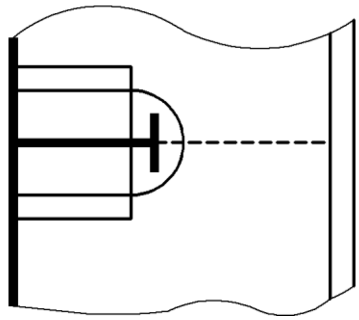


Figure 1.9.4 End connection of ordinary stiffener: Two large collar plates

1.9.2 Intercostal ordinary stiffeners

Where ordinary stiffeners are terminated at primary supporting members, brackets shall be fitted to ensure the structural continuity. Their section modulus and their sectional area shall not be less than those of the ordinary stiffeners.

All brackets for which:

$$\frac{\ell_b}{t} > 60$$

ℓ_b = length in mm of the free edge of the bracket
t = bracket net thickness in mm

shall be flanged or stiffened by a welded face plate.

The sectional area [cm^2] of the flange or the face plate shall not be less than $0.01 \cdot \ell_b$. The width of the face plate shall be not less than $10 \cdot t$.

1.9.3 Bracketed ordinary stiffeners

For the scantlings of brackets the required section modulus of the section is decisive. Where sections of different section moduli are connected to each other, the scantlings of the brackets are generally governed by the smaller section.

The net thickness of brackets shall be not less than:

$$t = c \cdot \sqrt[3]{\frac{W}{k_1}}$$

c = 1.2 for non-flanged brackets
0.95 for flanged brackets

= material factor k for the section according Ch 4 Sect [1.2]
W = section modulus of smaller section in cm^3
t_{min} = 5.0 mm

t_{max} = web thickness of smaller section

The arm length of brackets shall not be less than:

$$l = 46.2 \cdot \left(\frac{W}{k_1}\right)^{1/3} \cdot \sqrt{k_2} \cdot c_t$$

l = 100 mm

c_t = $\sqrt{\frac{t}{t_a}}$

t_a = as built thickness of bracket in mm

= ≥t (net thickness of brackets mentioned above)

W = section modulus of smaller section in cm^3

k_2 = material factor k for the bracket according to Ch 4 Sect [1.2]

The arm length l is the length of the welded connection.

Remark:

For deviating arm lengths, the thickness of brackets is to be estimated by direct calculations considering sufficient safety against buckling.

The throat thickness a of the welded connection shall be determined acc. to Pt.2 of Steel Ship Rules

Where flanged brackets are used, the width of flange shall be determined according to the following formula:

$$b = 40 + \frac{W}{30} \quad [mm]$$

b shall not be taken less than 50 mm and need not be taken greater than 90 mm.

1.9.4 Sniped ends of stiffeners

Stiffeners may be sniped at the ends if the thickness of the plating supported by the stiffeners is not less than:

$$t = c \cdot \sqrt{\frac{p \cdot s \cdot (\ell - 0.5 \cdot s)}{R_{eH}}}$$

p = stiffener design load in kN/m^2

c = coefficient

= 15.8 for watertight bulkheads and for tank bulkheads

= 19.6 for all other components

1.10 Span of primary supporting members

The span of primary supporting members shall be determined in compliance with Sec [1.6]

1.11 Width of attached plating

1.11.1 Girders

The effective width of plating e_m of frames and girders may be determined according to Table 1.11.1, considering the type of loading.
Special calculations may be required for determining the effective width of one-sided or non-symmetrical flanges.

The effective cross-sectional area of plates shall not be less than the cross-sectional area of the face plate.

The effective width of stiffeners and girders subjected to compressive stresses may be determined according Sec [2.3], but is in no case to be taken greater than the effective width determined by [1.11.1]

Table 1.11.1 Effective width e_m of frames and girders

ℓ/e	0	1	2	3	4	5	6	7	≥ 8
e_{m1}/e	0	0.36	0.64	0.82	0.91	0.96	0.98	1.00	1.0
e_{m2}/e	0	0.20	0.37	0.52	0.65	0.75	0.84	0.89	0.9

e_{m1} shall be applied where girders are loaded by uniformly distributed loads or else by not less than 6 equally spaced single loads.
e_{m2} shall be applied where girders are loaded by 3 or less single loads.

Intermediate values may be obtained by direct interpolation

ℓ = length between zero-points of bending moment curve, i.e. unsupported span in case of simply supported girders and 0.6 × unsupported span in case of constraint of both ends of girder
e = width of plating supported, measured from center to center of the adjacent unsupported fields

1.11.2 Cantilevers

Where cantilevers are fitted at every frame, the effective width of plating may be taken as the frame spacing. Where cantilevers are fitted at a greater spacing, the effective width of plating at the respective cross section may approximately be taken as the distance of the cross section from the point on which the load is acting, however, not greater than the spacing of the cantilevers.

1.11.3 Corrugated bulkheads

Where primary supporting members are attached to corrugated bulkheads, the effective width of plating shall be determined as follows:

a. when primary supporting members are parallel to the corrugations and are welded to the corrugation flanges, the width of the attached plating shall be calculated in accordance with [1.11.1] and [1.11.2], and shall be taken not greater than the corrugation flange width

b. when primary supporting members are perpendicular to the corrugations, the width of the attached plating shall be taken equal to the width of the primary supporting member face plate.

1.11.4 Geometric properties

The geometric properties of primary supporting members (including primary supporting members of double hull structures, such as double bottom floors and girders) are generally determined in accordance with [1.8.1] reducing the web height h_W by the depth of the cut-outs for the passage of the ordinary stiffeners, if any.

1.12 Bracketed end connections

1.12.1 Arm lengths of end brackets shall be equal, as far as practicable.

The height of end brackets shall be not less than that of the weakest primary supporting member.

1.12.2 The scantlings of end brackets are generally to be such that the section modulus of the primary supporting member with end brackets is not less than that of the primary supporting member at mid-span.

1.12.3 The bracket web thickness shall not be less than that of the weakest primary supporting member.

1.12.4 The face plate of end brackets shall have a width not less than the width of the primary supporting member faceplates.

Moreover, the thickness of the face plate shall not be less than that of the bracket web.

1.12.5 In addition to the above requirements, the scantlings of end brackets shall comply with the applicable requirements given in Ch 4 Sec 2 to Ch 4 Sec 5.

1.13 Bracket less end connections

1.13.1 In the case of bracket less end connections between primary supporting members, the strength continuity shall be obtained as schematically shown in Figure 1.13.1 or by any other method which INTLREG may consider equivalent.

1.13.2 In general, the continuity of the face plates shall be ensured.

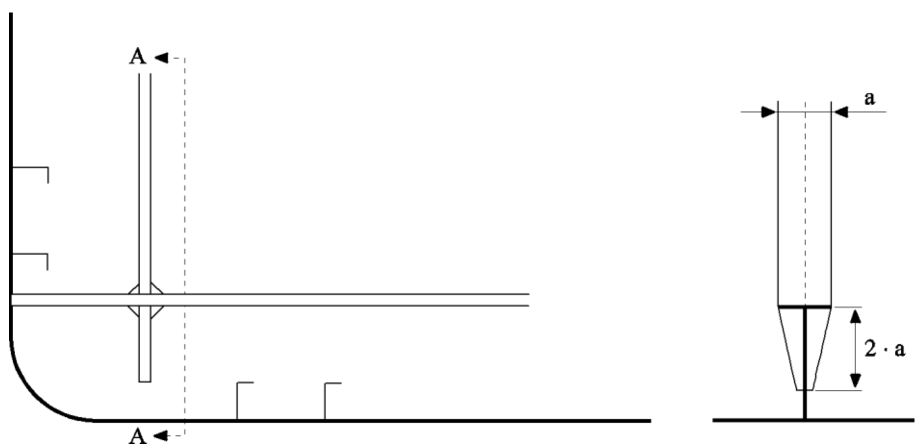


Figure 1.13.1 Connection of two primary supporting members

1.14 Cut-outs and holes

1.14.1 Cut-outs for the passage of ordinary stiffeners shall be as small as possible and well-rounded with smooth edges.

In general, the depth of cut-outs shall not be greater than 50% of the depth of the primary supporting member. Other cases shall be covered by calculations submitted to the Society.

1.14.2 Openings may not be fitted in way of toes of end brackets.

1.15 Stiffening arrangement

1.15.1 General

Webs of primary supporting members are generally to be stiffened where the height in mm is greater than 100 t, where t is the web thickness [mm] of the primary supporting member.

In general, the web stiffeners of primary supporting members shall be spaced not more than 110t.

1.15.2 Longitudinal framing system

In way of each longitudinal the transverses shall be stiffened. This stiffener shall extend between the longitudinal and the upper faceplate of the transverse, without any connection with that faceplate.

The stiffener shall be made of a flat, the width b and thickness t of which in mm shall not be less than:

$$b = \frac{20}{3}\sqrt{w_l}$$

$$t = \frac{2}{3}\sqrt{w_l}$$

w_l being the section modulus of the longitudinal in cm^3.

However, on deck transverses, side shell transverses or longitudinal bulkhead transverses, stiffeners may be provided only every two longitudinal spacings.

The Society may waive this requirement where the transverse is a rolled section or where it is otherwise covered by calculations.

The sectional area of the welded connection of the transverse stiffener to the longitudinal and to the transverses shall be not less than the stiffener rule sectional area.

1.15.3 Tripping brackets (refer Figure 1.15.1) welded to the face plate are generally to be fitted:

a. at intervals not exceeding 20 times the face plate width
b. at the toe of end brackets
c. at rounded/knuckled face plates
d. in way of cross ties
e. in way of concentrated loads.

Where the width of the symmetrical face plate is greater than 400 mm, backing brackets shall be fitted in way of the tripping brackets.

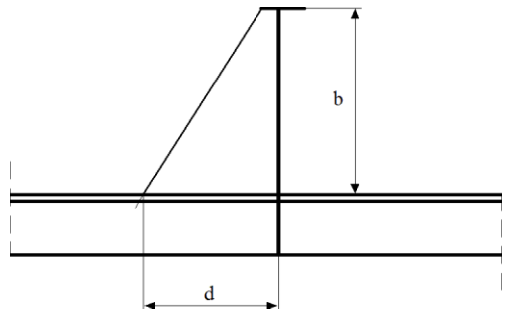


Figure 1.15.1 Primary supporting member: web stiffener in way of ordinary stiffener

1.15.4 The arm length of tripping brackets shall be not less than the greater of the following values in m:

$$d = 0.38b$$

$$= 0.85b \cdot \sqrt{\frac{s_t}{t}}$$

b = height in m of tripping brackets, shown in Figure 1.15.1
s_t = spacing in m of tripping brackets
t = thickness in mm of tripping brackets.

1.15.5 The thickness of the tripping brackets shall not be less than the web thickness of the primary supporting member.

1.16 Calculation point for Hull scantlings

1.16.1 General

The calculation point shall be considered with respect to the reference co-ordinate system defined in Ch 1 Sec [1.4]

1.16.2 Plating

The elementary plate panel is the smallest unstiffened part of plating. Unless otherwise specified, the loads shall be calculated:

a. for longitudinal framing, at the lower edge of the elementary plate panel or, in the case of horizontal plating, at the point of minimum y-value among those of the elementary plate panel considered
b. for transverse framing, at the lower edge of the strake

1.16.3 Ordinary stiffeners

Unless otherwise specified, the loads shall be calculated at mid-span of the ordinary stiffener considered.

1.16.4 Primary supporting members

Unless otherwise specified, the loads shall be calculated at mid-span of the primary supporting member considered.

1.17 Bracket coefficients

1.17.1 Ordinary stiffeners

These requirements apply to ordinary stiffeners without end brackets, with a bracket at one end or with two equal end brackets.

The bracket coefficients β_b and β_s, of ordinary stiffeners shall be obtained from Table 1.17.1.

Table 1.17.1 Bracket coefficients

Brackets at ends	β_b	β_s
0	1	1
1	0.90	0.95
2	0.81	0.90

1.17.2 Primary supporting members

Parameters of conventional end brackets are given in Figure 1.18.1. Special consideration shall be given to conditions different from those shown.

The bracket coefficients β_b and β_s, of primary supporting members shall be determined using the following formulae, and shall not be less than the values given in Table 1.17.1:

$$\beta_b = \left(1 - \sum_{i=1}^{n} \frac{l_{bi}}{l}\right)^2$$

$$\beta_s = 1 - \sum_{i=1}^{n} \frac{l_{bi}}{l}$$

l = span in m of primary supporting member, defined in [1.6]
l_{bi} = $l_b - 0.25 \cdot h_w$, $l_{bi} \geq 0$
l_b = minimum of d and b
d, b = length in m of brackets arms, defined in Figure 1.18.1
h_w = height in m of the primary supporting member (refer Figure 1.18.1)
n = number of end brackets

1.18 Coefficients for vertical structural members λ_b and λ_s

1.18.1 The coefficients λ_b and λ_S to be used for the scantlings of vertical structural members shall be determined as follows:

λ_S = $2\lambda_b - 1$

λ_b is the greater of:

$$= 1 + 0.2 \cdot \frac{p_{Sd} - p_{Su}}{p_{Sd} + p_{Su}}$$

$$= 1 - 0.2 \cdot \frac{p_{Sd} - p_{Su}}{p_{Sd} + p_{Su}}$$

p_{su} = still water pressure in kN/m^2 at the upper end of the structural member considered

p_{sd} = still water pressure in kN/m^2 at the lower end of the structural member considered.

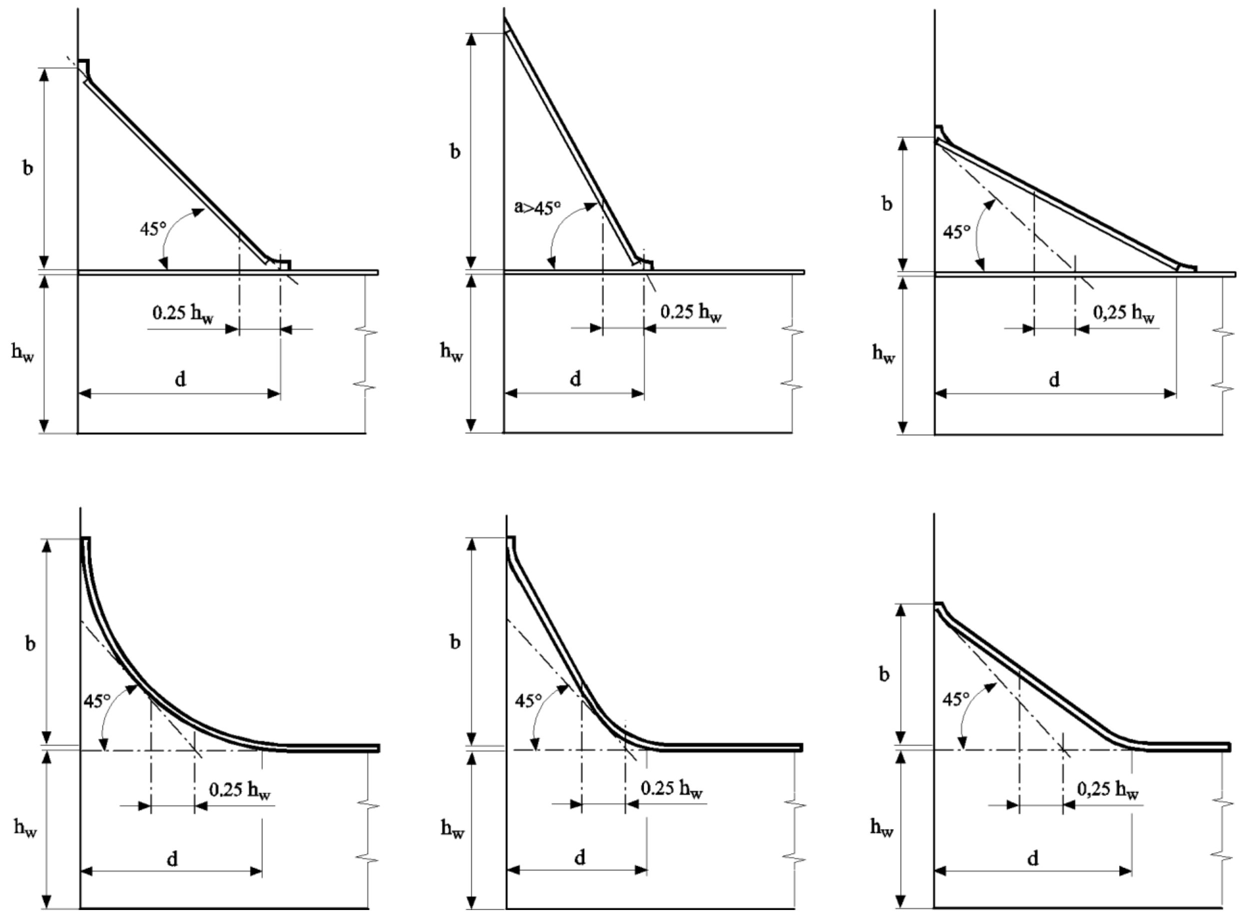


Figure 1.18.1 Characteristics of primary supporting member brackets

1.19 Plate panels

1.19.1 Thickness

The required thickness of plating subjected to lateral pressures may be reduced according to the aspect ratio and curvature of the panel considered, according to the formula:

$$t = t_0 \cdot c_a \cdot c_r$$

t_0 = plating thickness in mm as required in terms of the lateral pressure
c_a = aspect ratio defined in [1.19.2]
c_r = coefficient of curvature defined in [1.19.3]

1.19.2 Aspect ratio

The aspect ratio of a plate panel is given by following formula:

$$c_a = 1.21 \cdot \sqrt{1 + 0.33 \cdot \left(\frac{s}{\ell}\right)^2} - 0.69 \cdot \frac{s}{\ell} \le 1$$

s = length in m of the shorter side of the plate panel

l = length in m of the longer side of the plate panel

1.19.3 Curvature of plate panels

The coefficient of curvature of plate pane is given by the following formula:

$$c_r = 1 - 0.5 \cdot \frac{s}{r} \geq 0.75$$

r = radius of curvature in m

1.20 Net strength characteristic calculation

1.20.1 The scantlings obtained by applying the criteria specified in these rules are net scantlings, i.e. those which provide the strength characteristics required to sustain the loads, excluding any addition for corrosion. Exceptions are the scantlings of:

a. rudder structures and hull appendages in Ch 6 Sec 1.
b. massive pieces made of steel forgings, steel castings or iron castings

1.20.2 The required strength characteristics are:

a. thickness, for plating including that which constitutes primary supporting members
b. section modulus, shear sectional area, moments of inertia and local thickness, for ordinary stiffeners and primary supporting members
c. section modulus, moments of inertia and single moment for the hull girder

1.20.3 The vessel shall be built at least with the gross scantlings obtained by reversing the procedure described in [1.21]

1.21 Designer's proposal based on gross scantlings

1.21.1 General criteria

If the designer provides the gross scantlings of each structural element, the structural checks shall be carried out based on the net strength characteristics, derived as specified in [1.21.2] to [1.21.5]

1.21.2 Plating

The net thickness shall be obtained by deducting the corrosion addition t_c from the gross thickness.

1.21.3 Ordinary stiffeners

The net transverse section shall be obtained by deducting the corrosion addition t_c from the gross thickness of the elements which constitute the stiffener profile.

The net strength characteristics shall be calculated for the net transverse section. As an alternative, the net section modulus may be obtained from the following formula:

$$w = w_G \cdot (1 - \alpha \cdot t_C) - \beta \cdot t_C$$

w_G = stiffener gross section modulus in cm^3

α, β = coefficients defined in Table 1.21.1

Table 1.21.1 Coefficients α and β

Type of ordinary stiffeners		α	β
Flat bars	w_G > 17 cm^3	0.066	1.6
Flanged profiles	w_G> 17 cm^3	0.101	1.6
Bulb profiles:	w_G≤ 200 cm^3	0.070	0.4
	w_G> 200 cm^3	0.035	7.4

1.21.4 Primary supporting members

The net transverse section shall be obtained by deducting the corrosion addition t_C from the gross thickness of the elements which constitute the primary supporting members.

The net strength characteristics shall be calculated for the net transverse section.

1.21.5 Hull girder

For the hull girder, the net hull transverse sections shall be considered as being constituted by plating and stiffeners having net scantlings calculated based on the corrosion additions t_C, according to [1.21.2] to [1.21.4]

1.22 Corrosion additions

1.22.1 The designer may define values of corrosion additions greater than those specified in [1.22.2]

1.22.2 Corrosion additions for steel other than stainless steel

The corrosion addition for each of the two sides of a structural member, t_{C1} or t_{C2}, is specified in Table 1.23.1

a. for plating with a net thickness greater than 8 mm, the total corrosion addition t_C in mm for both sides of the structural member is obtained by the following formula:

$$t_C = t_{C1} + t_{C2}$$

b. for plating with a net thickness less than or equal to 8 mm, the smallest of the following values shall be applied:

   i. 25% of the net thickness of the plating

   ii. $t_C = t_{C1} + t_{C2}$

For an internal member within a given compartment, the total corrosion addition t_C is obtained from the following formula:

$$t_c = 2 \cdot t_{C1}$$

When a structural element is affected by more than one value of corrosion addition (e.g. plate in a dry bulk cargo hold extending in the double bottom), the scantling criteria are generally to be applied considering the severest value of corrosion addition applicable to the member.

1.22.3 Corrosion additions for stainless steel

For structural members made of stainless steel, the corrosion addition shall be taken equal to 0.25 mm, for one side exposure ($t_{C1} = t_{C2}$ = 0.25 mm).

Table 1.23.1 Corrosion additions in mm for one side exposure (t_{c1} or t_{c2})

Compartment type		General [1]
Ballast tank		1.00
Cargo tank and fuel oil tank	Plating of horizontal surfaces	0.75
	Plating of non-horizontal surfaces	0.50
	Ordinary stiffeners and primary supporting members	0.50
Dry bulk cargo hold	General	1.00
	Inner bottom plating Side plating for single hull vessel Inner side plating for double hull vessel Transverse bulkhead plating	1.75
	Frames. ordinary stiffeners and primary supporting members	0.50
Hopper well of dredging vessels		2.00
Accommodation space		0.00
Compartments and areas other than those mentioned above		0.50

1) General: corrosion additions are applicable to all members of the considered item

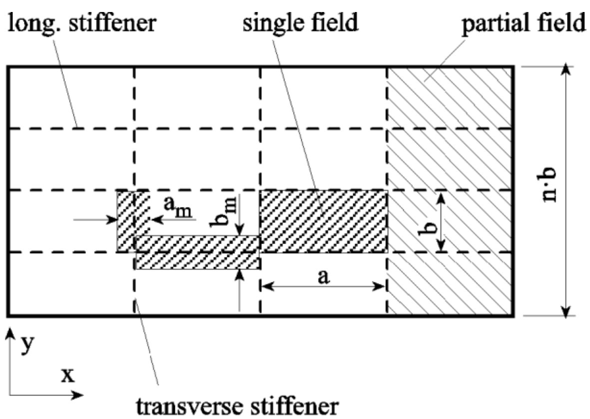
SECTION 2 PROOF OF BUCKLING STRENGTH

Contents

2.1 Definitions

a = length of single or partial plate field in mm
b = breadth of single plate field in mm
α = aspect ratio of single plate field
= a/b
n = number of single plate field breadths within the partial or total plate field
t = nominal plate thickness in mm
= $t_a - t_c$ in mm
t_a = plate thickness as built in mm
t_C = corrosion addition in mm according to Sect 1.22
σ_X = membrane stress in x-direction in N/mm^2
σ_Y = membrane stress in y-direction in N/mm^2
τ = shear stress in the x-y plane in N/mm^2
ψ = edge stress ratio according to Table 2
F_1 = correction factor for boundary condition at the long. stiffeners according to Table 2.1.1

Compressive and shear stresses shall be taken positive, tension stresses shall be taken negative.



longitudinal : stiffener in the direction of the length a
transverse : stiffener in the direction of the breath b

Figure 2.1.1 Definition of plate fields subject to buckling

Remark:

If the stresses in the x- and y-direction already contain the Poisson effect, the following modified stress values may be used:

Both stresses σ_x und σ_y* are to be compressive stresses, in order to apply the stress reduction according to the following formulae:*

$$\sigma_x = \left(\sigma_x^* - 0,3 \cdot \sigma_y^*\right) / 0,91$$

$$\sigma_y = \left(\sigma_y^* - 0,3 \cdot \sigma_x^*\right) / 0,91$$

σ_x^*, σ_y^*= stresses containing the Poisson effect
Where compressive stress fulfils the condition $\sigma_y^* < 0.3 \cdot \sigma_x^*$, then $\sigma_y = 0$ and $\sigma_x = \sigma_x^*$.
Where compressive stress fulfils the condition $\sigma_x^* < 0.3 \cdot \sigma_y^*$, then $\sigma_x = 0$ and $\sigma_y = \sigma_y^*$
When at least σ_x^* or σ_y^* is tension stress, then $\sigma_x = \sigma_x^*$ and $\sigma_y = \sigma_y^*$.

Table 2.1.1 Correction factor F1	
1.0	for stiffeners sniped at both ends
Guidance values where both ends are effectively connected to adjacent structures * :	
1.05	for flat bars
1.10	for bulb sections
1.20	for angle and tee-sections
1.30	for girders of high rigidity (e.g. bottom transverses)
*Exact values may be determined by direct calculations.	

σ_e = *reference stress*

$$= 0.9 \cdot E \cdot \left(\frac{t}{b}\right)^2 \ (N/mm^2)$$

E = *Young's modulus*
= 2.06 x 10^5 N/mm^2 for steel
R_{eH} = *nominal yield point in N/mm^2 for hull structural steels according to Pt 2*

S = *safety factor*
= 1.1 in general
= 1.2 for structures which are exclusively exposed to local loads
= 1.05 for combinations of statistically independent loads

λ = reference degree of slenderness

$$= \sqrt{\frac{R_{eH}}{K \cdot \sigma_e}}$$

K = buckling factor according to Table 2.3.1 and Table 2.3.2

In general, the ratio of plate field breadth to plate thickness shall not exceed b/t = 100.

2.2 Proof of single plate fields

2.2.1 Proof shall be provided that the following condition is complied with for the single plate field a · b:

$$\left(\frac{|\sigma_x| \cdot S}{\kappa_X \cdot R_{eH}}\right)^{e1} + \left(\frac{|\sigma_y| \cdot S}{\kappa_Y \cdot R_{eH}}\right)^{e2} - B\left(\frac{\sigma_x \cdot \sigma_y \cdot S^2}{R_{eH}^{\ 2}}\right) + \left(\frac{|\tau| \cdot S \cdot \sqrt{3}}{\kappa_\tau \cdot R_{eH}}\right)^{e3} \le 1.0$$

Each term of the above condition shall not exceed 1.0.
The reduction factors κ_x, κ_y and κ_T are given in Table 2.3.1 and/or Table 2.3.2. Where $\sigma_x \le 0$ (tension stress), $\kappa_x = 1.0$.S

Where $\sigma_y \le 0$ (tension stress), $\kappa_y = 1.0$.

The exponents e_1, e_2 and e_3 as well as the factor B are calculated or set respectively as per table 2.2.1

Table 2.2.1

Exponents e_1 to e_3 and factor B	plate field	
	plane	curved
e_1	$1+\kappa_x^4$	1.25
e_2	$1+\kappa_y^4$	1.25
e_3	$1+\kappa_x \cdot \kappa_y \cdot \kappa_\tau^2$	2.0
B σ_X and σ_Y positive (compression stress)	$(\kappa_x \cdot \kappa_y)^5$	0
B σ_X or σ_Y negative (tension stress)	1	—

2.3 Effective width of plating

The effective width of plating may be determined by the following formulae:

$b_m = \kappa_X\, b$ for longitudinal stiffeners
$a_m = \kappa_y\, a$ for transverse stiffeners
Refer also figure 2.1.1.

The effective width of plating shall not be taken greater than the effective breadth obtained from Ch 3 Sec [1.7] and Ch 3 Sec [1.11]

Table 2.3.1 Plane plate fields

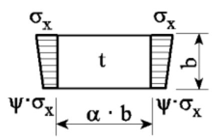
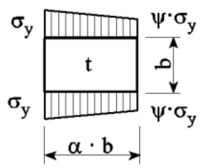
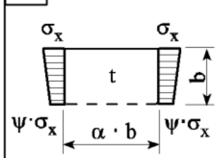
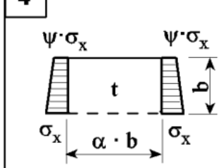
Load case	Edge stress ratio ψ	Aspect ratio α	Buckling factor K	Reduction factor κ
1 	$1 \geq \psi \geq 0$	$\alpha > 1$	$K = \frac{8.4}{\psi + 1.1}$	$\kappa_x = 1$ for $\lambda \leq \lambda_c$ $\kappa_x = c\left(\frac{1}{\lambda} - \frac{0.22}{\lambda^2}\right)$ for $\lambda > \lambda_c$ $c = (1.25 - 0.12\psi) \leq 1.25$ $\lambda_c = \frac{c}{2}\left(1 + \sqrt{1 - \frac{0.88}{c}}\right)$
	$0 > \psi > -1$		$K = 7.63 - \psi\,(6.26 - 10\,\psi)$	
	$\psi \leq -1$		$K = (1 - \psi)^2 \cdot 5.975$	
2 	$1 \geq \psi \geq 0$	$\alpha \geq 1$	$K = F_1\left(1 + \frac{1}{\alpha^2}\right)^2 \frac{2.1}{(\psi + 1.1)}$	$\kappa_y = c\left(\frac{1}{\lambda} - \frac{R + F^2\,(H - R)}{\lambda^2}\right)$ $c = (1.25 - 0.12\psi) \leq 1.25$ $R = \lambda\left(1 - \frac{\lambda}{c}\right)$ for $\lambda < \lambda_c$ $R = 0.22$ for $\lambda \geq \lambda_c$ $\lambda_c = \frac{c}{2}\left(1 + \sqrt{1 - \frac{0.88}{c}}\right)$ $F = \left(1 - \frac{\frac{K}{0.91} - 1}{\lambda_p^2}\right) c_1 \geq 0$ $\lambda_p^2 = \lambda^2 - 0.5 \quad 1 \leq \lambda_p^2 \leq 3$ $c_1 = 1$ for σ_y due to direct loads $c_1 = \left(1 - \frac{F_1}{\alpha}\right) \geq 0$ for σ_y due to bending (in general) $c_1 = 0$ for σ_y due to bending in extreme load cases (e. g. w. t. bulkheads) $H = \lambda - \frac{2\lambda}{c\,(T + \sqrt{T^2 - 4})} \geq R$ $T = \lambda + \frac{14}{15\lambda} + \frac{1}{3}$
	$0 > \psi > -1$	$1 \leq \alpha \leq 1.5$	$K = F_1\left[\left(1 + \frac{1}{\alpha^2}\right)^2 \frac{2.1\,(1 + \psi)}{1.1} - \frac{\psi}{\alpha^2}\,(13.9 - 10\,\psi)\right]$	
		$\alpha > 1.5$	$K = F_1\left[\left(1 + \frac{1}{\alpha^2}\right)^2 \frac{2.1\,(1 + \psi)}{1.1} - \frac{\psi}{\alpha^2}\left(5.87 + 1.87\,\alpha^2 + \frac{8.6}{\alpha^2} - 10\,\psi\right)\right]$	
	$\psi \leq -1$	$1 \leq \alpha \leq \frac{3\,(1 - \psi)}{4}$	$K = F_1\left(\frac{1 - \psi}{\alpha}\right)^2 5.975$	
		$\alpha > \frac{3\,(1 - \psi)}{4}$	$K = F_1\left[\left(\frac{1 - \psi}{\alpha}\right)^2 3.9675 + 0.5375\left(\frac{1 - \psi}{\alpha}\right)^4 + 1.87\right]$	
3 	$1 \geq \psi \geq 0$	$\alpha > 0$	$K = \frac{4\,(0.425 + 1/\alpha^2)}{3\,\psi + 1}$	$\kappa_x = 1$ for $\lambda \leq 0.7$ $\kappa_x = \frac{1}{\lambda^2 + 0.51}$ for $\lambda > 0.7$
	$0 > \psi \geq -1$		$K = 4\left(0.425 + \frac{1}{\alpha^2}\right)(1 + \psi) - 5 \cdot \psi\,(1 - 3.42\,\psi)$	
4 	$1 \geq \psi \geq -1$	$\alpha > 0$	$K = \left(0.425 + \frac{1}{\alpha^2}\right) \frac{3 - \psi}{2}$	

Table 2.3.1 Plane plate fields (contd.)

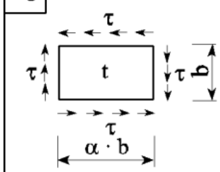
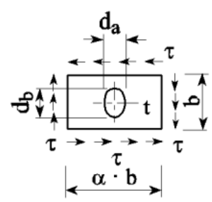
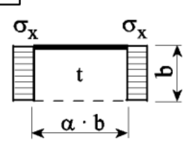
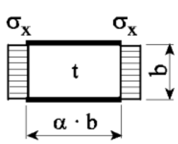
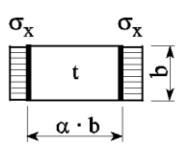
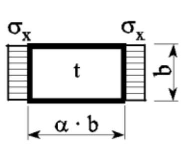
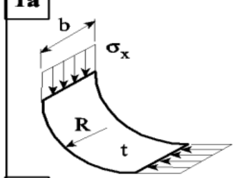
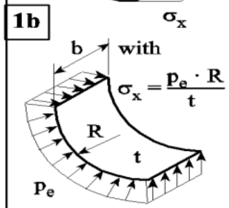
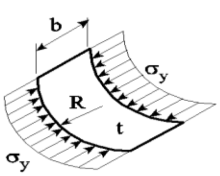
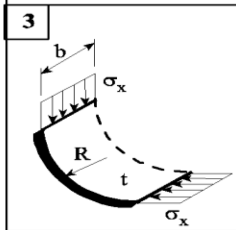
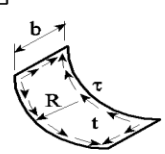
Load case	Edge stress ratio ψ	Aspect ratio α	Buckling factor K	Reduction factor κ
5 	—	$\alpha \geq 1$	$K = K_\tau \cdot \sqrt{3}$ $K_\tau = \left[5.34 + \frac{4}{\alpha^2}\right]$	$\kappa_\tau = 1 \quad \text{for } \lambda \leq 0.84$ $\kappa_\tau = \frac{0.84}{\lambda} \quad \text{for } \lambda > 0.84$
		$0 < \alpha < 1$	$K_\tau = \left[4 + \frac{5.34}{\alpha^2}\right]$	
6 	—		$K = K' \cdot r$ K' = K according to load case 5 r = Reduction factor $r = (1 - \frac{d_a}{a})(1 - \frac{d_b}{b})$ with $\frac{d_a}{a} \leq 0.7$ and $\frac{d_b}{b} \leq 0.7$	
7 	—	$\alpha \geq 1.64$	$K = 1.28$	$\kappa_x = 1 \quad \text{for } \lambda \leq 0.7$ $\kappa_x = \frac{1}{\lambda^2 + 0.51}$ for $\lambda > 0.7$
		$\alpha < 1.64$	$K = \frac{1}{\alpha^2} + 0.56 + 0.13\,\alpha^2$	
8 	—	$\alpha \geq \frac{2}{3}$	$K = 6.97$	$\kappa_x = 1 \quad \text{for } \lambda \leq 0.83$ $\kappa_x = 1.13\left[\frac{1}{\lambda} - \frac{0.22}{\lambda^2}\right]$ for $\lambda > 0.83$
		$\alpha < \frac{2}{3}$	$K = \frac{1}{\alpha^2} + 2.5 + 5\,\alpha^2$	
9 	—	$\alpha \geq 4$	$K = 4$	
		$4 > \alpha > 1$	$K = 4 + \left[\frac{4-\alpha}{3}\right]^4 2.74$	
		$\alpha \leq 1$	$K = \frac{4}{\alpha^2} + 2.07 + 0.67\,\alpha^2$	
10 	—	$\alpha \geq 4$	$K = 6.97$	
		$4 > \alpha > 1$	$K = 6.97 + \left[\frac{4-\alpha}{3}\right]^4 3.1$	
		$\alpha \leq 1$	$K = \frac{4}{\alpha^2} + 2.07 + 4\,\alpha^2$	
Explanations for boundary conditions	- - - - - - plate edge free ——— plate edge simply supported ▬▬▬ plate edge clamped			

Table 2.3.2 Curved plate field R/t ≤ 2500 [1]

Load case	Aspect ratio b / R	Buckling factor K	Reduction factor κ
1a 	$\frac{b}{R} \le 1.63\sqrt{\frac{R}{t}}$	$K = \frac{b}{\sqrt{R \cdot t}} + 3\,\frac{(R \cdot t)^{0.175}}{b^{0.35}}$	[2] $\kappa_x = 1$ for $\lambda \le 0.4$ $\kappa_x = 1.274 - 0.686\,\lambda$ for $0.4 < \lambda \le 1.2$ $\kappa_x = \frac{0,65}{\lambda^2}$ for $\lambda > 1.2$
1b  p_e = external pressure in [N/mm²]	$\frac{b}{R} > 1.63\sqrt{\frac{R}{t}}$	$K = 0.3\,\frac{b^2}{R^2} + 2.25\left(\frac{R^2}{b \cdot t}\right)^2$	
2 	$\frac{b}{R} \le 0.5\sqrt{\frac{R}{t}}$	$K = 1 + \frac{2}{3}\,\frac{b^2}{R \cdot t}$	[2] $\kappa_y = 1$ for $\lambda \le 0.25$ $\kappa_y = 1.233 - 0.933\,\lambda$ for $0.25 < \lambda \le 1$ $\kappa_y = 0.3/\lambda^3$ for $1 < \lambda \le 1.5$ $\kappa_y = 0.2/\lambda^2$ for $\lambda > 1.5$
	$\frac{b}{R} > 0.5\sqrt{\frac{R}{t}}$	$K = 0.267\,\frac{b^2}{R \cdot t}\left[3 - \frac{b}{R}\sqrt{\frac{t}{R}}\right]$ $\ge 0.4\,\frac{b^2}{R \cdot t}$	
3 	$\frac{b}{R} \le \sqrt{\frac{R}{t}}$	$K = \frac{0.6 \cdot b}{\sqrt{R \cdot t}} + \frac{\sqrt{R \cdot t}}{b} - 0.3\,\frac{R \cdot t}{b^2}$	as in load case 1a
	$\frac{b}{R} > \sqrt{\frac{R}{t}}$	$K = 0.3\,\frac{b^2}{R^2} + 0.291\left(\frac{R^2}{b \cdot t}\right)^2$	
4 	$\frac{b}{R} \le 8.7\sqrt{\frac{R}{t}}$	$K = K_\tau \cdot \sqrt{3}$ $K_\tau = \left[28.3 + \frac{0.67 \cdot b^3}{R^{1.5} \cdot t^{1.5}}\right]^{0.5}$	$\kappa_\tau = 1$ for $\lambda \le 0.4$ $\kappa_\tau = 1.274 - 0.686\,\lambda$ for $0.4 < \lambda \le 1.2$ $\kappa_\tau = \frac{0,65}{\lambda^2}$ for $\lambda > 1.2$
	$\frac{b}{R} > 8.7\sqrt{\frac{R}{t}}$	$K_\tau = 0.28\,\frac{b^2}{R\sqrt{R \cdot t}}$	

Explanations for boundary conditions:
- - - - - plate edge free
——— plate edge simply supported
▬▬▬ plate edge clamped

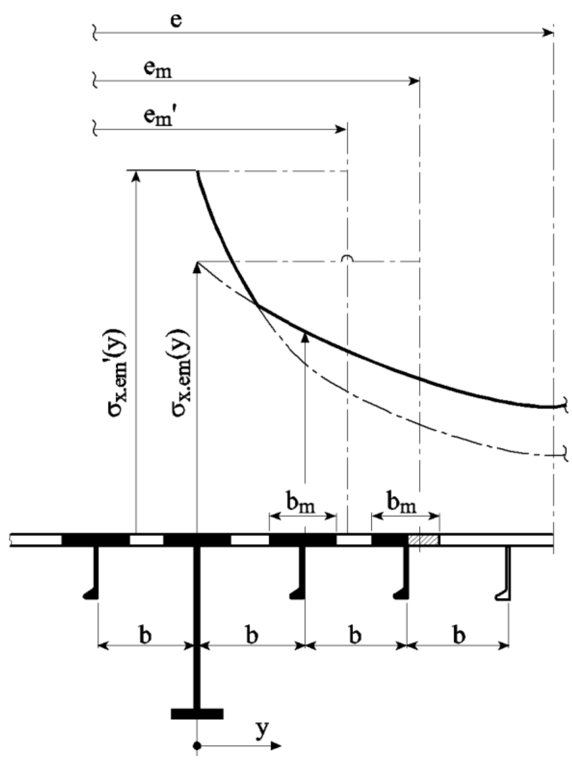
[1] For curved plate fields with a very large radius the κ-value need not to be taken less than one derived for the expanded plane field.

[2] For curved single fields. e.g. the bilge strake, which are located within plane partial or total fields, the reduction factor κ may taken as follow:

Load case 1b: $\kappa_x = 0.8/\lambda^2 \le 1.0$: load case 2: $\kappa_y = 0.65/\lambda^2 \le 1.0$

Remark:

The effective width e'_m of stiffened flange plates of girders may be determined as follows: Stiffening parallel to web of girder:

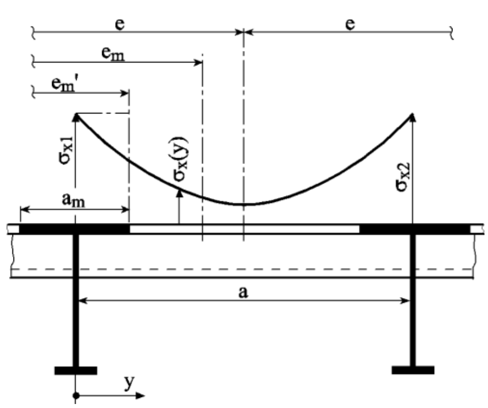


$b<e_m$

e'_m $= n \cdot b_m$

n = integer number of the stiffener spacing b inside the effective breadth e_m
$= int(e_m/b)$

Stiffening perpendicular to web of girder:



$a \geq e_m$

e'_m $= n \bullet a_m < e_m$

n = $2.7 \cdot e_m/a \leq 1$

e = *width of plating suported according to Ch 3 Sect [1.7] and Ch 3 Sect [1.11]*

For $b \geq e_m$ *or* $a < e_m$ *respectively, b and a must be exchanged.*

a_m *and* b_m *for flange plates are in general to be determined for* $\psi = 1$.

Stress distribution between two girders:

$$\sigma_x(y) = \sigma_{x1} \cdot \left\{1 - \frac{y}{e}\left[3 + c_1 - 4 \cdot c_2 - 2\frac{y}{e}(1 + c_1 - 2c_2)\right]\right\}$$

c_1 = $\frac{\sigma_{x2}}{\sigma_{x1}}, 0 \leq c_1 \leq 1$

c_2 = $\frac{1.5}{e}\left(e''_{m1} + e''_{m2}\right) - 0.5$

e''_{m1} = $\frac{e'_{m1}}{e_{m1}}$

e''_{m2} = $\frac{e'_{m2}}{e_{m2}}$

σ_{x1}, σ_{x2} = *normal stresses in flange plates of adjacent girder 1 and 2 with spacing e*

y = *distance of considered location from girder 1*

Scantlings of plates and stiffeners are in general to be determined according to the maximum stresses $\sigma_x(y)$ *at girder webs and stiffeners respectively. For stiffeners under compression arranged parallel to the girder web with spacing b, no lesser value than* $0.25 \cdot R_{eH}$ *shall be inserted for* $\sigma_x(y=b)$.

Shear stress distribution in the flange plates may be assumed linearly.

2.4 Webs and flanges

For non-stiffened webs and flanges of sections and girders, proof of sufficient buckling strength shall be provided as for single plate fields according to [2.2]

Remark:

Within 0.6 L amidships, the following guidance values are recommended for the ratio of web depth to web thickness and/or flange breadth to flange thickness:

$$\text{flat bars}: \frac{h_w}{t_w} \le 19.5\sqrt{k}$$

angle, tee and bulb sections:

$$\text{web}: \frac{h_w}{t_w} \le 60.0\sqrt{k}$$

$$\text{flange}: \frac{b_i}{t_f} \le 19.5\sqrt{k}$$

$b_i = b_1$ or b_2 according to Figure 1.6.4 the larger value is to be taken.

2.5 Proof of partial and total fields for Longitudinal and transverse stiffeners

Proof shall be provided that the continuous longitudinal and transverse stiffeners of partial and total plate fields comply with the conditions described in [2.6] and [2.7]

2.6 Lateral buckling

$$\frac{\sigma_a + \sigma_b}{R_{eH}} S \le 1$$

σ_a = uniformly distributed compressive stress in the direction of the stiffener axis in N/mm²
= σ_x for longitudinal stiffeners
= σ_y for transverse stiffeners

σ_b = bending stress in the stiffeners in N/mm²

$$= \frac{M_0 + M_1}{W_{st} \cdot 10^3}$$

M_0 = bending moment in N·mm due to deformation w of stiffener

$$= F_{Ki} \frac{p_z \cdot w}{c_f - p_z}; c_f - p_z > 0$$

M_1 = bending moment due to the lateral load p

for continuous longitudinal stiffeners:

$$= \frac{p \cdot b \cdot a^2}{24 \cdot 10^3} (N \cdot mm)$$

for transverse stiffeners:

$$= \frac{p \cdot a (n \cdot b)^2}{c_s \cdot 8 \cdot 10^3} (N \cdot mm)$$

p = lateral load in kN/m² according to Ch.2

c_S = factor accounting for the boundary conditions of the transverse stiffener
= 1.0 for simply supported stiffener
= 2.0 for partially constrained stiffeners

F_{Ki} = ideal buckling force of the stiffener in N

F_{Kix} = $\pi^2 \cdot E \cdot I_x \cdot 10^4 / a^2$ for long. stiffeners

F_{Kiy} = $\frac{\pi^2}{(n \cdot b)^2} \cdot E \cdot I_y \cdot 10^4$ for transverse stiffeners

I_x, I_y= moments of inertia of the longitudinal or transverse stiffener including effective width of plating according to [2.3] in cm4

$$I_x \geq \frac{b \cdot t^3}{12 \cdot 10^4}$$

$$I_y \geq \frac{a \cdot t^3}{12 \cdot 10^4}$$

p_z = nominal lateral load of the stiffener due to σx, σy and τ in N/mm²

for longitudinal stiffeners:

$$p_{zx} = \frac{t_a}{b}\left(\sigma_{x1}\left(\frac{\pi \cdot b}{a}\right)^2 + 2 \cdot c_y \cdot \sigma_y + \sqrt{2}\tau_1\right)$$

for transverse stiffeners:

$$p_{zy} = \frac{t_a}{a}\left(\sigma_y\left(\frac{\pi \cdot a}{n \cdot b}\right)^2\left(1 + \frac{A_y}{a \cdot t_a}\right) + 2 \cdot c_x \cdot \sigma_{x1} + \sqrt{2}\tau_1\right)$$

$$\sigma_{x1} = \sigma_x\left(1 + \frac{A_x}{b \cdot t_a}\right)$$

cx, cy = factor considering the stresses vertical to the stiffener's axis and distributed variable along the stiffener's length

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

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

Ψ = edge stress ratio according to Table 2.3.1

A_X, A_Y = sectional area of the longitudinal or transverse stiffener respectively in mm²

$$\tau_1 = \left(\tau - t \sqrt{R_{eH} \cdot E \left(\frac{m_1}{a^2} + \frac{m_2}{b^2} \right)} \right) \geq 0$$

for longitudinal stiffeners:

a/b≥ 2.0: m_1 = 1.47, m_2 = 0.49

a/b< 2.0: m_1 = 1.96, m_2 = 0.37

for transverse stiffeners:

a/(n•b)≥ 0.5: m_1 = 0.37, m_2 = 1.96/n^2

a/(n•b)< 0.5: m_1 = 0.49, m_2 = 1.47/n^2

w = w_0 + w_1
w_0 = assumed imperfection in mm

a/250 ≥ w_{OX} ≤ b/250 for longitudinal stiffeners
n•b/250≥ w_{OY}≤ a/250 for transverse stiffeners

however, w_o ≤ 10 mm

Remark:

For stiffeners sniped at both ends, w_0 shall not be taken less than the distance from the midpoint of plating to the neutral axis of the profile including effective width of plating.

w_1 = deformation of stiffener due to lateral load p at midpoint of stiffener span in mm.

In case of uniformly distributed load, the following values for w_1 may be used:

for longitudinal stiffeners: $$w_1 = \frac{p \cdot b \cdot a^4}{384 \cdot 10^7 \cdot E \cdot I_x}$$

for transverse stiffeners: $$w_1 = \frac{5 \cdot a \cdot p \left(n \cdot b \right)^4}{384 \cdot 10^7 \cdot E \cdot I_y \cdot c_s^2}$$

c_f = elastic support provided by the stiffener in N/mm²

$$c_{fx} = F_{Kix} \cdot \frac{\pi^2}{a^2} \cdot \left(1 + c_{px} \right)$$ for longitudinal stiffeners

$$c_{px} = \left\{ 1 + \frac{0.91}{c_{x\alpha}} \cdot \left(\frac{12 \cdot 10^4 \cdot I_x}{t^3 \cdot b} - 1 \right) \right\}^{-1}$$

$$c_{x\alpha} = \left(\frac{a}{2b} + \frac{2b}{a}\right)^2 \quad \text{for a} \geq 2\text{b}$$

$$= \left(1 + \left(\frac{a}{2b}\right)^2\right)^2 \quad \text{for a} < 2\text{b}$$

$$c_{fy} = c_s \cdot F_{Kiy} \cdot \frac{\pi^2}{(n \cdot b)^2} \cdot \left(1 + c_{py}\right) \quad \text{for transverse stiffeners}$$

c_S = factor accounting for the boundary conditions of the transverse stiffener

= 1.0 for simply supported stiffener

= 2.0 for partially constrained stiffeners

$$c_{py} = \left\{1 + \frac{0.91}{c_{y\alpha}} \cdot \left(\frac{12 \cdot 10^4 \cdot I_y}{t^3 \cdot a} - 1\right)\right\}^{-1}$$

$$c_{y\alpha} = \left(\frac{n \cdot b}{2a} + \frac{2a}{n \cdot b}\right)^2 \quad \text{for n} \cdot \text{b} \geq 2\text{a}$$

$$= \left(1 + \left(\frac{n \cdot b}{2a}\right)^2\right)^2 \quad \text{for n} \cdot \text{b} < 2\text{a}$$

W_{st} = section modulus of stiffener (long. or transverse) in cm^3 including effective width of plating according to [2.3]

If no lateral load p is acting the bending stress σ_b shall be calculated at the midpoint of the stiffener span for that fiber which results in the largest stress value. If a lateral load p is acting, the stress calculation shall be carried out for both fibers of the stiffener's cross-sectional area (if necessary, for the biaxial stress field at the plating side).

Remark:

Longitudinal and transverse stiffeners not subjected to lateral load p have sufficient scantlings if their moments of inertia I_x and I_y are not less than obtained by the following formulae:

$$I_x = \frac{p_{zx} \cdot a^2}{\pi^2 \cdot 10^4}\left(\frac{w_{OX} \cdot h_w}{\frac{R_{eH}}{S} - \sigma_x} + \frac{a^2}{\pi^2 \cdot E}\right) \quad (\text{cm}^4)$$

$$I_y = \frac{p_{zy} \cdot (n \cdot b)^2}{\pi^2 \cdot 10^4}\left(\frac{w_{OY} \cdot h_w}{\frac{R_{eH}}{S} - \sigma_Y} + \frac{(n \cdot b)^2}{\pi^2 \cdot E}\right) \quad (\text{cm}^4)$$

2.7 Torsional buckling

2.7.1 Longitudinal stiffeners

$$\frac{\sigma_x \cdot S}{\kappa_T \cdot R_{eH}} \le 1.0$$

$$\kappa_T = 1.0 \text{ for } \lambda_T \le 0.2$$

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

$$\varphi = 0.5\left(1 + 0.21(\lambda_T - 0.2) + \lambda_T^2\right)$$

$$\lambda_T = \text{ reference degree of slenderness}$$

$$= \sqrt{\frac{R_{eH}}{\sigma_{Kit}}}$$

$$\sigma_{Kit} = \frac{E}{I_P}\left(\frac{\pi^2 \cdot I_\omega \cdot 10^2}{a^2}\varepsilon + 0.385 \cdot I_T\right) \quad (\text{N/mm}^2)$$

For I_P, I_T, I_ω refer figure 2.7.1 and Table 2.7.1

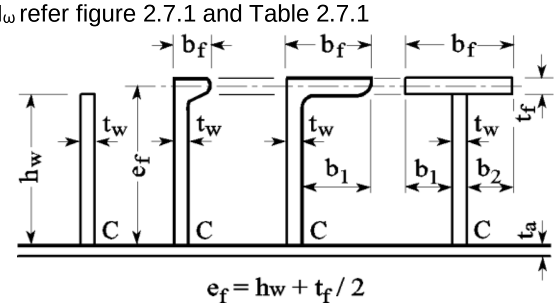


Figure 2.7.1 Main dimensions of typical longitudinal stiffeners

I_P = polar moment of inertia of the stiffener related to the point C in cm^4
I_T = St. Venant's moment of inertia of the stiffener in cm^4
I_ω = sectorial moment of inertia of the stiffener related to the point C in cm^6
ε = degree of fixation

$$= 1 + 10^{-4}\sqrt{\frac{a^4}{I_\omega\left(\frac{b}{t^3} + \frac{4h_w}{3t_w^3}\right)}}$$

h_W = web height in mm
t_W = web thickness in mm
b_f = flange breadth in mm

t_f = flange thickness in mm

A_W= web area $h_w \cdot t_w$

A_f = flange area $b_f \cdot t_f$

2.7.2 Transverse stiffeners

For transverse stiffeners loaded by compressive stresses and which are not supported by longitudinal stiffeners, proof shall be provided in accordance with 2.7.1 analogously.

Table 2.7.1 Formulae for the calculation of moments of inertia IP, IT and Iω

Section	I_P	I_T	I_ω
Flat bar	$\frac{h_w^3 \cdot t_w}{3 \cdot 10^4}$	$\frac{h_w \cdot t_w^3}{3 \cdot 10^4}\left(1 - 0.63\,\frac{t_w}{h_w}\right)$	$\frac{h_w^3 \cdot t_w^3}{36 \cdot 10^6}$
Sections with bulb or flange	$\left(\frac{A_w \cdot h_w^2}{3} + A_f \cdot e_f^2\right) 10^{-4}$	$\frac{h_w \cdot t_w^3}{3 \cdot 10^4}\left(1 - 0.63\,\frac{t_w}{h_w}\right)$ + $\frac{b_f \cdot t_f^3}{3 \cdot 10^4}\left(1 - 0.63\,\frac{t_f}{b_f}\right)$	for bulb and angle sections: $\frac{A_f \cdot e_f^2 \cdot b_f^2}{12 \cdot 10^6}\left(\frac{A_f + 2.6\,A_w}{A_f + A_w}\right)$ for tee-sections: $\frac{b_f^3 \cdot t_f \cdot e_f^2}{12 \cdot 10^6}$

SECTION 3 STRENGTH CHECK IN TESTING CONDITIONS

Contents

3.1 Symbols

t = net thickness in mm of plating
w = net section modulus in cm^3 of ordinary stiffeners
A_{sh} = net web sectional area in cm^2
k = material factor defined according to Ch 4 Sect [1.2]
s = spacing in m of ordinary stiffeners
S = spacing in m of primary supporting members
l = span in m of stiffeners
η = $1 - s / (2 \cdot l)$
z = Z co-ordinate in m of the calculation point
z_{TOP} = Z co-ordinate in m of the highest point of the tank
z_{AP} = Z co-ordinate in m of the deck line of the deck to which the air pipes extend, to be taken not less than z_{TOP}
p_{pv} = setting pressure in kN/m^2 of safety valves or maximum pressure in kN/m^2 in the tank during loading/unloading, whichever is the greater
d_{AP} = distance from the top of air pipe to the top of the compartment in m
p_{ST} = testing pressure kN/m^2 defined in Sec [3.5]
σ_1 = hull girder normal stress in N/mm^2 to be determined in testing conditions.

3.2 Strength check

3.2.1 The requirements of this section provide the minimum scantlings of platings and structural members of compartments subjected to testing conditions.

Where the test conditions are subject to induce additional loads, the strength check is to be carried out by direct calculation.

These requirements are not applicable to bottom shell plating and side shell plating.

3.3 Plating

3.3.1 The net thickness in mm of plating of compartments or structures defined in Table 3.5.1 is to be not less than:

$$t = s \cdot \sqrt{k \cdot p_{ST}}$$

where the testing pressure p_{ST} is defined in Sec [3.5]

3.4 Structural members

3.4.1 The net section modulus w in cm^3 and the net shear sectional area A_{sh} in cm^2 of structural members of compartments or structures defined in Table 3.5.1 are to be not less than the values obtained from the formulae given in Table 3.5.2

Table 3.4.1 Resistance partial safety factors γR

Structures	Ordinary stiffeners	Primary supporting members
Fore peak structures	1.25	1.25
Structures located aft of the collision bulkhead	1.02	1.02 1) 1.15 2)

1) in general
2) for bottom and side girders.

3.5 Still water testing pressure

3.5.1 The still water pressure to be considered as acting on plates and stiffeners subjected to tank testing is to be obtained, in kN/m², from the formulae in Table 3.5.1

Table 3.5.1 Testing – Still water pressures

Compartment or structure to be tested	Still water pressure p_{ST} in kN/m²
Double bottom tanks	$p_{ST} = 9.81((z_{TOP} - z) + d_{AP})$
Double side tanks Fore peaks used as tank After peaks used as tank	The greater of the following: $p_{ST} = 9.81((z_{TOP} - z) + d_{AP})$ $p_{ST} = 9.81((z_{TOP} - z) + 1)$
Cargo tank bulkheads Deep tanks Independent cargo tanks Residual cargo tanks	The greater of the following: $p_{ST} = 9.81((z_{TOP} - z) + d_{AP})$ $p_{ST} = 9.81((z_{TOP} - z) + 1)$ $p_{ST} = 9.81(z_{TOP} - z) + 1.3 p_{pv}$
Ballast compartments Fuel oil bunkers Cofferdams	The greater of the following: $p_{ST} = 9.81((z_{TOP} - z) + d_{AP})$ $p_{ST} = 9.81((z_{TOP} - z) + 1)$
Double bottom Fore peaks not used as tank After peaks not used as tank	$p_{ST} = 9.81(z_{AP} - z)$
Other independent tanks	The greater of the following: $p_{ST} = 9.81((z_{TOP} - z) + d_{AP})$ $p_{ST} = 9.81((z_{TOP} - z) + 2.4)$

Table 3.5.2 Strength check of stiffeners in testing conditions

Stiffener	w	A_{sh}
Vertical stiffeners	$w = \left(4.36 \cdot \gamma_R \cdot k \cdot \lambda_b \cdot \beta_b \cdot p_{ST} \cdot \eta_1 \cdot a \cdot l^2\right)/m$	$A_{sh} = 0.045 \cdot \gamma_R \cdot k \cdot \lambda_s \cdot \beta_s \cdot \eta_1 \cdot p_{ST} \cdot a \cdot l$
Transverse stiffeners Longitudinal stiffeners	$w = \left(4.36 \cdot \gamma_R \cdot k \cdot \beta_b \cdot p_{ST} \cdot \eta_1 \cdot a \cdot l^2\right)/m$	$A_{sh} = 0.045 \cdot \gamma_R \cdot k \cdot \beta_s \cdot \eta_1 \cdot p_{ST} \cdot a \cdot l$
Longitudinal stiffeners (in case of testing afloat)	$w = \dfrac{1000}{m \cdot \left(\dfrac{230}{\gamma_R} - \sigma_1\right)} \cdot k \cdot \beta_b \cdot \eta_1 \cdot p_{ST} \cdot a \cdot l^2$	

a = s for ordinary stiffeners
= S for primary supporting members
η_1 = η for ordinary stiffeners
= 1 for primary supporting members
β_b, β_S = bracket coefficients defined in Ch 3 Sect [1.17]
λ_b, λ_S = coefficients for vertical structural members defined in Ch 3 Sect.[1.18]
γ_R = resistance partial safety factor defined in Table 3.4.1
m = boundary coefficient, to be taken equal to:
= 12 in general, for stiffeners considered as clamped
= 8 for stiffeners considered as simply supported
= 10.6 for stiffeners clamped at one end and simply supported at the other

SECTION 4 DIRECT CALCULATIONS

Contents

4.1 Symbols

R_{eH} = minimum yielding stress in N/mm^2 of the material
γ_R = partial safety factor covering uncertainties regarding resistance, defined in Table 4.5.1

4.2 Application

4.2.1 This section gives guidance on how to perform yielding and buckling checks of structural members by direct calculations.

Such direct calculation may be adopted instead of rule scantling formulae or for the analysis of structural members not covered by the rules.

4.2.2 Yielding check

The yielding check is to be carried out according to Sec 3 for structural members analyzed through isolated beam models

4.2.3 Buckling check

The buckling check is to be carried out according to Sec.2 on the basis of the stresses in primary supporting members calculated according to Sec 3

4.3 Analysis documentation

4.3.1 For any direct calculation carried out, the following information is to be submitted to the society:

a. reference to the calculation program used
b. extent of the model, element types and properties, material properties and boundary conditions
c. loads given in print-out or suitable electronic format. In particular, the method used to consider the interaction between the overall, primary and local loadings is to be described. The direction and intensity of pressure loads, concentrated loads, inertia and weight loads are to be provided
d. stresses given in print-out or suitable electronic format
e. buckling checks
f. identification of the critical areas, where the results exceed 97.5 % of the permissible rule criteria defined in Sec 2.

According to the results of the submitted calculations, the Society may request additional runs of the model with structural modifications

4.4 Net scantlings

4.4.1 All scantlings referred to in this section are net, i.e., they do not include any margin for corrosion. The gross scantlings are obtained as specified in Sec.1.20

4.5 Resistance partial safety factors

4.5.1 The values of resistance partial safety factor covering uncertainties on resistance to be considered for checking structural members are specified in Table 4.5.1

Table 4.5.1 Resistance partial safety factor γ_R

Calculation model	Yielding check		Buckling check
	General	Watertight bulkhead	
Isolated beam model:			
− in general	1.02	1.02	1.10
− bottom and side girders	1.15	NA 1)	
− collision bulkhead	NA 1)	1.25	

4.6 Yielding check of structural members analyzed through an ISOLATED BEAM STRUCTURAL MODEL

4.6.1 The following requirements apply for the yielding check of structural members, which may be analyzed through an isolated beam model:

a. subjected to lateral pressure or to wheeled loads
b. for those contributing to the hull girder longitudinal strength and to hull girder normal stresses.

4.6.2 The yielding check is also to be carried out for structural members subjected to specific loads, such as concentrated loads.

4.7 Load point

4.7.1 Lateral pressure

Unless otherwise specified, lateral pressure is to be calculated at mid-span of the structural member considered.

4.7.2 Hull girder normal stresses

For longitudinal structural members contributing to the hull girder longitudinal strength, the hull girder normal stresses are to be calculated in way of the neutral axis of the structural member with attached plating.

4.8 Load model

4.8.1 General

The external pressure and the pressures induced by the various types of cargoes and ballast are to be considered, depending on the location of the structural member under consideration and the type of compartments adjacent to it, in accordance with Ch.2 Sec.3.

4.8.2 Pressure load in service conditions

The pressure load in service conditions is to be determined according to Ch 2 Sect [3.3] and Ch 2 Sec [3.7]

4.8.3 Wheeled loads

For structural members subjected to wheeled loads, the yielding check may be carried out according to [4.9] considering uniform pressures equivalent to the distribution of vertical concentrated forces, when such forces are closely located, considering the most unfavorable case.

4.8.4 Hull girder normal stresses

The hull girder normal stresses to be considered for the yielding check of structural members are to be determined according to Ch 3 Sec [7.6].

4.9 Checking criteria

4.9.1 It is to be checked that the normal stress σ and the shear stress τ are in compliance with the following formulae:

$$\sigma \le 0.98 \cdot \frac{R_{eH}}{\gamma_R}$$

$$\tau \le 0.49 \cdot \frac{R_{eH}}{\gamma_R}$$

SECTION 5 HULL STRENGTH PRINCIPLES

Contents

5.1 Symbols

B = breadth in m, defined in Ch 1 Sec 1

D = depth in m, defined in Ch 1 Sec 1

C_B = block coefficient, defined in Ch 1 Sec 1

T = draught in m, defined in Ch 1 Sec 1

R = loaded length ratio

$= \frac{L - d_{AV} - d_{AR}}{L}$, where d_{AV} and d_{AR} are parameters defined in Sec [6.2]

L = rule length in m, defined in Ch 1 Sec 1

5.2 Application

5.2.1 The following requirements apply to vessels with length up to 135 m, of types and characteristics listed hereafter:

a. self-propelled cargo carriers with machinery aft
$0.6 \le R \le 0.82$
$0.79 \le C_B < 0.95$

b. non-propelled cargo carriers
$0.8 \le R \le 0.92$
$C_B \ge 0.92$

c. passenger vessels with machinery aft
$0.79 \le C_B < 0.95$

d. service vessels with machinery amidships

5.2.2 For other vessel types or vessels of unusual design or loading sequences, a direct calculation of still water bending moment is to be carried out and submitted to INTLREG.

Direct calculation of still water bending moment is to be performed also if the actual lightship displacement shows at least 20% deviation from standard value derived from Sect [6.8] or [6.9] as applicable.

5.2.3 For cargo carriers, the cargo is assumed to be homogeneously distributed, and loading and unloading are assumed such as not to create excessive stresses.

5.3 Standard loading conditions for cargo carriers

5.3.1 Lightship

For non-propelled carriers, the vessel is assumed empty, without supplies nor ballast. For self-propelled carriers, the light standard loading conditions are:

a. supplies: 100%
b. ballast: 50%.

5.3.2 Fully loaded vessel

For non-propelled carriers, the vessel is homogeneously loaded at its maximum draught, without supplies nor ballast.

For self-propelled carriers, the vessel is homogeneously loaded at its maximum draught with 10% of supplies (without ballast).

5.4 Transitory conditions

5.4.1 General

Transitory standard conditions are listed in items [5.4.2] to [5.4.4]

For non-propelled carriers, the vessel is assumed without supplies nor ballast.

For self-propelled carriers, the vessel without ballast, is assumed to carry following amount of supplies:

a. in hogging condition: 100% of supplies
b. in sagging condition: 10% of supplies.

5.4.2 Loading/unloading in two runs

Loading and unloading are performed uniformly in two runs of almost equal masses.

For self-propelled vessels, the first loading/unloading run is carried out from the aft end of the cargo space, progressing to the fore end, the second run being performed from the fore end towards the aft end.

For non-propelled vessels, the two loading/unloading runs can be carried out from either the aft end or the fore end, progressing towards the opposite end.

5.4.3 Loading/unloading in one run

Loading and unloading are performed uniformly in one run, starting from the aft end of the cargo space, for self-propelled vessels, and from any cargo space end for non-propelled vessels.

5.4.4 Loading/unloading for liquid cargoes

Loading and unloading for liquid cargoes are assumed to be performed in two runs (refer [5.4.2]), unless otherwise specified.

5.5 Non-homogeneous loading conditions

5.5.1 General

If requested, in addition to design bending moments occurring in standard loading conditions described in Sect [5.3], the hull girder loads may be determined, by direct calculation, in any non-homogeneous loading conditions approved by the Society.

SECTION 6 DESIGN BENDING MOMENTS

Contents

6.1 Symbols

L = rule length in m, defined in Ch 1 Sec 1
B = breadth in m, defined in Ch 1 Sec 1
D = depth in m, defined in Ch 1 Sec 1
T = draught in m, defined in Ch 1 Sec 1
C_B = block coefficient, defined in Ch 1 Sec 1
M_H = design hogging bending moment in kNm
M_S = design sagging bending moment in kNm
M_{H0} = still water hogging bending moment in lightship conditions in kNm
M_{S0} = still water sagging bending moment in fully loaded conditions in kNm
M_{H1} = still water hogging bending moment while loading / unloading in one run in kNm
M_{H2} = still water hogging bending moment while loading / unloading in two runs in kNm
M_{S1} = still water sagging bending moment while loading/unloading in one run in kNm
M_{S2} = still water sagging bending moment while loading/unloading in two runs in kNm
M_C = correction value in kNm, given in section Sect [6.15], considering the deviation from standard loading conditions, light ship weight and weight distribution
M_{ad} = additional bending moment in kNm, defined in [6.14], for **IW (0.6)**, **IW (1.2)** and **IW (2)** ranges of navigation
F = loading factor
= P / P_T
P = actual cargo weight
P_T = cargo weight corresponding to the maximum vessel draught T

6.2 Definitions

6.2.1 Parameters d_{AV} and d_{AR}

d_{AV} and d_{AR} are defined as follows (refer Figure 6.2.1):

d_{AV} = distance between fore cargo hold bulkhead or fore cargo tank bulkhead and fore end (FE) in m

d_{AR} = distance between aft cargo hold bulkhead or aft cargo tank bulkhead and aft end (AE) in m

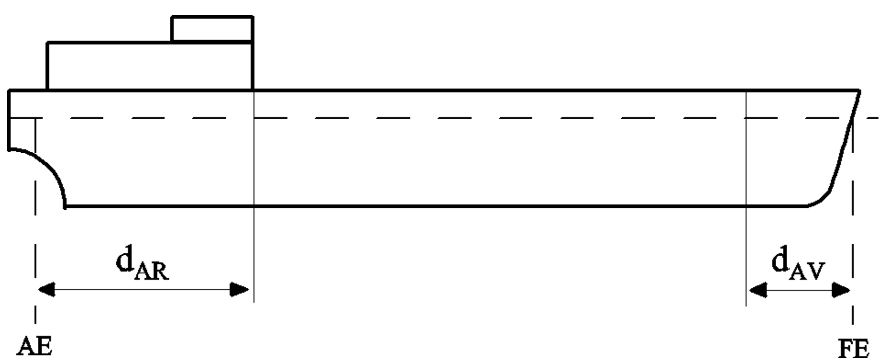


Figure 6.2.1 Parameters d_{AV} and d_{AR}

6.2.2 Loaded lengths l_1 and l_2

Loaded lengths l_1 and l_2 are parameters defined as:

$$l_1 = \frac{-k_3}{k_2} \cdot L$$

$$l_2 = \frac{-k_3}{k_4} \cdot L$$

k_2, k_3, k_4 = coefficients, defined in Table 6.2.1

Table 6.2.1 Coefficients k_i

Vessels	Conditions	k_1	k_2	k_3	k_4
Non-propelled	Hogging	0.063	0.01·L	−0.743	3.479
	Sagging	0	5	−1.213	4.736
Self-propelled	Hogging	−	3.455	−0.780	4.956
	Sagging	−	4.433	−0.870	3.735

6.2.3 Loaded lengths L_1 and L_2

Loaded lengths L_1 and L_2 are parameters defined as:

L_1 = $0.5 \cdot L - \ell_1 - d_{AV}$

L_2 = $0.5 \cdot L - \ell_2 - d_{AR}$

6.2.4 Loaded length ratios

Following coefficients are required for still water bending moment calculation:

$$R_{11} = \frac{0.5 \cdot L - d_{AV} - L_1}{L - d_{AV} - d_{AR}}$$

$$R_{12} = \frac{L_1}{0.5 \cdot L - d_{AV} - L_1}$$

$$R_{21} = \frac{0.5 \cdot L - d_{AR} - L_2}{L - d_{AV} - d_{AR}}$$

$$R_{22} = \frac{L_2}{0.5 \cdot L - d_{AR} - L_2}$$

6.3 Moment calcuation using formula for Dry cargo carriers

6.3.1 Hogging conditions

The design bending moment in hogging conditions is given by the formula:

M_H = Maximum of M_1 and M_2

M_1 = total hogging bending moment of lightship in kNm

= $M_{H0} + M_{ad} + \Sigma M_C$

M_2 = total hogging bending moment in corresponding transitory conditions:

for loading/unloading in one run:

= $M_{H1} + \Sigma M_C$

for loading/unloading in two runs:

= $M_{H2} + \Sigma M_C$

6.3.2 Sagging conditions

The design bending moment in sagging conditions is given by the formula:

M_S = maximum of M_3 and M_4

M_3 = total sagging bending moment of loaded vessel in kNm

= $M_{SO} + M_{ad} - \Sigma M_C$

M_4 = total sagging bending moment in corresponding transitory conditions:

for loading/unloading in one run:

= $M_{S1} - \Sigma M_C$

for loading/unloading in two runs:

= $M_{S2} - \Sigma M_C$

6.4 Moment calcuation using formula for Tankers

Where the loading/unloading is carried out according to Sec [5.4] for liquid cargoes:

a. the hogging design bending moment is equal to:
M_H= maximum of M_1 and M_2
with $M_2 = M_{H2} + \Sigma M_C$

b. the sagging design bending moment is equal to:
M_S = maximum of M_3 and M_4
with $M_4 = M_{S2} - \Sigma M_C$
where M_1 and M_3 are defined in [6.3.1]

6.5 Moment calcuation using formula for Other vessels

For vessels other than cargo carriers:

The hogging design bending moment is equal to: $M_H = M_{HO} + M_{ad}$

The sagging design bending moment is equal to: $M_S = M_{SO} + M_{ad}$

6.6 Design vertical shear force

The vertical design shear force in kN is to be obtained from the following formula:

$$T_s = \frac{\pi \cdot M}{L}$$

M = maximum design bending moment in kNm

= maximum of M_H and M_S

6.7 Direct calculation

6.7.1 In the case of direct calculation, all calculation documents are to be submitted to the Society.

6.7.2 Design still water bending moments

The design still water bending moments are to be determined by direct calculation for:

a. vessels of unusual type or design
b. unusual loading/unloading sequences.

The actual hull lines, lightweight distribution and the characteristics of the intended service are generally to be considered.

6.7.3 Additional bending moment

An additional bending moment considering the stream and water conditions in the navigation zone is to be considered.

This additional bending moment may be calculated according to Sec 6.14. or determined by the designer.

6.8 Still water bending moments for non-propelled cargo carriers

6.8.1 Standard light weights and weight distribution

The hull weight is assumed to be uniformly distributed over the vessel length, and in t equal to:

a. $P_0 = 0.12 \cdot L \cdot B \cdot D$ for $D < 3.7$ m

b. $P_0 = 0.10 \cdot L \cdot B \cdot D$ for $D \geq 3.7$ m.

6.8.2 Standard cargo weight and cargo distribution

The cargo is assumed to be uniformly distributed over the cargo space, and its weight in t is equal to:

$P_0 = 0.9 \cdot L \cdot B \cdot T \cdot C_B$

6.8.3 Still water bending moments

The hogging and sagging bending moments in still water conditions are to be obtained from formulae given in Table 6.13.1

Where the actual lightship weight or location of the center of gravity deviates by more than 10% with respect to the standard value, the still water bending moment is to be corrected using formulae given in table 6.15.2

See also Sec [5.2]

6.9 Still water bending moments for Self-propelled cargo carriers

6.9.1 Standard light weights and weight distribution

The formulae of still water bending moments are based on standard weights and weight distribution defined in Table 6.13.2

6.9.2 Standard cargo weight and cargo distribution

The cargo is assumed to be uniformly distributed over the cargo space, and its weight in t is equal to:

$P_0 = 0.85 \cdot L \cdot B \cdot T \cdot C_B$

6.9.3 Still water bending moments

The hogging and sagging bending moments in still water conditions are to be obtained from formulae given in Table 6.13.3

Where the weight or location of the center of gravity of a lightship component deviates by more than 10% with respect to standard value (refer Table 6.13.2), the still water bending moment is to be corrected using formulae given in Table 6.15.3.

Refer also Sec [5.2]

6.10 Still water bending moments for Passenger vessels

The values of the maximum still water bending moments in normal service conditions are to be supplied by the designer.

Where the direct calculation may not be carried out, the still water hogging bending moment in kNm for passenger vessels (other than ro-ro vessels) with machinery aft may be determined using the following formula:

$$M_{HO} = 0.273 \cdot L^2 \cdot B^{1.342} \cdot T^{0.172} \cdot (1.265 - C_B)$$

6.11 Still water bending moments for Dredgers

The values of the maximum still water bending moments in normal service conditions are to be supplied by the designer.

Where the direct calculation may not be carried out, the maximum still water bending moment is to be as required in [6.8] or [6.9] for hopper barges and hopper dredgers respectively.

6.12 Still water bending moments for Tugs and pushers

6.12.1 Application

The following requirements apply to tugs and pushers with engines arranged amidships and bunkers inside the engine room or adjoining it.

6.12.2 Still water bending moments

The values of the maximum hogging and sagging bending moments in normal service conditions are to be supplied by the designer.

Where the direct calculation may not be carried out, the still water bending moments in kNm may be determined using the following formulae:

a. still water hogging bending moment:

$$M_{H0} = 1.96 \cdot L^{1.5} \cdot B \cdot D \cdot (1 - 0.9 \cdot C_B)$$

b. still water sagging bending moment:

$$M_{S0} = 0.01 \cdot L^2 \cdot B \cdot T \cdot (\varphi_1 + \varphi_2)$$

$$\varphi_1 = 5.5 \cdot \left(0.6 \cdot (1 + C_B) - \frac{X}{L}\right)$$

$$\varphi_2 = 10 \cdot \Phi / L^2 \cdot B$$

X = length in m of the machinery space increased by the length of adjacent bunkers

Φ = total brake power of the propulsion installation in kW

6.13 Pontoons

6.13.1 The still water bending moments are to be obtained by direct calculation, according to the intended loading conditions.

Table 6.13.1 Non-propelled cargo carriers - still water bending moments

Load cases	Hogging moments in kNm	Sagging moments in kNm
Lightship	$M_{HO} = 0.62 \cdot L^2 \cdot B^{0.84} \cdot T^{0.8} \cdot (1 - C_B)$	N.A
Fully loaded vessel		$M_{SO} = 1.4 \cdot L^{0.88} \cdot B^{1.17} \cdot T^2 \cdot C_B \cdot \left[R_{11} \cdot (0.52 \cdot L - 1.84 \cdot l_1) \cdot (1 - R_{12}) + R_{21} \cdot (0.5 \cdot L - 1.23 \cdot l_2) \cdot (1 - R_{22}) \right]$

Loading and unloading in one run	$M_{H1} = M_{HO} + \left(M_{S1} - M_{SO}\right)$	$M_{S1} = 0.7 \cdot L^{0.88} \cdot B^{1.17} \cdot T^2 \cdot C_B \cdot \left[R_{11} \cdot \left(0.52 \cdot L - 1.84 \cdot l_1\right) \cdot (1 - R_{12}) + 1.15 \cdot R_{21} \cdot (0.5 \cdot L - 1.23 \cdot l_2) \right]$
Loading and unloading in two runs	$M_{H2} = M_{HO} + \left(M_{S2} - M_{SO}\right)$	$M_{S2} = 0.7 \cdot L^{0.88} \cdot B^{1.17} \cdot T^2 \cdot C_B \cdot \left[R_{11} \cdot \left(0.52 \cdot L - 1.84 \cdot l_1\right) \cdot (1 - R_{12}) + R_{21} \cdot (0.5 \cdot L - 1.23 \cdot l_2) \right]$

l_1, l_2 = parameters defined in [6.2]

R_{11}, R_{12} = coefficients defined in [6.2]

R_{21}, R_{22} = coefficients defined in [6.2]

1) In the case of partly filled barge, M_{S0} is to be substituted by M_{SF} given by the formula:

$M_{SF} = F\,(M_{H0} + M_{S0}) - M_{H0}$

Table 6.13.2 Self-propelled cargo carriers - standard weights and weight distribution

Item	Weight in t, P_0	Centre of gravity from AE in m	Location in m	
			X_1	X_2
Hull: D ≤ 3.7 m D > 3.7 m	 0.150·L·B·D 0.100·L·B·D		 0 0	 L L
Deckhouse: D ≤ 3.7 m D > 3.7 m	 0.010·L·B·D 0.006·L·B·D		 0 0	 d_{AR} d_{AR}
Machinery (main)	0.005·L·B·T	d_{AR} / 2		
Machinery Installations	0.010·L·B·T		0	d_{AR}
Piping *	0.005·L·B·T		d_{AR}	$L - d_{AV}$
Mooring gear	0.005·L·B·T	$L - d_{AV}$ / 3		
Supplies (fore) Supplies (aft)	0.005·α1·L·B·T 0.005·α1·L·B·T	$L - d_{AV}$ / 2 d_{AR} / 2		
Ballast (fore): D ≤ 3.7 m D > 3.7 m Ballast (aft): D ≤ 3.7 m D > 3.7 m	 0.010·α2·L·B·D 0.003·α2·L·B·D 0.010·α2·L·B·D 0.003·α2·L·B·D	 $L - d_{AV}$ / 2 $L - d_{AV}$ / 2 d_{AR} / 2 d_{AR} / 2		

d_{AR}, d_{AV} = parameters defined in [6.2].
α_1, α_2 = coefficients defined in Table 6.13.4
* for tankers.

Table 6.13.3 Self-propelled cargo carriers - still water bending moments		
Load cases	**Hogging moments in kNm**	**Sagging moments in kNm**
Lightship	$M_{HO} = 0.273 \cdot L^2 \cdot B^{1.342} \cdot T^{0.172} \cdot (1.265 - C_B)$ $M_{HH} = 0.344 \cdot L^2 \cdot B^{1.213} \cdot T^{0.352} \cdot (1.198 - C_B)$	$M_{HS} = 0.417 \cdot L^2 \cdot B^{1.464} \cdot (0.712 - 0.622 C_B)$
Fully loaded vessel	NA	$M_{SO} = M_{CS} - M_{HS}$ $M_{CS} = 0.4 \cdot F \cdot L^{1.86} \cdot B^{0.8} \cdot T^{0.48} \cdot (C_B - 0.47) \cdot [3.1 + R_{11} \cdot (10.68 \cdot L - 53.22 \cdot l_1) \cdot (1 - R_{12}) + R_{21} \cdot (0.17 \cdot L - 0.15 \cdot l_2) \cdot (1 - R_{22})]$
Loading and unloading in one run	$M_{H1} = M_{HH} + M_L$	$M_{S1} = 0.8 M_{SO} + M_L$
Loading and unloading in two runs	$M_{H2} = M_{HH} + 0.5 M_L$	$M_{S2} = 0.8 M_{SO} + 0.5 M_L$
M_L = $p_L(k_2\, l_3 + k_3\, L)$ k_3, k_2 = coefficients defined in table 6.2.1 $p_L = \dfrac{0.77 L_1}{L - d_{AR} - d_{AV}} F \cdot L \cdot B \cdot T \cdot C_B$		l_1, l_2 = parameters defined in [6.2] l_3 = 0.5 L -0.5 L_1 - d_{AV} L_1 = parameter defined in 6.2 R_{11}, R_{12} = coefficients defined in 6.2

Table 6.13.4 Values of coefficients α_1 and α_2		
Loading conditions	α_1	α_2
Lightship	1	0.5
Fully loaded vessel	0.1	0
Transitory conditions –hogging –sagging	 1 0.1	 0 0

6.14 Additional bending moments

6.14.1 Ranges of navigation **IW (1.2)** and **IW (2)**
For ranges of navigation **IW (1.2)** and **IW (2)**, a wave-induced bending moment, considering the significant wave height in m of the navigation area, is to be added to the still water bending moment.

The absolute value of the wave-induced bending moment amidships is to be obtained in kNm from the following formula:

M_{ad} = $0.021 \cdot n \cdot C \cdot L^2 \cdot B \cdot (C_B + 0.7)$
C = parameter, defined in Table 6.15.1
n = navigation coefficient, defined in Ch.2 Sec.[2.1]

For intermediate significant wave heights, the value of the wave-induced bending moment may be obtained by interpolation.

6.14.2 Range of navigation **IW (0.6)**

For range of navigation **IW (0.6)**, the absolute value of the additional bending moment amidships is to be obtained in kNm from the following formula:
$M_{ad} = 0.01 \cdot n \cdot C \cdot L^2 \cdot B \cdot (C_B + 0.7)$
where parameter C is defined in Table 6.15.1

6.15 Correction formulae

6.15.1 Non-propelled cargo carriers
The correction formulae applicable to non-propelled cargo carriers are given in Table 6.15.2, where values of coefficients k_1, k_2, k_3, and k_4 are defined in Table 6.2.1.

6.15.2 Self-propelled cargo carriers
The correction formulae applicable to self-propelled cargo carriers are given in Table 6.15.3, where the coefficients k_2, k_3 and k_4 are given in Table 6.2.1

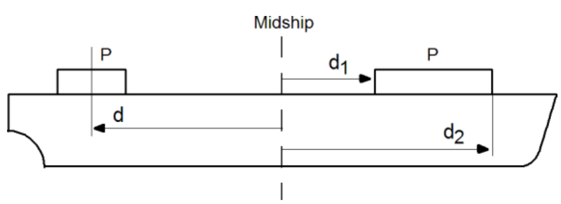


Figure 6.15.1 Definition of distances d, d_1, d_2

Table 6.15.1 Values of parameter C

Significant wave height	**C**		
	L < 60	**60 ≤ L ≤ 90**	**90 < L**
H < 1.2 m	$C = (130 - 0.36 \cdot L) \cdot \frac{L}{1000}$	C = 9.14 – 0.044·L	$C = (90 - 0.36 \cdot L) \cdot \frac{L}{1000}$
H ≥ 1.2 m	$C = (118 - 0.36 \cdot L) \cdot \frac{L}{1000}$		$C = 10.75 - \left(\frac{300 - L}{100}\right)^{1.5}$

Table 6.15.2 Non-propelled cargo carriers - correction formulae

Item	x>L/2	x≤ L/2
Concentrated weights or loads	$M_c = P\cdot(k_1\cdot d_2 + k_2\cdot d + k_3\cdot L) - P_0\cdot (k_1 d_0^2 + k_2 d_0 + k_3 L)$	$M_c = P(k_4 d + k_3 L) - P_0(k_4 d_0 + k_3 L)$
Distributed weights or loads	$M_C = M - M_0$	
Hull weight *	$M_C = (P - P_0)\cdot\begin{bmatrix}0.0416\cdot k_1\cdot L^2 + \\ L\cdot(0.125\cdot k_2 + k_3 + 0.125\cdot k_4)\end{bmatrix}$	

M = $P\cdot\left[0.33\cdot k_1\cdot\left(d_2^2 + d_2\cdot d_1 + d_1^2\right) + 0.5k_2\cdot(d_2 + d_1) + k_3 L\right]$

M_0 = $P_0\cdot\left[0.33\cdot k_1\cdot\left(d_{02}^2 + d_{02}\cdot d_{01} + d_{01}^2\right) + 0.5k_2\cdot(d_{02} + d_{01}) + k_3 L\right]$

P = actual weight or load in t
P_0 = standard weight or load in t defined in [6.8.2]
= 0, if not defined in 6.8.2
d = actual distance in m from midship of center of gravity of concentrated weights (refer figure 6.15.1):
= L / 2 – X for X ≤ L / 2
= X – L / 2 for X > L / 2
d_0 = standard distance in m from midship of center of gravity of concentrated weights ($d_0 \geq 0$)
d_1,d_2 = distances measured in m from midship defining the extent of actual distributed weight (refer fig 6.15.1)
d_{01},d_{02} = distances measured in m from midship defining the extent of standard distributed weight

* - Uniform weight distribution

Table 6.15.3 Self-propelled cargo carriers - correction formula

Item	x>L/2	x≤ L/2
Concentrated weights or loads Distributed weights or loads	$M_c = P\cdot(k_2\cdot d + k_3\cdot L) - P_0\cdot (k_2 d_0 + k_3 L)$	$M_c = P\cdot(k_4\cdot d + k_3\cdot L) - P_0\cdot (k_4 d_0 + k_3 L)$
Hull weight *	$M_C = (P - P_0)\cdot L\cdot[0.125\cdot k_2 + k_3 + 0.125\cdot k_4]$	

P = actual weight or load in t
P_0 = standard weight or load in t defined in [6.9.2]
= 0, if not defined in [6.9.2]
d = actual distance in m from midship of center of gravity of concentrated weights (refer figure 6.15.1):
= L / 2 – X for X ≤ L / 2
= X – L / 2 for X > L / 2
d_0 = standard distance in m from midship of center of gravity of concentrated weights ($d_0 \geq 0$)

* - Uniform weight distribution

SECTION 7 STRENGTH CHARACTERISTICS OF THE HULL GIRDER TRANSVERSE SECTIONS

Contents

7.1 Symbols

Z = hull girder section modulus in cm^3

M_H = design hogging bending moment in kNm

M_S = design sagging bending moment in kNm

7.2 General

7.2.1 In the following, the criteria are specified for calculating the hull girder strength characteristics to be used for the checks, in association with the hull girder loads.

7.3 Hull girder transverse sections

7.3.1 General

The hull girder transverse sections are to be considered as being constituted by the members contributing to the hull girder longitudinal strength, i.e. all continuous longitudinal members below the strength deck defined in [7.4], considering [7.3.2] to [7.3.5]

7.3.2 Longitudinal bulkheads with vertical corrugations

Longitudinal bulkheads with vertical corrugations may not be included in the hull girder transverse sections.

7.3.3 Members in materials other than steel

Where a member is made of a material other than steel, its contribution to the longitudinal strength will be determined by the Society on case-by-case basis.

7.3.4 Large openings and scallops

Large openings are:

a. in the side shell plating: openings having a diameter greater than or equal to 300 mm
b. in the strength deck: openings having a diameter greater than or equal to 350 mm.

Large openings and scallops, where scallop welding is applied, are always to be deducted from the sectional areas included in the hull girder transverse sections.

7.3.5 Lightening holes, draining holes and single scallops

Lightening holes, draining holes and single scallops in longitudinals or girders need not be deducted if their height is less than 0.25 h_W, without being greater than 75 mm, where h_W is the web height in mm.

Otherwise, the excess is to be deducted from the sectional area or to be compensated.

7.4 Strength deck

7.4.1 The strength deck is, in general, the uppermost continuous deck.

In the case of a superstructure or deckhouses contributing to the longitudinal strength, the strength deck is the deck of the superstructure or the deck of the deckhouse.

7.5 Hull girder section modulus

The section modulus at any point of a hull transverse section is obtained in cm^3 from the following formula:

$$Z = \frac{I_Y}{100|z - N|}$$

I_Y = moment of inertia in cm^4 of the hull girder transverse section defined in [7.3], about its horizontal neutral axis

N = z co-ordinate in m of the center of gravity of the hull transverse section

Z = z co-ordinate in m of the calculation point of a structural element.

7.6 Hull girder normal stresses

The normal stresses induced by vertical bending moments are obtained in N/mm^2 from the following formulae:

In hogging conditions: $\sigma_1 = \frac{M_H}{Z} \cdot 10^3$

In sagging conditions: $\sigma_1 = \frac{M_S}{Z} \cdot 10^3$

CHAPTER 4 HULL SCANTLINGS

CONTENTS

SECTION 1 GENERAL

Contents

1.1 Application

This section contains the requirements for the determination of the minimum hull scantlings applicable to the midship region (refer Ch 1 Sec [1.3]) of all types of inland waterway vessels.

1.2 Material factor

When steels with a minimum guaranteed yield stress R_{eH} other than 235 N/mm^2 are used on a vessel, the scantlings shall be determined by considering the material factor k defined as follows:

— thickness:

Refer relevant requirements of the following paragraphs

— section modulus:

$w = k \cdot w_0$

— sectional area:

$A = k \cdot A_0$

w_0, A_0 = scantlings corresponding to a steel with a minimum guaranteed yield stress R_{eH} = 235 N/mm^2

Unless otherwise specified, the material factor k is defined in Table 1.3.1, as a function of the minimum yield stress R_{eH}.

For high strength steel grades with other nominal yield stresses up to 390 N/mm^2, the material factor k may be determined by the following formula:

$$k = \frac{295}{R_{eH} + 60}$$

Steels with a yield stress lower than 235 N/mm^2 or greater than 390 N/mm^2 are considered by INTLREG on a case-by-case basis

Table 1.3.1 Material factor k

R_{eH} (N/mm^2)	k
235	1
315	0.78
355	0.72
390	0.66

1.3 Hull arrangements

1.3.1 Arrangements for hull openings

Arrangements for hull opening shall follow Ch 5 Sec 7

1.4 River chests

1.4.1 Shell plating

The shell plate gross thickness in mm in way of river chests as well as the gross thickness of all boundary walls of the river chests shall not be less than:

$$t = 1.2 \cdot s \cdot \sqrt{p \cdot k} + 1.5$$

s = width of the plate panel or stiffener spacing, respectively in m

p = pressure setting of at the safety relief valve in kN/m^2:

a. in general, $p \geq 196$ kN/m^2

b. for river chests without any compressed air connection and which are accessible at any time, p = 98 kN/m^2

1.4.2 Stiffeners

The gross section modulus in cm^3 of river chest stiffeners shall not be less than:

w = $0.58 \cdot s \cdot p \cdot l^2$
s, p = parameters defined in [1.4.1]
l = unsupported span of stiffener in m

1.5 Pipe connections at the shell plating

Scupper pipes and valves shall be connected to the shell by weld flanges. Instead of weld flanges, short- flanged sockets with an adequate thickness may be used if they are welded to the shell in an appropriate manner.

SECTION 2 BOTTOM SCANTLINGS

Contents

2.1 Symbols

L	=	rule length in m, defined in Ch 1 Sec [1.1]
B	=	breadth in m, defined in Ch 1 Sec [1.1]
D	=	depth in m, defined in Ch 1 Sec [1.1]
T	=	draught in mm, defined in Ch 1 Sec [1.1]
t	=	net thickness in mm of plating
s	=	spacing in m of ordinary stiffeners
S	=	spacing in m of primary supporting members
l	=	span in m of ordinary stiffeners or primary supporting members
n	=	navigation coefficient defined in Ch.2 Sec.2
	=	$0.85 \cdot H$
H	=	significant wave height in m
σ_1	=	hull girder normal stress in N/mm^2
β_b, β_s	=	bracket coefficients defined in Ch 3 Sect [1.17]
η	=	$1 - s / (2 \cdot \ell)$
w	=	net section modulus in cm^3 of ordinary stiffeners or primary supporting members
A_{Sh}	=	net web sectional area in cm^2
k	=	material factor defined in Ch 4 Sec [1.2]
z	=	Z co-ordinate in m of the calculation point
B_1	=	breadth in m of the hold
B_2	=	breadth in m of the side tank
M_H	=	design bending moment in kN·m in hogging condition
M_S	=	design bending moment in kN·m in sagging condition

2.2 Application

The following requirements apply to longitudinally or transversely framed single and double bottom structures of inland waterway vessels.

2.3 General arrangement

2.3.1 The bottom structure shall be designed as to withstand the loads resulting from the dry-docking of the vessel.

2.3.2 The bottom shall be locally stiffened where concentrated loads are envisaged.

2.3.3 In general, girders or floors shall be fitted under each line of pillars.

2.3.4 Adequate continuity shall be provided in the case of height variation in the double bottom.

2.3.5 Provision shall be made for the free passage of water from all parts of the bottom to the suctions.

2.4 Keel

Vessels having a rise of floor shall be fitted with a keel plate of about 0.1 · B in width, with a thickness equal to 1.15 times the bottom plating thickness.
In the case there is no rise of floor, the keel plate thickness shall be not less than the bottom plating thickness.

2.5 Bilge

2.5.1 Radius

Where the bilge plating is rounded, the radius of curvature is not to be less than 20 times the thickness of the plating.

2.5.2 Extension

The bilge shall extend at least 100 mm on either side of the rounded part and 150 mm above the floor upper edge.

2.5.3 On tank vessels for oil and/or chemicals wear plates in form of doubling plates are not permitted to be attached to the bilge plating within the cargo area, i.e. between the aft most and the foremost cofferdam bulkhead.

2.5.4 Drainage and openings for air passage

Drainage openings shall be provided in floors and girders to ensure the free passage of air and liquids from all parts of the double bottom.

2.6 Bottom, inner bottom and bilge plating

2.6.1 In the central part, the bottom and inner bottom plating net thickness in mm are not to be less than the values given in Table 2.6.1

2.6.2 Rounded bilge

The bilge plating net thickness in mm shall be not less than the following values, where t_0 is the bottom plating net thickness in mm:

a. in the case of a bilge radius practically equal to the floor depth or bottom transverse depth:

$$t = 1.15 \cdot t_0$$

b. in the case of a bilge radius less than the floor depth or bottom transverse depth but greater than 20 times the bottom plating thickness:

$$t = 1.15 \cdot t_0 + 1$$

Table 2.6.1 Bottom and inner bottom plating net thickness in mm

Item	Transverse framing	Longitudinal framing
	t = largest of t_1, t_2 and t_3 $t_1 = 1.85 + 0.03 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.6 \cdot s \cdot \sqrt{k \cdot p}$	t = largest of t_1, t_2 and t_3 $t_1 = 1.1 + 0.03 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.2 \cdot s \cdot \sqrt{k \cdot p}$
	$t_3 = 68 \cdot \frac{s}{k_2} \sqrt{\frac{M_H}{Z_B}}$	$t_3 = 39 \cdot s \cdot \sqrt{\frac{M_H}{Z_B}}$

Bottom plating	if $t_3 / s > \dfrac{22}{\sqrt{k} \cdot k_2}$:	if $t_3 / s > \dfrac{12.5}{\sqrt{k}}$
	$t_3 = \dfrac{7.1 \cdot \sqrt{k} \cdot s}{k_2 \cdot \sqrt{0.21 - \dfrac{M_H}{Z_B}}}$	$t_3 = \dfrac{4.1 \cdot \sqrt{k} \cdot s}{\sqrt{0.21 - \dfrac{M_H}{Z_B}}}$
	see 1)	see 1)
	t = largest of t_1, t_2 and t_3 $t_1 = 1.5 + 0.016 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.6 \cdot s \cdot \sqrt{k \cdot p}$	t = largest of t_1, t_2 and t_3 $t_1 = 1.5 + 0.016 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.2 \cdot s \cdot \sqrt{k \cdot p}$
Inner bottom plating	$t_3 = 68 \cdot \dfrac{s}{k_2} \sqrt{\dfrac{M_H}{Z_B}}$	$t_3 = 39 \cdot s \cdot \sqrt{\dfrac{M_H}{Z_B}}$
	see 1)	see 1)

p = design load in kN/m^2

a. in way of ballast tanks:

p = maximum of p_E and p_B-p_M for bottom plating
= maximum of p_C and p_B for inner bottom plating

b. elsewhere

p = p_E for bottom plating
= p_C for inner bottom plating

p_M = minimum external pressure in kN/m^2, $p_M \geq 0$:

= $9.81 \cdot (0.15 \cdot T - 0.6 \cdot n)$

p_E, p_C, p_B = pressures transmitted to the hull structure defined in Ch 2 Sect [3.7]and Ch 2 Sect[3.8]

k_2 = $1 + \alpha^2$
α = b_2 / b_1

b_1 = unsupported plate width in y direction in m
b_2 = unsupported plate width in x direction in m
Z_B = bottom net hull girder section modulus in cm^3
Z_{DB} = inner bottom net hull girder section modulus in cm^3

1) A lower value of thickness t_3 may be accepted if in compliance with the buckling analysis carried out according to Ch 3 Sec 2

2.6.3 Square bilge

In the case of a square bilge with chine bars (sketches a, b, c of Figure 2.6.1), the net scantling of the chine bar shall be determined as follows:

a. angle bars

The net thickness of the bars plating in mm shall be not less than the following formulae, where t_0 is the bottom plating net thickness:

b. angle bars inside the hull:

$t = t_0 + 2$

c. other cases:

$t = t_0 + 3$

d. round bars and square bars

The diameter of the round bars or the side of the square bars shall be not less than 30 mm.

In the case of a double chine bilge without chine bars (sketch d of Figure 2.6.1):

The thickness of the doublers in mm, shall be not less than:

$t = t_0 + 3$

where t_0 is the bottom plating thickness.

In the case of a double chine bilge with round chine bars (sketch e of Figure 2.6.1):

The diameter of the round bars shall be not less than 30 mm. The thickness of the plating is equal to the bottom plating thickness.

2.6.4 Bilge plate thickness reduction

Forward of the forward shoulder and aft of the aft shoulder, the bilge plate thicknesses according to [2.6.2] and [2.6.3] may be reduced to the bottom plate thickness according to Ch 5 Sec 1, Sec 2 and Sec.3 and Sec.4 respectively.

2.6.5 Strength check in testing conditions

Plating of compartments or structures to be checked in testing conditions shall comply with Ch 3 Sec 3.

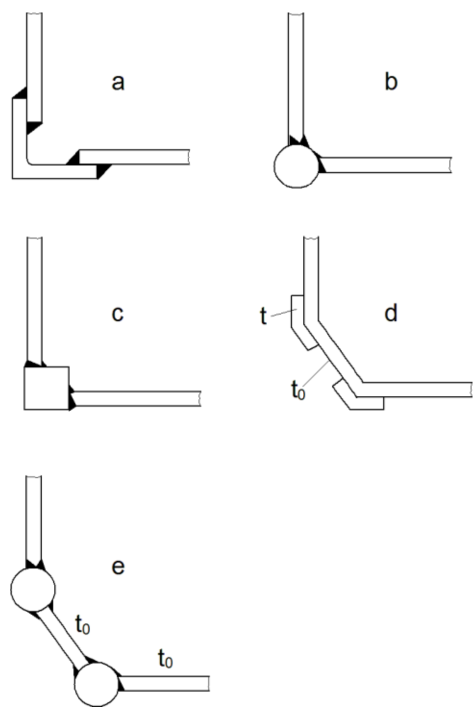


Figure 2.6.1 Square bilge

2.7 Bottom and inner bottom structures

2.7.1 Minimum net thickness of web plating

The net thickness in mm of the web plating of ordinary stiffeners shall be not less than:

$t = 1.63 + 0.004 \cdot L \cdot \sqrt{k} + 4.5 \cdot s$ for $L < 120$ m

$= 3.9 \cdot \sqrt{k} + s$ for $L \geq 120$ m

The net thickness in mm of plating which forms the web of primary supporting members shall be not less than the value obtained from the following formula:

$t = 3.8 + 0.016 \cdot L \cdot \sqrt{k}$

2.7.2 Net scantlings of bottom and inner bottom structural members in service conditions

The net scantlings of bottom and inner bottom structural members in service conditions shall be obtained from Table 2.8.1 for single bottom structure and Table 2.8.2 for double bottom structure.

2.7.3 Net scantlings of bottom and inner bottom structural members in testing conditions

The net scantlings of bottom and inner bottom structural members being part of compartments or structures containing liquid shall comply with Ch 3 Sec 3.

2.7.4 Buckling check

Bottom and inner bottom structural members shall comply with the requirements stated under Ch 3 Sec 2.

2.8 Transversely framed single bottom

2.8.1 Floors

Floors shall not be connected to the bottom shell plating by means of a flange.

Floors shall be fitted at every frame.

2.8.2 Minimum shear sectional area of floors

In the region where the shear force is maximum, the minimum shear sectional area A_{sh} of floors in cm^2 shall not be taken less than the value given in Table 2.8.1.

INTLREG may waive this rule subject to direct calculation of the shearing stresses.

2.8.3 Floor height

The ratio of the floor height to the web net thickness shall be not more than r_T values, given in Table 2.8.3

In the case of vessels with considerable rise of floor, this height may be required to be increased to assure a satisfactory connection to the frames.

2.8.4 Girders

- Center girder

  All single bottom vessels shall have a center girder. INTLREG may waive this requirement for vessels with breadth B_F measured on the top of floors less than 6 m, where the floor is a rolled section or for other special arrangements based on a case-by-case consideration.

The web depth of the center girder shall extend to the floor plate upper edge. The web thickness is not to be less than that of the floor plates.

Centre girder shall be fitted with a face plate, a flat or a flange, the net sectional area of which in cm^2 is not to be less than:

$$A_f = 0.764 \cdot B + 3.3$$

- Side girders

Depending on the breadth B_F measured on the top of floors, side girders shall be fitted in compliance with the following:

a. $B_F \leq 6$ m: no side girder
b. 6 m < $B_F \leq 9$ m: one side girder at each side
c. $B_F > 9$ m: two side girders at each side.

Side girders shall be fitted with a face plate, a flat or a flange, the net sectional area of which is not to be less than that of the floor plate.

Table 2.8.1 Net scantlings of single bottom structure

Item	w in cm^3	A_{sh} in cm^2
Bottom longitudinals	$w = \dfrac{83.3}{214-\sigma_1}\beta_b \cdot \eta \cdot p_E \cdot s \cdot l^2$	$A_{sh} = 0.045 \cdot \beta_s \cdot \eta \cdot p_E \cdot s \cdot \ell$
Floors 1), 2)	$w = 0.58 \cdot \beta_b \cdot p_{\gamma E} \cdot s \cdot \ell^2$	$A_{sh} = 0.045 \cdot \beta_s \cdot p_{\gamma E} \cdot s \cdot \ell$
Bottom transverses 2)	$w = 0.58 \cdot \beta_b \cdot p_{\gamma E} \cdot S \cdot \ell^2$	$A_{sh} = 0.045 \cdot \beta_s \cdot p_{\gamma E} \cdot S \cdot \ell$

Item	w in cm^3	A_{sh} in cm^2
Bottom center and side girders 3)	$w = \dfrac{125}{197-\sigma_1}\beta_b \cdot \eta \cdot p_{\gamma E} \cdot S \cdot l^2$	$A_{sh} = 0.056 \cdot \beta_s \cdot p_{\gamma E} \cdot S \cdot \ell$

p_E = design load in kN/m^2 defined in Ch 2 Sec 3.7.1

$p_{\gamma E}$ = design load in kN/m^2 of bottom primary supporting members
= $9.81 (\gamma \cdot T + 0.6 \cdot n)$

γ = loading sequence coefficient
= 1 for loading/unloading in one run
= 0.575 for loading/unloading in two runs

1) In way of side ordinary frames: $\beta_b = \beta_S = 1$
2) Scantlings of floors and bottom transverses have to be adequate to those of web frames or side transverses connected to them.
3) The span ℓ shall be taken equal to the web frames / side transverses spacing.

Table 2.8.2 Net scantlings of double bottom structure

Item	**Parameter**	**Transverse framing**	**Longitudinal framing**
Floors in the hold 1)	section modulus in cm^3	w = largest of w_1 and w_2 $w_1 = 0.58 \cdot \beta_b \cdot p_1 \cdot s \cdot \ell^2$ $w_2 = 0.58 \cdot \beta_b \cdot p_{\gamma l} \cdot s \cdot (\ell^2 - 4 \cdot B_2^2)$	NA
	thickness in mm	t = largest of t_1 and t_2 $t_1 = 3.8 + 0.016 \cdot L \cdot \sqrt{k}$ $t_2 = d / r_T$	NA
	shear sectional area in cm^2	A_{sh} = largest of A_1 and A_2 $A_1 = 0.067 \cdot \beta_s \cdot p_1 \cdot s \cdot \ell$ $A_2 = 0.067 \cdot \beta_s \cdot p_{\gamma l} \cdot s \cdot (\ell - 2 \cdot B_2)$	NA
Floors in the side tank 1)	section modulus in cm^3	w = largest of w_1 and w_2 $w_1 = 2.32 \cdot \beta_b \cdot p_1 \cdot s \cdot B_2 \cdot (\ell - B_2)$ $w_2 = 2.32 \cdot \beta_b \cdot p_{\gamma l} \cdot s \cdot B_2 \cdot (\ell - 2 \cdot B_2)$	NA
	shear sectional area in cm^2	A_{sh} = largest of A_1 and A_2 $A_1 = 0.067 \cdot \beta_s \cdot p_1 \cdot S \cdot \ell$ $A_2 = 0.067 \cdot \beta_s \cdot p_{\gamma l} \cdot S \cdot (\ell - 2 \cdot B_2)$	NA
Bottom and inner bottom longitudinals	section modulus in cm^3	NA	$w = \frac{83.3}{214 - \sigma_1} \cdot \beta_b \cdot \eta \cdot p_2 \cdot s \cdot l^2$
	shear sectional area in cm^2	NA	$A_{sh} = 0.045 \cdot \beta_s \cdot \eta \cdot p_2 \cdot s \cdot \ell$
Item	Parameter	Transverse framing	Longitudinal framing
Bottom transverses in the hold	section modulus in cm^3	NA	w = largest of w_1 and w_2 $w_1 = 0.58 \cdot \beta_b \cdot p_1 \cdot S \cdot \ell^2$ $w_2 = 0.58 \cdot \beta_b \cdot p_{\gamma l} \cdot S \cdot (\ell^2 - 4 \cdot B_2^2)$
	thickness in mm	NA	t = largest of t_1 and t_2 $t_1 = 3.8 + 0.016 \cdot L \cdot \sqrt{k}$ $t_2 = d / r_T$

	shear sectional area in cm^2	NA	A_{sh} = largest of A_1 and A_2 $A_1 = 0.067 \cdot \beta_s \cdot p_1 \cdot s \cdot \ell$ $A_2 = 0.067 \cdot \beta_s \cdot p_{\gamma I} \cdot s \cdot (\ell - 2 \cdot B_2)$
Bottom transverses in the side tank	section modulus in cm^3	NA	w = largest of w_1 and w_2 $w_1 = 2.32 \cdot \beta_b \cdot p_1 \cdot s \cdot B_2 \cdot (\ell - B_2)$ $w_2 = 2.32 \cdot \beta_b \cdot p_{\gamma I} \cdot s \cdot B_2 \cdot (\ell - 2 \cdot B_2)$
	shear sectional area in cm^2	NA	A_{sh} = largest of A_1 and A_2 $A_1 = 0.067 \cdot \beta_s \cdot p_1 \cdot s \cdot \ell$ $A_2 = 0.067 \cdot \beta_s \cdot p_{\gamma I} \cdot s \cdot (\ell - 2 \cdot B_2)$
Bottom center and side girders 2)	shear sectional area in cm^2	$A_{sh} = 0.051 \cdot \beta_s \cdot p \cdot S \cdot \ell$	

p = design load of primary supporting members in kN/m^2

= largest of p_1 and $p_{\gamma I}$

p_1 = $p_{\gamma E}$

p_2 = design load of bottom and inner bottom longitudinals in kN/m^2:

a. in way of ballast tanks:
- for bottom longitudinals: p_2 = largest of p_E and $(p_B - p_M)$
- for inner bottom longitudinals: p_2 = largest of p_C and p_B

b. elsewhere:
- for bottom longitudinals: $p_2 = p_E$
- for inner bottom longitudinals: $p_2 = p_C$

p_M = minimum external pressure in kN/m^2, $p_M \geq 0$:

$= 9.81 \cdot (0.15 \cdot T - 0.6 \cdot n)$

$p_{\gamma E}$ = external pressure in kN/m^2 taking into account the loading sequence:

$= 9.81 \cdot (\gamma \cdot T + 0.6 \cdot n)$

γ = loading sequence coefficient:

= 1 for loading/unloading in one run

= 0.575 for loading/unloading in two runs

$p_{\gamma I}$ = internal load in kN/m^2 taking into account the loading sequence

	$= \gamma_1 \cdot p_C - p_M$
γ_1	$= (\gamma - 0.15) / 0.85$
d	= double bottom height in mm
r_T, r_L	= coefficients defined in table 2.8.3

p_E; p_B; p_C = pressures transmitted to the hull structure defined in Ch 2 Sect [3.7] and Ch 2 Sect [3.8]

1) In way of side ordinary frames: $\beta_b = \beta_S = 1$
2) The span ℓ shall be taken equal to the web frames or side transverses spacing

NA = not applicable

Table 2.8.3 Values of coefficients r_T (transverse framing) and r_L (longitudinal framing)

Cargo	r_T	r_L
Uniform	100	90
Non-uniform	90	80

Center and side girders shall be extended as far aft and forward as practicable. Intercostal web plates shall be aligned and welded to floors.

Where two girders are slightly offset, they shall be shifted over a length at least equal to two frame spacings.

Towards the ends, the thickness of the web plate as well as the sectional area of the top plate may be reduced by 10 %. Lightening holes shall be avoided.

Where side girders are fitted in lieu of the center girder, the scarfing shall be adequately extended, and additional stiffening of the center bottom may be required.

2.9 Longitudinally framed single bottom

2.9.1 Bottom transverses

In general, the transverse spacing shall be not greater than 8 frame spacings or 4m, whichever is the lesser.

2.9.2 Minimum shear sectional area of bottom transverses

In the region where the shear force is maximum and taking into account the possible cuttings provided for the longitudinals, the minimum shear sectional area A_{sh} of bottom transverses in cm^2 shall be not less than the value given in Table 2.8.1

INTLREG may waive this rule subject to direct calculation of the shearing stresses.

2.9.3 Bottom transverse height

The ratio of the bottom transverse height to the web net thickness shall be not more than r_L values, given in Table 2.8.3

In the case of vessels with considerable rise of floor, this height may be required to be increased to assure a satisfactory connection to the side transverses.

2.9.4 Girders

The requirements in [2.8.4] apply also to longitudinally framed single bottoms, with transverses instead of floors.

2.9.5 Bottom longitudinals

Longitudinal ordinary stiffeners are generally to be continuous when crossing primary supporting members.

2.9.6 Strengthening

The section modulus of longitudinals located in way of the web frames of transverse bulkheads shall be increased by 10%.

The Society may require strengthening of the longitudinal located in the centerline of the vessel.

2.10 Transversely framed double bottom

2.10.1 Double bottom arrangement

Where it is not possible to access double bottoms, they shall be well protected against corrosion.

Where the height of the double bottom varies, the variation is generally to be made gradually and over an adequate length; the knuckles of inner bottom plating shall be in way of plate floors or girders.

Where this is impossible, suitable structures such as partial girders, brackets, etc., fitted across the knuckle, shall be arranged.

In vessels without a flat bottom, the height of double bottom specified in this section may be required to be adequately increased such as to ensure sufficient access to the areas towards the sides.

2.10.2 Strength continuity

Adequate strength continuity of floors shall be ensured in way of the side tank by means of brackets.

2.10.3 Floors

Spacing:

Floors shall be fitted at every frame. Watertight floors shall be fitted:

a. in way of transverse watertight bulkheads
b. in way of double bottom steps

In general, floors shall be continuous.

In the region where the shear force is maximum, the minimum shear sectional area A_{sh} of floors in cm^2 shall be not less than the value given in Table 2.8.2

The Society may waive this rule subject to direct calculation of the shearing stresses.

Where the double bottom height does not make it possible to connect the floors and girders to the double bottom top by fillet welding, slot welding may be used. In that case, the floors and girders shall be fitted with a faceplate or flange.

2.10.4 Bilge wells

Bilge wells arranged in the double bottom shall be limited in depth and formed by steel plates having a thickness not less than the greater of that required for watertight floors and that required for the inner bottom.

In vessels subject to stability requirements, such bilge wells shall be fitted so that the distance of their bottom from the shell plating is not less than 400 mm.

2.10.5 Girders

A center girder shall be fitted on all vessels exceeding 6 m in breadth.

This girder shall be formed by a vertical intercostal plate connected to the bottom plating and fitted with an appropriate face plate.

The intercostal center girder shall extend over the full length of the vessel or over the greatest length accordant with the lines. It shall have the same thickness as the floors. No manholes shall be provided in the center girder.

On vessels with ranges of navigation **IW (1.2)** to **IW (2)**, continuous or intercostal girders shall be fitted in the extension of the inner sides. These girders shall have a net thickness equal to that of the inner sides.

On vessels with ranges of navigation **IW (1.2)** to **IW (2)**, built in the transverse system and without web frames, partial intercostal girders shall be fitted in way of the transverse bulkheads of the side tanks. These girders shall be extended at each end by brackets having a length equal to one frame spacing. They shall have a net thickness equal to that of the inner sides.

2.11 Longitudinally framed double bottom

2.11.1 The requirements in [2.10.1], [2.10.3] and [2.10.4] are also applicable to longitudinally framed double bottoms.

2.11.2 Transverses

The spacing of transverses in m is generally to be not greater than 8 frame spacings or 4m, whichever is the lesser.

Additional transverses shall be fitted in way of transverse watertight bulkheads.

2.11.3 Bottom and inner bottom longitudinal ordinary stiffeners

Bottom and inner bottom longitudinal ordinary stiffeners are generally to be continuous through the transverses.

In the case the longitudinals are interrupted in way of a transverse, fully aligned brackets shall be fitted on both sides of the transverse.

- Strut:

  Bottom longitudinals may be connected to the inner bottom longitudinals by means of struts having a sectional area not less than those of the connected longitudinals.

  Struts are generally to be connected to bottom and inner bottom longitudinals by means of brackets or by appropriate weld sections.

  Where struts are fitted between bottom and inner bottom longitudinals at mid-span, the section modulus of bottom longitudinals and inner bottom longitudinals may be reduced by 30 %.

2.11.4 Brackets to centerline girder

In general, intermediate brackets shall be fitted connecting the center girder to the nearest bottom and inner bottom ordinary stiffeners.

Such brackets shall be stiffened at the edge with a flange having a width not less than 1/10 of the local double bottom height.

If necessary, a welded flat bar may be required to be arranged in lieu of the flange.

SECTION 3 SIDE SCANTLINGS

Contents

3.1 Symbols

L	=	rule length in m, defined in Ch 1 Sec 1.1
B	=	breadth in m, defined in Ch 1 Sec 1.1
D	=	depth in m, defined in Ch 1 Sec 1.1
T	=	draught in mm, defined in Ch 1 Sec 1.1
t	=	net thickness in mm of plating
s	=	spacing in m of ordinary stiffeners
S	=	spacing in m of primary supporting members
l	=	span in m of ordinary stiffeners or primary supporting members
n	=	navigation coefficient defined in Ch.2 Sec.2
	=	$0.85 \cdot H$
H	=	significant wave height in m
σ_1	=	hull girder normal stress in N/mm^2
β_b, β_s	=	bracket coefficients defined in Ch 3 Sec [1.17]
η	=	$1 - s / (2 \cdot \ell)$
w	=	net section modulus in cm^3 of ordinary stiffeners or primary supporting members
A_{Sh}	=	net web sectional area in cm^2
k	=	material factor defined in Ch 4 Sec [1.2]
z	=	Z co-ordinate in m of the calculation point
H_F	=	floor height in way of vertical side stiffener in m 0, in way of side web frames and side transverses

3.2 Application

3.2.1 The following requirements apply to longitudinally or transversely framed single and double side structures of inland waterway vessels.

3.2.2 The transversely framed side structures shall be built with transverse frames possibly supported by struts, side stringers and web frames.

3.2.3 The longitudinally framed side structures are built with longitudinal ordinary stiffeners supported by side vertical primary supporting members.

3.3 Scantlings

3.3.1 Side and inner side plating

In the central part, the side and inner side plating net thickness in mm shall not be less than the values given in Table 3.4.1

- Strength check in testing conditions

  The plating of compartments or structures to be checked in testing conditions shall comply with Ch 3 Sec 3

3.3.2 Side and inner side structure

- Minimum net thickness of web plating:

  The net thickness of the web plating of ordinary stiffeners shall be not less than:

  $t = 1.63 + 0.004 \cdot L \cdot \sqrt{k} + 4.5 \cdot s$ for L < 120 m

  $t = 3.9 \cdot \sqrt{k} + s$ for L ≥ 120 m

  The minimum net thickness in mm of plating which forms the web of side and inner side primary supporting members shall be not less than the value obtained from the formula:

  $t = 3.8 + 0.016 \cdot L \cdot \sqrt{k}$

- Net scantlings of side and inner side structural members in service conditions:

  The net scantlings of side and inner side structural members in service conditions shall comply with Table 3.4.2 or Table 3.5.1, as applicable.

- Net scantlings of side and inner side structural members in testing conditions:

  The net section modulus w in cm^3 and the net shear sectional area A_{sh} in cm^2 of side and inner side structural members being part of compartments or structures containing liquid shall comply with Ch 3 Sec 3.

- Buckling check:

  Side and inner side structural members shall comply with the requirements stated under of Ch 3 Sec 2.

3.4 Transversely framed single side

3.4.1 Side frames

Transverse frames shall be fitted at every frame.

Frames are generally to be continuous when crossing primary supporting members.

Otherwise, the detail of the connection shall be examined by the Society on a case-by-case basis.

- Connection with floors:

  The frames shall be connected to the floors in accordance with Figure 3.4.1, or in an equivalent way. For overlapping connection as to Figure 3.4.1 b) and c), a fillet weld run all around shall be provided.

- Connection with deck structure:

  At the upper end of frames, connecting brackets shall be provided, in compliance with 3.8. On single hull open deck vessels, such brackets shall extend to the hatch coaming.

  For the case of longitudinally framed deck, connecting brackets shall extend to the outermost deck longitudinal and, as applicable to:

  a. the hatch coaming, in general
  b. the side trunk bulkhead, in the case of a trunk vessel.

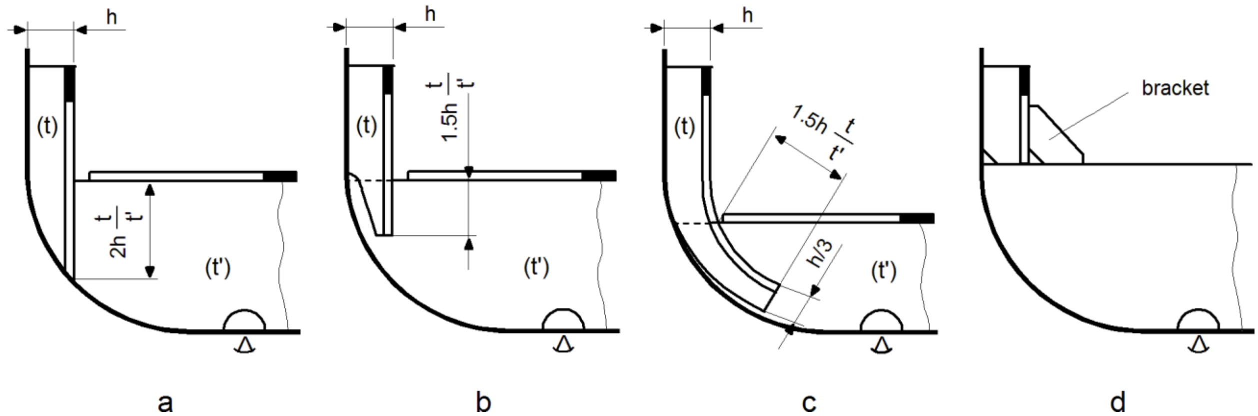


Figure 3.4.1 Connection with floors

Table 3.4.1 Side and inner side plating net thickness in mm

Item	Transverse framing	Longitudinal framing
Side plating	t = largest of t_1, t_2 and t_3 $t_1 = 1.68 + 0.025 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.6 \cdot s \cdot \sqrt{k \cdot p}$ $t_3 = k_1 \cdot t_0$	t = largest of t_1, t_2 and t_3 $t_1 = 1.25 + 0.02 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.2 \cdot s \cdot \sqrt{k \cdot p}$ $t_3 = k_1 \cdot t_0$
Inner side plating	t = largest of t_1 and t_2 $t_1 = 2.2 + 0.013 \cdot L \cdot k^{0.5} + 3.6 \cdot s$ $t_2 = 1.6 \cdot s \cdot \sqrt{k \cdot p}$	t = largest of t_1 and t_2 $t_1 = 2.2 + 0.013 \cdot L \cdot k^{0.5} + 3.6 \cdot s$ $t_2 = 1.2 \cdot s \cdot \sqrt{k \cdot p}$

p = design load in kN/m^2

a. in way of ballast tanks:

- for side plating: p = largest of p_E and ($p_B - p_M$)
- for inner side plating: p = largest of p_C and p_B

b. elsewhere:

- for side plating: $p = p_E$
- for inner side plating: $p = p_C$

p_M = minimum external load in kN/m^2, $p_M \geq 0$:

= $9.81 \cdot (0.15 \cdot T - 0.6 \cdot n)$ for $z \leq 0.15$

= 0 for z >0.15

t_0 = t_{bottom}

k_1 = 0.85 if transversely framed bottom

= 0.90 if longitudinally framed bottom

p_E; p_B; p_C = pressures transmitted to the hull structure defined in Ch 2 Sec [3.7], Ch2 Sec [3.10]-[3.14]

- Reduction of section modulus

  When a side stringer is fitted at about mid-span of the frame, the required section modulus of the frame may be reduced by 20 %.

- Single bottom: connection of frames to bottom longitudinals

  In the case of a longitudinally framed single bottom, the side frames shall be connected to the outermost bottom longitudinal, either directly or by means of a bracket, in accordance with Figure 3.4.2.

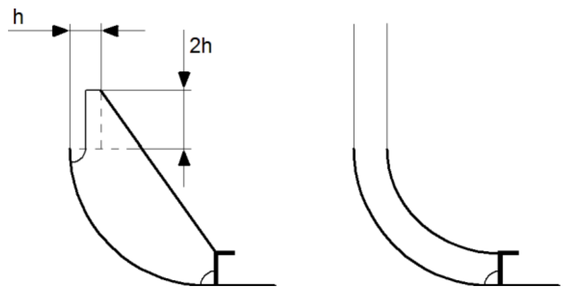


Figure 3.4.2 Connection of frames to bottom longitudinals

Table 3.4.2 Net scantlings of side single hull structure

Item	w in cm³	Ash in cm²
Side frames	$w = 0.58 \cdot \beta_b \cdot \eta \cdot s \cdot \left(1.2 \cdot k_0 \cdot p \cdot l_0^{\,2} + l_t \cdot p_{\gamma E} \cdot l_F^2\right)$	$A_{sh} = 0.08 \cdot \beta_s \cdot \eta \cdot k_0 \cdot p \cdot s \cdot \ell_0$
Side longitudinals	$w = \dfrac{83.3}{214 - \sigma_1} \beta_b \cdot \eta \cdot p \cdot s \cdot l^2$	$A_{sh} = 0.045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Side web frames Side transverses 1)	$w = 1.96 \cdot \beta_b \cdot k_0 \cdot p \cdot S \cdot l_0^{\,2}$	$A_{sh} = 0.063 \cdot \beta_s \cdot k0 \cdot p \cdot S \cdot \ell_0$
Side stringers 2)	$w = \dfrac{125}{197 - \sigma_1} \beta_b \cdot p \cdot s \cdot l^2$	$A_{sh} = 0.056 \cdot \beta_s \cdot p \cdot S \cdot \ell$

H_F = floor height or bottom transverse height in m

p = design load of side structural members in kN/m²: $p = p_E$

ℓ_F = floor span in m

ℓ_0 = $T - H_F + 0.6 \cdot n$

k_0 = coefficient given by the formula:

= $1 + (\ell - \ell_0) / \ell_0$

λ_t =coefficient to be taken equal to:

- in transverse framing:

$$\lambda_t = 0.1\left(0.8 - \frac{l^2}{l_F^2}\right) \geq 0$$

- in combination framing:

= 0

pE = external pressure transmitted to the hull structure

- in general:

p_E shall be determined in compliance with Ch 2. Sec 3.7

- for vertical stiffeners:

= 4.9 · ℓ0

$p_{\gamma E}$ = floor external load in kN/m^2 considering the loading sequence:

= 9.81 · (γ · T + 0.6 · n)

γ = loading sequence coefficient:

= 1.0 for loading/unloading in one run

= 0.575 for loading/unloading in two runs.

1) Scantlings of web frames and side transverses at the lower end have to be adequate to those of floors or bottom transverses connected to them.

2) The span of side stringers shall be taken equal to the side transverses spacing or web frames spacing.

3.4.2 Side stringers

Side stringers, if fitted, shall be flanged or stiffened by a welded face plate.

The side stringers shall be connected to the frames by welds, either directly or by means of collar plates.

3.4.3 Web frames

Web frames shall be fitted with a spacing in m not greater than 5 m.

For a construction with a combined system, side web frames shall be provided in way of bottom transverses.

- End connections:

  Where web frames are connected to floors or strong beams, web frame strength continuity shall be ensured, according to Ch 3 Sec [1.13]

- End connection in the case of a trunk deck:

  For vessels fitted with a trunk having a breadth greater than 0.8 · B, the web frames shall extend up to the level of the trunk deck where they shall be connected to strong beams.

3.5 Longitudinally framed single side

3.5.1 Side transverses

Side transverses shall be fitted:

a. in general, with a spacing not greater than 8 frame spacings or 4m, whichever is the lesser.
b. in way of hatch end beams

The side transverses shall be directly welded to the shell plating. In the case of a double bottom, the side transverses shall be connected to the bottom transverses by brackets.

- Minimum shear sectional area of transverse web

  In the region where the shear force is maximum and taking into account the possible cuttings provided for the longitudinals, the minimum shear sectional area of a transverse web in cm^2 shall be not less than the value given in Table 3.5.1.

  INTLREG may waive this rule subject to direct calculation of the shearing stresses.

3.5.2 Side longitudinals

Longitudinal ordinary stiffeners are generally to be continuous when crossing primary supporting members.

In the case the longitudinals are interrupted by a primary supporting member, fully aligned brackets shall be fitted on both sides of the primary supporting member.

The section modulus of side longitudinals located in way of transverse bulkhead stringers shall be increased by 20 %.

Table 3.5.1 Net scantlings of side double hull structure

Item	W in cm^3	A_{sh} in cm^2
Side frames subjected to external load	$w = 0.7 \cdot \beta_b \cdot \eta_1 \cdot k_0 \cdot p \cdot s \cdot \ell_0^2$	$A_{sh} = 0.08 \cdot \beta_s \cdot \eta_1 \cdot k_0 \cdot p \cdot s \cdot \ell_0$
Side frames and Inner side frames in other loading cases	$w = 0.58 \cdot \ell_b \cdot \beta_b \cdot \eta_1 \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0.058 \cdot \ell_s \cdot \beta_s \cdot \eta_1 \cdot p \cdot s \cdot \ell$
Side longitudinals and Inner side longitudinals	$w = \frac{83.3}{214 - \sigma_1} \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot l^2$	$A_{sh} = 0.045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Side web frames and Side transverses subjected to external load	$w = 0.7 \cdot \beta_b \cdot k_0 \cdot p \cdot S \cdot \ell_0^2$	$A_{sh} = 0.063 \cdot \beta_s \cdot k_0 \cdot p \cdot S \cdot \ell_0$
Side and inner side web frames and Side and inner side transverses in other loading cases	$w = 0.58 \cdot \lambda_b \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0.045 \cdot \ell_s \cdot \beta_s \cdot p \cdot S \cdot \ell$
Plate web frames subjected to external load	$w = 1.96 \cdot \beta_b \cdot k_0 \cdot p \cdot S \cdot \ell_0^2$	$A_{sh} = 0.063 \cdot \beta_s \cdot k_0 \cdot p \cdot S \cdot \ell_0$
Plate web frames in other loading cases	$w = 1.63 \cdot \lambda_b \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0.045 \cdot \ell_s \cdot \beta_s \cdot p \cdot S \cdot \ell$
Side stringers and Inner side stringers [1)]	$w = \frac{125}{197 - \sigma_1} \cdot \beta_b \cdot p \cdot S \cdot l^2$	$A_{sh} = 0.056 \cdot \beta_s \cdot p \cdot S \cdot \ell$

η_1 = 1 if no side web frames are fitted

= η otherwise

p = design load of double side structural members in kN/m^2:

a. in way of ballast tanks:

for side plating: p = largest of p_E and ($p_B - p_M$)

for inner side plating: p = largest of p_C and p_B

b. elsewhere:

for side structure: p = p_E

for inner side structure: p = p_C

H_F = floor height or bottom transverse height in m

ℓ_0 = T − H_F + 0.6 · n

k_0 = coefficient given by the formula:

$=1 + (\ell - \ell_0) / \ell_0$

p_E = external pressure transmitted to the hull structure:

a. in general:

p_E shall be determined in compliance with Ch 2 Sec [3.7]

b. for vertical stiffeners:

= 4.9 · ℓ_0

p_M = minimum external load in kN/m^2, $p_M \geq 0$:

= 9.81 · (0.15 · T − 0.6 · n) for z ≤ 0.15

= 0 for z >0.15

p_B, p_C = pressures transmitted to the hull structure defined in Ch 2 Sec [3.10]-[3.14]

1) The span of side stringers shall be taken equal to the side transverses spacing or web frames spacing

3.6 Transversely framed double side

3.6.1 General

Adequate continuity of strength shall be ensured in way of breaks or changes in width of the double side. In particular, scarfing of the inner side shall be ensured beyond the cargo hold region.

3.6.2 Side and inner side frames

- Struts:

Side frames may be connected to the inner side frames by means of struts having a sectional area not less than those of the connected frames.

Struts are generally to be connected to side and inner side frames by means of vertical brackets or by appropriate weld sections.

Where struts are fitted between side and inner side frames at mid-span, the section modulus of side frames and inner side frames may be reduced by 30 %.

3.6.3 Side and inner side web frames

It is recommended to provide web frames, fitted every 3 m and in general not more than 6 frame spacings apart.

In any case, web frames shall be fitted in way of strong deck beams.

At their upper end, side and inner side web frames shall be connected by means of a bracket. This bracket can be a section or a flanged plate with a section modulus at least equal to that of the web frames.

At mid-span, the web frames shall be connected by means of struts, the cross-sectional area of which shall not be less than those of the connected web frames.

At their lower end, the web frames shall be adequately connected to the floors.

3.7 Longitudinally framed double side

3.7.1 General

The requirements in [3.6] also apply to longitudinally framed double side.

3.7.2 Side and inner side longitudinals

- Struts:

  Side longitudinals may be connected to the inner side longitudinals by means of struts having a sectional area not less than those of the connected longitudinals.

  Struts are generally to be connected to side and inner side longitudinals by means of brackets or by appropriate weld sections.

  Where struts are fitted between side and inner side longitudinals at mid-span, the section modulus of side longitudinals and inner side longitudinals may be reduced by 30 %.

3.7.3 Side transverses

The requirements in [3.6.3] also apply to longitudinally framed double side, with side transverses instead of side web frames.

3.8 Frame connections

3.8.1 General

- End connections:

  At their lower end, frames shall be connected to floors, by means of lap weld or by means of brackets.

  At the upper end of frames, connecting brackets shall be provided, in compliance with [3.8.2]. In the case of open deck vessels, such brackets shall extend to the hatch coaming.

  Brackets are normally connected to frames by lap welds. The length of overlap shall be not less than the depth of frames.

- Brackets:
  The same minimum value d is required for both arm lengths of straight brackets.
  A curved bracket shall be considered as the largest equal-sided bracket contained in the curved bracket.

3.8.2 Upper and lower brackets of frames

- Arm length
  The arm length of upper brackets, connecting frames to deck beams, and the lower brackets, connecting frames to the inner bottom or to the face plate of floors shall be not less than the value obtained [mm] from the following formula:

$$d = \varphi \sqrt{\frac{w+30}{t}}$$

φ = coefficient
= 50 for unflanged bracket
= 45 for flanged brackets
w = required net section modulus of the stiffener in cm^3, given in the next sub section and depending on the type of connection
t = bracket net thickness in mm to be taken not less than the stiffener thickness

- Section modulus of connections:

  For connections of perpendicular stiffeners located in the same plane (refer Figure 3.8.1) or connections of stiffeners located in perpendicular planes (refer Figure 3.8.1), the required section modulus shall be taken equal to:

  $w = w_2$ if $w_2 \leq w_1$

  $w = w_1$ if $w_2 > w_1$

  where w_1 and w_2 are the required net section moduli of stiffeners, as shown in Figure 3.8.1 and Figure 3.8.2

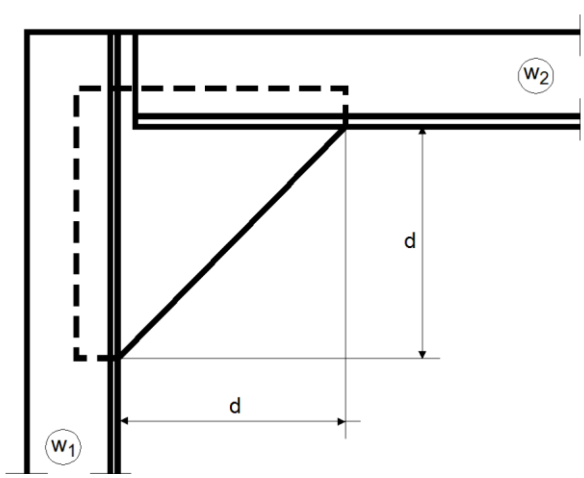


Figure 3.8.1 Connections of perpendicular stiffeners in the same plane

- All brackets for which:

$$\frac{\ell_b}{t} > 60$$

ℓ_b = length in mm of the free edge of the bracket
t = bracket net thickness in mm

shall be flanged or stiffened by a welded face plate.

The sectional area in cm^2 of the flange or the face plate shall be not less than $0.01 \cdot \ell_b$. The width of the face plate shall be not less than 10 t.

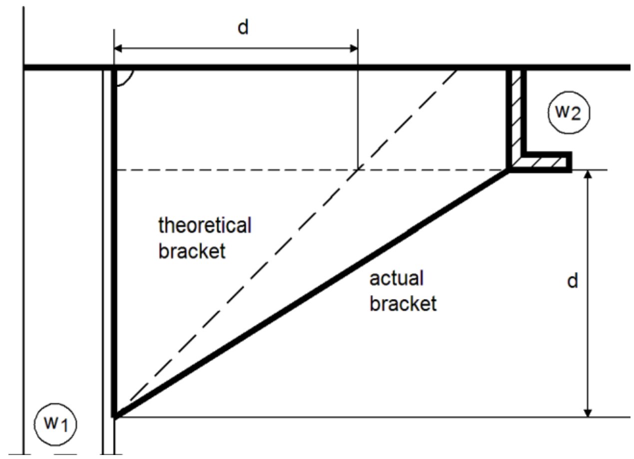


Figure 3.8.2 Connections of stiffeners located in perpendicular planes

SECTION 4 DECK SCANTLINGS

Contents

4.1 Symbols

L	=	rule length in m, defined in Ch 1 Sec [1.1]
B	=	breadth in m, defined in Ch 1 Sec [1.1]
D	=	depth in m, defined in Ch 1 Sec [1.1]
T	=	draught in mm, defined in Ch 1 Sec [1.1[
t	=	net thickness in mm of plating
s	=	spacing in m of ordinary stiffeners
S	=	spacing in m of primary supporting members
l	=	span in m of ordinary stiffeners or primary supporting members
n	=	navigation coefficient defined in Ch.2 Sec.2
	=	$0.85 \cdot H$
H	=	significant wave height in m
σ_1	=	hull girder normal stress in N/mm^2
β_b, β_s	=	bracket coefficients defined in Ch 3 Sec [1.17]
η	=	$1 - s / (2 \cdot \ell)$
w	=	net section modulus in cm^3 of ordinary stiffeners or primary supporting members
A_{Sh}	=	net web sectional area in cm^2
k	=	material factor defined in Ch 4 Sec [1.2]
z	=	Z co-ordinate in m of the calculation point
M_H	=	design bending moment in kNm in hogging condition
M_S	=	design bending moment in kNm in sagging condition

4.2 Application

The following requirements apply to inland waterway vessels with:

a. open decks, consisting of a stringer plate and a longitudinal hatch coaming (Figure 4.2.1)
b. flush decks, consisting of a deck continuous over the breadth of the vessel (Figure 4.2.2 and Figure 4.2.3)
c. trunk decks, differing from flush decks solely by the presence of a trunk.

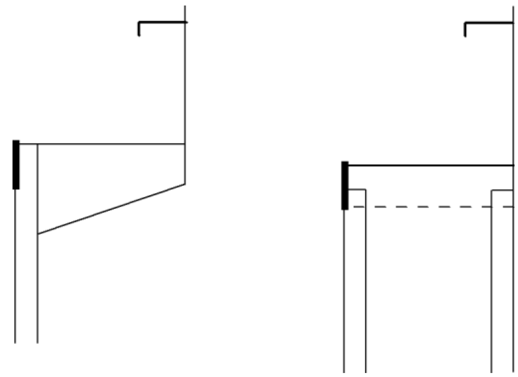


Figure 4.2.1 Open deck

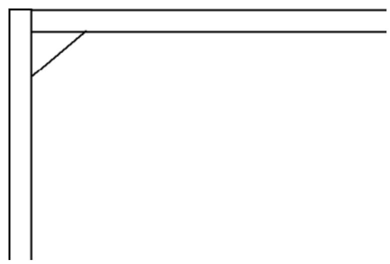


Figure 4.2.2 Transversely framed flush deck

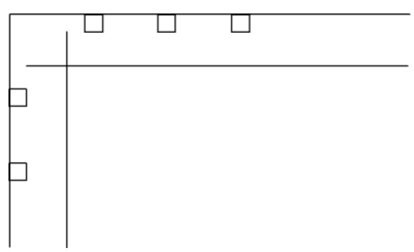


Figure 4.2.3 Longitudinally framed flush deck

These decks can be longitudinally or transversely framed and may be supported by pillars, bulkheads or strong beams.

4.3 General arrangement

4.3.1 It is recommended to avoid structural breaks in the deck of the cargo hold zone. In any case, the continuity of longitudinal strength shall be ensured at such places.

To ensure continuity in the case of such break, the stringer plate of the lower deck shall:

a. extend beyond the break, over a length at least equal to three times its width
b. stop at a web frame of sufficient scantlings.

Decks which are interrupted shall be tapered on the side by means of horizontal brackets to avoid stiff corners.

4.3.2 Adequate continuity of strength is also to be ensured in way of changes in the framing system. Details of structural arrangements shall be submitted to the Society for approval.

4.3.3 Sufficient deck supporting structures shall be provided below deck machinery, cranes and king posts shall be adequately stiffened.

4.3.4 Where devices for vehicle lashing and/or corner fittings for containers are directly attached to deck plating, suitable reinforcements shall be provided as required by the loads carried.

4.3.5 Stiffeners shall be fitted in way of the ends and corners of deckhouses and partial superstructures.

4.3.6 Manholes and flush deck plugs

Manholes and flush deck plugs exposed to the weather shall be fitted with steel covers of efficient construction capable of ensuring tightness. These covers shall be fitted with permanent securing device, unless they are secured with closely spaced bolts.

4.3.7 Freeing ports

Arrangements shall be made to ensure efficient drainage of water on the decks; in particular, where the bulwarks constitute wells on the weather deck, freeing ports of adequate sectional area shall be provided.

4.3.8 Scuppers

Scuppers on the weather deck terminating at the outer side shall be made of pipes of the same thickness as the side plating below the sheer strake, not exceeding 8mm.

Refer also Ch 5 Sec [7.7]

4.3.9 Stringer plate openings

The openings made in the stringer plate other than scupper openings shall be wholly compensated to the satisfaction of INTLREG

4.4 Open deck - Single hull vessels

4.4.1 Stringer plate

- Width:

  The stringer plate shall extend between the side shell plating and the hatch coaming. In principle its width in m

  shall be not less than: $b = 0.1 \cdot B$

  The stringer plate width and arrangements shall be so that safe movement is possible.
- Stringer plate net thickness:

  The stringer plate shall have a net thickness in mm not less than the values obtained from Table 4.4.1
- Stringer angle:

  If a stringer angle is provided, its thickness shall be at least equal to that of the side shell plating plus 1 mm, being not less than that of the stringer plate. This stringer angle shall be continuous over the length of the cargo hold.

Table 4.4.1 Stringer plate net thickness in mm - single hull vessels

α ≥ 1	α < 1
t = largest of t_1 and t_2 $t_1 = 2 + 0.02 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 39 \cdot s \cdot \sqrt{\frac{M_s}{Z_D}}$ if $t_2 / s > 12.5 / \sqrt{k}$: $t_2 = \frac{4.1\sqrt{k} \cdot s}{\sqrt{0.21 - \frac{M_s}{Z_D}}}$ see 1)	t = largest of t_1 and t_2 $t_1 = 2 + 0.02 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 74 \cdot \frac{s}{k_2} \cdot \sqrt{\frac{M_s}{Z_D}}$ if $t_2 / s > \frac{23.9}{k_2 \cdot \sqrt{k}}$ $t_2 = \frac{7.76\sqrt{k} \cdot s}{k_2 \sqrt{0.21 - \frac{M_s}{Z_D}}}$ see 1)

k_2 = coefficient

= $1 + \alpha^2$

α = b_2 / b_1

b_1 = unsupported stringer plate width in y direction in m

b_2 = unsupported stringer plate width in x direction in m

s = lower of b_1 and b_2

Z_D = deck net hull girder section modulus in cm^3

1) A lower value of thickness t_2 may be accepted if in compliance with the buckling analysis carried out according to Ch 3 Sec 2

In vessels having range of navigation **IW (1.2)** or **IW (2)**, INTLREG may require transverse deck plating strips efficiently strengthened and joining the stringer plates of both sides to be fitted.

4.4.2 Sheerstrake

The sheerstrake may be either an inserted side strake welded to the stringer plate or a doubling plate.

- Net thickness:

  The sheerstrake net thickness is not to be less than that of the stringer plate nor than that of the side shell plating.

  Moreover, this thickness is not to be less than the minimum value in mm obtained from following formula:

$$t = 3.6 + 0.11 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$$

  Where a doubling plate is provided instead of an inserted side strake, its thickness in mm is not to be less than:

$$t = 2.6 + 0.076 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$$

- Width

  Where the sheerstrake thickness is greater than that of the adjacent side shell plating, the sheerstrake shall extend over a height b, measured from the deckline, in compliance with the following relation:

  $0.08 \cdot D \leq b \leq 0.15 \cdot D$

4.4.3 Hatch coaming

- Height:

  The height of the hatch coaming above the deck in m is not to be less than the value obtained from the following formula, where b is the stringer plate width defined in [4.4.2]:

  $h_c = 0.75 \cdot b$

  Furthermore, the height of the hatch coaming above the deck shall comply with the following relation:

  $D + h_C > T + n / 1.7 + 0.15$

- Expanded depth:

  The expanded depth of the underdeck portion of the hatch coaming shall be not less than 0.15 m.

- Net thickness

  The net thickness of the hatch coaming shall be maintained over the length of the hold and shall be determined according to Table 4.4.2

- Stiffening

  The coaming boundaries shall be fitted with a horizontal stiffening member close to the coaming upper edge. In the case the coaming is higher than 750 mm, a second stiffener shall be fitted at about 0.75 times the hatch coaming height.

  The hatch coaming longitudinals shall have at least the following characteristics:

  a. Net cross sectional area in cm^2 without attached plating:
     - upper stiffener: $A = 2.5 \cdot h_C \cdot t$
     - additional stiffener: $A = 2.5 \cdot h_{AS} \cdot t$

  b. Radius of gyration in cm with attached plating:

  $$i = 0.074 \cdot l \cdot \sqrt{\sigma_1}$$

  if $i / \ell > 0.76 / \sqrt{k}$

  $$i = \frac{7.79 \cdot \sqrt{k \cdot l}}{\sqrt{210 - \sigma_1}}$$

  t = hatch coaming net thickness in mm determined according to [4.4.3]

  h_C = hatch coaming height in m

  h_{AS} = distance of the additional stiffener from the deck in m

  ℓ = span of hatch coaming stiffener in m

  i = radius of gyration in cm

$$= \sqrt{\frac{I_e}{A_e}}$$

I_e = net moment of inertia in cm^4 of the stiffener with attached plating

A_e = net cross sectional area in cm^2 of the stiffener with attached plating

σ_1 = compression hull girder normal stress in N/mm^2

The upper strake of the hatch coaming (above the upper stiffener) shall be reinforced in way of the stiffening member where its height in m exceeds $8 \cdot 10^{-3} \cdot t$, t being the hatch coaming net thickness defined in [4.4.3]

Other cases may be accepted based on buckling strength check (direct calculation).

- Stays:

The coaming boundaries shall be stiffened with stays, the ends of which shall be connected to the deck and to the stiffeners mentioned in [4.4.3]

These stays shall be fitted with a spacing of maximum 3 m. In any case, they shall be fitted in way of web frames and bulkheads. They may be constituted by:

a. sections of net moment of inertia (I_{eS}) with attached plating in cm^4, according to the following formula:

$$I_{eS} = 13 \cdot \left(\frac{h_c}{l}\right) \cdot I_e$$

I_e= net moment of inertia in cm^4, of the upper hatch coaming longitudinal stiffener with attached plating
ℓ = span of hatch coaming longitudinal stiffener in m

b. or brackets with thickness $t = 6 + 0.2 \cdot t_0$, (where t_0 is the hatch coaming thickness) and with a flanged edge having a width equal to 10 times the bracket thickness.

Strength continuity of the stays shall be ensured below the deck, as far as practicable, in way of web frames and bulkheads. Stiffeners shall be provided under the deck where necessary, in way of the intermediate stays and of the transverse boundary stays.

4.4.4 Transverse strength of topside structure

The topside structure shall be considered as a girder consisting of the stringer plate, the sheerstrake and the hatch coaming, with scantlings according to [4.4.1], [4.4.2] and [4.4.3]

The distributed transverse load in kN/m acting on the topside structure shall be taken not less than:

$q = 0.25 \cdot (1.2 \cdot k_0 \cdot p_1 \cdot \ell_0 + \lambda_t \cdot p_2 \cdot B)$
$l_0 = T - H_F + 0.6 \cdot n$

k_0 = 1 + (ℓ–ℓ_0) / ℓ_0
ℓ = side frame span in m
H_F = floor height in way of the side frame in m
p_1 = side frame design load in kN/m^2
= 4.9 · ℓ_0
p_2 = floor design load in kN/m^2
= $p_{\gamma E}$

Refer Ch 4 Sec 2.8

λ_t = coefficient given by the formula

$$= 0.1 \cdot \left(0.8 - \frac{l_2}{B_2}\right), \lambda_t \geq 0$$

in the case of combination framing system

= 0

The actual section modulus of the topside structure in cm^3 may be determined by means of the following formula:

$$w = A \cdot b + \frac{t \cdot b^2}{60}\left(1 + \frac{A_a - A}{A_a + 0.05 \cdot t \cdot b}\right)$$

t = thickness of stringer plate [mm]
b = width of stringer plate [cm]
A = minimum of A_1, A_2
A_a= largest among A_1, A_2
A_1= sheerstrake sectional area in cm^2 including a part of the shell plating extending on 0.15*D
A_2= hatch coaming sectional area in cm^2 including longitudinal stiffeners. The width m of the hatch coaming to be considered is:

h = h_1 + minimum among (0.75·h_C and 1)
h_1 = expanded depth of the underdeck portion of the hatch coaming in m defined in [4.4.3]

- Unsupported stringer plate length:
  The unsupported stringer plate length D_1 in m shall be taken as the distance between transverse efficient supports (transverse bulkheads, transverse partial bulkheads, reinforced rings).

- Topside structure strength check:
  The minimum required net section modulus in cm^3 of the topside structure shall be obtained using the formula:

$$Z_{TS} = \frac{83.3}{k_1\left(197 - \sigma_1\right)} \cdot q \cdot D_1^2$$

D_1 = length not to be taken greater than 33.3 m

k_1 = coefficient

$$= 1 + 0.25 \cdot \left(\frac{D_1}{s} - 1 \right) \cdot \frac{w}{100 \cdot D}$$

w = side frame net section modulus in cm^3

Table 4.4.2 Hatch coaming plate net thickness in mm

α ≥ 1	α < 1
t = largest of t_1, t_2 and t_3 $t_1 = 1.6 + 0.04 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = t_0$ $t_3 = 26.8 \cdot s \cdot \sqrt{\frac{(1.1+\psi) \cdot M_S}{Z_H}}$ if $t_3/s > 8.65 \cdot \sqrt{\frac{1.1+\psi}{k}}$ $t_3 = 2.86 \cdot s \cdot \sqrt{\frac{k(1.1+\psi)}{0.21 - \frac{M_s}{Z_H}}}$ see [1]	t = largest of t_1, t_2 and t_3 $t_1 = 1.6 + 0.04 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = t_0$ $t_3 = 51 \cdot \frac{s}{k_2} \cdot \sqrt{\frac{(1.1+\psi) \cdot M_S}{Z_H}}$ if $t_3/s > \frac{16.5}{k_2} \cdot \sqrt{\frac{1.1+\psi}{k}}$ $t_3 = \frac{5.6 \cdot s}{k_2} \cdot \sqrt{\frac{k(1.1+\psi)}{0.21 - \frac{M_s}{Z_H}}}$ see [1]

t_0 = stringer plate net thickness

k_2 = coefficient

= $1 + \alpha^2$

α = b_4 / b_3

b_3 = unsupported hatch coaming height in m

b_4 = unsupported hatch coaming width in x direction in m

s = minimum of b_3 and b_4

Z_H = net hull girder section modulus in way of the hatch coaming mid-height in cm^3

ψ = $\sigma_{1L} / \sigma_{1U}$

σ_{1L} = compression stress in N/mm^2 on the lower edge of the hatch coaming panel

σ_{1U} = compression stress in N/mm^2 on the upper edge of the hatch coaming panel.

1) A lower value of thickness t_3 may be accepted if in compliance with the buckling analysis carried out according to Ch 3 Sec 2.

- Strong deck box beams

  Where the stringer plate is supported by reinforced rings, the net section modulus of the strong deck box beams shall be not less than:

$$w = \frac{125}{214 - \sigma_A} \cdot p \cdot D_1 \cdot l_1^2$$

p = deck design load in kN/m^2 to be defined by the designer. In any case, p is not to be taken less than the value derived from formula given under Ch 4,Sect [4.8]

σ_A = deck box beam axial stress in N/mm^2:

$$\sigma_A = \frac{10 \cdot q \cdot D_1}{A}$$

A = deck box beam sectional area in cm^2 to be determined in compliance with [4.11.2], where

P_S = q · D_1

ℓ_1 = span of strong box beam in m

4.5 Open deck - double hull vessels

4.5.1 Stringer plate

- Width:

  The stringer plate shall extend between the side shell plating and the hatch coaming. In principle, its width b in m is not to be less than 0.6 m, unless otherwise justified.
- Stringer plate net thickness

  The stringer plate shall have a net thickness in mm not less than the values obtained from Table 4.5.1.

Table 4.5.1 Stringer plate net thickness in mm of Double hull vessels

α ≥ 1	α < 1
t = largest of t_1 and t_2 $t_1 = 2 + 0.02 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 39 \cdot s \cdot \sqrt{\frac{M_s}{Z_D}}$ if $t_2 / s > 12.5 / \sqrt{k}$: $t_2 = \frac{4.1\sqrt{k} \cdot s}{\sqrt{0.21 - \frac{M_s}{Z_D}}}$ see 1)	t = largest of t_1 and t_2 $t_1 = 2 + 0.02 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 74 \cdot \frac{s}{k_2} \cdot \sqrt{\frac{M_s}{Z_D}}$ if $t_2 / s > \frac{23.9}{k_2 \cdot \sqrt{k}}$ $t_2 = \frac{7.76\sqrt{k} \cdot s}{k_2\sqrt{0.21 - \frac{M_s}{Z_D}}}$ see 1)

k_2	= coefficient
	$= 1 + \alpha^2$
α	$= b_2 / b_1$
b_1	= unsupported stringer plate width in y direction in m
b_2	= unsupported stringer plate width in x direction in m
s	= lower of b_1 and b_2
Z_D	= deck net hull girder section modulus in cm^3
1)	A lower value of thickness t_2 may be accepted if in compliance with the buckling analysis carried out according to Ch 3 Sec 2

- Stringer angle

  If a stringer angle is provided, its thickness shall be at least equal to that of the side shell plating plus 1 mm, being not less than that of the stringer plate. This stringer angle shall be continuous over the length of the cargo hold.

  In vessels having range of navigation **IW (1.2)** or **IW (2)**, INTLREG may require transverse deck plating strips efficiently strengthened and joining the stringer plates of both sides to be fitted.

4.5.2 Sheerstrake

The sheerstrake may be either an inserted side strake welded to the stringer plate or a doubling plate.

- Net thickness:

  The sheerstrake net thickness is not to be less than that of the stringer plate nor than that of the side shell plating.

  Moreover, this thickness is not to be less than the minimum value in mm obtained from the following formula:

  $$t = 3.6 + 0.11 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$$

  Where a doubling plate is provided instead of an inserted side strake, its thickness in mm is not to be less than:

  $$t = 2.6 + 0.076 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$$

- Width:

  Where the sheerstrake thickness is greater than that of the adjacent side shell plating, the sheerstrake shall extend over a height b, measured from the deckline, in compliance with the following relation:

  $$0.08 \cdot D \le b \le 0.15 \cdot D$$

4.5.3 Hatch coaming

- Height:
  The height of the hatch coaming above the deck in m is not to be less than the value obtained from the following formula, where b is the stringer plate width defined in 4.5.1:
  $h_c = 0.75 \cdot b$
  Furthermore, the height of the hatch coaming above the deck shall comply with the following relation:
  $D + h_C > T + n / 1.7 + 0.15$

- Extension of hatch coaming under the deck:
  The hatch coaming thickness shall be maintained to a depth under the deck not less than 0.25·b.

- Net thickness:
  The thickness of the hatch coaming shall be maintained over the length of the hold and shall be determined in compliance with [4.4.3]
- Stiffening:
  The coaming boundaries shall be stiffened with a horizontal stiffening member whose scantlings and arrangements shall be in compliance with [4.4.3].
- Stays
  The coaming boundaries shall be stiffened with stays, the ends of which shall be connected to the deck and to the stiffeners mentioned in the current section.
  The scantlings and arrangements of stays shall be in compliance with [4.4.3]

4.6 Flush deck

4.6.1 General

In general, on tankers for oil or chemical cargoes, doubling plates are not allowed to be fitted within the cargo tank area, i.e. from the aftermost to the foremost cofferdam bulkhead.

4.6.2 Stringer plate

- Net thickness
  The stringer plate net thickness in mm is not to be less than that of the adjacent deck plating nor than the value derived from the following formula:

$$t = 2 + 0.032 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$$

- Width:
  Where the stringer plate has a thickness greater than that of the deck plating, its width shall be not less than 50 times of its thickness.
- Stringer angle:
  Where a stringer angle is fitted, its thickness is not to be less than that of the side shell plating increased by 1 mm nor when the vessel is built on the transverse system, than that of the stringer plate.

If the stringer plate is rounded at side, it shall extend on the side shell plating over a length at least equal to 25 times its thickness, for vessels built on the transverse system.

4.6.3 Deck plating

The deck plating net thickness in mm shall be obtained from Table 4.8.1

- Deck plating subjected to lateral pressure in testing conditions:
  Deck plating of compartments or structures to be checked in testing conditions shall comply with Ch 3 Sec 3.

4.6.4 Sheerstrake

The sheerstrake may be either an inserted side strake welded to the stringer plate or a doubling plate.

- Net thickness:
  The sheerstrake net thickness is not to be less than that of the stringer plate nor than that of the side shell plating.

  Moreover, this thickness is not to be less than the minimum value in mm obtained from following formula:

$$t = 3.6 + 0.11 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$$

  Where a doubling plate is provided instead of an inserted side strake, its thickness in mm is not to be less than:

$$t = 2.6 + 0.076 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$$

- Rounded sheerstrake
  In the case of a rounded sheerstrake connecting the side shell to the deck, the radius of curvature of the strake in mm is not to be less than 5 times its thickness.

- Width
  Where the sheerstrake thickness is greater than that of the adjacent side shell plating, the sheerstrake shall extend over a height b, measured from the deckline, in compliance with the following relation:

$$0.08 \cdot D \le b \le 0.15 \cdot D$$

  Where a sheerstrake does not rise above deck, a footguard angle or flat shall be fitted at about 100 mm from the side shell.
  The height of the sheerstrake/footguard above the deck shall be at least 50 mm.

4.6.5 Coamings of separate hatchways

- Height:
  The coaming upper edge is not to be less than 300 mm above the deck.
  Furthermore, the height of the hatch coaming, h_C, above the deck shall comply with the following relation:
  $D + h_C > T + n / 1.7 + 0.15$
- Net thickness:

The net thickness of the coaming boundaries is not to be less than:

$$t = 0.25 \cdot a + 3 \leq 5 \text{ mm},$$

a being the greater dimension of the hatchway in m.

INTLREG reserves the right to increase the above scantlings requirements where range of navigation

IW (1.2) or **IW (2)** is assigned, or to reduce them where range of navigation **IW (0)** is assigned.

- Stiffening:

  The coaming boundaries shall be stiffened with an horizontal stiffening member close to the coaming upper edge. In the case the coaming is higher than 750 mm, a second stiffener shall be fitted at about 0.75 times the hatch coaming height.

  The coaming boundaries shall be stiffened with stays, the ends of which shall be connected to the deck and to the upper horizontal stiffeners.

  Where necessary, stiffeners shall be provided under deck in way of the stays.

  The upper strake of the hatch coaming (above the upper stiffener) shall be reinforced in way of the stiffening member where its height in m exceeds $8 \cdot 10^{-3} \cdot t$, t being the hatch coaming net thickness defined in [5.5.2]. also refer Ch4/Sect [4.4.3]

- Strength continuity:

  Arrangements shall be made to ensure strength continuity of the top structure, at the end of large-size hatchways, mainly by extending the deck girders along the hatchway, beyond the hatchways, up to the end bulkhead or over two frame spacings, whichever is greater.

4.7 Trunk deck

4.7.1 Plating net thickness

The trunk sheerstrake, stringer and longitudinal bulkhead plating shall be of the same thickness. That thickness in mm is not to be less than that of the side shell plating nor than that obtained from following formulae:

a. transverse framing:

$$t_1 = 0.2 + 0.04 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$$

b. longitudinal framing:

$$t_2 = t_1 - 0.5$$

Where the sheerstrake has a thickness greater than that of the adjacent side shell plating, it shall extend to a height at least equal to 25 times of its thickness, as measured from the deckline.

The trunk deck plating shall be not less than that obtained from [4.6.3]

Where the trunk is transversely framed, the thickness of the longitudinal bulkhead of the trunk shall be maintained on the trunk top over a width equal to 25 times its thickness.

4.8 Deck supporting structure

4.8.1 The deck supporting structure consists of ordinary stiffeners (beams or longitudinals), longitudinally or transversely arranged, supported by primary supporting members which may be supported by pillars.

4.8.2 Minimum net thickness of web plating

- Deck ordinary stiffeners:
  The net thickness in mm of the web plating of ordinary stiffeners is not to be less than:

$$t = 1.63 + 0.004 \cdot L \cdot \sqrt{k} + 4.5 \cdot s \text{ for } L < 120 \text{ m}$$

$$t = 3.9 \cdot \sqrt{k} + s \text{ for } L \geq 120 \text{ m}$$

- Deck primary supporting members
  The net thickness in mm of plating which forms the web of primary supporting members shall be not less than the value obtained from the following formula:

$$t = 3.8 + 0.016 \cdot L \cdot \sqrt{k}$$

4.8.3 Net scantlings in service conditions

The net section modulus w in cm^3 and the net shear sectional area A_{sh} in cm^2 of deck structural members in service conditions shall be obtained from Table 4.8.2.

4.8.4 Net scantlings in testing conditions

The net section modulus w in cm^3 and the net shear sectional area A_{sh} in cm^2 of deck structural members being part of compartments or structures containing liquid shall comply with Ch 3 Sec 3.

4.8.5 Buckling check
Deck structural members shall comply with the requirements stated under Ch 3 Sec 2.

Table 4.8.1 Deck plating net thickness in mm

Transverse framing	Longitudinal framing
t = largest of t_1, t_2 and t_3 $t_1 = 0.9 + 0.034 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.6 \cdot s \cdot \sqrt{k \cdot p}$	t = largest of t_1, t_2 and t_3 $t_1 = 0.57 + 0.031 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.2 \cdot s \cdot \sqrt{k \cdot p}$
$t_3 = 74 \cdot \frac{s}{k_2} \sqrt{\frac{M_S}{Z_D}}$	$t_3 = 39 \cdot s \sqrt{\frac{M_S}{Z_D}}$
if $t_3 / s > 23.9 / (\sqrt{k} \cdot k_2)$:	if $t_3 / s > 12.5 / \sqrt{k}$:

Table 4.8.1 Deck plating net thickness in mm (contd.)	
Transverse framing	Longitudinal framing
$t_3 = \dfrac{7.76\sqrt{k} \cdot s}{k_2 \sqrt{0.21 - \dfrac{M_s}{Z_D}}}$ see 1)	$t_3 = \dfrac{4.1\sqrt{k} \cdot s}{\sqrt{0.21 - \dfrac{M_s}{Z_D}}}$ see 1)

k_2 = coefficient

= $1 + \alpha_2$

α = b_2 / b_1

b_1 = unsupported deck width in y direction in m

b_2 = unsupported deck width in x direction in m

Z_D = deck net hull girder section modulus in cm^3

p = deck design load in kN/m2 to be defined by the designer. In any case p is not to be taken less than the value derived from applicable formulae given under Ch 2 Sec [3.8] and Ch 2 Sec [3.10] – [3.14]

1) A lower value of thickness t_3 may be accepted if in compliance with the buckling analysis carried out according to Ch.3 Sec.2..

Table 4.8.2 Net scantlings of deck supporting structure		
Item	w	A_{sh}
Deck beams	$w = 0.58 \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0.045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Vertical stiffeners on longitudinal trunk bulkheads 1)	$w = 0.58 \cdot \lambda_b \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0.045 \cdot \lambda_s \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Deck longitudinals	$w = \dfrac{83.3}{214 - \sigma_1} \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot l^2$	$A_{sh} = 0.045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Deck transverses	$w = 0.58 \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0.045 \cdot \beta_s \cdot p \cdot S \cdot \ell$
Web frames on longitudinal trunk bulkheads 2)	$w = 0.58 \cdot \lambda_b \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0.045 \cdot \lambda_s \cdot \beta_s \cdot p \cdot S \cdot \ell$
Deck girders	$w = \dfrac{1000}{m \cdot (214 - \sigma_1)} \cdot \beta_b \cdot p \cdot S \cdot l^2$	$A_{sh} = 0.045 \cdot \beta_s \cdot p \cdot S \cdot \ell$

p = deck design load in kN/m^2 to be defined by the designer. In any case p is not to be taken less than the value derived from applicable formulae given under Ch 2 Sec [3.8] and Ch 2 Sec [3.10] – [3.14]

m = boundary coefficient

= 12.0 in general, for stiffeners considered as clamped

= 8.0 for stiffeners considered as simply supported

= 10.6 for stiffeners clamped at one end and simply supported at the other
1) Scantlings of vertical stiffeners on longitudinal trunk bulkheads are not to be less than those of deck beams connected to them. 2) Scantlings of web frames on longitudinal trunk bulkheads are not to be less than those of deck transverses connected to them.

4.9 Transversely framed deck

4.9.1 Deck beams

In general, deck beams or deck half-beams shall be fitted at each frame.

- Open-deck vessels

  In the hatchway region, it is recommended to replace the half-beams by brackets, extending to the hatch coaming, as shown on Figure 4.2.1.

4.9.2 Deck girders

Where deck beams are fitted in a hatched deck, they shall be effectively supported by longitudinal girders located in way of hatch side girders to which they shall be connected by brackets and/or clips.

Deck girders subjected to concentrated loads shall be adequately strengthened.

Deck girders shall be fitted with tripping stiffeners or brackets:

a. spaced not more than 20 times the girder faceplate width
b. in way of concentrated loads and pillars

Where a deck girder comprises several spans and its scantlings vary from one span to another, the connection of two different parts shall be effected gradually by strengthening the weaker part over a length which shall be equal to 25 % of its length.

The connection of girders to the supports shall ensure transmission of stresses. In particular, connection to the bulkheads shall be obtained by means of flanged brackets having a depth equal to twice that of the deck girder and the thickness of the girder, or by any equivalent method.

4.10 Longitudinally framed deck

4.10.1 Deck longitudinals

Deck longitudinals shall be continuous, as far as practicable, in way of deck transverses and transverse bulkheads.

Other arrangements may be considered, provided adequate continuity of longitudinal strength is ensured.

The section modulus of deck longitudinals located in way of the web frames of transverse bulkheads shall be increased by 20 %.

Frame brackets, in vessels with transversely framed sides, are generally to have their horizontal arm extended to the adjacent longitudinal ordinary stiffener.

4.10.2 Deck transverses

Where applicable, deck transverses of reinforced scantlings shall be aligned with floors.

- Deck and trunk deck transverses:

  The section modulus of transverse parts in way of the stringer plate and of the trunk sides is not to be less than the rule value obtained by determining them as deck transverses or as side shell transverses, whichever is greater.

4.11 Pillars

4.11.1 General

Pillars or other supporting structures are generally to be fitted under heavy concentrated loads.

Structural members at heads and heels of pillars as well as substructures shall be constructed according to the forces they are subjected to. The connection shall be so dimensioned that at least 1 cm2 cross sectional area is available for 10 kN of load.

Where pillars are affected by tension loads doublings are not permitted.

Pillars in tanks shall be checked for tension. Tubular pillars are not permitted in tanks for flammable liquids.

Pillars shall be fitted, as far as practicable, in the same vertical line.

The wall thickness in mm of tubular pillars which may be expected to be damaged during loading and unloading operations is not to be less than:

$t = 4.5 + 0.15 \cdot d_a$ for $d_a \leq 30$ cm

$t = 0.3 \cdot d_a$ for $d_a > 30$ cm

where d_a is defined in [4.11.2]

4.11.2 Scantlings

- Definitions:

p = deck load in kN/m^2

P_S = pillar load in kN
= $p \cdot A + P_i$

A = load area for one pillar in m^2

P_i = load from pillars located above the pillar considered in kN

λ_S = degree of slenderness of the pillar
= ℓ_S / i_S

ℓ_S = length of the pillar in cm

i_S = radius of gyration of the pillar in cm

$$i_s = \sqrt{\frac{I_S}{A_S}}$$

- for solid pillars of circular cross

section:
$i_S = 0.25\, d_S$

- for tubular pillars:

$$i_s = 0.25 \cdot \sqrt{d_a^2 + d_i^2}$$

I_S = moment of inertia of the pillar in cm^4
A_S = sectional area of the pillar in cm^2
d_S = pillar diameter in cm

d_a = outside diameter of pillar in cm

d_i = inside diameter of pillar in cm

- The sectional area in cm^2 of pillars is not to be less than:

$$A = 10 \cdot \frac{P_S}{\sigma_P}$$

σ_P= permissible compressive stress according to Table 4.11.1

- Where pillars support eccentric loads, they shall be strengthened for the additional bending moment

Table 4.11.1 Permissible compressive stress

Degree of slenderness λ_S	Permissible compressive stress σ_P in N/mm²	
	Pillars within accommodation	Elsewhere
≤ 100	$140 - 0.0067 \cdot \lambda_S^2$	$117 - 0.0056 \cdot \lambda_S^2$
> 100	$7.3 \cdot 10^5 / \lambda_S^2$	$6.1 \cdot 10^5 / \lambda_S^2$

4.11.3 Connections

Pillars shall be attached at their heads and heels by continuous welding.

Pillars working subjected to pressure may be fitted by welds only, in the case the thickness of the attached plating is at least equal to the thickness of the pillar.
Where the thickness of the attached plating is smaller than the thickness of the pillar, a doubling plate shall be fitted.
Heads and heels of pillars which may subjected to tension (such as those in tanks) shall be attached to the surrounding structure by means of brackets or insert plates so that the loads are well distributed.
Pillars shall be connected to the inner bottom, where fitted, at the intersection of girders and floors.

Where pillars connected to the inner bottom are not located in way of intersections of floors and girders, partial floors or girders or equivalent structures suitable to support the pillars shall be arranged.

Manholes and lightening holes may not be cut in the girders and floors below the heels of pillars.

4.12 Bulkheads supporting beams

4.12.1 Scantlings

Partial or complete bulkheads may substitute pillars.

The scantlings of the vertical stiffeners of the bulkheads shall be such as to allow these stiffeners to offer the same compression and buckling strengths as a pillar, taking account of a strip of attached bulkhead plating, whose width shall be determined according to Ch 3 Sec [2.3]

Where a bulkhead supporting beams is part of the watertight subdivision of the vessel or bounds a tank intended to contain liquids, its vertical stiffeners shall be fitted with head and heel brackets and their scantlings shall be increased taking account of the additional hydrostatic pressure.

4.13 Hatch supporting structures

4.13.1 General

Hatch side girders and hatch end beams of reinforced scantlings shall be fitted in way of cargo hold openings.

In general, hatched end beams and deck transverses shall be in line with bottom and side transverse structures, so as to form a reinforced ring.

Clear of openings, adequate continuity of strength of longitudinal hatch coamings shall be ensured by underdeck girders.

The details of connection of deck transverses to longitudinal girders and web frames shall be submitted to INTLREG.

SECTION 5 BULKHEAD SCANTLINGS

Contents

5.1 Symbols

L	=	rule length in m, defined in Ch 1 Sec [1.1]
B	=	breadth in m, defined in Ch 1 Sec [1.1]
D	=	depth in m, defined in Ch 1 Sec [1.1]
T	=	draught in mm, defined in Ch 1 Sec [1.1]
t	=	net thickness in mm of plating
s	=	spacing in m of ordinary stiffeners
S	=	spacing in m of primary supporting members
l	=	span in m of ordinary stiffeners or primary supporting members
β_b, β_s	=	bracket coefficients defined in Ch 3 Sec [1.17]
η	=	$1 - s / (2 \cdot \ell)$
w	=	net section modulus in cm^3 of ordinary stiffeners or primary supporting members
A_{Sh}	=	net web sectional area in cm^2
k	=	material factor defined in Ch 4 Sec [1.2]
λ_b, λ_s	=	coefficients for vertical structural members defined in Ch 3 Sec [1.18]

5.2 Application

5.2.1 The following requirements apply to transverse or longitudinal bulkhead structures which may be plane or corrugated.

5.2.2 Bulkheads may be horizontally or vertically stiffened

Horizontally framed bulkheads consist of horizontal ordinary stiffeners supported by vertical primary supporting members.

Vertically framed bulkheads consist of vertical ordinary stiffeners which may be supported by horizontal girders.

5.3 Scantlings

5.3.1 Bulkhead plating

- Minimum net thickness:
  The minimum bulkhead plating thickness in mm shall be obtained from Table 5.3.1
- Strength check of bulkhead plating in service conditions:
  The bulkhead plating net thickness in mm in service conditions shall be obtained from Table 5.3.2

Table 5.3.1 Minimum bulkhead plate thickness

Plating	**t in mm**
Watertight bulkheads	$t = 0.026 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$
Cargo hold bulkhead	$t = 2.2 + 0.013 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$
Tank and wash bulkhead	$t = 2 + 0.0032 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$

Table 5.3.2 Bulkhead plating thickness	
Plating	**t in mm**
- Watertight bulkhead - Hold bulkhead - Tank bulkhead	$t = s \cdot \sqrt{k \cdot p}$
Collision bulkhead	$t = 1.1 \cdot s \cdot \sqrt{k \cdot p}$
p = p_{WB}, p_B or p_C bulkhead plating design load in kN/m^2 defined in Ch2 Sect 3.9 -3.14	

- Strength check of bulkhead plating in testing conditions:
  Bulkhead plating of compartments or structures to be checked in testing conditions shall comply with Ch 3 Sec 3

- Buckling check:
  Bulkhead plating shall comply with requirements stated under Ch 3 Sec 2

5.3.2 Bulkhead ordinary stiffeners

- Minimum net thickness of web plating:
  The net thickness of the web plating of ordinary stiffeners is not to be less than:

$$t = 1.1 + 0.0048 \cdot L \cdot \sqrt{k} + 4.8 \cdot s$$

- Net scantlings of bulkhead ordinary stiffeners in service conditions:
  The net section modulus w in cm^3 of bulkhead ordinary stiffeners in service conditions shall be obtained from Table 5.4.1.
  The minimum net shear sectional area A_{sh} in cm^2 of the stiffener is not to be less than the value given by the formulae in Table 5.4.1

- Net scantlings of bulkhead ordinary stiffeners in testing conditions:
  The net section modulus in cm^3 and the net shear sectional area in cm^2 of bulkhead ordinary stiffeners being part of compartments or structures containing liquid shall comply with Ch 3 Sec 3.

- Buckling check:
  Ordinary stiffeners of bulkheads shall comply with the requirements stated under Ch 3 Sec 2.

5.3.3 Net scantlings of bulkhead primary supporting members

- Minimum net thickness of web plating:
  The net thickness in mm of the web plating of bulkhead primary supporting members shall be not less than:

  a. in general: $t = 3.8 + 0.016 \cdot L \cdot \sqrt{k}$

  b. for collision bulkhead: $t = 4.4 + 0.018 \cdot L \cdot \sqrt{k}$

- Net scantlings of bulkhead primary supporting members in service conditions:

The net section modulus w in cm^3 and the net shear sectional area A_{sh} in cm^2 of bulkhead primary supporting members in service conditions shall be obtained from Table 5.4.2

- Net scantlings of bulkhead ordinary stiffeners in testing conditions:

  The net section modulus in cm^3 and the net shear sectional area cm^2 of bulkhead primary supporting members being part of compartments or structures containing liquid shall comply with Ch 3 Sec 3

- Buckling check:

  Bulkhead primary supporting members shall comply with the requirements stated under Ch 3 Sec 2.

5.4 Watertight bulkheads

5.4.1 Number of watertight bulkheads

- General:

  All vessels, , shall have at least the following transverse watertight bulkheads:

  a. a collision bulkhead arranged in compliance with Sec [5.5]
  b. an after peak bulkhead, arranged in compliance with Sec [5.6]
  c. two bulkheads, complying with 6. forming the boundaries of the machinery space in vessels with machinery amidships, and one bulkhead forward of the machinery space in vessels with machinery aft. In the case of vessels with an electrical propulsion plant, both the generator room and the engine room shall be enclosed by watertight bulkheads.

Table 5.4.1 Net scantlings of bulkhead ordinary stiffeners

Item	W in cm^3	A_{sh} in cm^2
Vertical stiffeners	$w = k_1 \cdot \lambda_b \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$	$A_{sh} = k_2 \cdot \lambda_s \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Transverse stiffeners	$w = k_1 \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$	$A_{sh} = k_2 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Longitudinal stiffeners	$w = \frac{83.3}{214 - \sigma_1} \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot l^2$	$A_{sh} = 0.045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$

p = bulkhead design load in kN/m^2 defined in Ch 2 Sec [3.9]

k_1 = 4.60/m in general, 5.37/m for collision bulkhead

k_2 = 0.045 in general, 0.052 for collision bulkhead

m = boundary coefficient for ordinary stiffeners

= 8.0 in the case of primary supporting members simply supported at both ends

= 10.6 in the case of primary supporting members simply supported at one end and clamped at the other

= 12.0 in the case of primary supporting members clamped at both ends.

Table 5.4.2 Net scantlings of bulkhead primary supporting members

Item	**W in cm³**	**A_{sh} in cm²**
Bulkhead web frames, bulkhead transverses	$w = k_1 \cdot \lambda_b \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = k_2 \cdot \lambda_s \cdot \beta_s \cdot p \cdot S \cdot \ell$
Stringers on transverse bulkheads	$w = k_1 \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = k_2 \cdot \beta_s \cdot p \cdot S \cdot \ell$
Stringers on longitudinal bulkheads	$w = \frac{83.3}{214 - \sigma_1} \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot l^2$	$A_{sh} = 0.045 \cdot \beta_s \cdot p \cdot S \cdot \ell$
p, k_1, k_2 = as defined in Sect 3		

- Additional bulkheads:

  In the cargo space of single hull open deck vessels, additional transverse bulkheads may be recommended in order to ensure an efficient support to the topside structure.

  Additional bulkheads may be required also for vessels having to comply with stability criteria.

  In the cargo space of double hull vessels, transverse bulkheads shall be fitted in the side tanks in way of watertight floors.

5.4.2 General arrangement

Where an inner bottom terminates at a bulkhead, the lowest strake of the bulkhead forming the watertight floor of the double bottom shall extend at least 300 mm above the inner bottom.

Accommodations, engine rooms and boiler rooms, and the workspaces forming part of these, shall be separated from the holds by watertight transverse bulkheads that extend up to the deck.

Longitudinal bulkheads shall terminate at transverse bulkheads and shall be effectively tapered to the adjoining structure at the ends and adequately extended in the machinery space, where applicable.

The structural continuity of the bulkhead vertical and horizontal primary supporting members with the surrounding supporting structures shall be carefully ensured.

The height of vertical primary supporting members of longitudinal bulkheads may be gradually tapered from bottom to deck.

Requirements in Sec [3.6.3] or Sec [3.7.3] shall be complied with too.

5.4.3 Height of transverse watertight bulkheads

Transverse watertight bulkheads other than the collision bulkhead and the after peak bulkhead shall extend up to the upper deck.

Where it is not practicable to arrange a watertight bulkhead in one plane, a stepped bulkhead may be fitted. In this case, the part of the deck which forms the step shall be watertight and equivalent in strength to the bulkhead.

5.4.4 Openings in watertight bulkheads

Certain openings below the main deck are permitted in bulkheads other than the collision bulkhead, but these shall be kept to a minimum compatible with the design and proper working of the vessel and to be provided with watertight doors having strength such as to withstand the head of water to which they may be subjected.

5.4.5 Watertight doors

Doors cut out in watertight bulkheads shall be fitted with watertight closing appliances. Respective closing arrangements shall be approved by the Society.

The thickness of watertight doors shall be not less than that of the adjacent bulkhead plating, taking account of their actual spacing.

Where vertical stiffeners are cut in way of watertight doors, reinforced stiffeners shall be fitted on each side of the door and suitably overlapped; cross-bars shall be provided to support the interrupted stiffeners.

Watertight doors required to be open during navigation shall be of the sliding type and capable of being operated both at the door itself, on both sides, and from an accessible position above the bulkhead deck.

Means shall be provided at the latter position to indicate whether the door is open or closed, as well as arrows indicating the direction in which the operating gear shall be operated.

Watertight doors may be of the hinged type if they are always intended to be closed during navigation.

Such doors shall be framed and capable of being secured watertight by handle-operated wedges which are suitably spaced and operable from both sides.

5.4.6 Cofferdams

In general, adequately ventilated cofferdams shall be provided between compartments intended for the carriage of different liquids where, based on information supplied by the owner, there exists a risk of pollution of one product by another.

Cofferdams shall be provided between fuel bunkers and freshwater tanks.

5.5 Collision bulkhead

5.5.1 Arrangement of collision bulkhead

The collision bulkhead shall be positioned aft of the fore perpendicular at a distance d_C in m such that: $0.04 \cdot L_H \leq d_c \leq 0.04 \cdot L_H + 2$

L_H = length of the vessel's hull in m, excluding rudder and bowsprit

The Society may, on a case-by-case basis, accept a greater distance from the collision bulkhead to the forward perpendicular to that specified in [5.5.1], on basis of calculations which show that the buoyancy of the fully loaded vessel is ensured and the residual safety clearance is at least 100 mm when the compartment ahead of the collision bulkhead is flooded.

The Society may, on a case-by-case basis, accept a reduction of the distance in [5.5.1] up to atleast 0.03 L_H, on the basis of calculations which show that the buoyancy of the fully loaded vessel is ensured and the residual safety clearance is at least 100 mm when the compartment ahead of and behind the collision bulkhead is flooded.

The increase/reduction of distances mentioned above are subject to approval to be granted by the competent authority.

The collision bulkhead shall extend to the uppermost deck in the fore part of the vessel.

5.5.2 Openings in the collision bulkhead

Openings may not be cut in the collision bulkhead below the main deck.

The number of openings in the collision bulkhead above the main deck shall be kept to the minimum compatible with the design and proper working of the vessel.

All such openings shall be fitted with means of closing to weathertight standards.

- Doors and manholes:

  No doors or manholes are permitted in the collision bulkhead below the bulkhead deck.

- Passage of piping:

  No bilge cock or similar device shall be fitted on the collision bulkhead.

  A maximum of two pipes may pass through the collision bulkhead below the main deck, unless otherwise justified. Such pipes shall be fitted with suitable valves operable from above the main deck. The valve chest shall be secured at the bulkhead inside the fore peak. Such valves may be fitted on the after side of the collision bulkhead if they are easily accessible and the space in which they are fitted is not a cargo space.

5.6 After peak, machinery space bulkheads and stern tubes

5.6.1 Extension

These bulkheads shall extend to the uppermost continuous deck.

5.6.2 Stern tubes

The after peak bulkhead shall enclose the stern tube and the rudder trunk in a watertight compartment. Alternative measures to minimize the danger of water penetrating into the vessel in case of damage to stern tube arrangements may be taken in consultation with the Society.

For vessels less than 65 m, where the after peak bulkhead is not provided in way of the stern tube stuffing box, the stern tubes shall be enclosed in watertight spaces of sufficient volume.

5.7 Tank bulkheads

5.7.1 Number and arrangement of tank bulkheads

The number and location of transverse and longitudinal watertight bulkheads in vessels intended for the carriage of liquid cargoes (tankers and similar) shall comply with the stability requirements to which the vessel is subject.

In general, liquid compartments extending over the full breadth of the vessel shall be fitted with at least one longitudinal bulkhead, whether watertight or not, where the mean compartment breadth is at least equal to $2 \cdot B/3$.

In general, where the bulkhead is perforated, the total area of the holes is generally to be about 5 % of the total area of the bulkhead.

5.8 Tanks

5.8.1 Arrangements

Liquid fuel or lubrication oil shall be carried in oil tight tanks which shall either form part of the hull or shall be solidly connected with the vessel’s hull.

Fuel oil, lubrication oil and hydraulic oil tanks provided in the machinery space are not to be located above the boilers nor in places where they are likely to be subjected to a high temperature, unless special arrangements are provided with the agreement of the Society.

Where a cargo space is adjacent to a fuel bunker which is provided with a heating system, the fuel bunker boundaries shall be adequately heat insulated.

Arrangements shall be made to restrict leaks through the bulkheads of liquid fuel tanks adjacent to the cargo space.

Gutterways shall be fitted at the foot of bunker bulkheads, in the cargo space and in the machinery space to facilitate the flow of liquid due to eventual leaks towards the bilge suctions.

The gutterways may however be dispensed with if the bulkheads are entirely welded.

Where ceilings are fitted on the tank top or on the top of deep tanks intended for the carriage of fuel oil, they shall rest on grounds 30 mm in depth so arranged as to facilitate the flow of liquid due to eventual leaks towards the bilge suctions.

The ceilings may be positioned directly on the plating in the case of welded top platings.

Fuel tanks formed by the vessel’s hull shall not have a common wall with cargo tanks, lubricating oil tanks, freshwater tanks or drinking water tanks.

Upon special approval on small vessels the arrangement of cofferdams between fuel oil and lubricating oil tanks may be dispensed with provided that the common boundary is continuous, i.e. it does not abut at the adjacent tank boundaries, refer Figure 5.8.1

Fuel tanks or lubrication oil tanks which are in normal service under static pressure of the liquid shall not have any common surfaces with passenger areas and accommodations.

Fuel tanks, lubrication oil and hydraulic oil tanks shall not be located forward of the collision bulkhead.

5.8.2 Scantlings

Scantlings of fuel tanks shall be in compliance with Sec [5.2].

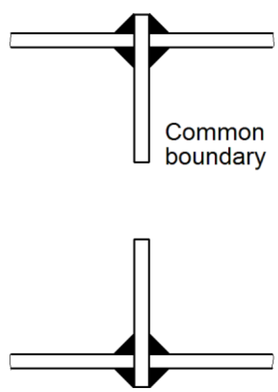


Figure 5.8.1 Continuous common boundary

5.9 Plane bulkheads

5.9.1 General

Where a bulkhead does not extend up to the uppermost continuous deck (such as the after peak bulkhead), suitable strengthening shall be provided in the extension of the bulkhead.

Bulkheads shall generally be stiffened in way of deck girders.

The stiffener webs of side tank watertight bulkheads are generally to be aligned with the webs of inner hull longitudinal stiffeners.

Floors shall be fitted in the double bottom in way of plane transverse bulkheads.

In way of the sterntube, the thickness of the after peak bulkhead plating shall be increased by 60%. Alternatively, a doubling plate of the same thickness as the bulkhead plating may be fitted.

5.9.2 Bulkhead stiffeners

Generally, stiffeners shall be fitted in way of structural components likely to exert concentrated loads, such as deck girders and pillars, and for engine room end bulkheads, at the ends of the engine seatings.

On vertically framed watertight bulkheads, where stiffeners are interrupted in way of the watertight doors, stanchions shall be fitted on either side of the doors and carlings shall be fitted to support the interrupted stiffeners.

5.9.3 End connections

In general, end connections of ordinary stiffeners shall be welded directly to the plating or bracketed. However, stiffeners may be sniped, provided the scantlings of such stiffeners are modified accordingly.

Sniped ends may be accepted where the hull lines make it mandatory in the following cases (lower strength category):

- liquid compartment boundaries
- collision bulkhead.

Where sniped ordinary stiffeners are fitted, the snipe angle shall be not greater than 30° and their ends shall be extended, as far as practicable, to the boundary of the bulkhead.

Moreover, the thickness of the bulkhead plating supported by the stiffener shall follow Ch 3 Sec [1.9.4]

5.10 Corrugated bulkheads

5.10.1 General

The main dimensions a, b, c and d of corrugated bulkheads are defined in Figure 5.10.1.

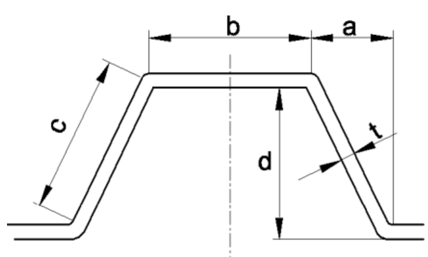


Figure 5.10.1 Corrugated bulkhead

Unless otherwise specified, the following requirement shall be complied with:

$a \leq d$

Moreover, in some cases, the Society may require an upper limit for the ratio b / t.

In general, the bending internal radius R_i shall be not less than the following values in mm:

- for normal strength steel:

$R_i = 2.5$ t

- for high tensile steel:

$R_i = 3.0$ t

where t is the thickness in mm of the corrugated plate.

When butt welds in a direction parallel to the bend axis are provided in the zone of the bend, the welding procedures shall be submitted to the Society for approval, depending on the importance of the structural element.

Transverse corrugated bulkheads having horizontal corrugations shall be fitted with vertical primary supporting members of number and size sufficient to ensure the required vertical stiffness of the bulkhead.

In general, where girders or vertical primary supporting members are fitted on corrugated bulkheads, they shall be arranged symmetrically.

5.10.2 Bulkhead scantlings

- Bulkhead plating:

  The bulkhead plating net thickness shall be determined as specified in [5.3.1], substituting the stiffener spacing by the greater of the two values b and c in m as per [5.10.1]

- Corrugations:

  The section modulus of a corrugation shall be not less than that of the equivalent stiffener having the same span as the corrugation and an attached plating width equal to (b + a).

  The actual section modulus of a corrugation shall be obtained in cm^3 from following formula:

$$w = \frac{t \cdot d}{6} \cdot (3 \cdot b + c) \cdot 10^{-3}$$

  t = net thickness of the plating of the corrugation in mm

  d, b, c = dimensions of the corrugation in mm shown in Figure 5.10.1

  Moreover, where the ratio b / t ≥ 46, the net section modulus required for a bulkhead shall be in accordance with the following formula, where the coefficient c_k is defined in Table 5.10.1

$$w = c_k \cdot (b + a) \cdot p \cdot \left(\frac{l \cdot b}{80 \cdot t} \right)^2 \cdot 10^{-3}$$

- Stringers and web frames:

  It is recommended to fit stringers or web frames symmetrically with respect to the bulkhead. In all cases, their section modulus shall be determined in the same way as for a plane bulkhead stringer or web frame.

Table 5.10.1 Values of coefficient c_K

Boundary conditions	Collision bulkhead	Watertight bulkhead	Cargo hold Bulkhead
Simply supported	1.73	1.38	1.04
Simply supported (at one end)	1.53	1.20	0.92
Clamped	1.15	0.92	0.69

5.10.3 Structural arrangement

The strength continuity of corrugated bulkheads shall be ensured at ends of corrugations.

Where corrugated bulkheads are cut in way of primary members, attention shall be paid to ensure correct alignment of corrugations on each side of the primary member.

In general, where vertically corrugated transverse bulkheads are welded on the inner bottom, floors shall be fitted in way of the flanges of corrugations.
However, other arrangements ensuring adequate structural continuity may be accepted by the Society.

Where stools are fitted at the lower part of transverse bulkheads, the thickness of adjacent plate floors shall be not less than that of the stool plating.

In general, where vertically corrugated longitudinal bulkheads are welded on the inner bottom, girders shall be fitted in double bottom in way of the flanges of corrugations.
However, other arrangements ensuring adequate structural continuity may be accepted by the Society.

In general, the upper and lower parts of horizontally corrugated bulkheads shall be flat over a depth equal to $0.1 \cdot D$.

5.10.4 Bulkhead stool

In general, plate diaphragms or web frames shall be fitted in bottom stools in way of the double bottom longitudinal girders or plate floors.

Brackets or deep webs shall be fitted to connect the upper stool to the deck transverses or hatch end beams.

The continuity of the corrugated bulkhead with the stool plating shall be adequately ensured. In particular, the upper strake of the lower stool shall be of the same thickness and yield stress as the lower strake of the bulkhead.

5.11 Hold bulkheads of open deck vessels

5.11.1 Special arrangements

The upper end of vertical stiffeners shall be connected either to a box beam or a stringer located at the stringer plate level or above.
As far as practicable, the bottom of the box beam or the bulkhead end stringer shall be in the same plane as the stringer plate.

Where this is not the case, the bulkhead plating or the box beam sides shall be fitted with an efficient horizontal framing at that level.

Connection details of the upper part of horizontally framed bulkheads shall be submitted to the society for approval.

5.12 Non-tight bulkheads

5.12.1 Definition

A bulkhead is considered to be acting as a pillar when it is also subjected to axial loads.

5.12.2 Non-tight bulkheads not acting as pillars

Non-tight bulkheads not acting as pillars shall be provided with vertical stiffeners with a maximum spacing equal to:

a. 0.9 m, for transverse bulkheads
b. two frame spacings, with a maximum of 1.5 m, for longitudinal bulkheads.

5.12.3 Non-tight bulkheads acting as pillars

Non-tight bulkheads acting as pillars shall be provided with vertical stiffeners with a maximum spacing equal to:

a. two frame spacings, when the frame spacing does not exceed 0.75 m,
b. one frame spacing, when the frame spacing is greater than 0.75 m.

Each vertical stiffener, in association with a width of plating equal to 35 times the plating thickness, shall comply with the applicable requirements for pillars in Sec.[4.11]; the load supported being determined in accordance with the same requirements.

In the case of non-tight bulkheads supporting longitudinally framed decks, web frames shall be provided in way of deck transverses.

5.13 Wash bulkheads

5.13.1 General

The requirements in [5.12.2] apply to transverse and longitudinal wash bulkheads whose main purpose shall reduce the liquid motions in partly filled tanks.

5.13.2 Openings

The total area of openings in a transverse wash bulkhead is generally to be between 10 % and 30 % of the total bulkhead area.

In the upper, central and lower portions of the bulkhead (the depth of each portion being 1/3 of the bulkhead height), the areas of openings, expressed as percentages of the corresponding areas of these portions, shall be within the limits given in Table 5.13.1

In any case, the distribution of openings shall fulfil the strength requirements specified in [5.12].

In general, large openings may not be cut within $0.15 \cdot D$ from bottom and from deck.

Table 5.13.1 Areas of openings in transverse wash bulkheads		
Bulkhead portion	Lower limit	Upper limit
Upper	10 %	15 %
Central	10 %	50 %
Lower	2 %	10 %

SECTION 6 VESSELS LESS THAN 40 M IN LENGTH

Contents

6.1 Symbols

L	=	rule length in m, defined in Ch 1 Sec [1.1]
B	=	breadth in m, defined in Ch 1 Sec [1.1]
D	=	depth in m, defined in Ch 1 Sec [1.1]
T	=	draught in mm, defined in Ch 1 Sec [1.1]
t	=	net thickness in mm of plating
s	=	spacing in m of ordinary stiffeners
S	=	spacing in m of primary supporting members
l	=	span in m of ordinary stiffeners or primary supporting members
β_b, β_s	=	bracket coefficients defined in Ch 3 Sec [1.17]
λ_b, λ_s	=	Coefficients for vertical structural members defined in Ch 3 Sec [1.18]
η	=	$1 - s / (2 \cdot \ell)$
w	=	net section modulus in cm^3 of ordinary stiffeners or primary supporting members
A_{Sh}	=	net web sectional area in cm^2
k	=	material factor defined in Ch 4 Sec [1.2]

6.2 General

6.2.1 Application

This section contains the requirements for the determination of minimum hull scantlings for the central part of all types of single hull inland waterway vessels less than 40 m in length, of normal design and dimensions.

It is assumed that the machinery is arranged aft and the vessel is loaded/unloaded in two runs.

Arrangement and scantlings not covered in the following shall be as specified in Sec 2 to Sec 5.

6.2.2 Definition

In the following requirements, the coefficient K_{MZ} to be used for the scantling of small vessels shall be derived from the formula:

$$K_{MZ} = \sqrt{\frac{K_M}{K_Z}}$$

where the coefficients K_M and K_Z are given in Table 6.3.1 and Table 6.3.2.

6.3 Bottom scantlings

6.3.1 Bottom and bilge plating

The bottom plating net thickness mm is not to be less than the values derived from Table 6.3.3.

The bilge plating scantling shall comply with Sec [2.6.2] to Sec [2.6.4] as applicable.

- Strength check of bottom plating in testing conditions:
  Bottom plating of compartments or structures to be checked in testing conditions shall comply with Ch 3 Sec 3

Table 6.3.1 Values of coefficient K_M

Range of navigation	Vessel type	K_M		
		Bottom plating	Top plating	Stiffeners
IW (0)	All	1.0	1.0	1.0
IW (0.6)	Self-propelled cargo carriers and passenger vessels	1.08	1.056	1.08
	Non-propelled cargo carriers	1.0	1.0	1.0
	Other vessels	1.2	1.5	1.5
IW (1.2) to **IW (2)**	Self-propelled cargo carriers and passenger vessels	$0.83 + 0.98 \cdot n$	$0.88 + 0.69 \cdot n$	$0.83 + 0.98 \cdot n$
	Non-propelled cargo carriers	$0.385 + 2.08 \cdot n$	$0.75 + 0.75 \cdot n$	$0.385 + 2.08 \cdot n$
	Other vessels	$1+n$	$1+2.1 \cdot n$	$1+2.1 \cdot n$

Table 6.3.2 Values of coefficient K_Z

Range of navigation	K_Z	Range of navigation	K_Z
IW (0) **IW (0.6)**	1.0	**IW (1.2)** to **IW (2)**	$1 + 0.158 \cdot n$

Table 6.3.3 Bottom plating net thickness in mm

Transverse framing	Longitudinal framing
t = largest of t_1, t_2 and t_3	t = largest of t_1, t_2 and t_3
$t_1 = 1.85 + 0.03 \cdot L \cdot\sqrt{k} + 3.6 \cdot s$	$t_1 = 1.1 + 0.03 \cdot L \cdot\sqrt{k} + 3.6 \cdot s$
$t_2 = 1.6 \cdot s \cdot\sqrt{k \cdot p}$	$t_2 = 1.2 \cdot s \cdot\sqrt{k \cdot p}$
$t_3 = 1.5 \cdot s \cdot K_{MZ} \cdot\sqrt{L \cdot k}$	$t_3 = 0.86 \cdot s \cdot K_{MZ} \cdot\sqrt{L \cdot k}$
p = design load in kN/m^2 $= 9.81 \cdot (T + 0.6 \cdot n)$	

6.3.2 Bottom structure

- Minimum net thickness of web plating:
  The net thickness in mm of the web plating of ordinary stiffeners shall be not less than:

$$t = 1.63 + 0.004 \cdot L \cdot\sqrt{k} + 4.5 \cdot s$$

The net thickness in mm of plating which forms the web of primary supporting members shall be not less than the value obtained from the following formula:

$$t = 3.8 + 0.016 \cdot L \cdot \sqrt{k}$$

- Net scantlings of bottom structural members in service conditions:

  The net scantlings of bottom structural members in service conditions shall be obtained from Table 6.4.1.

- Net scantlings of bottom structural members in testing conditions:

  The net section modulus w in cm^3 and the net shear sectional area A_{sh} in cm^2 of bottom structural members being part of compartments or structures containing liquid shall comply with Ch 3 Sec 3.

6.4 Side scantlings

6.4.1 Side plating

The side plating net thickness in mm is not to be less than the values given in Table 6.4.2

- Strength check of side plating in testing conditions:

  The side plating of compartments or structures to be checked in testing conditions shall comply with Ch 3 Sec 3.

Table 6.4.1 Net scantlings of bottom structure

Item	w	A_{sh}
Bottom longitudinals	$w = \dfrac{0.4 \cdot \beta_b \cdot \eta \cdot p_E \cdot s \cdot l^2}{1 - 0.18 \cdot K_{MZ}}$	$A_{sh} = 0.045 \cdot \beta_s \cdot \eta \cdot p_E \cdot s \cdot \ell$
Floors 1), 2	$w = 0.58 \cdot \beta_b \cdot p \cdot s \cdot B^2$	$A_{sh} = 0.045 \cdot \beta_s \cdot p \cdot s \cdot B$
Bottom transverses 2)	$w = 0.58 \cdot \beta_b \cdot p \cdot S \cdot B^2$	$A_{sh} = 0.045 \cdot \beta_s \cdot p \cdot S \cdot B$
Bottom center and side girders 3)	$w = 0.63 \cdot \beta_b \cdot p \cdot S \cdot \ell^2 \geq w_0$	$A_{sh} = 0.056 \cdot \beta_s \cdot p \cdot S \cdot \ell$

p_E = design load of bottom longitudinals in kN/m^2 defined in Ch 2 Sec 3.7

p = design load in kN/m^2 of bottom primary supporting members = $9.81 \cdot (\gamma \cdot T + 0.6 \cdot n)$

γ = 0.575 for cargo carriers

= 1.0 for other vessels

w_0 = section modulus of floors or bottom transverses

1) In way of side ordinary frames: $\beta_b = \beta_S = 1$

2) Scantlings of floors and bottom transverses shall be adequate to those of web frames or side transverses connected to them.

3) The span ℓ shall be taken equal to the web frame spacing.

Table 6.4.2 Side plating net thickness in mm	
Transverse framing	Longitudinal framing§
t = largest of t_1, t_2 and t_3 $t_1 = 1.68 + 0.025 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.6 \cdot s \cdot \sqrt{k \cdot p}$	t = largest of t_1, t_2 and t_3 $t_1 = 1.25 + 0.02 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.2 \cdot s \cdot \sqrt{k \cdot p}$
$t_3 = k_1 \cdot t_0$	$t_3 = k_1 \cdot t_0$
p = design load in kN/m^2 $= 9.81 \cdot (T + 0.6 \cdot n)$ $t_0 = t_{bottom}$ k_1 = 0.85 if transversely framed bottom = 0.90 if longitudinally framed bottom.	

6.4.2 Side structure

- Minimum net thickness of web plating:

  The net thickness of the web plating of ordinary stiffeners shall be not less than:

  $$t = 1.63 + 0.004 \cdot L \cdot \sqrt{k} + 4.5 \cdot s$$

  The thickness in mm of plating which forms the web of primary supporting members shall be not less than the value obtained from the formula:

  $$t = 3.8 + 0.016 \cdot L \cdot \sqrt{k}$$

- Net scantlings of side structural members in service conditions:

  The net scantlings of side structural members in service conditions shall be obtained from Table 6.5.1.

- Net scantlings of side structural members in testing conditions:

  The net section modulus w in cm^3 and the net shear sectional area A_{sh} in cm^2 of side structural members being part of compartments or structures containing liquid shall comply with Ch 3 Sec 3.

6.5 Deck scantlings

6.5.1 Open deck vessels

The arrangement and stiffening of the topside structure shall be as specified in Sec [4.2]

- Topside structure scantlings:

  The topside structure scantlings shall be derived from Table 6.5.2

6.5.2 Flush deck and trunk deck

Scantlings of the topside strakes shall comply with Sec [4.6] and Sec [4.7]

The deck plating net thickness in mm shall be obtained from Table 6.5.3.

Within the midship region, the sectional area in cm^2 of the deck structure in way of the hatchways, including the side and top of trunk, is not to be less than:

$$A = 6 \cdot B \cdot s \cdot K_{MZ} \cdot \sqrt{L}$$

Table 6.5.1 Net scantlings of side structure

Primary supporting members	w	A_{sh}
Side frames	$w = 0.58 \cdot s \cdot \beta_b \cdot \eta \cdot (1.2 \cdot k_0 \cdot p \cdot \ell_0^2 + \lambda_t \cdot p_F \cdot B^2)$	$A_{sh} = 0.08 \cdot \beta_s \cdot \eta \cdot k_0 \cdot p \cdot s \cdot \ell_0$
Side longitudinals	$w = 0.40 \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0.045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Side webs, side transverses 1)	$w = 1.96 \cdot \beta_b \cdot k_0 \cdot p \cdot S \cdot \ell_0^2$	$A_{sh} = 0.063 \cdot \beta_s \cdot k_0 \cdot p \cdot S \cdot \ell_0$
Side stringers 2	$w = 0.63 \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0.056 \cdot \beta_s \cdot p \cdot S \cdot \ell$

p = design load of side structural members in kN/m^2 :

= $4.9 \cdot \ell_0$ for vertical stiffeners

= p_E for longitudinal stiffeners

where p_E is defined in Ch. 2, Sec. [3.7]

ℓ_0 = $T - H_F + 0.6 \cdot n$
H_F = floor height or bottom transverse height in m

p_F = floor design load in kN/m^2 to be obtained from the following formula:

= $9.81 \cdot (\gamma \cdot T + 0.6 \cdot n)$

γ = 0.575 for cargo carriers

= 1.0 for other vessels

k_0 = coefficient given by the formula:

= $\ell + (\ell - \ell_0) / \ell_0$

λ_t = coefficient ≥0

$$\lambda_t = 0.1\left(0.8 - \frac{l^2}{l_F^2}\right) \geq 0$$

In combination framing: $\lambda_t = 0$

1) Scantlings of web frames and side transverses shall be adequate to those of floors or bottom transverses connected to them.

2) The span of side stringers shall be taken equal to the side transverses spacing or web frames spacing in m

Table 6.5.2 Topside structure net scantlings

Item	Thickness in mm		Minimum width/height in m
	$\alpha \geq 1$	$\alpha < 1$	
Stringer plate	t = largest of t_1 and t_2 $t_1 = 2 + 0.02 \cdot L \cdot \sqrt{k} + 3.6 \cdot s_1$ $t_2 = 1.24 \cdot s_1 \cdot K_{MZ} \cdot \sqrt{k \cdot L}$	t = largest of t_1 and t_2 $t_1 = 2 + 0.02 \cdot L \cdot \sqrt{k} + 3.6 \cdot s_1$ $t_2 = 1.33 \cdot s_1 \cdot K_{MZ} \cdot \sqrt{k \cdot L}$	$b = 0.1 \cdot B$
Sheerstrake	$t = 2.6 + 0.076 \cdot L \cdot \sqrt{k} + 3.6 \cdot s_2$		$b = 0.08 \cdot D$
Hatch coaming	t = largest of t_1 and t_2 $t_1 = 1.6 + 0.04 \cdot L \cdot \sqrt{k} + 3.6 \cdot s_3$ $t_2 = (1 + h / D) \cdot t_0$	t = largest of t_1 and t_2 $t_1 = 1.6 + 0.04 \cdot L \cdot \sqrt{k} + 3.6 \cdot s_3$ $t_2 = (1 + h / D) \cdot t_0$	Refer Sec.[4.4.3]
α = b_2 / b_1 s_1 = lower of b_1 and b_2 b_1 = unsupported stringer plate width in y direction in m b_2 = unsupported stringer plate width in x direction in m s_2 = side ordinary stiffener spacing in m s_3 = lower of b_3 and b_4 b_3 = unsupported hatch coaming height in m b_4 = unsupported hatch coaming width in x direction in m t_0 = stringer plate thickness in mm. h = actual hatch coaming height above the deck in m			

Table 6.5.3 Flush deck net scantlings in mm

Transverse framing	Longitudinal framing
Deck plating: t = largest of t_1, t_2 and t_3 $t_1 = 0.9 + 0.034 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.6 \cdot s \cdot \sqrt{k \cdot p}$ $t_3 = 1.33 \cdot s \cdot K_{MZ} \cdot \sqrt{k \cdot L}$	Deck plating: t = largest of t_1, t_2 and t_3 $t_1 = 0.57 + 0.031 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.20 \cdot s \cdot \sqrt{k \cdot p}$ $t_3 = 1.24 \cdot s \cdot K_{MZ} \cdot \sqrt{k \cdot L}$
p = deck design load in kN/m^2 to be defined by the designer. In any case p is not to be taken less than: = $3.75 \cdot (n + 0.8)$	

- Deck plating subjected to lateral pressure in testing conditions:
  Deck plating of compartments or structures to be checked in testing conditions shall comply with Ch 3 Sec 3

6.5.3 Deck structure

- Minimum net thickness of web plating:
  The net thickness in mm of the web plating of ordinary stiffeners shall be not less than:
  $t = 1.63 + 0.004 \cdot L \cdot \sqrt{k} + 4.5 \cdot s$

The net thickness in mm of plating which forms the web of primary supporting members shall be not less than the value obtained from the following formula:

$$t = 3.8 + 0.016 \cdot L \cdot \sqrt{k}$$

- Net scantlings of deck structural members in service conditions:

  The net scantlings of deck structural members in service conditions shall be obtained from Table 6.6.1.

- Net scantlings of deck structural members in testing conditions:

  The net section modulus w in cm^3 and the shear sectional area in cm^2 of deck structural members being part of compartments or structures containing liquid shall comply with Ch 3 Sec 3.

6.6 Subdivision

The arrangement and scantlings of bulkheads shall be as specified in Ch 4 Sec 5.

Table 6.6.1 Net scantlings of deck structure

Item	w in cm^3	A_{sh} in cm^2
Deck beams	$w = 0.58 \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0.045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Vertical stiffeners on longitudinal trunk bulkheads 1)	$w = 0.58 \cdot \lambda_b \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$	$A_{sh} = 0.045 \cdot \lambda_s \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Deck longitudinals		$A_{sh} = 0.045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$
Deck transverses	$w = 0.58 \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0.045 \cdot \beta_s \cdot p \cdot S \cdot \ell$
Vertical primary supporting members on longitudinal trunk bulkheads 1	$w = 0.58 \lambda_b \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0.045 \cdot \lambda_s \cdot \beta_s \cdot p \cdot S \cdot \ell$
Deck girders	$w = 0.63 \cdot \beta_b \cdot p \cdot S \cdot \ell^2$	$A_{sh} = 0.056 \cdot \beta_s \cdot p \cdot S \cdot \ell$

p =deck design load in kN/m^2 to be defined by the designer. In any case p is not to be taken less than:
$= 3.75 \cdot (n + 0.8)$

1) Scantlings of vertical structural members on longitudinal trunk bulkheads are not to be less than those of deck stiffeners connected to them.

CHAPTER 5 OTHER STRUCTURES

CONTENTS

SECTION 1 FORE PART

Contents

1.1 Symbols

L = rule length in m defined in Ch 1 Sec [1.1]
B = breadth in m defined in Ch 1 Sec [1.1]
D = depth in m defined in Ch 1 Sec [1.1]
T = draught in m defined in Ch 1 Sec [1.1]
t = thickness in mm of plating
p = design load in kN/m^2 according to Ch 3,Sect [2.6]
s = spacing in m of ordinary stiffeners
S = spacing in m of primary supporting members
ℓ = span in m of ordinary stiffeners or primary supporting members
n = navigation coefficient defined in Ch 2 Sec 2
= $0.85 \cdot H$
H = significant wave height in m
β_b, β_s = bracket coefficients defined in Ch 3 Sec.[1.17]
η = $1 - s / (2 \cdot \ell)$
w = net section modulus, in in cm^3 of ordinary stiffeners or primary supporting members
A_{sh} = net web sectional area, in cm^2
k = material factor defined in Ch 4 Sec [1.2]
z = Z co-ordinate in m of the calculation point
m = boundary coefficient, to be taken equal to:
= 12.0 in general, for stiffeners considered as clamped
= 8.0 for stiffeners considered as simply supported
= 10.6 for stiffeners clamped at one end and simply supported at the other
f = coefficient defined as follows:
= 1.0 in case of **IW (1.2)** and **IW (2)**

= 0.9 in case of **IW (0.6)**

= 0.8 in case of **IW (0)**

1.2 General

1.2.1 Application

The following requirements apply to all vessels for the scantling of the fore part structures as defined in Ch 1 Sec .[1.3]

1.2.2 Net scantlings

As specified in Ch 3 Sec [1.7], all scantlings referred to in this section, with the exception of those indicated in Sec 7, are net scantlings, i.e. they do not include any margin for corrosion.

1.2.3 Resistance partial safety factors

The resistance partial safety factors to be considered for the checking of the fore part structures are as specified in Table 1.2.1

Table 1.2.1 Resistance partial safety factors γ_R

Structures	Ordinary stiffeners	Primary supporting members
Fore peak structures	1.40	1.60
Structures located aft of the collision bulkhead	1.02	1.20

1.3 Material factor

1.3.1 When steels with a minimum guaranteed yield stress R_{eH} other than 235 N/mm^2 are used on a vessel, the scantlings shall be determined by taking into account the material factor as follows:

a. thickness: see relevant requirements in the following paragraphs
b. section modulus:
$w = k \cdot w_0$
c. sectional area:
$A = k \cdot A_0$
w_0, A_0 = scantlings corresponding to a steel with a minimum guaranteed yield stress R_{eH} = 235 N/mm^2

1.4 Connections of the fore peak with structures located aft of thecollision bulkhead

Adequate tapering shall be ensured between the scantlings in the fore peak and those aft of the collision bulkhead. The tapering shall be such that the scantling requirements for both areas are fulfilled.

1.5 Design loads

1.5.1 Pressure on sides and bottom

The design pressure in kN/m^2 on sides and bottom shall be derived from the following formulae:

p_E = $9.81 \cdot (T - z + 0.6 \cdot n)$ for $z \le T$
= largest of $(5.9 \cdot n$ and $3) + p_{WD}$ for $z > T$
p_{WD} = specific wind pressure in kN/m^2
= 0.25 for **IW (0)** and **IW (0.6)**

= $0.4 \cdot n$ for **IW (1.2)** to **IW (2)**.

1.5.2 Pressure on exposed deck

The external pressure on exposed decks shall be defined by the designer and, in general, may not be taken less than:

$p = 3.75 \cdot (n + 0.8)$ kN/m^2

1.5.3 Pressure on tween deck

The external pressure on tween decks shall be defined by the designer and, in general, may not be taken less than:

$P = 4.0$ kN/m^2

1.6 Bottom scantlings and arrangements

1.6.1 Longitudinally framed bottom

- Plating and ordinary stiffeners

  The net scantlings of plating and ordinary stiffeners shall be not less than the values obtained from the formulae in table 1.6.1.

  For bilge plating, refer Ch 4 Sect [2.5]

- Bottom transverses:

  Bottom transverses shall be fitted at every 8 frame and generally spacings no more than 4 m apart. The arrangements of bottom transverses shall be as required in the midship region.

  Their scantlings are to neither be less than required in table 1.6.1 nor lower than those of the corresponding side transverses, as defined in [4.2.2].

- Fore peak arrangement:

  Where no centerline bulkhead shall be fitted, a center bottom girder having the same dimensions and scantlings as required for bottom transverses shall be provided.

  The center bottom girder shall be connected to the collision bulkhead by means of a large end bracket.

  Side girders, having the same dimensions and scantlings as required for bottom transverses, are generally to be fitted every two longitudinals, in line with bottom longitudinals located aft of the collision bulkhead. Their extension shall be compatible in each case with the shape of the bottom.

1.6.2 Transversely framed bottom

- Plating:

  The scantling of plating shall be not less than the value obtained from the formulae in table 1.6.1

- Floors:

  Floors shall be fitted at every frame.

  The floor net scantlings shall be not less than those derived from table 1.6.1

  A relaxation from these requirements may be granted by INTLREG for very low draught vessels.

  Where no centerline bulkhead shall be fitted, a center bottom girder shall be provided according to [3.8.2]

1.6.3 Keel plate

The thickness of the keel plate shall be not less than that of the adjacent bottom plating.

Adequate tapering shall be ensured between the bottom and keel plating in the central part and the stem.

Table 1.6.1 Net scantlings of bottom plating and structural member		
Item	**Scantlings**	**Minimum web thickness in mm**
Plating	Net thickness in mm: t = largest of t_1 and t_2 a. longitudinal framing: $t_1 = 1.1 + 0.03 \cdot L \cdot + 3.6 \cdot s$ b. transverse framing: $t_1 = 1.85 + 0.03 \cdot L \cdot + 3.6 \cdot s$ $t_2 = 1.1\ s$	
Inner bottom plating	Net thickness in mm: t = largest of t_1 and t_2 $t_1 = 1.5 + 0.016 \cdot L \cdot + 3.6 \cdot s$ $t_2 = 1.1\ s$	
Bottom longitudinals Inner bottom longitudinals	Net section modulus in cm^3: Net shear sectional area in cm^2: $A_{sh} = 0.045 \cdot \gamma_R \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$	$t = 1.63 + 0.004 \cdot L \cdot + 4.5 \cdot s$
Floors Bottom transverses	Net section modulus in cm^3: $w = 0.54 \cdot \gamma_R \cdot \beta_b \cdot p \cdot a \cdot \ell^2$ Net shear sectional area in cm^2: $A_{sh} = 0.045 \cdot \gamma_R \cdot \beta_s \cdot p \cdot a \cdot \ell$	$t = 3.8 + 0.016 \cdot L \cdot$
p = design load according to Ch 2 Sec [3.6] a = spacing in m of floors (s) or bottom transverses(s) m = boundary coefficient defined in Sec [1.1] γ_R = resistance partial safety factor defined in Table 1.2.1.		

1.7 Side scantlings and arrangements

1.7.1 Arrangement

In way of the anchors, the side plating net thickness shall be increased by 50 %, or a doubling plate shall be provided.

Where a break is in the fore part deck, the net thickness of the sheerstrake shall be increased by 40 % in the region of the break

1.7.2 Longitudinally framed side

- Plating and ordinary stiffeners:

  The scantlings of plating and ordinary stiffeners shall be not less than the values obtained from the formulae in Table 1.7.1
- Side transverses:

Side transverses shall be located in way of bottom transverses and shall extend to the upper deck. Their ends shall be amply faired in way of bottom and deck transverses.

Their net section modulus w in cm^3 and net shear sectional area A_{sh} in cm^2 shall be not less than the values derived from Table 1.7.1

1.7.3 Transversely framed side

- Plating and ordinary stiffeners (side frames):

Side frames fitted at every frame shall have the same vertical extension as the collision bulkhead.

Where, due to the hull design, the actual spacing between transverse stiffeners, measured on the plating, is quite greater than the hull lines, the spacing of side frames shall be reduced, or intermediate frames along with scantlings in considerably with Table 1.7.1, shall be provided.

The net scantlings of plating and side stiffeners shall be not less than the values obtained from the formulae in Table 1.7.1

The value of the side frame section modulus is generally to be maintained for the full extension of the side frame.

- Web frames:

The web frames in a transverse framing system shall be spaced not more than 4 m apart.

The web frame section modulus shall be equal to the section modulus of the floor connected to it.

- Fore peak arrangement:

Depending on the hull body shape and structure aft of the collision bulkhead, one or more adequately spaced side stringers per side shall be fitted. In particular, it is recommended to provide a side stringer where intermediate frames are fitted over a distance equal to the breadth B of the vessels.

The side stringer net section modulus w in cm^3 and shear sectional area A_{sh} in cm^2 shall be not less than the values obtained from Table 1.7.1

Non-tight platforms may be fitted in lieu of side girders. Their openings and scantlings shall be in accordance with 6.1 and their spacing shall be not greater than 2.5 m.

- Access to fore peak:

Manholes may be cut in the structural members to provide convenient access to all parts of the fore peak. These manholes shall be cut smooth along a well-rounded design and are not to be greater than that strictly necessary to provide access. Where manholes of greater sizes are needed, edge reinforcement by means of flat bar rings or other suitable stiffeners may be required.

Table 1.7.1 Net scantlings of side plating and structural members

Item	Scantlings	Minimum web thickness in mm
Plating	Net thickness in mm: t = largest of t_1 and t_2 a. longitudinal framing: $t_1 = 1.25 + 0.025 \cdot L \cdot + 3.6 \cdot s$ b. transverse framing: $t_1 = 1.68 + 0.02 \cdot L \cdot + 3.6 \cdot s$ $t_2 = 1.1\ s$	
Side longitudinals	Net section modulus in cm³: Net shear sectional area in cm²: $A_{sh} = 0.045 \cdot \gamma_R \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$	
Side frames	Net section modulus in cm³: $w = \frac{4.36 \cdot \gamma_R}{m} \beta_b \cdot \eta \cdot p \cdot s \cdot l^2$ Net shear sectional area in cm²: $A_{sh} = 0.045 \cdot \gamma_R \cdot \beta_s \cdot \eta \cdot k_0 \cdot p_0 \cdot s \cdot \ell_0$	$t = 1.63 + 0.004 \cdot L \cdot \sqrt{k} + 4.5 \cdot s$
Intermediate side frames	Net section modulus in cm³: $w = \frac{4.36 \cdot \gamma_R}{m} \beta_b \cdot \eta \cdot (1.2 \cdot k_0 p_0 l_0^2 + \lambda_t p_F l_F^2)$ Net shear sectional area in cm²: $A_{sh} = 0.045 \cdot \gamma_R \cdot \beta_s \cdot \eta \cdot k_0 \cdot p_0 \cdot s \cdot \ell_0$	
Side transverses Side web frames	Net section modulus in cm³: $w = 0.54 \cdot \gamma_R \cdot \beta_b \cdot k_0 \cdot p_0 \cdot S \cdot l_0^2$ Net shear sectional area in cm²: $A_{sh} = 0.045 \cdot \gamma_R \cdot \beta_s \cdot k_0 \cdot p_0 \cdot S \cdot \ell_0$	$t = 3.8 + 0.016 \cdot L \cdot \sqrt{k}$
Side stringers	Net section modulus in cm³: $w = 0.54 \cdot \gamma_R \cdot \beta_b \cdot p \cdot S \cdot l^2$ Net shear sectional area in cm²: $A_{sh} = 0.045 \cdot \gamma_R \cdot \beta_s \cdot p \cdot S \cdot \ell$	

m = boundary coefficient defined in Section [1.1]
γ_R = resistance partial safety factor defined in Table 1.2.1

ℓ_0 = $T - H_F + 0.6 \cdot n$
p_0 = $4.6 \cdot l_0$
p = design load according to [2.6]

k_0 = coefficient given by the formula:

$= \ell + (\ell - \ell_0) / \ell_0$

l_F = floor span in m
H_F = floor height or bottom transverse height in m

p_F = floor design load in kN/m^2 defined in [3.6.2]

λ_t = coefficient ≥0

$$= 0.1 \cdot \left(0.8 - \frac{l^2}{B^2}\right)$$

In combination framing: $\lambda_t = 0$

1.8 Decks

1.8.1 Deck scantlings and arrangements

The scantlings of deck plating and structural members shall be not less than the values obtained from the formulae in Table 1.8.1

Where the hatchways form corners, the deck plating shall have the same thickness as the stringer plate.

The deck plating shall be reinforced in way of the anchor windlass and other deck machinery, bollards, cranes, masts and derrick posts.

- Supporting structure of windlasses and chain stoppers:
  For the supporting structure under windlasses and chain stoppers the permissible stresses as stated in Ch 5,Sect [2.4.4]shall be observed.
  The acting forces shall be calculated for 80 % or 45 % of the rated breaking load of the chain cable as follows:
  a) For chain stoppers: 80 %
  b) For windlasses:
     - 80 % when no chain stopper is fitted
     - 45 % when a chain stopper is fitted

1.8.2 Stringer plate

The net thickness of stringer plate in mm, shall be not less than the greater of:

- $t = 2 + 0.032 \cdot L \cdot + 3.6 \cdot s$
- $t = t_0$
  t_0 = is the deck plating net thickness

Table 1.8.1 Net scantlings of deck plating and structural members

Item	Scantlings	Minimum web thickness in mm
Plating	Net thickness in mm: t = largest of t_1 and t_2 a. longitudinal framing: $t_1 = 0.57 + 0.031 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ b. transverse framing: $t_1 = 0.9 + 0.034 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.1\ s\sqrt{k \cdot p}$	
Plating of tween decks	Net thickness in mm: t = largest of t_1 and t_2 $t_1 = 3.5 + 0.01 \cdot L \cdot \sqrt{k}$ $t_2 = 1.1\ s\sqrt{k \cdot p}$	
Deck ordinary stiffeners	Net section modulus in cm^3: $w = \frac{4.36 \cdot \gamma_R}{m} \beta_b \cdot \eta \cdot p \cdot s \cdot l^2$ Net shear sectional area in cm^2: $A_{sh} = 0.045 \cdot \gamma_R \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$	$t = 1.60 + 0.004 \cdot L \cdot \sqrt{k} + 4.5 \cdot s$
Deck transverses	Net section modulus in cm^3: $w = 0.54 \cdot \gamma_R \cdot \beta_b \cdot p \cdot S \cdot l^2$ Net shear sectional area in cm^2: $A_{sh} = 0.045 \cdot \gamma_R \cdot \beta_s \cdot p \cdot S \cdot \ell$	$t = 3.8 + 0.016 \cdot L \cdot \sqrt{k}$
Deck girders	Net section modulus in cm^3: $w = \frac{4.36 \cdot \gamma_R}{m} \beta_b \cdot p \cdot S \cdot l^2$ Net shear sectional area in cm^2: $A_{sh} = 0.045 \cdot \gamma_R \cdot \beta_s \cdot \eta \cdot p \cdot S \cdot \ell$	$t = 3.8 + 0.016 \cdot L \cdot \sqrt{k}$
p = design load according to 2.6 Ch 5,Sect[4.4] m = boundary coefficient defined in Ch 5 Section [1.1] γ_R = resistance partial safety factor defined in Table 1.2.1		

1.9 Non-tight bulkheads and platforms

1.9.1 Arrangements and scantlings

Non-tight platforms or bulkheads located inside the peak shall be provided with openings having a total area not less than 10 % of that of the platforms or bulkheads.

The scantlings of bulkheads and platforms shall comply with the requirements of non-tight bulkheads (refer Ch 4 Sec [5.12]).

The number and depth of non-tight platforms within the peak is considered by the Society on a case-by-case basis.

The platforms may be replaced by equivalent horizontal structures whose scantlings shall be supported by direct calculations.

1.10 Stems

1.10.1 General

Adequate continuity of strength shall be ensured at the connection of stems to the surrounding structure. Abrupt changes in sections shall be avoided.

1.10.2 Plate stems

- Thickness:

  The gross thickness in mm of the plate stem shall be not less than the value obtained in mm from the following formula:

  For non-propelled vessels, this value may be reduced by 20 %.

  This thickness shall be maintained from at least 0.1 m aft of the forefoot till the load waterline. Above the load waterline, this thickness may be gradually tapered towards the stem head, where it shall be not less than the local value required for the side plating or, in case of pontoon-shaped foreship, the local value required for the bottom plating.

- Centerline stiffener:

  If considered necessary, and particularly where the stem radius is large, a centerline stiffener or web of suitable scantlings shall be fitted.

  Where the stem plating is reinforced by a centerline stiffener or web, its thickness may be reduced by 10 %.

- Horizontal diaphragms:

  The plating forming the stems shall be supported by horizontal diaphragms spaced not more than 500 mm apart and connected, as far as practicable, to the adjacent frames and side stringers.

  The diaphragm plate shall be at least 500 mm deep and its thickness shall be not less than 0.7 times that of the stem.

1.10.3 Bar stems

- Sectional area:

  The sectional area of bar stems constructed of forged or rolled steel shall be not less than the value obtained in cm^2, from the following formulae:

  $A_p = f \cdot (0.006 \cdot L^2 + 12)$

- Thickness:

  The gross thickness of the bar stems constructed of forged or rolled steel, shall be not less than the value obtained in mm from the following formula:

  $T = 0.33 \cdot L + 10$

- Extension:
  The bar stem shall extend beyond the forefoot by about 1 m.
  Its cross sectional area may be gradually tapered from the load waterline to the upper end.

- Stiffened bar stem:
  Where the bar stem is reinforced by a flanged plate or a bulb flat stiffener, its sectional area may be reduced according to Table 1.10.1

Table 1.10.1 Stiffened bar stem

Sectional area in cm^2	Reduction on sectional area of the bar stem
> 0.95 t	10 %
> 1.50 t	15 %
t = web thickness in mm of the plate stiffener	

1.11 Thruster tunnel

1.11.1 Scantlings of the thruster tunnel and connection with the hull

- Net thickness of tunnel plating:
  The net thickness in mm of the tunnel plating shall be neither less than the thickness of the adjacent bottom plating, increased by 2 mm, nor than that obtained from following formula:

$$t = 4.4 + 0.024 \cdot L \cdot$$

- Connection with the hull:
  The tunnel shall be fully integrated into the bottom structure.
  Adequate continuity with the adjacent bottom structure shall be ensured.

SECTION 2 AFT PART

Contents

2.1 Symbols

L = rule length in m defined in Ch 1 Sec [1.1]
B = breadth in m defined in Ch 1 Sec [1.1]
D = depth in m defined in Ch 1 Sec [1.1]
T = draught in m defined in Ch 1 Sec [1.1]
t = thickness in mm of plating
p = design load in kN/m^2 according to [4.4]
s = spacing in m of ordinary stiffeners
S = spacing in m of primary supporting members
ℓ = span in m of ordinary stiffeners or primary supporting members
n = navigation coefficient defined in Ch 2 Sec 2
= 0.85 · H
H = significant wave height in m
β_b, β_s= bracket coefficients defined in Ch 3,[1.17]
η = 1 − s / (2 · ℓ)
w = net section modulus, in in cm^3 of ordinary stiffeners or primary supporting members
A_{sh} = net web sectional area, in cm^2
k = material factor defined in Ch 4 Sec [1.2]
z = Z co-ordinate in m of the calculation point
m = boundary coefficient, to be taken equal to:
= 12.0 in general, for stiffeners considered as clamped
= 8.0 for stiffeners considered as simply supported
= 10.6 for stiffeners clamped at one end and simply supported at the other
f = coefficient defined as follows:
= 1.0 in case of **IW (1.2)** and **IW (2)**

= 0.9 in case of **IW (0.6)**

= 0.8 in case of **IW (0)**

2.2 General

2.2.1 Application

The following requirements apply for the scantling of structures located aft of the after peak bulkhead.

2.2.2 Net scantlings

As specified in Ch 3 [1.20], all scantlings referred to in the following, except for those indicated in Sec 4, are net scantlings, i.e. they do not include any margin for corrosion.

2.2.3 Material factor

When steels with a minimum guaranteed yield stress R_{eH} other than 235 N/mm^2 are used on a vessel, the scantlings shall be determined by considering the material factor as follows:

a. thickness:
Refer relevant requirements given at sections
b. section modulus:
$w = k \cdot w_0$

c. sectional area:
$A = k \cdot A_0$

w_0, A_0 = scantlings corresponding to a steel with a minimum guaranteed yield stress R_{eH} = 235 N/mm²

2.3 Design loads

2.3.1 Pressure on sides and bottom

The design pressure on sides and bottom shall be derived from following formulae:

p_E = $9.81 \cdot (T - z + 0.6 \cdot n)$ for $z \leq T$
= largest of $(5.9 \cdot n$ and $3) + p_{WD}$ for $z > T$

p_{WD} = specific wind pressure in kN/m²
= 0.25 for **IW (0)** and **IW (0.6)**

= $0.4 \cdot n$ for **IW (1.2)** to **IW (2)**.

2.3.2 Pressure on exposed deck

The external pressure on exposed decks shall be defined by the designer and, in general, may not be taken less than:

$P = 3.75 \cdot (n + 0.8)$

2.3.3 Pressure on tween deck

The external pressure on tween decks shall be defined by the designer and, in general, may not be taken less than:

$$P = 4.0 \text{ kN/m}^2$$

2.3.4 Connections of the aft part with structures located fore of theafter bulkhead

- Tapering:

  Adequate tapering shall be ensured between the scantlings in the aft part and those fore of the after bulkhead. The tapering shall be such that the scantling requirements for both areas are fulfilled.

2.4 After peak

2.4.1 Arrangement

The after peak is, in general, to be transversely framed.

- Floors:

  Floors shall be fitted at every frame.

  The floor height shall be adequate in relation to the shape of the hull. Where a sterntube is fitted, the floor height shall extend at least above the sterntube. Where the hull lines do not allow such extension, plates of suitable height with upper and lower edges stiffened and securely fastened to the frames shall be fitted above the sterntube.

  In way of and near the rudder post and propeller post, higher floors of increased thickness shall be fitted. The increase will be considered by INTLREG on a case-by-case basis, depending on the arrangement proposed.

- Side frames:

  Side frames shall be extended up to the deck.

  Where, due to the hull design, the actual spacing between transverse stiffeners, measured on the plating, is significantly larger than the hull lines, the spacing of side frames shall be reduced, or intermediate frames along with scantlings in accordance with Table 2.4.1, shall be provided.

Table 2.4.1 Net scantlings of bottom plating and structural members

Item	Scantlings	Minimum web thickness in mm
Bottom plating	Net thickness in mm: t = largest of t_1 and t_2 a. longitudinal framing: $t_1 = 1.1 + 0.03 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ b. transverse framing: $t_1 = 1.85 + 0.03 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.1\, s \sqrt{k \cdot p}$	
Inner bottom plating	Net thickness in mm: t = largest of t_1 and t_2 $t_1 = 1.5 + 0.03 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.1\, s \sqrt{k \cdot p}$	
Bottom longitudinals Inner bottom longitudinals	Net section modulus in cm³: $w = \frac{6.1}{m} \beta_b \cdot \eta \cdot p \cdot s \cdot l^2$ Net shear sectional area in cm²: $A_{sh} = 0.045 \cdot \gamma_R \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$	$t = 1.63 + 0.004 \cdot L \cdot \sqrt{k} + 4.5 \cdot s$
Floors Bottom transverses	Net section modulus in cm³: $w = 0.87 \cdot \beta_b \cdot p \cdot a \cdot \ell^2$ Net shear sectional area in cm²: $A_{sh} = 0.069 \cdot \beta_s \cdot p \cdot a \cdot \ell$	$t = 3.8 + 0.016 \cdot L \cdot \sqrt{k}$
a = spacing in m of floors (s) or bottom transverses (S) m = boundary coefficient defined in section 1 p = design load in kN/m² defined in Ch 5,Sect [3.7.3]		

- Platforms and side girders:

  Platforms and side girders within the peak shall be arranged in line with those located in the adjacent forward areas immediately forward.

  Where this arrangement is not possible due to the shape of the hull and access requirements, structural continuity between the peak and the structures of the adjacent forward areas shall be ensured by adopting wide tapering brackets.

- Longitudinal bulkheads:

  A longitudinal non-tight bulkhead shall be fitted on the centerline of the vessel, in general in the upper part of the peak, and stiffened at each frame.

  Where no longitudinal bulkhead is fitted, center line bottom and deck girders having the same dimensions and scantlings as required for bottom and deck transverses respectively shall be provided.

- Local reinforcement:

  The deck plating shall be reinforced in way of the anchor windlass, steering gear and other deck machinery, bollards, cranes, masts and derrick posts.

2.4.2 Bottom scantlings

- Bottom plating and structural members:

  The net scantlings of bottom plating and structural members shall not be less than those obtained from formulae in Table 2.4.1.

  For bilge plating refer Ch 4 Sect [2.5].

  The floor scantlings shall be increased satisfactorily in way of the rudder stock.

2.4.3 Side scantlings

- Plating and structural members:

  The net scantlings of plating and structural members shall be not less than those obtained from formulae in Table 2.4.2

- Side transverses:

  Side transverses shall be located in way of bottom transverses and shall extend to the upper deck. Their ends shall be amply faired in way of bottom and deck transverses.

- Side stringers:

  Where the vessel depth exceeds 2 m, a side stringer shall be fitted at about mid-depth.

2.4.4 Deck scantlings and arrangements

- Plating and ordinary stiffeners:

  The net scantlings of deck plating and structural members shall not be less than those obtained from the formulae in Table 2.5.1.

  Where a break is located in the after part deck, the thickness of the sheerstrake shall be increased by 40 % in the region of the break.

  The supporting structure of windlasses and chain stoppers shall comply with Sec .[1.8]

- Stringer plate:

  The net thickness of stringer plate in mm shall not be less than the greater of:

  a. $t = 2 + 0.032 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$

  b. $t = t_0$

  t_0 = deck plating net thickness

2.5 Sternframes

2.5.1 General

Sternframes may be made of cast or forged steel, with a hollow section, or fabricated from plates.

2.5.2 Connections

- Heel:

Sternframes shall be effectively attached to the aft structure. The propeller post heel shall extend forward over a length in m including the scarf, at least equal to:

$$d = 0.01 \cdot L + 0.6 \text{ with } 1.2 \leq d \leq 1.8$$

In order to provide an effective connection with the keel. However, the sternframe need not extend beyond the after peak bulkhead.

The value of d may however be reduced to 1 m where no centerline propeller is fitted.

Table 2.4.2 Net scantlings of shell plating and structural members

Item	**Scantlings**	**Minimum web thickness in mm**
Side plating Transom plating	Net thickness in mm: t = largest of t_1 and t_2 a. longitudinal framing: $t_1 = 1.25 + 0.025 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ b. transverse framing: $t_1 = 1.68 + 0.02 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.1\, s \sqrt{k \cdot p}$	
Side longitudinals	Net section modulus in cm^3: $w = \frac{6.1}{m} \beta_b \cdot \eta \cdot p \cdot s \cdot l^2$ Net shear sectional area in cm^2: $A_{sh} = 0.063 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$	$t = 1.63 + 0.004 \cdot L \cdot \sqrt{k} + 4.5 \cdot s$
Side frames	Net section modulus in cm^3: $w = \frac{6.1}{m} \cdot \beta_b \cdot \eta \cdot (1.2 \cdot k_0 \cdot p_0 \cdot l_0^2 + \lambda_t \cdot p_F \cdot l_F^2)$ Net shear sectional area in cm^2: $A_{sh} = 0.063 \cdot \beta_s \cdot \eta \cdot k_0 \cdot p_0 \cdot s \cdot \ell_0$	
Intermediate side frames	Net section modulus in cm^3: $w = \frac{6.1}{m} \beta_b \cdot \eta \cdot s \cdot k_0 \cdot p_0 \cdot l_0^2$ Net shear sectional area in cm^2: $A_{sh} = 0.063 \cdot \beta_s \cdot \eta \cdot k_0 \cdot p_0 \cdot s \cdot \ell_0$	

Table 2.4.2 Net scantlings of shell plating and structural members (contd.)

Item	Scantlings	Minimum web thickness in mm
Side transverses Side web frames	Net section modulus in cm^3: $w = 0.87 \cdot \beta_b \cdot p_0 \cdot k_0 \cdot S \cdot \ell_0^2$ Net shear sectional area in cm^2: $A_{sh} = 0.072 \cdot \beta_s \cdot p_0 \cdot k_0 \cdot S \cdot \ell_0$	$t = 3.8 + 0.016 \cdot L \cdot \sqrt{k}$
Side stringers	Net section modulus in cm^3: $w = 0.87 \cdot \beta_b \cdot p \cdot S \cdot \ell^2$ Net shear sectional area in cm^2: $A_{sh} = 0.072 \cdot \beta_s \cdot p \cdot S \cdot \ell$	

m = boundary coefficient defined in Section 1

ℓ_0 = $T - H_F + 0.6 \cdot n$

p_0 = $4.9 \cdot l_0$

p = design load according to 2.4

k_0 = coefficient given by the formula:

= $\ell + (\ell - \ell_0) / \ell_0$

l_F = floor span in m

H_F = floor height or bottom transverse height in m

p_F = floor design load in kN/m^2 defined in 2.6.1

λ_t = coefficient ≥0

= $0.1 \cdot \left(0.8 - \frac{l^2}{B^2}\right)$

In combination framing: $\lambda_t = 0$

Table 2.5.1 Net scantlings of deck plating and structural members

Item	Scantlings	Minimum web thickness in mm
Deck plating	Net thickness in mm: t = largest of t_1 and t_2 a. longitudinal framing: $t_1 = 0.57 + 0.031 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ b. transverse framing: $t_1 = 0.90 + 0.034 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.1\ s \sqrt{k \cdot p}$	
Plating of tween decks	Net thickness in mm: t = largest of t_1 and t_2 $t_1 = 3.5 + 0.01 \cdot L \cdot \sqrt{k}$ $t_2 = 1.1\ s \sqrt{k \cdot p}$	
Deck longitudinals Deck beams	Net section modulus in cm^3: $w = \frac{6.1}{m} \beta_b \cdot \eta \cdot p \cdot s \cdot l^2$ Net shear sectional area in cm^2: $A_{sh} = 0.063 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$	$t = 1.63 + 0.004 \cdot L \cdot \sqrt{k} + 4.5 \cdot s$
Deck transverses	Net section modulus in cm^3: $w = 0.87 \cdot \beta_b \cdot p \cdot S \cdot \ell^2$ Net shear sectional area in cm^2: $A_{sh} = 0.072 \cdot \beta_s \cdot p \cdot S \cdot \ell$	$t = 3.8 + 0.016 \cdot L \cdot \sqrt{k}$
Deck girders	Net section modulus in cm^3: $w = \frac{4.36 \cdot \gamma_R}{m} \beta_b \cdot p \cdot S \cdot l^2$ Net shear sectional area in cm^2: $A_{sh} = 0.045 \cdot \gamma_R \cdot \beta_s \cdot \eta \cdot p \cdot S \cdot \ell$	$t = 3.8 + 0.016 \cdot L \cdot \sqrt{k}$
p = design load according to Sect [4.4] m = boundary coefficient defined in Section [1.1] γ_R = resistance partial safety factor defined in Sec 1 Table 1.2.1		

- Connection with hull structure:
  The thickness of shell plating connected with the sternframe shall not be less than the rule thickness of the bottom plating amidships.
- Connection with the keel:
  The thickness of the lower part of the sternframe shall be gradually tapered to that of the solid bar keel or keel plate.
  Where a keel plate is fitted, the lower part of the sternframe shall be so designed as to ensure an effective connection with the keel.
- Connection with transom floors:

Propeller post and rudder post should in their upper part be led and shall be connected to the vessel's structure such as to allow for effective transmission of forces. In range where the forces of the rudder post are led into the vessel structure the shell plating shall be strengthened.

The arrangement of the vessel's stern including the rudder and propeller well shall be designed such as to minimize forces induced by the propeller.

In the vessel’s transverse direction, the propeller post shall to be connected to strengthened and higher floor plates, which are connected by a longitudinal girder in plane of the propeller post over a range of several frames. Floor plates and plates of longitudinal webs which are directly connected to the propeller post shall have thickness of at least 0.30 times the thickness of the bar propeller post according to [4.3.1].

- Connection with center keelson:

  Where the sternframe is made of cast steel, the lower part of the sternframe shall be fitted, as far as practicable, with a longitudinal web for connection with the center keelson.

2.5.3 Propeller posts

- Scantlings of propeller posts:

  The gross scantlings of propeller posts shall not be less than those obtained from the formulae in Table 2.5.2 for single and twin-screw vessels.

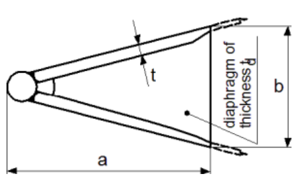
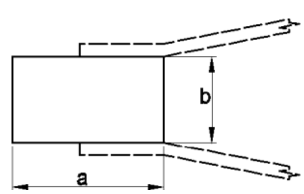
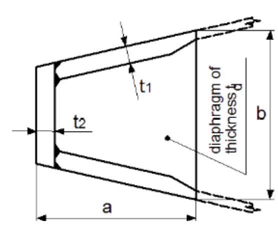
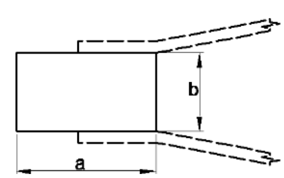
  These scantlings shall be maintained from the bottom to above the propeller boss. At the upper part, the scantlings may be reduced gradually to those of the rudderpost, where the latter joins the propeller post.

  In vessels having a high engine power with respect to their size, or subjected to abnormal stresses, strengthening of the propeller post may be required by INTLREG.

  Scantlings and proportions of the propeller post which differ from those specified may be considered acceptable provided that the section modulus of the propeller post section about its longitudinal axis is not less than that calculated with the propeller post scantlings in Table 2.5.2

- Welding of fabricated propeller post with the propeller shaft bossing:

  Welding of a fabricated propeller post with the propeller shaft bossing shall be in accordance with Pt 2 Ch 5 Sec.[2.3.3]

Table 2.5.2 Gross scantlings of propeller post			
Single screw vessels		Twin screw vessels	
Fabricated propeller post 	Bar propeller post, cast or forged, having rectangular section 	Fabricated propeller post 	Bar propeller post, cast or forged, having rectangular section 
a in mm = 29 $\cdot\sqrt{L}$	a in mm = 14.1 $\cdot\sqrt{A}$	a in mm = 29 $\cdot\sqrt{L}$	a in mm = 14.1 $\cdot\sqrt{A}$
b/a = 0.7	b/a = 0.5	b/a = 0.7	b/a = 0.5

t in mm = $2.5 \cdot \sqrt{L}$ with $t \geq 1.3 \cdot t_{bottom\ midship}$	thickness: NA	t in mm = $2.5 \cdot \sqrt{L}$ with $t_1 \geq 1.3 \cdot t_{bottom\ midship}$ t_2 in mm = $3.2 \cdot \sqrt{L}$ with $t_2 \geq 1.3 \cdot t_{bottom\ midship}$	thickness: NA
Sectional area: NA	for L ≤ 40: A in cm^2 = f · (1.4·L + 12) for L > 40: A in cm^2 = f · (2 · L − 12)	Sectional area: NA	A in cm^2 = f · (0.005 · L^2 + 20)
t_d in mm = $1.3 \cdot \sqrt{L}$	t_d : NA	t_d in mm = $1.3 \cdot \sqrt{L}$	t_d : NA
f = coefficient defined in Sec [1.1] A = sectional area in cm^2, of the propeller post NA = not applicable			

2.5.4 Propeller shaft bossing

- Thickness:
  In single screw vessels, the thickness of the propeller shaft bossing, included in the propeller post in mm shall not be less than:

$$t = 6 \cdot \sqrt{f \cdot (0.7L + 6)} \text{ for } L \leq 40$$

$$t = 6 \cdot \sqrt{f \cdot (L - 6)} \text{ for } L > 40$$

f = coefficient defined in Sec [1.1]

2.5.5 Stern tubes

The stern tube thickness shall be considered by INTLREG on a case-by-case basis. In no case, however, may it be less than the thickness of the side plating adjacent to the sternframe.
Where the materials adopted for the stern tube and the plating adjacent to the sternframe are different, the stern tube thickness shall be at least equivalent to that of the plating.

SECTION 3 MACHINERY SPACE

Contents

3.1 Symbols

L = rule length in m defined in Ch 1 Sec [1.1]
B = breadth in m defined in Ch 1 Sec [1.1]
D = depth in m defined in Ch 1 Sec [1.1]
T = draught in m defined in Ch 1 Sec [1.1]
t = thickness in mm of plating
p = design load in kN/m^2
s = spacing in m of ordinary stiffeners
S = spacing in m of primary supporting members
ℓ = span in m of ordinary stiffeners or primary supporting members
n = navigation coefficient defined in Ch 2 Sec [2.1.2]
= 0.85 · H
H = significant wave height in m
β_b, β_s = bracket coefficients defined in Ch 3Sect [1.17]
$\eta = 1 - s / (2 \cdot \ell)$
w = net section modulus, in in cm^3 of ordinary stiffeners or primary supporting members
A_{sh} = net web sectional area, in cm^2
k = material factor defined in Ch 4 Sec [1.2]
z = Z co-ordinate in m of the calculation point
P = maximum power in kW of the engine
n_R = number of revolutions per minute of the engine shaft at power equal to P
M_H = design bending moment in kNm in hogging condition
M_S = design bending moment in kNm in sagging condition

3.2 General

3.2.1 Application

The following requirements apply for the arrangement and scantling of the machinery space structures.

3.2.2 Connections of the machinery space with the structures located aftand forward

- Tapering:

  Adequate tapering shall be ensured between the scantlings in the machinery space and those located aft and forward. The tapering shall be such that the scantling requirements for all areas are fulfilled.
- Hull girder strength check:

  On vessels with machinery space aft, the hull girder strength in way of the connection of the machinery space with the central part shall be assessed.

  The following indicated value may be used for the design bending moment:

$$M_D = 2 \cdot \frac{d_{AR} M}{L}$$

M = design bending moment in kNm M_H or M_S

= M_H in hogging condition according to Ch 3 Sec [6.1]

= M_S in sagging condition according to Ch 3 Sec.[6.1]

d_{AR} = length of aft deck beyond the cargo space in m (refer Ch 3 Sect [6.2]

- Deck discontinuities:

a) Decks that are interrupted in the machinery space shall be tapered on the side by means of horizontal brackets.

Where the deck is inclined, the angle of inclination shall be limited. The end of slope shall be located in way of reinforced ring.

b) Where transverse bulkheads limit the inclination of deck, the continuity of the longitudinal members shall be ensured.

In way of breaks in the deck, the continuity of longitudinal strength shall be ensured. To that effect, the stringer of the lower deck shall:

- extend beyond the break, over a length at least equal to three times its width
- stop at a web frame of sufficient scantlings

c) At the ends of the sloped part of the deck, suitable arrangements are required to take into account the vertical component of the force generated in the deck.

3.2.3 Arrangements

Every engine room shall normally have two exits. The second exit may be an emergency exit. If a skylight is permitted as an escape, it shall be possible to open it from the inside.

For the height of entrances to machinery space, Refer Sect [7.9.3]

3.2.4 Material factor

When steels with a minimum guaranteed yield stress R_{eH} other than 235 N/mm^2 are used on a vessel, the scantlings shall be determined by taking into account the material factor as follows:

a. thickness:

see relevant requirements in the following

b. section modulus:

$w = k \cdot w_0$

c. sectional area:

$A = k \cdot A_0$

w_0, A_0 = scantlings corresponding to a steel with a minimum guaranteed yield stress R_{eH} = 235 N/mm^2

3.3 Design loads

3.3.1 Local loads

- Pressure on sides and bottom:

The design pressure on sides and bottom shall be derived from following formulae:

p_E = $9.81 \cdot (T - z + 0.6 \cdot n)$ for $z \leq T$

= largest of ($5.9 \cdot n$ and 3) + p_{WD} for $z > T$

p_{WD} = specific wind pressure in kN/m^2

= 0.25 for **IW (0)** and **IW (0.6)**

= 0.4·n for **IW (1.2)** to **IW (2).**

- Pressure on deck:

  The external pressure on deck shall be defined by the designer and, in general, may not be taken less than:

  $p = 3.75 \cdot (n + 0.8)$

3.3.2 Hull girder loads

The normal stress, σ_1 induced by hull girder loads shall be neglected if the fore bulkhead of the machinery space is located at a distance less than $0.2 \cdot L$ from the aft end defined in Ch 1 Sect [1.2.5]

3.4 Hull scantlings

3.4.1 Shell plating

Where the machinery space is located aft, the shell plating thickness shall be determined as specified in Table 3.4.1. Otherwise, requirements of Ch.4 Sec.2, Ch.4 Sec.3, and Ch.4 Sec.4 shall be complied with.

For bilge plating see Ch 4 Sec 2.3

3.4.2 Shell structure

Where the machinery space is located aft, the scantlings of ordinary stiffeners and primary supporting members shall be as required by Table 3.4.2. Otherwise, requirements of Ch 4 Sec 2, Ch 4 Sec 3, and Ch 4 Sec 4 shall be complied with.

3.4.3 Topside structure

The scantlings and arrangement of the topside structure shall be in compliance with Ch 4 Sect [4.5.2] and Ch 4 Sect [4.5.3]

3.5 Bottom structure

3.5.1 General

Where the vessel's bottom is flat, the bottom structure may be transversely or longitudinally framed. In other areas, the bottom structure shall be transversely framed.

3.5.2 Transversely framed bottom

- Arrangement of floors:

  Where the bottom in the machinery space is transversely framed, floors shall be arranged at every frame. Furthermore, reinforced floors shall be fitted in way of important machinery and at the end of keelsons if not extending up to the transverse bulkhead.

  The floors shall be fitted with welded face plates, which are preferably to be symmetrical. Flanges are forbidden.

3.5.3 Longitudinally framed bottom

- Transverses:

  Where the bottom is longitudinally framed, transverses shall be arranged every 4 frame spacings. Additional transverses shall be fitted in way of important machinery.

3.6 Side structure

3.6.1 General

The type of side framing in machinery spaces is generally to be the same as that adopted in the adjacent areas. In any case, it shall be continuous over the full length of the machinery space.

3.6.2 Transversely framed side

- Web frames:

  Web frames shall be aligned with floors. One web frame is preferably to be located in way of the forward end and another in way of the after end of the machinery casing.

  The mean web frame spacing in the machinery space shall in general not more than 5 frame spacings.

Table 3.4.1 Shell plating net scantlings

Item	Transverse framing	Longitudinal framing
Bottom plating	t = largest of t_1 and t_2 $t_1 = 1.85 + 0.03 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.6 \cdot s \cdot \sqrt{k \cdot p}$	t = largest of t_1 and t_2 $t_1 = 1.1 + 0.03 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.2 \cdot s \cdot \sqrt{k \cdot p}$
Side plating	t = largest of t_1 and t_2 $t_1 = 1.68 + 0.025 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.6 \cdot s \cdot \sqrt{k \cdot p}$	t = largest of t_1 and t_2 $t_1 = 1.25 + 0.02 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.2 \cdot s \cdot \sqrt{k \cdot p}$
Deck plating	t = largest of t_1 and t_2 $t_1 = 0.9 + 0.034 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.6 \cdot s \cdot \sqrt{k \cdot p}$	t = largest of t_1 and t_2 $t_1 = 0.57 + 0.031 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.2 \cdot s \cdot \sqrt{k \cdot p}$
p = design load in kN/m^2 defined in [3.1]		

Table 3.4.2 Shell structure net scantlings

Item	Scantlings	Minimum web thickness in mm
Bottom, side and deck longitudinals	Net section modulus in cm^3: $w = 0.45 \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$ Net shear sectional area in cm^2: $A_{sh} = 0.045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$	a. for L < 120 m: $t = 1.63 + 0.004 \cdot L \cdot \sqrt{k} + 4.5 \cdot s$ b. for L ≥ 120 m: $t = 3.9 \cdot \sqrt{k} + s$
Deck beams	Net section modulus. in cm^3: $w = 0.58 \cdot \beta_b \cdot \eta \cdot p \cdot s \cdot \ell^2$ Net shear sectional area in cm^2: $A_{sh} = 0.045 \cdot \beta_s \cdot \eta \cdot p \cdot s \cdot \ell$	

Deck transverses Floors and bottom transverses	Net section modulus in cm^3: $w = 0.58 \cdot \beta_b \cdot p \cdot a \cdot \ell$ Net shear sectional area in cm^2: $A_{sh} = 0.045 \cdot \beta_s \cdot p \cdot a \cdot \ell$	$t = 3.8 + 0.016 \cdot L \cdot \sqrt{k}$
Deck girders	Net section modulus in cm^3: $w = \frac{4.36 \cdot \gamma_R}{m} \beta_b \cdot p \cdot S \cdot l^2$ Net shear sectional area in cm^2: $A_{sh} = 0.045 \cdot \gamma_R \cdot \beta_s \cdot p \cdot S \cdot \ell$	
Side frames	Net section modulus in cm^3: $w = 0.58 \cdot s \cdot \beta_b \cdot \eta \cdot (1.2 \cdot k_0 \cdot p \cdot \ell_0^2 + \lambda_t \cdot p\gamma E \cdot l_F^2)$ Net shear sectional area in cm^2: $A_{sh} = 0.045 \cdot \beta_s \cdot \eta \cdot k_0 \cdot p \cdot s \cdot \ell_0$	a. for L < 120 m: $t = 1.63 + 0.004 \cdot L \cdot \sqrt{k} + 4.5 \cdot s$ b. for L ≥ 120 m: $t = 3.9 \cdot \sqrt{k} + s$
Side web frames Side transverses	Net section modulus in cm^3: $w = 0.70 \cdot \beta_b \cdot k_0 \cdot p \cdot S \cdot \ell_0^2$ Net shear sectional area in cm^2: $A_{sh} = 0.063 \cdot \beta_s \cdot k_0 \cdot p \cdot S \cdot \ell_0$	$t = 3.8 + 0.016 \cdot L \cdot \sqrt{k}$
Side stringers	Net section modulus in cm^3: $w = 0.75 \cdot \beta_b \cdot p \cdot S \cdot \ell^2$ Net shear sectional area in cm^2: $A_{sh} = 0.056 \cdot \beta_s \cdot p \cdot S \cdot \ell$	

a = primary supporting member spacing in m:
= s for floors
= S for other primary supporting members

m = boundary coefficient defined in Section 1

p = design load determined according to [3.3]in kN/m^2

= $4.9 \cdot (T - H_F + 0.6 \cdot n)$ for side vertical stiffeners

$p_{\gamma E}$ = floor design load in kN/m^2

= $9.81 \cdot (T + 0.6 \cdot n)$

ℓ_0 = $T - H_F + 0.6 \cdot n$

l_F = floor span in m

H_F = floor height or bottom transverse height in m

γ_R = resistance partial safety factor defined in Table 1.2.1

k_0 = coefficient given by the formula:

= $\ell + (\ell - \ell_0) / \ell_0$

λ_t = coefficient ≥0

= $0.1 \cdot \left(0.8 - \frac{l^2}{l_F^2}\right)$

= In combination framing: $\lambda_t = 0$

- Side stringers:

  In the machinery space, where the mean value of the depth exceeds 2 m, a side stringer shall generally be fitted at half the vessel's depth. Its scantlings shall be the same as those of the web frames.

  The stringer shall be constituted by an intercostal plate between web frames.

  Stringer strength continuity in way of the web frames shall be ensured by suitable weld connection. Stringers located in fuel bunkers shall be determined in the same way as bulkhead stringers.

  In case a side stringer is fitted in the engine room, it shall be continued aft of the aft bulkhead by a bracket at least over two frame spacings.

3.6.3 Longitudinally framed side

- Extension of the hull longitudinal structure within the machinery space:

  In vessels where the machinery space is located aft and where the side is longitudinally framed, the longitudinal structure is preferably to extend for the full length of the machinery space.

  In any event, the longitudinal structure shall be maintained for at least 0.3 times the length of the machinery space, calculated from the forward bulkhead of the latter, and abrupt structural discontinuities between longitudinally and transversely framed structures shall be avoided.
- Side transverses:

  Side transverses shall be aligned with floors. One side transverse preferably to be located in way of the forward end and another in way of the after end of the machinery casing.

  The side transverse spacing shall not be greater than 4 frame spacings.

3.7 Machinery casing

3.7.1 Arrangement

- Ordinary stiffener spacing:

  Ordinary stiffeners shall be located:

  a. at each frame, in longitudinal bulkheads
  b. at a distance of not more than 750 mm, in transverse bulkheads

3.7.2 Openings

- General:

  All machinery space openings, which have to comply with the requirements in Sec 7.9, shall be enclosed with a steel casing leading to the highest open deck. Casings shall be reinforced at the ends by deck beams and girders supported by pillars.

  In the case of large openings, the arrangement of cross-ties as a continuation of deck beams may be required.

3.7.3 Scantlings

- Design loads:

  Design loads for determination of machinery casing scantlings shall be taken as stated under Sec [4.4]
- Plating and ordinary stiffeners:

The net scantlings of plating and ordinary stiffeners shall be not less than those obtained according to the applicable requirements in Sec 4.

3.8 Engine foundation

3.8.1 General

The arrangement and scantlings of the engine foundation shall comply with the manufacturer recommendations. The net scantlings of the structural elements in way of the seatings of main engines shall be determined as required in [3.8.2] to [3.8.4].

3.8.2 Longitudinal girders

- Extension:

  The longitudinal girders under the engine shall extend over the full length of the engine room and extend beyond the bulkheads, at least for one frame spacing, by means of brackets of the same thickness.

  Where such an arrangement is not practicable aft, because of the lines, the girders may end at a deep floor strengthened to that effect and in way of which the frames shall be fitted.

  Longitudinal girders under the engine shall be continuous and the floors shall be intercostal, except for large size engine rooms. Strength continuity shall be ensured over the full girder length. Cutouts and other discontinuities shall be carefully compensated.

- Scantlings:

  The longitudinal girder net section modulus w in cm^3 and net shear sectional area A_{sh} in cm^2 shall not be less than:

$$w = 0.75 \cdot \beta_b \cdot p \cdot b \cdot \ell^2$$

$$A_{sh} = 0.056 \cdot \beta_s \cdot p \cdot b \cdot \ell_E$$

b = plating parameter in m to be obtained from the following formula:

$$b = \frac{B_1 - n_E \cdot S}{2 \cdot (n_E + 1)} + \frac{S}{2}$$

S = longitudinal girders spacing in m (under main engine)

n_E = number of engines

ℓ_E = length of the engine foundation in m shall not be taken less than 3 m

B_1 = width of the machinery space in m

The ratio of the longitudinal girder height to the web thickness shall not be greater than 50.

Over the outer quarters of the longitudinal girder length, the section modulus of the girder may decrease towards the ends up to a quarter of this value.

The scantlings specified above may be reduced when additional longitudinal bottom girders, either center or side girders, are provided over the full length of the engine room.

The net cross sectional area in cm^2 of top plate shall not be less than:

$$A = 40 + 23\frac{P}{n_R}$$

Its minimum net thickness in mm shall be determined using the formula:

$$t = 18 + 2.3\frac{P}{n_R}$$

3.8.3 Floors

Strength continuity of floors shall be obtained as shown in Figure 3.8.1 or Figure 3.8.2, or according to any other method considered equivalent by INTLREG

- Scantlings:

  In way of the engine foundation, the floor net section modulus w in cm^3 and shear sectional area A_{sh} in cm^2 shall not be less than:

$$w = 0.58\beta_b \cdot p \cdot s \cdot l^2 + 175\frac{P}{n_R}$$

$$A_{sh} = 0.045\beta_s \cdot p \cdot s \cdot l + 17.5\frac{P}{n_R}$$

  The section modulus of the floors in the section A-A (refer Figure 3.8.1 and Figure 3.8.2) shall be at least 0.6 times that determined according to the above formula.

3.8.4 Bottom plating in way of engine foundation

The net thickness of the bottom plating in mm in way of the engine seatings shall be determined using the formula:

$$t = t_0 + 2.3 \cdot \frac{P}{n_R}$$

t_0 = net thickness of the bottom plating in mm in the central part.

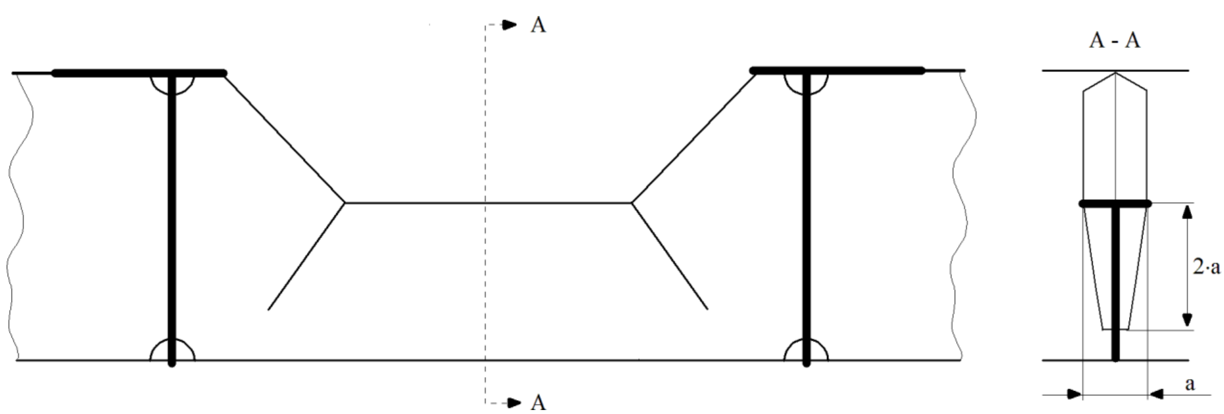


Figure 3.8.1 Floor in way of main engine seating: 1st version

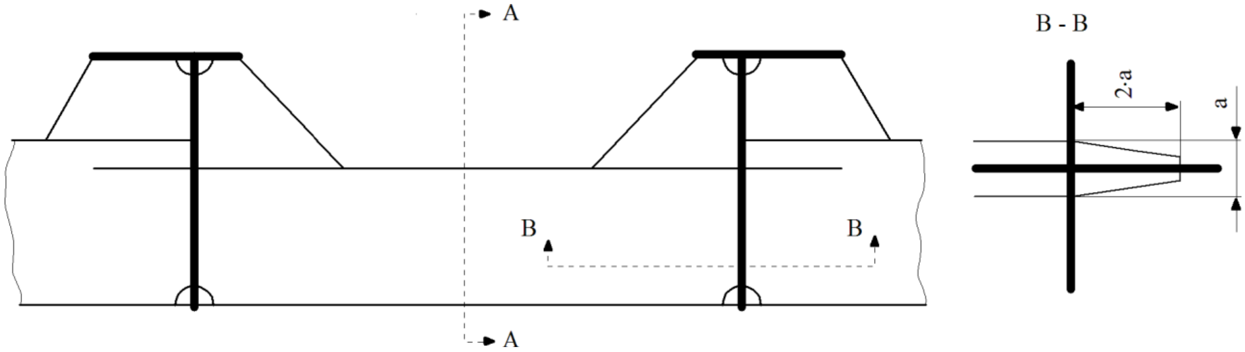


Figure 3.8.2 Floor in way of main engine seating: 2nd version

SECTION 4 SUPERSTRUCTURES AND DECKHOUSES

Contents

4.1 Symbols

L = rule length in m defined in Ch 1 Sec [1.1]
t = thickness in mm of plating
s = spacing in m of ordinary stiffeners
S = spacing in m of primary supporting members
n = navigation coefficient defined in Ch 2 Sec 2
= 0.85 · H
H = significant wave height in m
w = net section modulus, in in cm^3 of ordinary stiffeners or primary supporting members
A_{sh} = net web sectional area, in cm^2
k = material factor defined in Ch 4 Sec [1.2]

4.2 General

4.2.1 Application

The following requirements apply for the scantlings of plating and associated structures of front, side, aft bulkheads/decks of superstructures and deckhouses. These may or may not contribute to the longitudinal strength.

4.2.2 Definitions

- Deckhouses:

  A closed deckhouse is a construction consisting of strong bulkheads permanently secured to the deck and made watertight. The openings shall be fitted with efficient weathertight means of closing.

  The deckhouses considered have:

  a. for an aft deckhouse: the fore bulkheads less than 0.25·L from the aft perpendicular
  b. for a midship deckhouse: a length at most equal to L/6
  c. for a fore deckhouse: the aft bulkhead less than 0.25·L from the fore perpendicular

- Superstructures:

  Superstructures are defined in Ch 1 Sec [1.2.6]
- Tiers of superstructures and deckhouses

  The lowest tier is normally that which is directly situated above the strength deck defined in Ch1 Sect [1.2.8].

  The second tier is that located immediately above the lowest tier, and so on.

4.2.3 Material factor

When steels with a minimum guaranteed yield stress R_{eH} other than 235 N/mm^2 are used on a vessel, the scantlings shall be determined by taking into account the material factor as follows:

a. thickness: refer relevant requirements in the following sections
b. section modulus: $w = k \cdot w_0$
c. sectional area: $A = k \cdot A_0$

   w_0, A_0 = scantlings corresponding to a steel with a minimum guaranteed yield stress R_{eH} = 235 N/mm^2.

4.3 Arrangements

4.3.1 Connections of superstructures and deckhouses with the hull structure:

Superstructure and deckhouse frames shall be aligned as far as practicable with structures below underlying and shall be effectively connected to both the latter and the deck beams above.

Ends of superstructures and deckhouses shall be efficiently supported by bulkheads, diaphragms, webs or pillars arranged below.

Connection to the deck of corners of superstructures and deckhouses is considered by the Society on a case-by-case basis. Where necessary, doublers or reinforced welding may be required.

The frames of sides of superstructures and deckhouses shall have the same spacing as the beams of the supporting deck.

Web frames shall be arranged to support the sides and ends of superstructures and deckhouses.

The side plating at ends of superstructures shall be tapered into the bulwark or sheerstrake of the strength deck. Where a raised deck is fitted, this arrangement shall extend over at least 3 frame spacings.

4.3.2 Arrangement

The accommodation shall be separated from engine rooms, boiler rooms and holds by gastight bulkheads.

The accommodation shall be arranged behind the collision bulkhead.

4.4 Design loads

4.4.1 Sides and bulkheads

The lateral pressure to be used for the determination of scantlings of structure of sides and bulkheads of superstructures, deckhouses and machinery casing shall be obtained in kN/m^2 from the following formula:

$p = 2 + p_{WD}$

p_{WD} = specific wind pressure in kN/m^2 defined in Table 4.4.1.

Table 4.4.1 Specific wind pressure

Navigation notation	Wind pressure p_{WD} in kN/m^2
IW (1.2) to **IW (2)**	$0.4 \cdot n$
IW (0.6), **IW (0)**	0.25

4.4.2 Pressure on decks

The pressure on decks shall be defined by the designer and, in general, may not be taken less than the values given in Table 4.4.2 or Table 4.4.3.

Table 4.4.2 Deck pressure in accommodation compartments	
Type of accommodation compartment	**p in kN/m^2**
Large spaces, such as: restaurants, halls, cinemas, lounges, kitchen, service spaces, games and hobbies rooms, hospitals	4.0
Cabins	3.0
Other compartments	2.5

Table 4.4.3 Pressure on exposed decks	
Exposed deck location	**p in kN/m^2**
First tier (non-public)	2.0
Upper tiers (non-public)	1.5
Public	4.0

Local reinforcements shall be provided in way of areas supporting cars or ladders.

4.5 Scantlings

4.5.1 Net scantlings

All scantlings referred to in the following are net scantlings, i.e., they do not include any margin for corrosion.

The gross scantlings are obtained as specified in Ch 3 Sect-[1.21]

4.5.2 Scantling requirements

- Superstructures and deckhouses not contributing to the longitudinal strength:

  The net scantlings of superstructures and deckhouses not contributing to the longitudinal strength shall be derived from formulae given in Table 4.5.1.

- Superstructures and deckhouses contributing to the longitudinal strength:

The net scantlings of superstructures contributing to the longitudinal strength shall be determined in accordance with Table 4.5.2 and Table 4.5.3.

Table 4.5.1 Net scantlings for non-contributing superstructures		
Item	**Parameter**	**Scantling**
Plating of sides Plating of aft end bulkheads Plating of non-exposed deck	thickness in mm	t = largest of t_1 and t_2 $t_1 = 3.5 + 0.01 \cdot L \cdot \sqrt{k}$ $t_2 = 0.8 \cdot s \cdot \sqrt{k \cdot p}$
Plating of exposed decks Plating of front bulkheads	thickness in mm	t = largest of t_1 and t_2 $t_1 = 4 + 0.01 \cdot L \cdot \sqrt{k}$ $t_2 = 1.6 \cdot s \cdot \sqrt{k \cdot p}$
Longitudinal ordinary stiffeners	section modulus in cm^3	$w = 0.4 \cdot p \cdot s \cdot \ell^2$
Other ordinary stiffeners	section modulus in cm^3	$w = k_1 \cdot p \cdot s \cdot \ell^2$
Primary supporting members	section modulus in cm^3	$w = k_1 \cdot p \cdot S \cdot \ell^2$
p = design load defined in section 4 ℓ = span in m of ordinary stiffeners or primary supporting members ≥ 2.5 m k_1 = load coefficient: = 0.58 for horizontal stiffeners = $0.58 + 0.1 \cdot n_t$ for vertical stiffeners n_t = number of tiers above the tier considered		

Table 4.5.2 Plating net thickness for contributing superstructures		
Item	**Framing system**	**Scantling**
Side plating	Transverse framing	t = largest of t_1 and t_2 $t_1 = 1.68 + 0.025 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.6 \cdot s \cdot \sqrt{k \cdot p}$
	Longitudinal framing	t = largest of t_1 and t_2 $t_1 = 1.25 + 0.02 \cdot L \cdot \sqrt{k} + 3.6 \cdot s$ $t_2 = 1.2 \cdot s \cdot \sqrt{k \cdot p}$

Deck plating	Transverse framing	t = largest of t_1, t_2 and t_3 For exposed decks: $t_1 = 4 + 0.01 \cdot L \cdot \sqrt{k}$ For non-exposed decks: $t_1 = 3.5 + 0.01 \cdot L \cdot \sqrt{k}$ $t_2 = 1.6 \cdot s \cdot \sqrt{k \cdot p}$ $t_3 = 74 \cdot \frac{s}{k_2} \sqrt{\frac{\psi \cdot M_S}{Z_D}}$ If $\frac{t_3}{s} > \frac{23.9}{k_2 \sqrt{k}}$: $t_3 = \frac{7.76\sqrt{k} \cdot s}{k_2 \sqrt{0.21 - \frac{\psi \cdot M_S}{Z_D}}}$ refer 1)
	Longitudinal framing	t = largest of t_1, t_2 and t_3 for exposed decks: $t_1 = 4 + 0.01 \cdot L \cdot \sqrt{k}$ for non-exposed decks: $t_1 = 3.5 + 0.01 \cdot L \cdot \sqrt{k}$ $t_2 = 1.2 \cdot s \cdot \sqrt{k \cdot p}$ $t_3 = 39 \cdot s \sqrt{\frac{\psi \cdot M_S}{Z_D}}$ see 1
Plating of end bulkheads	all	t = largest of t_1 and t_2 $t_1 = 3.5 + 0.01 \cdot L \cdot \sqrt{k}$ $t_2 = 1.6\ s\ \sqrt{k \cdot p}$
Plating of front bulkheads	all	t = largest of t_1 and t_2 $t_1 = 4 + 0.01 \cdot L \cdot \sqrt{k}$ $t_2 = 1.6\ s\ \sqrt{k \cdot p}$

p = design load defined in section 4
k_2 = coefficient
= $1+\alpha^2$
α = b_2 / b_1
b_1 = unsupported deck width in y direction in m
b_2 = unsupported deck width in x direction in m
Z_D = net hull girder section modulus at deck level in cm^3
M_S = design bending moment in kNm in sagging condition
ψ = superstructure efficiency

1) A lower value of thickness t_3 may be accepted if in compliance with the buckling analysis carried out according to Ch 3 Sec 2

Table 4.5.3 Structural member net scantlings for contributing superstructures		
Item	**w**	**A_{sh}**
Longitudinal ordinary stiffeners	$\frac{83.3}{214 - \psi \cdot \sigma_1} p \cdot s \cdot l^2$	$0.045 \cdot p \cdot s \cdot \ell$
Other ordinary stiffeners	$k_1 \cdot p \cdot s \cdot \ell^2$	
Longitudinal primary supporting members	$\frac{125}{14 - \psi \cdot \sigma_1} p \cdot S \cdot l^2$	$0.045 \cdot p \cdot S \cdot \ell$
Other primary supporting members	$0.58 \cdot p \cdot S \cdot \ell^2$	
σ_1 = hull girder normal stress in N/mm^2 ψ= superstructure efficiency For other symbols, see definitions in Table 4.5.1.		

4.6 Additional requirements applicable to movable wheelhouses

4.6.1 General

The structures of movable wheelhouse shall be checked in low and high position.

The supports or guide of movable wheelhouses, connections with the deck, under deck reinforcements and locking devices shall be checked considering loads due to list and wind action and, eventually, inertial loads.

The safety of persons on board shall be guaranteed in any position of the wheelhouse. Movements of the wheelhouse shall be signaled by optical and acoustic means.

In the case of emergency, it should be possible to lower the wheelhouse by means independent of the power drive. Emergency lowering of the wheelhouse shall be effected by its own weight and shall be smooth and controllable. It should be possible from both inside and outside the wheelhouse and can be effected by one person under all conditions.

4.6.2 Arrangement

The hoisting mechanism shall be capable to hoist at least 1.5 times the weight of the wheelhouse fully equipped and manned.

The feed cables for systems inside the wheelhouse shall be arranged in such a way as to prevent mechanical damage to them.

4.7 Elastic bedding of deckhouses

4.7.1 General

The structural members of elastically bedded deckhouses may, in general, be dimensioned in accordance with Sec 5.

Strength calculations for the load bearing rails, elastic elements and antilift-off devices as well as for supporting structure of the deckhouse bottom and the hull shall be carried out assuming the following loads:

a. vertical:
   $P = 1.2 \cdot G$
b. horizontal:
   $P = 0.3 \cdot G$
   G = total weight of the complete deckhouse, outfitting and equipment included Additional loads due to vessel's heel need not be considered, in general.

SECTION 5 HATCH COVERS

Contents

5.1 Symbols

L = rule length in m defined in Ch 1 Sec [1.1]
t = thickness in mm of plating
s = spacing in m of ordinary stiffeners
S = spacing in m of primary supporting members
n = navigation coefficient defined in Ch 2 Sec 2
= 0.85 · H
H = significant wave height in m
w = net section modulus, in in cm^3 of ordinary stiffeners or primary supporting members
A_{sh} = net web sectional area, in cm^2
k = material factor defined in Ch 4 Sec [1.2]
P = hatchway design load in kN/m^2
m = boundary coefficient for ordinary stiffeners and primary supporting members
= 8 in the case of ordinary stiffeners and primary supporting members simply supported at both ends or supported at one end and clamped at the other
= 12 in the case of ordinary stiffeners and primary supported members clamped at both ends

5.2 General

5.2.1 Application

The following requirements apply to hatchways which are closed with self-bearing hatch covers. These shall bear on coamings.

Hatch covers supported by hatchway beams and other supporting systems shall be considered by the Society on a case-by-case basis. In any case, they shall ensure the same degree of strength and weather tightness.

These rules do not cover the classification of vessels with range of navigation **IW (0)**, for which however the rules applicable to the range of navigation **IW (0.6)** may be used.

5.2.2 Definitions

- Weather tightness:

  Weather tightness is ensured when, for all the navigation conditions envisaged, the closing devices comply with applicable requirements.

  Systems to ensure the weather tightness are mentioned in [5.4.3]
- Water tightness:

  Water tightness is ensured when, for all the navigation conditions envisaged, the closing devices comply with applicable requirements.

5.2.3 Materials

Hatch covers shall be made of steel. The use of other materials shall be considered by INTLREG on a case-by-case basis.

5.2.4 Net scantlings

All scantlings referred to in the following are net, i.e. they do not include any margin for corrosion. The gross scantlings are obtained as specified in Ch 3 Sec-[1.21]

5.3 Design loads

5.3.1 General

The design loads to be considered for the scantling of hatch covers are, on one hand, the structural weight of the items themselves, and on the other, the expected hatch cover load, if any, defined in [5.3]

5.3.2 Hatch covers carrying uniform cargoes

The expected hatch cover load shall be defined by the designer and, in any case, shall not be taken less than:

$$P = \text{largest of } 1.5 \text{ and } 6 \cdot n - 1.5$$

5.4 Arrangements

5.4.1 Hatch covers on exposed decks

Hatchways on exposed decks shall be fitted with hatch covers the strength, rigidity and weather tightness of which shall be adequate:

a. on vessels assigned the ranges of navigation **IW (1.2)** to **IW (2)**
b. on vessels assigned the range of navigation **IW (0.6)** on which the height of the hatch coaming above the deck in m, h_C, is such that:

$$D + h_C > T + (n / 1.7) + 0.15$$

5.4.2 Hatch covers in closed superstructures

Hatch covers in closed superstructures need not to be weathertight.

However, hatch covers fitted in way of ballast tanks, fuel oil tanks or other tanks shall be watertight.

5.4.3 Weather tightness of hatch covers

The hatch cover tightness is not subjected to testing.

Tightness may be obtained by fitting of flanged metal hatch covers which constitute baffles intended to prevent water penetrating into the hold below.

Hatch covers shall have a mean slope of not less than 0.1, unless they are covered by tarpaulins. Where tarpaulins are fitted, they shall have adequate characteristics of strength and weather tightness. The tarpaulin shall be secured by means of batten, cleats and wedges.

5.4.4 Securing of hatch covers

Supports or guides of efficient construction shall ensure the position and securing go hatch covers. Where broaches or bolts are used, their diameter shall be such that the mean shearing stress, under the action of the loads mentioned in [5.3], does not exceed 44 N/mm^2.

Efficient arrangements shall be made to prevent unexpected displacement or lifting of the hatch covers.

The width of each bearing surface for hatch covers shall be at least 65 mm.

5.5 Scantlings

5.5.1 Application

The following scantling requirements are applicable to rectangular hatch covers subjected to a uniform pressure.

In the case of hatch covers arranged with primary supporting members as a grillage, the scantlings shall be determined by direct calculations.

5.5.2 Plating of hatch covers

- Minimum net thickness of steel hatch covers:

  In any case, the thickness of steel hatch covers shall not be less than:

  a. galvanized steel: 2 mm
  b. other materials: 3 mm.

- Net thickness of metal hatch covers:

  The net thickness of metal hatch covers subjected to lateral uniform load shall not be less than:

$$t = 1.2\, s \sqrt{k \cdot p}$$

  nor than the thickness derived from the following formulae:

  for **IW (1.2)** to **IW (2)**:

$$t = 4.9\, s \sqrt[3]{k^{1.5} \cdot (1 + 0.34 \cdot p)}$$

  for **IW (0.6)**:

$$t = 3.4\, s \sqrt[3]{k^{1.5} \cdot (1 + p)}$$

5.5.3 Stiffening members of self-bearing hatch covers

- Width of attached plating:

  The width of the attached plating shall be in compliance with Ch 3 Sec [1.4.3] or Ch 3 Sec [1.5] as applicable.

- Minimum web thickness:

  The minimum thickness of the web of the stiffeners in mm shall not be less than the thickness of the plating of the hatch covers, given in 5.5.2

- Section modulus and shear sectional area:

  The net section modulus w in cm^3 and the net shear sectional area A_{sh} in cm^2 of self-bearing hatch cover ordinary stiffeners and primary supporting members shall not be less than those obtained from the following formulae:

$$w = 4.6\, k\, \frac{p}{m}\, a\, l^2$$

$$A_{sh} = 0.045 \cdot k \cdot p \cdot a \cdot \ell$$

a = Stiffener spacing in m
= s for ordinary stiffeners
= S for primary supporting members

SECTION 6 MOVABLE DECKS AND RAMPS

Contents

6.1 Movable decks and inner ramps

6.1.1 Materials

The movable decks and inner ramps shall be made of steel. INTLREG may allow the use of other materials of equivalent strength, subject to a case-by-case examination.

6.1.2 Net scantlings

As specified in Ch 3 Sec- [1.21] all scantlings referred to in this section are net, i.e. they do not include any margin for corrosion.

The gross scantlings shall be obtained as specified in Ch 3 Sec. [1.21]

6.1.3 Primary supporting members

- General:

  The supporting structure of movable decks and inner ramps shall be verified through direct calculation, considering the following cases:

  a. movable deck stowed in upper position, empty and locked in navigation conditions
  b. movable deck in service, loaded, in lower position, resting on supports or supporting legs and locked in navigation conditions
  c. movable inner ramp in sloped position, supported by hinges at one end and by a deck at the other, with possible intermediate supports, loaded, at harbor
  d. movable inner ramp in horizontal position, loaded and locked, in navigation conditions.

- Loading cases:

  The scantlings of the structure shall be verified in both navigation and harbor conditions for the following cases:

  a. loaded movable deck or inner ramp under loads according to the load distribution indicated by the designer

  b. loaded movable deck or inner ramp under uniformly distributed loads corresponding to a pressure in kN/ m^2 taken equal to:

$$p_1 = \frac{n_V \cdot P_V + P_P}{A_P}$$

  c. empty movable deck under uniformly distributed masses corresponding to a pressure in kN/m^2 taken equal to:

$$p_0 = \frac{P_P}{A_P}$$

n_V = maximum number of vehicles loaded on the movable deck or inner ramp

P_V = weight of a vehicle in kN

P_P = weight of the movable deck or inner ramp in kN

A_P = effective area of the movable deck or inner ramp in m

- Lateral pressure:

  The lateral pressure is constituted by still water pressure and inertial pressure. The lateral pressure in kN/m² is obtained from the following formula:

  $$P = p_S + 1.10 \cdot p_W$$

  p_S, p_W = still water and inertial pressures transmitted to the movable deck or inner ramp structures, obtained in kN/m² from Table 6.2.1.

- Checking criteria:

  It shall be checked that the combined stress σ_{VM} in N/mm² complies with the criteria defined in Ch 3 Sect [4.3]

- Allowable deflection:

  The scantlings of main stiffeners and the distribution of supports shall be such that the deflection of the movable deck or inner ramp does not exceed 5 mm/m.

6.1.4 Supports, suspensions and locking devices

Scantlings of supports and wire suspensions shall be determined by direct calculation on the basis of the loads in [1.5.2] and [1.5.3] taking account of a safety factor at least equal to 5.

It shall be checked that the combined stress σ_{VM} in N/mm² in rigid supports and locking devices is in compliance with the criteria defined in Ch 3 Sect [4.3]

6.1.5 Tests and trials

Tests and trials shall be carried out in the presence of the surveyor, in compliance with the rules.

6.2 External ramps

6.2.1 General

External ramps shall be able to operate at a heel angle of 5° and a trim angle of 2°.

The net thicknesses of plating and the net scantlings of ordinary stiffeners and primary supporting members shall be determined under vehicle loads in harbor condition, at rest, as defined in Table 6.2.1.

External ramps shall be examined for their water tightness, if applicable.

INTLREG shall examine the locking mechanism of external ramps in stowage position in navigation conditions on a case-by-case basis.

The vessel’s structure subjected to reaction forces from the ramp is examined by the Society on a case-by-case basis.

Table 6.2.1 Movable decks and inner ramps - still water and inertial pressures

Vessel condition	Load case	Still water pressure p_S and inertial pressure p_W in kN/m²
Still water condition		$p_S = p_0$ in harbor condition during lifting $p_S = p_1$ in other cases
Upright navigation condition		$p_{W.X} = 0.1 \cdot a_{X1} \cdot p_1$ in x direction $p_{W.Z} = 0.1 \cdot a_{Z1} \cdot p_1$ in z direction
Inclined navigation condition		$p_{W.Y} = 0.07 \cdot a_{Y2} \cdot p_1$ in y direction $p_{W.Z} = 0.07 \cdot a_{Z2} \cdot p_1$ in z direction
Harbor condition [1)]	during lifting	$p_{W.X} = 0.035 \cdot p_0$ in x direction $p_{W.Y} = 0.087 \cdot p_0$ in y direction $p_{W.Z} = 0.200 \cdot p_0$ in z direction
	at rest	$p_{W.X} = 0.035 \cdot p_1$ in x direction $p_{W.Y} = 0.087 \cdot p_1$ in y direction $p_{W.Z} = 0.100 \cdot p_1$ in z direction

1) For harbor conditions, a heel angle of 5° and a trim angle of 2° are taken into account.
p_0, p_1 = pressures in kN/m² to be calculated according to [1.5.2] for the condition considered
a_{X1}, a_{Z1}, a_{Y2}, a_{Z2} = reference values of the accelerations defined in Ch.2 Sec.3 Table 3.6.3

SECTION 7 ARRANGEMENTS FOR HULL AND SUPERSTRUCTURE OPENINGS

Contents

7.1 Symbols

L = rule length in m defined in Ch 1 Sec [1.1]
t = thickness in mm of plating
s = spacing in m of ordinary stiffeners
S = spacing in m of primary supporting members
n = navigation coefficient defined in Ch 2 Sec 2
= $0.85 \cdot H$
H = significant wave height in m

7.2 Side shell openings

7.2.1 General

Openings in the vessel's sides, e.g. for cargo ports, shall be well rounded at the corners and located well clear of superstructure ends or any openings in the deck areas at sides of hatchways.

7.2.2 Arrangement

- Shell plating openings:

  Openings shall be compensated if their edge is less than $0.25 \cdot D$ from the bottom or from the deck and if all these openings are located over $0.25 \cdot L$ from either end perpendicular.

  Compensation is not required for circular openings having a diameter at most equal to 300 mm.

- Openings for water intakes:

  Openings for water intakes shall be well rounded at the corners and, within $0.6 \cdot L$ amidships, located outside the bilge strakes. Where arrangements are such that water intakes are unavoidably located in the curved zone of the bilge strakes, such openings shall be elliptical with the major axis in the longitudinal direction.

- Sheerstrake openings:

  Circular openings in the sheerstrake need not be compensated where their diameter does not exceed 20 % of the sheerstrake minimum width, and where they are located away from openings in deck at the side of hatchways or superstructure ends.

- Other openings:

  INTLREG shall consider other openings on a case-by-case basis.

7.2.3 Strengthening

Openings in [7.2.2] shall be compensated by means of insert plates or doublers sufficiently extended in length. Such compensation shall be partial or total depending on the stresses occurring in the area of the openings.

7.3 Deck openings

7.3.1 Openings in the strength deck

Openings in the strength deck shall be kept to a minimum and spaced as far apart from one another as possible. Openings shall also be kept as far apart from breaks of effective superstructures and hatchway corners as practicable.

Stringer plate cut-outs situated in the cargo hold space of open deck vessels shall be strengthened by means of plates having an increased thickness or by means of doubling plates. This is not applicable to scupper openings.

In case of flush deck vessels, no compensation is required where the openings are:

a. circular of less than 350 mm in diameter and at a distance, sufficiently far, from any other opening
b. elliptical with the major axis in the longitudinal direction and the ratio of the major to minor axis not less than 2. Minor axis shall have a max length of 350 mm.

7.4 Cargo hatchways on open deck vessels

7.4.1 Corners of hatchways

The corners of hatchways are recommended to be rounded. In any case, continuity shall be ensured by means of brackets and extended girders.

7.4.2 Deck strengthening in way of hatch corners

- Plating thickness in way of the corners:

  The deck plating in way of hatch corners shall have:

  a. twice the thickness of the stringer plate over 0.5·L amidships
  b. the same thickness as the stringer plate over 0.15·L at the ends of the vessel

  As an alternative for small hatch openings, the deck plating may be strengthened by a doubling plate having the same thickness as the stringer plate.

The area of strengthened plating shall extend over twice the actual stringer plate width on either side of the hatch end and, if necessary, beyond the transverse bulkheads of passenger and crew accommodation if the floor of these cabins is not level with the upper deck.

The reinforcements mentioned above may be partly or wholly dispensed with if the hatch coamings coincide with the longitudinal bulkheads of the accommodation located beyond the hatchway, thus ensuring longitudinal strength continuity in that region.

7.4.3 Coamings on open deck vessels

- Scantling and stiffening:

  Refer Ch 4 Sec 4, deck scantlings.
- Cut-outs

  Where there are cut-outs in the coaming upper part to make way for the hatchway beams, the edges of the cut-outs shall be carefully rounded and a doubling plate or a plate with an increased thickness shall be provided to ensure adequate bearing capability of the hatchway beams.

- Extension and strength continuity:

Longitudinal coamings shall be extended under the deck. In the case of single hull vessels, the longitudinal coaming extension shall be bent under the brackets to which it is connected.

It is recommended to extend the part of the hatch coaming which is located above deck and to connect it to the side bulkheads of the accommodation spaces.

At the end of large-size hatchways, strength continuity of the top structure shall be ensured. This shall be arranged by extending the deck girders beyond the hatchways over two frame spacings or over a distance equal to the height of the hatch coaming.

Transverse coamings shall extend below the deck at least to the lower edge of longitudinals. Transverse coamings not in line with ordinary deck beams below shall extend below the deck up to the next deck girder.

7.5 Cargo hatchways on flush deck vessels

7.5.1 Corners of hatchways

Hatchways shall be rounded at their corners. The radius of circular corners shall be not less than:

a. 5 % of the hatch width, where a continuous longitudinal deck girder is fitted below the hatchcoaming
b. 8 % of the hatch width, where no continuous longitudinal deck girder is fitted below the hatchcoaming

In corner radiusing, the case of the arrangement of two or more hatchways athwart ships, corner radii are considered by INTLREG on a case-by-case basis.

- Elliptical and parabolic corners:

  Strengthening by insert plates in the cargo area is, in general, not required in way of corners where the plating cutout has an elliptical or parabolic profile and the half axis of elliptical openings, or the half lengths of the parabolic arch, are not less than:

  a. 1/20 of the hatchway width or 600 mm, whichever is the lesser, in transverse direction
  b. twice the transverse dimension, in fore and aft direction

7.5.2 Deck strengthening in way of hatch corners

Where the hatchways from corners, the deck plating shall be increased by 60 % with respect to the adjacent plates. As an alternative, the deck plating may be strengthened by a doubling plate having the same thickness.

A lower thickness may be accepted by INTLREG on the basis of calculations showing that stresses at hatch corners are lower than permissible values.

7.5.3 Coamings on flush deck vessels

- Scantling and stiffening:

  Refer Ch.4 Sec.4, deck scantlings.

  The edges of cut-outs shall be carefully rounded.
- Extension and strength continuity:

  The lower part of longitudinal coamings shall extend to the lower edge of the nearest beams to which they shall be efficiently connected.

In case of girders fitted under deck or under beams in the plane of the coaming longitudinal sides, strength continuity shall be ensured by means of suitable shifting. The same applies in case of strengthened beams in the plane of the coaming transverse boundaries.

- Vertical brackets or stays:

  Where necessary, the coaming boundaries shall be stiffened with stays, as mentioned in Ch 4 Sect. [4.4.3].

7.5.4 Small hatches

The following requirements apply to small hatchways with a length and width of not more than 1.2 m.

In case of small hatches, no brackets are required.

Small hatch covers shall have strength equivalent to that required for main hatchways. In any case, weather tightness shall be maintained.

The sill's upper edge is neither to be less than 0.15 m above the deck nor lower than (n/1.7 + 0.15) m above the load waterline.

Access openings to cofferdams and ballast tanks shall be of manhole type, fitted with watertight covers fixed with bolts, which are closely spaced, and shall be in accordance with a recognized standard, e.g. ISO 5894.

Manholes and flush scuttles exposed to the weather shall be closed by substantial covers capable of being made watertight. The covers shall be permanently attached unless secured by closely spaced bolts,

Hatchways of special design are considered by INTLREG on a case-by-case basis.

7.6 Side scuttles, windows and skylights

7.6.1 Definition

Side scuttles are round or oval openings with an area not exceeding 0.16m^2. Round or oval openings having areas exceeding 0.16 m^2 shall be treated as windows.

The safety range is equivalent to the significant wave height H to be deducted from the uppermost load line, but at least up to the bulkhead deck.

7.6.2 Requirements

Side scuttles shall be built and tested in accordance with ISO 1751.

Windows shall be built and tested in accordance with ISO 3903.

Skylights of fixed or opening type shall have a glass thickness appropriate to their size and position, as required for windows and side scuttles.

Skylight glasses shall be protected from mechanical damage if they can be damaged by e.g. loading operations.

Alternative constructions to the standards mentioned above shall be of equivalent and approved design.

Toughened safety glass pane (ESG) or laminated safety glass (VSG) shall be used, in accordance with ISO 21005.

7.6.3 Arrangement

Windows and side scuttles fitted in the side shell below the bulkhead deck shall be watertight and of the non-opening type and in accordance with ISO 3903 (type E) or ISO 1751 (type B), each to be provided with a permanently attached inside deadlight.

Windows and side scuttles in the shell shall be adequately protected against direct contact by efficient fenders or shall be recessed into the shell.

Deadlights are not required on ships with the service range **IW (0)** and **IW (0.6)**.

Windows, side scuttles and skylights situated above the bulkhead deck with their lower glass edges within the safety range defined in 6.1.2 shall be watertight and of the non-opening type. If they do not protect a direct access leading below bulkhead deck or are provided with a sill of at least 0.15 m, they shall be weathertight and may be of the opening type.

The examination of windows, side scuttles and skylights located above the range defined in [6.1.2] is no matter of class – except for windows according to[7.6.3.]

Windows used for protection against falling down, e.g. windscreens or full-height windows, shall be shown to have equivalent strength against the loads as provided by EN 711. For these windows, laminated safety glass (VSG) or heat-soak-tested toughened safety glass (ESG-H) shall be used.

7.6.4 Glass thickness

The thickness of toughened safety glass in side scuttles shall be neither less than 6 mm nor less than the value in mm obtained from the following formula:

d = side scuttle diameter in mm

p = lateral pressure in kN/m^2 defined in Ch 3, Sec [4.7.1]for vessel hull or in

Sec [4.4] for superstructures and deckhouses.

- Thickness of toughened glasses in rectangular windows:

  The thickness of toughened glasses in rectangular windows is neither to be less than 6 mm nor less than the value in mm obtained from the following formula:

  p = lateral pressure in kN/m^2 defined in [7.6.4]

  β = coefficient defined in Table 7.6.1. β may be obtained by linear interpolation for intermediate values of a / b

  a = length in mm of the longer side of the window

  b = length in mm of the shorter side of the window

Table 7.6.1 Coefficient β	
a/b	**β**
1.0	0.284
1.5	0.475
2.0	0.608
2.5	0.684
3.0	0.716
3.5	0.734
≥ 4.0	0.750

7.6.5 Miscellaneous

National statutory rules and regulations shall be observed, as far as applicable.

Required tests shall be carried out in the presence and to the satisfaction to the Society's surveyor.

The Society may require both limitations on the size of rectangular windows and the use of glasses of increased thickness in way of front bulkheads, which are particularly exposed.

7.7 Scuppers and discharges

7.7.1 Material

The scuppers and discharge pipes shall be constructed of steel. Other equivalent materials are considered by INTLREG on a case-by-case basis.

7.7.2 Wall thickness

The wall thickness of scuppers and discharge pipes shall not be less than the shell plating thickness in way of the scuppers, respectively discharge pipes, but needs not exceed 8 mm.

7.8 Freeing ports

7.8.1 General provisions

Where bulwarks on weather decks form wells, provisions shall be made for rapidly freeing the decks of water and draining them.

A well is any area on the deck exposed to the weather, where water may be entrapped

7.9 Machinery space openings

7.9.1 Closing devices

Openings in machinery space casings shall be surrounded by a steel casing of efficient construction. The openings of the casings exposed to the weather shall be fitted with strong and weathertight doors.

7.9.2 Position of openings

The height in m of the lower edge of the opening above the load waterline shall not be less than n/1.7.

7.9.3 Entrances

The height in m of entrances to machinery space, h_C, above the deck shall not be less than the values given in Table 7.9.1.

Furthermore, this height, h_C, above the deck shall be such that:

$D + h_C > T + (n / 1.7) + 0.15$

Table 7.9.1 Height of machinery space entrance

Vessel type	**Significant wave height. H in m**	**h_C in m**
Carriage of dangerous goods	$0 \le H \le 2$	0.5
Other vessels	$H \le 1.2$	0.3
	$H > 1.2$	0.5

7.10 Companionway

7.10.1 Companionway

Companions leading under the freeboard deck shall be protected by a superstructure or closed deckhouse, or by a companionway having equivalent strength and tightness.

7.10.2 Companionway sill height

In vessels assigned the range of navigation **IW (0)**, the companion sill height, above the deck, h_C, shall not be less than 0.05 m.

In other vessels, the sill upper edge is neither to be less than 0.15 m above the deck nor less than (n/1.7 + 0.15) m above the load waterline.

7.11 Ventilators

7.11.1 General

Ventilator openings below main deck shall have coamings of steel or other equivalent material, substantially constructed and efficiently connected to the deck.

7.11.2 Coamings

In vessels assigned the range of navigation other than **IW (0)**, the coaming height, above the deck, h_C, shall not be less than 0.3 m.

Furthermore, this height, h_C, above the deck shall be such that:

$D + h_C > T + (n / 1.7) + 0.15$

CHAPTER 6 HULL OUTFITTING

CONTENTS

SECTION 1 RUDDERS

Contents

1.1 Symbols

L = rule length in m defined in Ch 1 Sec [1.1]

B = breadth in m defined in Ch 1 Sec [1.1]

D = depth in m defined in Ch 1 Sec [1.1]

T = draught in m defined in Ch 1 Sec [1.1]

n = navigation coefficient defined in Ch 2 Sec 2
= 0.85 · H

H = significant wave height in m

k_1 = material factor defined in 1.2.4

k = material factor defined in Ch 4 Sec [1.2]

M_{TR} = rudder torque in N·m acting on the rudder blade defined in [1.3]

M_B = bending moment in N·m in the rudder stock, defined in [1.6]

C_R = rudder force in N acting on the rudder blade as defined in [1.3]

V_{AV} = maximum ahead service speed in km/h at maximum draught T; this value shall not be taken less than 8

V_{AD} = maximum astern speed in km/h shall not be taken less than $0.5 \cdot V_{AV}$

A = total area of the rudder blade in m^2 bounded by the blade external contour, including the main piece and the part forward of the centerline of the rudder pintles, if any

1.2 General

1.2.1 Application

- Ordinary profile rudders:

  The following requirements apply to ordinary profile rudders, without any special arrangement for increasing the rudder force, whose maximum orientation at maximum vessel speed is limited to 35° on each side.

  In general, an orientation greater than 35° is accepted for maneuvers or navigation at very low speed.
- High lift profiles:

  The following requirements also apply to rudders fitted with flaps to increase rudder efficiency. For these rudder types, an orientation at maximum speed greater than 35° may be accepted. In these cases, the rudder forces shall be calculated by the designer for the most severe combinations between orientation angle and vessel speed. These calculations shall be considered by INTLREG on a case-by-case basis.

  The rudder scantlings shall be designed to be able to endure possible failures of the orientation control system, or, alternatively, redundancy of the control system may be required.
- Steering nozzles:

  The requirements for steering nozzles are given in Section 9.
- Special rudder types:

  Rudders others than those mentioned in Sec 1.2.1 will be considered by the Society on a case-by-case basis.

1.2.2 Gross scantlings

With reference to Ch 3 Sect [1.21], all scantlings and dimensions referred to in the following are gross, i.e. they include the margins for corrosion.

1.2.3 Arrangements

Effective means shall be provided for supporting the weight of the rudder without excessive bearing pressure, e.g. by means of a rudder carrier attached to the upper part of the rudder stock. The hull structure in way of the rudder carrier shall be suitably strengthened.

Suitable arrangements shall be provided to prevent the rudder from lifting.

The rudder stock shall be carried through the hull either enclosed in a watertight trunk or with glands to be fitted above the deepest load waterline, so as to prevent water from entering the steering gear compartment and the lubricant from being washed away from the rudder carrier. If the top of the rudder trunk is below the deepest waterline, two separate stuffing boxes shall be provided.

The steering system as a whole has to be designed for a permanent heeling of up to 15° and ambient temperatures from –20 °C to +50 °C.

1.2.4 Materials

Rudder stocks, pintles, coupling bolts, keys and cast parts of rudders shall be made of rolled steel, steel forgings or steel castings according to the applicable SHIP Pt.2 – Materials and welding.

The material used for rudder stocks, pintles, keys and bolts is to have a minimum yield stress not less than 200 N/mm^2.

The requirements relevant to the determination of scantlings contained in the following apply to steels having a minimum yield stress equal to 235 N/mm^2.

Where the material used for rudder stocks, pintles, coupling bolts, keys and cast parts of rudders has a yield stress different from 235 N/mm^2, the scantlings calculated with the formulae contained in the requirements shall be modified, as indicated, depending on the material factor k_1, to be obtained from the following formula:

$$k_1 = \left(\frac{235}{R_{eH}}\right)^{n_1}$$

R_{eH} = yield stress in N/mm^2, of the steel used, and not exceeding the lower of 0.7 R_m and 450 N/mm^2

R_m = minimum ultimate tensile strength in N/mm^2, of the steel used

n_1 = coefficient to be taken equal to:

= 0.75 for $R_{eH} > 235$ N/mm^2

= 1.00 for $R_{eH} \leq 235$ N/mm^2

Significant reductions in rudder stock diameter due to the application of steels with yield stresses greater than 235 N/mm^2 may be accepted by the Society subject to the results of a check calculation of the rudder stock deformations.

Large rudder stock deformations shall be avoided in order to avoid excessive edge pressures in way of bearings.

Welded parts of rudders shall be made of approved rolled hull materials. For these members, the material factor k defined in Pt 2 (Materials and Welding) of Ship Rules shall be used. .

1.3 Force and torque acting on the rudder

1.3.1 Rudder blade

- Rudder blade description:
  A rudder blade may have trapezoidal or rectangular contour.

- Rudder force:

C_R = $28.86 \cdot (1 + n)^{0.15} A \cdot V^2 \cdot r_1 \cdot r_2 \cdot r_3$

V = V_{AV}, or V_{AD}, depending on the condition under consideration (for high lift profiles refer 1.2.1)

r_1 = shape factor

$= \frac{\lambda+2}{3}$

λ = coefficient, to be taken equal to:

$= \frac{h^2}{A_T} \leq 2$

h = mean height in m, of the rudder area to be taken equal to (refer Figure 1.3.1)

$= \frac{z_3+z_4-z_2}{2}$

A_T = area in m² to be calculated by adding the rudder blade area A to the area of the rudder post or rudder horn, if any, up to the height h

r_2 = coefficient to be obtained from Table 1.3.1

r_3 = coefficient

= 0.8 for rudders outside the propeller jet (center rudders on twin screw vessels, or similar cases)

= 1.15 for rudders behind a fixed propeller nozzle

= 1.0 in other cases

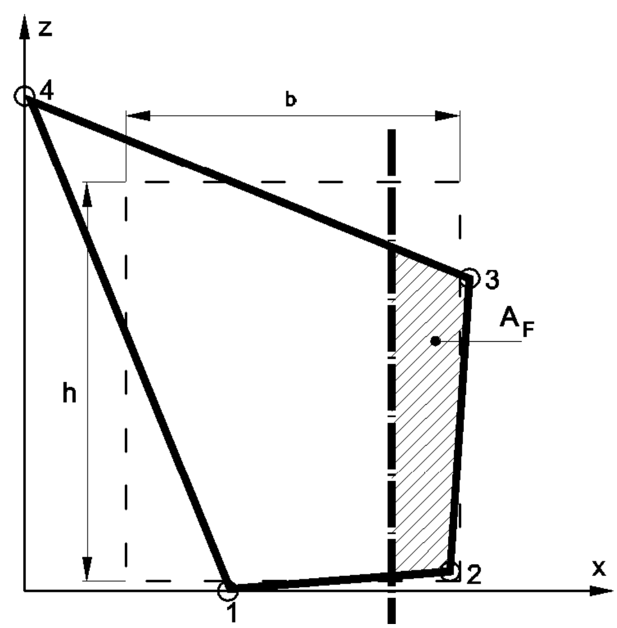
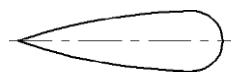
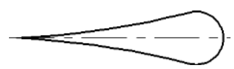
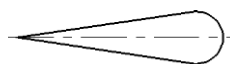
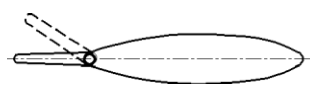
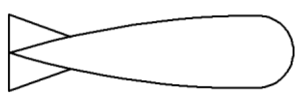
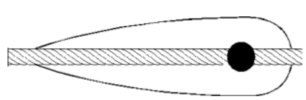


Figure 1.3.1 Geometry of rudder blade without cut-outs

Table 1.3.1 Values of coefficient r_2

Rudder profile type	r_2 for ahead condition	r_2 for astern condition
NACA 00 – Goettingen 	1.10	0.80
Hollow 	1.35	0.90
Flat side 	1.10	0.90
High lift 	1.70	1.30
Fish tail 	1.40	0.80
Single plate 	1.00	1.00

- Rudder torque:

  The rudder torque M_{TR}, for both ahead and astern conditions, shall be obtained in N·m from the following formula:

  $M_{TR} = C_R \cdot r$

  r = in m, lever of the force C_R equal to:

  $= b \cdot \left(\alpha - \frac{A_F}{A}\right)$

  and to be taken not less than 0.1 · b for the ahead condition

  b = mean breadth in m, of rudder area (refer Figure 1.3.1)

  $= \frac{x_2 + x_3 - x_1}{2}$

α = coefficient
= 0.33 for ahead condition
= 0.66 for astern condition
A_F = area in m^2, of the rudder blade portion in front of the centerline of rudder stock (refer Figure 1.3.1)

1.4 Rudder stock scantlings

1.4.1 Rudder stock diameter

- Rudder stock subjected to torque only:

  For rudderstocks subjected to torque only, the diameter shall not be less than the value obtained in mm, from the following formula:

$$d_T = 4.2 \cdot \sqrt[3]{M_{TR} \cdot k_1}$$

- Rule stock diameter:

  The rudder stock diameter, at the lower part, shall not be less than the value obtained in mm, from the following formula:

$$d_{TF} = 4.2 \cdot \sqrt[3]{M_{TR} \cdot k_1} \cdot \left(1 + \frac{4}{3} \cdot \left(\frac{M_B}{M_{TR}}\right)^2\right)^{1/6}$$

  M_B = maximum absolute value of bending moment M_{Bi} over the rudder stock length, to be obtained according to [1.6.1].

- Rule rudder stock diameter in way of the tiller:

  In general, the diameter of a rudder stock subjected to torque and bending may be gradually tapered above the lower stock bearing so as to reach, from d_{TF} value, the value of d_T in way of the quadrant or the tiller.

1.5 Rudder stock couplings

1.5.1 Horizontal flange couplings

- General:In general, the coupling flange and the rudder stock are to be forged from a solid piece. A shoulder radius as large as practicable is to be provided between the rudder stock and the coupling flange. This radius shall not be less than 0.13 · d_1, where d_1 is the greater of the rudder stock diameters d_T and d_{TF} in mm to be calculated as given in [1.4.1]

  The coupling flange may be welded onto the stock if its thickness is increased by 10%, and that the weld extends through the full thickness of the coupling flange and that the assembly obtained is subjected to heat treatment. This heat treatment is not required if the diameter of the rudder stock is less than 75 mm.

  Where the coupling flange is welded, the grade of the steel used is to be of weldable quality, particularly with a carbon content not greater than 0.25 % and the welding conditions shall be specified to the satisfaction of the Society. The throat weld at the top of the flange shall be concave shaped to give a fillet shoulder radius as large as practicable.

- Bolts

Horizontal flange couplings shall be connected by fitted bolts having a diameter not less than the value obtained in mm from the following formula:

$$d_B = 0.62 \cdot \sqrt{\frac{d_1^3 \cdot k_{1B}}{n_B \cdot e_M \cdot k_{1S}}}$$

d_1 = rudder stock diameter in mm defined in [1.4.1]

k_{1S} = material factor k_1 for the steel used for the rudder stock

k_{1B} = material factor k_1 for the steel used for the bolts

e_M = mean distance in mm from the bolt axes to the longitudinal axis through the coupling center (i.e. the center of the bolt system)

n_B = total number of bolts, which shall not be less than 6

Non-fitted bolts may be used provided that, in way of the mating plane of the coupling flanges, a key is fitted having a section of ($0.25 \cdot d_T \cdot x \cdot 0.10 \cdot d_T$) in mm^2 and keyways in both the coupling flanges, and provided that at least two of the coupling bolts are fitted bolts.

The distance from the bolt axes to the external edge of the coupling flange shall not be less than $1.2 \cdot d_B$

- Coupling flange:

  The thickness of the coupling flange shall not be less than the value obtained in mm from the following formula:

$$t_p = d_B \sqrt{\frac{k_{1F}}{k_{1B}}}$$

d_B = bolt diameter in mm calculated in accordance with [1.5.1], where the number of bolts n_B is to be taken not greater than 8

k_{1F} = material factor k_1 for the steel used for the flange

k_{1B} = material factor k_1 for the steel used for the bolts

In any case, the thickness t_P shall not be less than $0.9 \cdot d_B$.

- Locking device:

  A suitable locking device shall be provided to prevent the accidental loosening of nuts.

1.5.2 Couplings between rudder stocks and tillers

- Application:

  The requirements in [1.5.2] apply in addition to those specified in Pt 4 Ch 6 Sec [1.4.2]

  The requirements specified in [1.5.3]and [1.5.4] apply to solid rudder stocks in steel and to tiller bosses, either in steel or in SG iron, with constant external diameter. Solid rudder stocks others than those above will be considered by the SG iron to be defined on a case-by-case basis.

- General:

The entrance edge of the tiller bore and that of the rudder stock cone shall be rounded or beveled.

The right fit of the tapered bearing shall be checked before final fit up, to ascertain that the actual bearing is evenly distributed and at least equal to 80 % of the theoretical bearing area; push-up length is measured from the relative positioning of the two parts corresponding to this case.

The required push-up length shall be checked after releasing the hydraulic pressure applied in the hydraulic nut and in the assembly.

- Push-up length of cone couplings with hydraulic arrangements for assembling and disassembling the coupling:

  It shall be checked that the push-up length Δ_E of the rudder stock tapered part into the tiller boss is in compliance with the following formula:

$$\Delta_0 \le \Delta_E \le \Delta_1$$

$$\Delta_0 = 6.2 \frac{M_{TR} \cdot \eta \cdot \gamma \cdot 10^{-3}}{c \cdot d_M \cdot t_s \cdot \mu_A \cdot \beta}$$

$$\Delta_1 = \frac{2 \cdot \eta + 5}{1.8} \cdot \frac{\gamma \cdot d_0 \cdot R_{eH} \cdot 10^{-6}}{c}$$

η = coefficient

= 1 for keyed connections

= 2 for keyless connections

c = taper of conical coupling measured on diameter, to be obtained from the following formula:

$= \frac{d_U - d_0}{t_s}$

Where t_S, d_U, d_0 = geometrical parameters of the coupling, defined in Figure 1.5.1

β = coefficient

$= 1 - \left(\frac{d_M}{d_E}\right)^2$

d_M = mean diameter in mm of the conical bore, to be obtained from the following formula:

$= d_U - 0.5 \cdot c \cdot t_S$

d_E = external boss diameter in mm

μ_A = coefficient

$= \sqrt{\mu^2 - 0.25 \cdot c^2}$

R_{eH} = defined in 1.2.4

μ, γ = coefficients to be taken equal to:

	μ	γ
Rudder stocks and bosses made of steel	0.15	1.0
Rudder stocks and bosses made of SG iron	0.13	1.24-0.1·β

- Boss of cone couplings with hydraulic arrangements for assembling and disassembling the coupling:

  The scantlings of the boss are to comply with the following formula:

$$\frac{1.8}{2\eta+5}\frac{\Delta_E \cdot c \cdot 10^6}{\gamma \cdot d_0} \le R_{eH}$$

Δ_E = push-up length adopted in mm

c, η, γ = defined in [1.5.2]

d_0 = defined in Figure 1.5.1

R_{eH} = defined in 1.2.4

- Cylindrical couplings by shrink fit:

  It shall be checked that the diametric shrinkage allowance δ_E is in compliance with the following formula:

$\delta_0 \le \delta_E \le \delta_1$

$$\delta_0 = 6.2\frac{M_{TR} \cdot \eta \cdot \gamma \cdot 10^{-3}}{d_U \cdot t_s \cdot \mu \cdot \beta_1}$$

$$\delta_1 = \frac{2 \cdot \eta + 5}{1.8} \cdot \gamma \cdot d_U \cdot R_{eH} \cdot 10^{-6}$$

η, μ, γ = defined in [1.5.2]

d_U = defined in Figure 1.5.1

β_1 = coefficient

$= 1 - \left(\frac{d_U}{d_E}\right)^2$

R_{eH} = defined in1.2.4

- Keyless couplings through special devices:

  The use of special devices for frictional connections, such as expansible rings, may be accepted by the Society on a case-by-case basis if the following conditions are complied with:

  a. evidence that the device is efficient (theoretical calculations and results of experimental tests, references of behavior during service, etc.) shall be submitted to the Society
  b. the torque transmissible by friction is to be not less than $2 \cdot M_{TR}$
  c. design conditions and strength criteria are to comply with [1.5.2]
  d. instructions provided by the manufacturer are to be complied with, notably concerning the pre-stressing of the tightening screws

1.5.3 Cone couplings between rudder stocks and rudder blades

- Taper on diameter:

The taper on diameter of the cone couplings is to be in compliance with the following formulae:

a. for cone couplings without hydraulic arrangements for assembling and disassembling the coupling:

$$\frac{1}{12} \leq \frac{d_U - d_0}{t_s} \leq \frac{1}{12}$$

b. for cone couplings with hydraulic arrangements for assembling and disassembling the coupling (assembling with oil injection and hydraulic nut):

$$\frac{1}{20} \leq \frac{d_U - d_0}{t_s} \leq \frac{1}{12}$$

d_U, t_S, d_0 = geometrical parameters of the coupling, defined in Figure 2.

- Push-up length of cone coupling with hydraulic arrangements for assembling and disassembling the coupling:

It shall be checked that the push-up length Δ_E of the rudder stock tapered part into the boss is in compliance with the following formula:

$\Delta_0 \leq \Delta_E \leq \Delta_1$

where Δ_0 and Δ_1 shall be obtained from the formulae in Table 1.5.1.

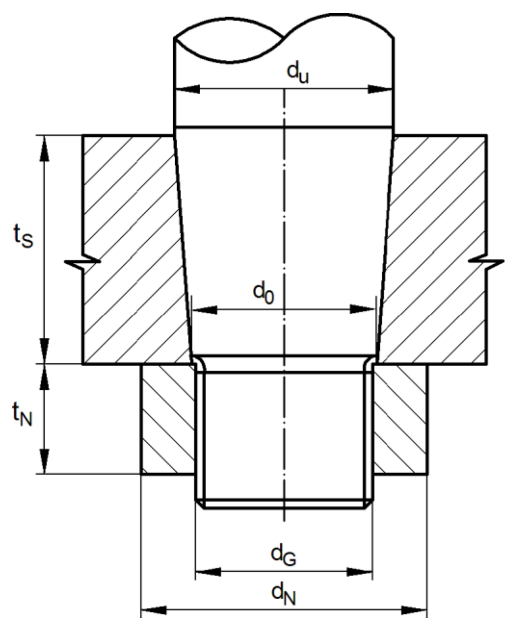


Figure 1.5.1 Geometry of cone coupling

Table 1.5.1 Push-up length values

Rudder type	Δ_0	Δ_1
Rudder without intermediate pintles Spade rudders	The greater of: $6.2\dfrac{M_{TR}\cdot\eta\cdot\gamma\cdot 10^{-3}}{c\cdot d_M\cdot t_s\cdot\mu_A\cdot\beta}$ $16\dfrac{M_{TR}\cdot\eta\cdot\gamma\cdot 10^{-3}}{c\cdot t_s^2\cdot\beta}\sqrt{\dfrac{d_{1L}^6-d_{1S}^6}{d_{1S}^6}}$	$\dfrac{2\cdot\eta+5}{1.8}\cdot\dfrac{\gamma\cdot d_0\cdot R_{eH}}{c\cdot(1+p_1)\cdot 10^6}$
High lift profile and special rudder types	The greater of: $6.2\dfrac{M_{TR}\cdot\eta\cdot\gamma\cdot 10^{-3}}{c\cdot d_M\cdot t_s\cdot\mu_A\cdot\beta}$ $16\dfrac{M_{TR}\cdot\eta\cdot\gamma\cdot 10^{-3}}{c\cdot t_s^2\cdot\beta}\sqrt{\dfrac{d_{1L}^6-d_{1S}^6}{d_{1S}^6}}$ $6.2\dfrac{M_T\cdot\eta\cdot\gamma\cdot 10^{-3}}{c\cdot d_M\cdot t_s\cdot\mu_A\cdot\beta}$ $18.4\dfrac{M_F\cdot\eta\cdot\gamma\cdot 10^{-3}}{c\cdot t_s^2\cdot\beta}$	The smaller of: $\dfrac{2\cdot\eta+5}{1.8}\cdot\dfrac{\gamma\cdot d_0\cdot R_{eH}}{c\cdot(1+p_1)\cdot 10^6}$ $\dfrac{2\cdot\eta+5}{1.8}\cdot\dfrac{\gamma\cdot d_0\cdot R_{eH}}{c\cdot(1+p_2)\cdot 10^6}$

$$p_1=\frac{80\cdot\sqrt{d_{1L}^6-d_{1S}^6}}{R_{eH}\cdot d_M\cdot t_S^2\left(1-\left(\frac{d_0}{d_E}\right)^2\right)}$$

$$p_2=\frac{7.4\cdot M_F\cdot 10^3}{R_{eH}\cdot d_M\cdot t_S^2\left(1-\left(\frac{d_0}{d_E}\right)^2\right)}$$

R_{eH} = as defined in 1.2.4

M_F, M_T = bending moment and torsional moment, respectively in N·m provided by the manufacturer

d_{1L} = rudder stock diameter d_{TF} in mm calculated in way of the lower part of the rudder stock (between the top of the rudder plate and the lower bearing of the rudder stock) in compliance with 4.1.2 , considering $k_1 = 1$

d_{1S} = rudder stock diameter d_T in mm calculated in way of the upper part of the rudder stock (at tiller level) in compliance with 4.1.1, considering $k_1 = 1$

η, c, β, d_M, d_E, μ_A, μ, γ defined in [1.5.2]

t_S, d_U, d_0 = defined in Figure 1.5.2

- Lower rudder stock end

  The lower rudder stock end shall be fitted with a threaded part having a core diameter, d_G in mm not less than:

  d_G = $0.65 \cdot d_1$

  d_1 = rudder stock diameter defined in [1.4.1]

  This threaded part shall be fitted with an adequate slogging nut efficiently locked in rotation.

  The dimensions of the massive part and slogging nut shall be in accordance with the following formulae:

  $t_S \geq 1.5 \cdot d_1$

  $d_E \geq d_M + 0.6 \cdot d_1$

  $t_N \geq 0.60 \cdot d_G$

  $d_N \geq 1.2 \cdot d_0$ and, in any case, $d_N \geq 1.5 \cdot d_G$

  d_1 = rudder stock diameter defined in 1.4.1]

  d_E = external diameter in mm of the massive part of Figure 1.5.1, having the thickness t_S

  d_M = mean diameter in mm of the conical bore, as defined in [1.5.2]

  t_S, d_G, t_N, d_N, d_0 = geometrical parameters of the coupling, defined in Figure 1.5.1

  The above minimum dimensions of the locking nut are only given for guidance, the determination of adequate scantlings being left to the designer.

- Washer:

  For cone couplings with hydraulic arrangements for assembling and disassembling the coupling, a washer shall be fitted between the nut and the rudder gudgeon, having a thickness not less than $0.13 \cdot d_G$ and an outer diameter not less than $0.13 \cdot d_0$ or $1.6 \cdot d_G$, whichever is the greater.

- Key:

  For cone couplings without hydraulic arrangements for assembling and disassembling the coupling, a key shall be fitted having a section of $(0.25 \cdot d_T \cdot x \cdot 0.10 \cdot d_T)$ (mm^2) and keyways in both the tapered part and the rudder gudgeon.

  The key shall be machined and located on the fore or aft part of the rudder. The key shall be inserted at half- thickness into stock and into the solid part of the rudder.

  For cone couplings with hydraulic arrangements for assembling and disassembling the coupling, the key may be omitted. In this case the designer is to submit to the Society shrinkage calculations supplying all data necessary for the relevant check.

- Instructions

  All necessary instructions for hydraulic assembly and disassembly of the nut, including indication of the values of all relevant parameters, are to be available on board.

1.5.4 Vertical flange couplings

Vertical flange couplings are to be connected by fitted bolts having a diameter not less than the value obtained in mm, from the following formula:

$$d_B = \frac{0.81 \cdot d_1}{\sqrt{n_B}} \sqrt{\frac{k_{1B}}{k_{1S}}}$$

d_1 = rudder stock diameter in mm, defined in [1.4.1]
k_{1S}, k_{1B} = material factors, defined in [1.5.1]
n_B = total number of bolts, which shall not be less than 8

The first moment of area of the sectional area of bolts about the vertical axis through the center of the coupling shall not be less than the value obtained in cm^3 from the following formula:

$$M_S = 0.43 \cdot d_1^3 \cdot 10^{-6}$$

d_1 = rudder stock diameter in mm, defined in 4.1.2
The thickness of the coupling flange in mm shall not be less than d_B, defined in 5.4.1.
The distance in mm from the bolt axes to the external edge of the coupling flange shall not be less than $1.2 \cdot d_B$, where d_B is defined in [1.5.1]

A suitable locking device shall be provided to prevent the accidental loosening of nuts.

1.5.5 Couplings by continuous rudder stock welded to the rudder blade

When the rudder stock extends through the upper plate of the rudder blade and is welded to it, the thickness of this plate in the vicinity of the rudder stock shall not be less than $0.20 \cdot d_1$, where d_1 is defined in [1.4.1]

The welding of the upper plate of the rudder blade with the rudder stock is to be made with a full penetration weld and shall be subjected to non-destructive inspection through dye penetrant or magnetic particle test and ultrasonic testing.

The throat weld at the top of the rudder upper plate shall be concave shaped to give a fillet shoulder radius as large as practicable. This radius shall not be less than $0.15 \cdot d_1$, where d_1 is defined in [1.4.1]

1.5.6 Skeg connected with rudder trunk

In case of a rudder trunk connected with the bottom of a skeg, the throat weld shall be concave shaped to give a fillet shoulder radius as large as practicable. This radius is considered by the Society on a case-by-case basis.

1.6 Rudder stock and pintle bearings

1.6.1 Forces on rudder stock and pintle bearings

- Support forces F_{Ai}, for i = 1, 2, 3 are to be obtained according to.[1.6.2] and [1.6.3]
  The spring constant Z_C for the support in the sole piece (see Figure 1.6.1) is to be obtained N/m from the following formula:

$$Z_c = \frac{6.18 \cdot J_{50} \cdot 10^3}{l_{50}^3}$$

l_{50} = length in m of the sole piece

J_{50} = moment of inertia about the z axis in cm of the sole piece

- Rudder supported by sole piece:

  The rudder structure shall be calculated according to load, shear force and bending moment diagrams shown in Figure 1.6.1.

  The force per unit length p_R acting on the rudder body is to be obtained in N/m from the following formula:

$$p_R = \frac{c_R}{l_{10}}$$

l_{10} = height of the rudder blade in m

The spring constant Z_C shall be calculated according to .[1.6.1]

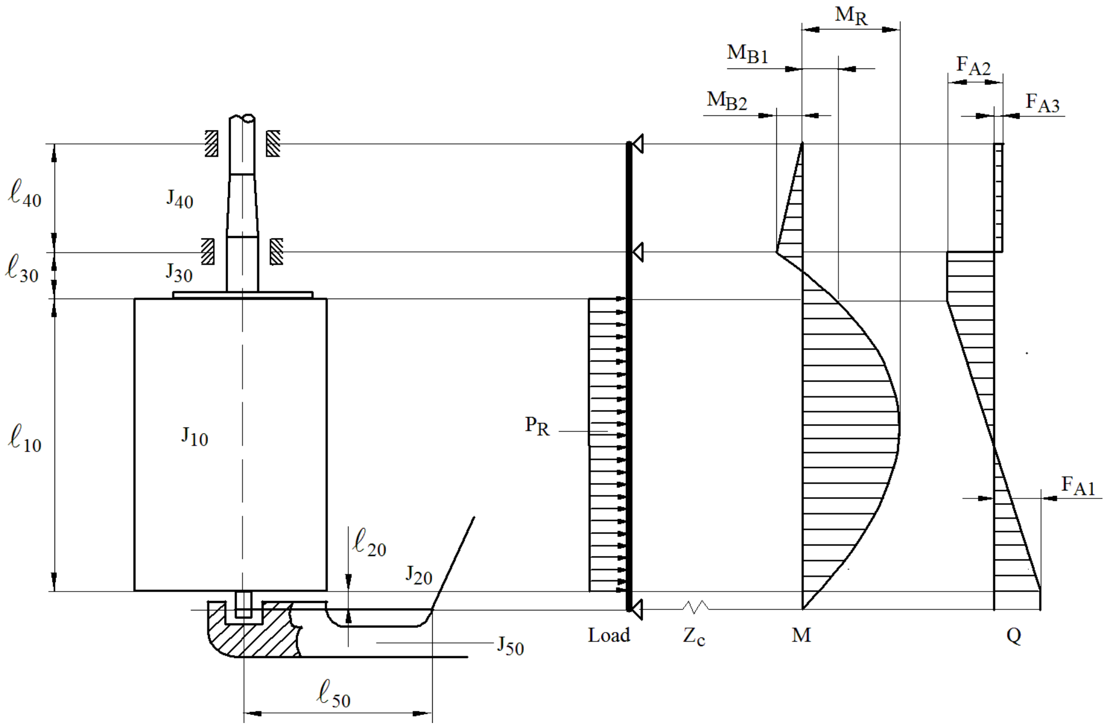


Figure 1.6.1 Rudder supported by sole piece

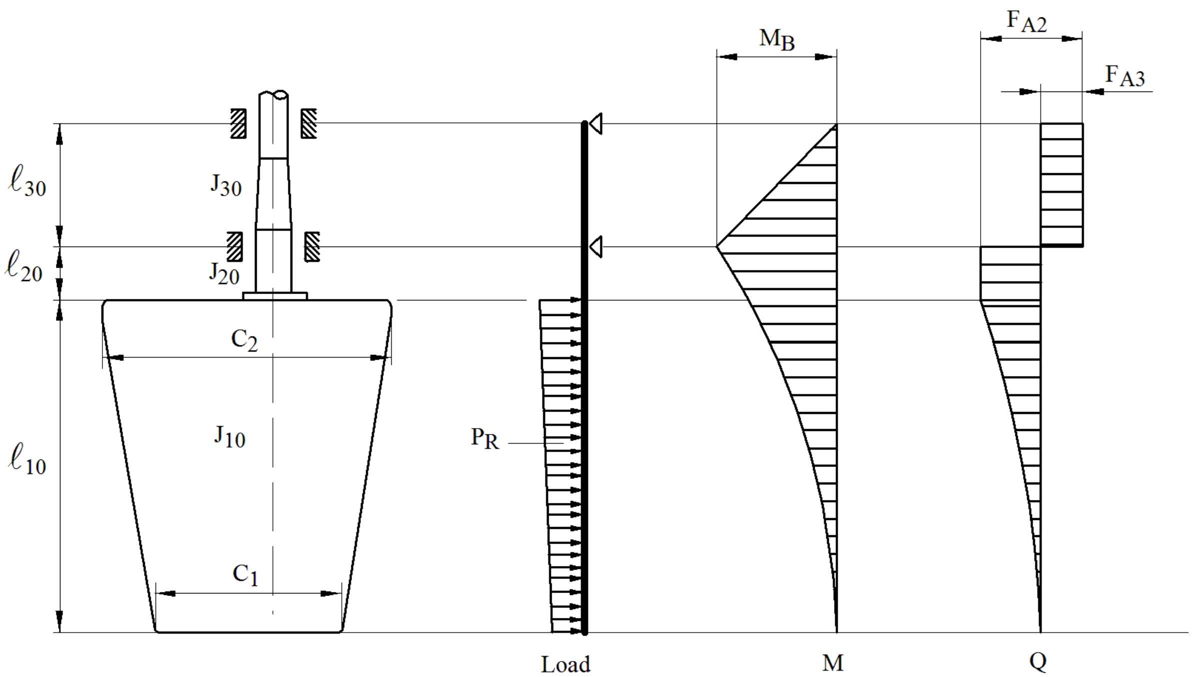


Figure 1.6.2 Spade rudders

- Spade rudders:
  The rudder structure shall be calculated according to load, shear force and bending moment diagrams shown in Figure 1.6.2
  The force per unit length p_R acting on the rudder body shall be obtained in N/m from the following formula:

$$p_{RZ} = p_{R1} + \left(\frac{p_{R2} - p_{R1}}{l_{10}}\right) z$$

z = position of rudder blade section in m taken over ℓ_{10} length
p_{RZ} = force per unit length in N/m obtained at the z position
p_{R1} = force per unit length in N/m obtained for z equal to zero
p_{R2} = force per unit length in N/m obtained for z equal to ℓ_{10}

For this type of rudder, the results of calculations performed according to diagrams shown in Figure 1.6.2 may also be obtained from the following formulae:

a. maximum bending moment in the rudder stock in N·m:

$$M_B = C_R\left(l_{20} + \frac{l_{10} \cdot (2C_1 + C_2)}{3 \cdot (C_1 + C_2)}\right)$$

where C_1 and C_2 are the lengths in m defined in Figure 1.6.2

b. support forces in N:

$$F_{A3} = \frac{M_B}{l_{30}}$$

$$F_{A2} = C_R + F_{A3}$$

c. maximum shear force in the rudder body in N:

$$Q_R = C_R$$

1.6.2 Rudder stock bearing

The mean bearing pressure acting on the rudder stock bearing shall be in compliance with the following formula:

$p_F \le p_{F,ALL}$

p_F = mean bearing pressure acting on the rudder stock bearings in N/mm^2

$$= \frac{F_{Ai}}{d_m \cdot h_m}$$

F_{Ai} = force acting on the rudder stock bearing in N
d_m = actual inner diameter in mm of the rudder stock bearings (contact diameter)
h_m = bearing length in mm .Refer [1.6.2]
$p_{F,ALL}$ = allowable bearing pressure in N/mm^2 defined in Table 1.6.1

Values greater than those given in Table 1.6.1 may be accepted by the Society on the basis of specific tests

An adequate lubrication of the bearing surface shall be ensured.

The length/diameter ratio of the bearing surface shall not be greater than 1.2.

The manufacturing tolerance t_0 on the diameter of metallic supports shall not be less than the value obtained in mm from the following formula:

$$t_0 = \frac{d_m}{1000} + 1$$

In the case of non-metallic supports, the tolerances shall be carefully evaluated on the basis of the thermal and distortion properties of the materials employed.

In any case, the tolerance on support diameter shall not be less than 1.5 mm.

Table 1.6.1 Allowable bearing pressure

Bearing material	**$p_{F,ALL}$ in N/mm^2**
Lignum vitae	2.5
White metal, oil lubricated	4.5
Synthetic material with hardness between 60 and 70 Shore D [1)]	5.5
Steel, bronze and hot-pressed bronze-graphite materials [2)]	7.0

1) Indentation hardness test at 23 °C and with 50 % moisture to be performed according to a recognized standard. Type of synthetic bearing materials shall be approved by the Society.
2) Stainless and wear-resistant steel in combination with stock liner approved by the Society.

1.6.3 Pintle bearings

The mean bearing pressure acting on the gudgeons shall be in compliance with the following formula:

$$p_F \le p_{F,ALL}$$

p_F = mean bearing pressure acting on the gudgeons in N/mm^2

$$= \frac{F_{Ai}}{d_m \cdot h_m}$$

F_{Ai} = force acting on the pintle in N calculated as specified in [1.6.2]
d_A = actual diameter in mm of the rudder pintles
h_L = bearing length in mm
$p_{F,ALL}$ = allowable bearing pressure in N/mm^2 defined in Table 1.6.1

INTLREG may be accept values greater than those given in Table 1.6.1 based on specific tests.

An adequate lubrication of the bearing surface shall be ensured.

The length/diameter ratio of the bearing surface shall not be less than 1 and not to be greater than 1.2.

The manufacturing tolerance t_0 on the diameter of metallic supports shall not be less than the value obtained in mm from the following formula:

$$t_0 = \frac{d_A}{1000} + 1$$

In the case of non-metallic supports, the tolerances shall be carefully evaluated based on the thermal and distortion properties of the materials employed.

In any case, the tolerance on support diameter shall not be less than 1.5 mm.

1.6.4 Pintles

Rudder pintles are to have a diameter not less than the value obtained in mm from the following formula:

$$d_A = \sqrt{k_1}\left(\frac{0.21 \cdot V_{AV}\sqrt{F_{Ai}}}{0.54 \cdot V_{AV} + 3} + 30\right)$$

F_{Ai} = force in N acting on the pintle, calculated as specified in [1.6.2]

Provision shall be made for a suitable locking device to prevent the accidental loosening of pintles.

The pintles are to have a conical coupling with a taper on diameter in accordance with [1.5.3]

The conical coupling shall be secured by a nut the dimensions of which shall be in accordance with [1.5.3]

The length of the pintle housing in the gudgeon shall not be less than the value obtained in mm from the following formula:

$$h_L = 0.35 \cdot \sqrt{F_{Ai} \cdot k_1}$$

F_{Ai} = force in N acting on the pintle, calculated as specified in [1.6.2]

The thickness of pintle housing in the gudgeon in mm shall not be less than $0.25 \cdot d_A$, where d_A is defined in [1.7.3]

1.7 Rudder blade scantlings

1.7.1 General

- Application:

  The requirements in [1.7.1] to [1.7.5] apply to streamlined rudders and, when applicable, to rudder blades of single plate rudders.

- Rudder blade structure:

  The structure of the rudder blade is to be such that stresses are effectively transmitted to the rudder stock and pintles. To this end, horizontal and vertical web plates are to be provided.

  Horizontal and vertical webs acting as main bending girders of the rudder blade are to be sufficiently reinforced.

- Access openings:

  Streamlined rudders, including those filled with pitch, cork or foam, shall be fitted with plug-holes and the necessary devices to allow their mounting and dismounting.

  Access openings to the pintles shall be provided. If necessary, the rudder blade plating shall be strengthened in way of these openings.

  The corners of openings intended for the dismantling of pintle or stock nuts shall be rounded off with a radius as large as practicable.

  Where the access to the rudder stock nut is closed with a welded plate, a full penetration weld shall be provided.

1.7.2 Rudder blade plating

- Plate thickness

  The thickness of each rudder blade plate panel shall not be less than the value obtained in mm from the following formula:

$$t_F = \sqrt{k}\left(1.5 + 5.5 \cdot s \cdot \beta \cdot \sqrt{T + 0.6 \cdot n + \frac{C_R \cdot 10^{-4}}{A}}\right)$$

β = coefficient

$= \sqrt{1.1 - 0.5 \cdot \left(\frac{s}{b_L}\right)^2}$

to be taken not greater than 1.0 if $b_L/s > 2.5$

s = length in m of the shorter side of the plate panel

b_L = length in m of the longer side of the plate panel

- Thickness of the top and bottom plates of the rudder blade

  The thickness of the top and bottom plates of the rudder blade shall not be less than the thickness t_F defined in [1.7.2], without being less than 1.2 times the thickness obtained from [1.7.2] for the attached side plating.

  Where the rudder is connected to the rudder stock with a coupling flange, the thickness of the top plate which is welded in extension of the rudder flange shall not be less than 1.1 times the thickness calculated above.

- Web spacing:

  The spacing between horizontal web plates shall not be greater than 1.20 m. Vertical webs are to have spacing not greater than twice that of horizontal webs.

- Web thickness:

  Web thickness shall be at least 70 % of that required for rudder plating and in no case is it to be less than 8 mm, except for the upper and lower horizontal webs. The thickness of each of these webs shall be uniform and not less than that of the web panel having the greatest thickness t_F, as calculated in [1.7.2]. In any case it is not required that the thickness is increased by more than 20 % in respect of normal webs.

When the design of the rudder does not incorporate a main piece, this shall be replaced by two vertical webs closely spaced, having a thickness not less than that obtained from Table 1.7.1.

- Welding:

  The welded connections of blade plating to vertical and horizontal webs shall be in compliance with the applicable requirements of Part 2 of Rules for Classification of Ships – Materials and Welding.

  Where the welds of the rudder blade are accessible only from outside of the rudder, slots on a flat bar welded to the webs shall be provided to support the weld root, to be cut on one side of the rudder only.

- Rudder nose plate thickness:

  Rudder nose plates are to have a thickness not less than 1.25 t_F, where t_F is defined in . [1.7.2]

  In general, this thickness need not exceed 22 mm, unless otherwise required in special cases to be considered individually by the Society.

1.7.3 Connections of rudder blade structure with solid parts in forged or cast steel

- General

  Solid parts in forged or cast steel constituting the housing of the rudder stock or of the pintle are in general to be connected to the rudder structure by means of two horizontal web plates and two vertical web plates.

- Minimum section modulus of the connection with the rudder stock housing

  The section modulus of the rudder blade cross-section in way of rudder stock housing, which is made by vertical web plates and rudder plating, shall not be less than that obtained in cm^3 from the following formula:

$$w_s = c_s \cdot d_1^3 \cdot \left(\frac{H_E - H_X}{H_E}\right) \cdot \frac{k}{k_1} \cdot 10^{-4}$$

c_S = coefficient

= 1.0 if there is no opening in the rudder plating

= 1.5 if there is an opening in the considered cross-section of the rudder

d_1 = rudder stock diameter in mm defined in [1.4.1]

H_E = vertical distance in m between the lower edge of the rudder blade and the upper edge of the solid part

H_X = vertical distance in m between the considered cross-section and the upper edge of the solid part

k, k_1 = material factors, defined in ,[1.1] for the rudder blade plating and the rudder stock, respectively

- Calculation of the actual section modulus of the connection with the rudder stock housing:

  The breadth of the rudder plating to be considered for the calculation of the actual section modulus shall be not greater than that obtained in m from the following formula:

$$b = s_v + 2 \cdot \frac{H_x}{m}$$

s_V = spacing in m between the two vertical webs (refer Figure 1.7.1)

H_X = distance defined in [1.7.3]

m = coefficient to be taken, in general, equal to 3

Where openings for access to the rudder stock nut are not closed by a full penetration welded plate according to [1.7.1] they shall be deducted for the calculation in b (refer Figure 1.7.1).

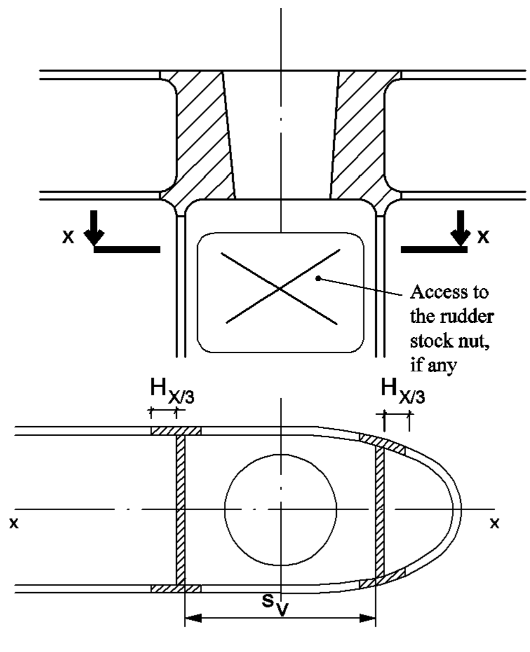


Figure 1.7.1 Cross-section of the connection between rudder blade structure and rudder stock housing

- Thickness of horizontal web plates:

  Near the solid parts, the thickness of the horizontal web plates, as well as that of the rudder blade plating between these webs, shall not be less than the greater of the values obtained in mm from the following formulae:

  $t_H = 1.2 \cdot t_F$

  $= 0.045 \frac{d_s^2}{s_H}$

  t_F = thickness defined in [1.7.2]

  d_S = diameter in mm to be taken equal to:

  d_1 for the solid part connected to the rudder stock

  d_A for the solid part connected to the pintle

  d_1 = rudder stock diameter in mm defined in [1.4.1]

  d_A = pintle diameter in mm defined in [1.7.3]

  s_H = spacing in mm between the two horizontal web plates

Different thickness may be accepted when justified based on direct calculations submitted to the Society.

- Thickness of side plating and vertical web plates welded to the solid part:

  The thickness of the vertical web plates welded to the solid part where the rudder stock is housed as well as the thickness of the rudder side plating under this solid part is to be not less than the values obtained in mm from Table 1.7.1.

Table 1.7.1 Thickness of the vertical webs and rudder side plating welded to solid part or to rudder flange

Type of rudder	Thickness of vertical web plates in mm		Thickness of rudder plating in mm	
	Rudder blade without opening	At opening boundary	Rudder blade without opening	Area with opening
Rudder supported by sole piece	$1.2 \cdot t_F$	$1.6 \cdot t_F$	$1.2 \cdot t_F$	$1.4 \cdot t_F$
Spade rudders	$1.4 \cdot t_F$	$2.0 \cdot t_F$	$1.3 \cdot t_F$	$1.6 \cdot t_F$
t_F = defined in [1.7.2]				

- Solid part protrusions:

  The solid parts shall be provided with protrusions. Vertical and horizontal web plates of the rudder shall be butt welded to these protrusions.

  These protrusions are not required when the web plate thickness is less than:

a. 10 mm for vertical web plates welded to the solid part of the rudder stock coupling of spade rudders

b. 20 mm for the other web plates

1.7.4 Connection of the rudder blade with the rudder stock by means of horizontal flanges

- Minimum section modulus of the connection

  The section modulus of the cross-section connection the rudder blade with the flange shall not be less than the value obtained in cm^3 from the following formula:

$$w_s = 1.3 \cdot d_1^3 \cdot 10^{-4}$$

  Where d_1 is calculation as given in [1.4.1], taking k_1 equal to 1.

- Actual section modulus of the connection:

  The section modulus of the cross-section connection the rudder blade with the flange.

  For the calculation of the actual section modulus, the length of the rudder cross-section equal to the length of the rudder flange is to be considered.

  Where the rudder plating is provided with an opening under the rudder flange, the actual section modulus of the rudder blade is to be calculated in compliance with [1.7.3]

- Welding of the rudder blade structure to the rudder blade flange:

  The welds between the rudder blade structure and the rudder blade flange are to be of full penetration type (or of equivalent strength) and are to be 100 % inspected by means of non-destructive testing.

Where the full penetration welds of the rudder blade are accessible only from outside of the rudder, a backing flat bar is to be provided to support the weld root.

The external fillet welds between the rudder blade plating and the rudder flange are to be of concave shape and their throat thickness is to be at least equal to 0.5 times the rudder blade thickness.

Moreover, the rudder flange shall be checked before welding by non-destructive inspection for lamination and inclusion detection in order to reduce the risk of lamellar tearing.

- Thickness of side plating and vertical web plates welded to the rudder flange:

  The thickness of the vertical web plates directly welded to the rudder flange as well as the plating thickness of the rudder blade upper strake in the area of the connection with the rudder flange shall not be less than the values obtained in mm from Table 4.

1.7.5 Single plate rudders

- Main piece diameter

  The main piece diameter shall be obtained from the formulae in [1.4.1] In any case, the main piece diameter shall not be less than the stock diameter.

  For spade rudders the lower third may taper down to 0.75 times the stock diameter.

- Blade thickness:

  The blade thickness shall not be less than the value obtained in mm from the following formula:

$$t_B = \sqrt{k} \cdot (0.81 \cdot s \cdot V_{AV} + 2.5)$$

s = spacing of stiffening arms in m to be taken not greater than 1 m (Refer Figure 1.7.2)

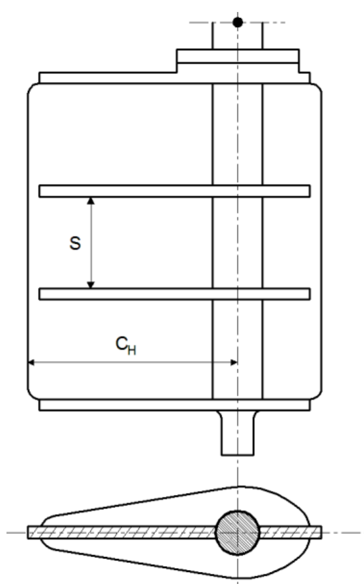


Figure 1.7.2 Single plate rudder

- Stiffening arms:
  The thickness of the stiffening arms shall not be less than the blade thickness.

  The section modulus of the generic section shall not be less than the value obtained in cm^3 from the following formula:

$$Z_A = 0.15 \cdot s \cdot C_H^2 \cdot V_{AV}^2 \cdot k$$

  C_H = horizontal distance in m from the aft edge of the rudder to the centerline of the rudder stock (refer Figure 1.7.2)

  s = defined in [1.7.2]

1.8 Sole piece scantlings

1.8.1 General

The weight of the rudder is normally supported by a carrier bearing inside the rudder trunk.

Robust and effective structural rudder stops shall be fitted, except where adequate positive stopping arrangements are provided in the steering gear, in compliance with the requirements of Pt 4 Ch 6 Sec [1.4.5] and/or Pt 4 Ch 6 Sec [1.4.6]

The bottom plate connected to the stern frame sole piece shall have the following gross thickness t in mm over a length of at least 5 m:

$$t = 1.3 \cdot \sqrt{L + 0.1 \cdot P_1}$$

P_1 = maximum power in kW of main engine driving the central propeller

Where equivalent measures are taken to constrain the sole piece in the body, this strengthening may be given up.

1.8.2 Scantlings

- Bending moment: The bending moment acting on the generic section of the sole piece shall be obtained in N·m from the following formula:

  $M_S = F_{A1} \cdot x$

  F_{A1} = supporting force in N in the pintle bearing, to be determined through a direct calculation; where such a direct calculation is not carried out, this force may be taken equal to $\frac{C_R}{2}$

x = distance in m, defined in Figure 1.8.1

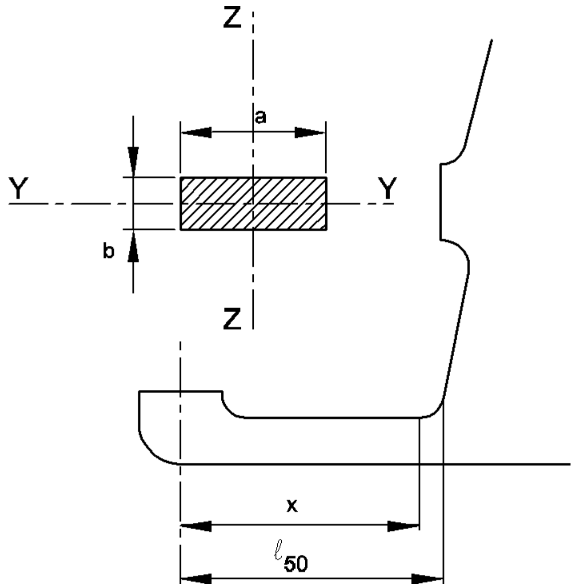


Figure 1.8.1 Sole piece cross-section geometry

- Strength checks:

  For the generic section of the sole piece within the length ℓ_{50}, defined in Figure 1.8.1, it shall be checked that

$\sigma_E \leq \sigma_{E,ALL}$

$\sigma_B \leq \sigma_{B,ALL}$

$\tau \leq \tau_{ALL}$

σ_E = equivalent stress to be obtained in N/mm^2 from the following formula:

$$= \sqrt{\sigma_B^2 + 3 \cdot \tau^2}$$

σ_B = bending stress to be obtained in N/mm^2 from the following formula:

$$= \frac{M_S}{W_Z}$$

τ = shear stress to be obtained in N/mm^2 from the following formula:

$$= \frac{F_{A1}}{A_s}$$

M_S = bending moment at the section considered in N·m defined in [1.8.2]
F_{A1} = force in N defined in [1.8.2] above
W_Z = section modulus in cm^3 around the vertical axis Z (refer Figure 1.8.1)
A_S = shear sectional area in Y direction in mm^2
$\sigma_{E, ALL}$ = allowable equivalent stress in N/mm^2
= 115 / k_1
$\sigma_{B, ALL}$ = allowable bending stress in N/mm^2
= 80 / k_1
τ_{ALL} = allowable shear stress, in N/mm^2
= 48 / k_1

- Minimum section modulus around the horizontal axis:
  The section modulus around the horizontal axis Y (Refer Figure 1.8.1) shall not be less than the value obtained in cm^3 from the following formula:
  W_Y = 0.5 · W_Z
  W_Z = section modulus in cm^3 around the vertical axis Z

1.9 Steering nozzles

1.9.1 General

The following requirements apply to the scantlings of steering nozzles for which the power transmitted to the propeller is less than the value obtained in kW from the following formula:

$$P = \frac{16900}{d_M}$$

d_M = inner diameter of the nozzle in m

Nozzles for which the power transmitted is greater than the value obtained from the above formula are considered on a case-by-case basis.

The following requirements may apply also to fixed nozzle scantlings.

Nozzles normally consist of a double skin cylindrical structure stiffened by ring webs and other longitudinal webs placed perpendicular to the nozzle.
At least two ring webs shall be fitted, one of which, of greater thickness, shall be placed in way of the axis of rotation of the nozzle.
For nozzles with an inner diameter d_M exceeding 3 m, the number of ring webs shall be suitably increased.
Care shall be taken in the manufacture of the nozzle to ensure the welded connection between plating and webs.
The internal part of the nozzle shall be adequately protected against corrosion.

1.9.2 Nozzle plating and internal diaphragms

The thickness of the inner plating of the nozzle shall not be less than the value obtained in mm from the following formula:

$$t_F = \sqrt{k} \cdot \left(0.085 \cdot \sqrt{P \cdot d_M}\right)$$

P, d_M = defined in [1.9.1]

The thickness t_F is to extend over the forward part of the nozzle, across the transverse section containing the propeller blade tips, equal to one third of the total nozzle length.

Outside this length, the thickness of the inner plating is to be not less than ($t_F - 7$) mm and, in any case, not less than 7 mm.

The thickness of the outer plating of the nozzle shall not be less than ($t_F - 9$) mm where t_F is defined in [1.9.2] and, in any case, not less than 7 mm.

The thicknesses of ring webs and longitudinal webs are to be not less than ($t_F - 7$) mm where t_F is defined in [1.9.2], and, in any case, not less than 7 mm.
However, the thickness of the ring web, in way of the headbox and pintle support structure, shall not be less than t_F.

INTLREG may consider reduced thicknesses where an approved stainless steel is used, depending on the type of material.

1.9.3 Nozzle stock

The diameter of the nozzle stock shall not be less than the value obtained in mm from the following formula:

$$d_{NTF} = 6.42 \cdot \sqrt[3]{M_T \cdot k_1}$$

M_T = torque to be taken as the greater of those obtained in N·m from the following:

a. $M_{TAV} = 0.3 \cdot S_{AV} \cdot a$
b. $M_{TAD} = S_{AD} \cdot b$

S_{AV} = force in N
$= 43.7 \cdot V_{AV}^2 \cdot A_N$
S_{AD} = force in N
$= 58.3 \cdot V_{AV}^2 \cdot A_N$
A_N = area in m^2
$= 1.35 \cdot A_{1N} + A_{2N}$
A_{1N} = area in m^2
$= L_M \cdot d_M$
A_{2N} = area in m^2
$= L_1 \cdot H_1$

a, b, L_M, d_M, L_1, H_1 are geometrical parameters of the nozzle in m defined in Figure 1.9.1.

The diameter of the nozzle stock may be gradually tapered above the upper stock bearing so as to reach, in way of the tiller or quadrant, the value obtained in mm from the following formula:

$d_{NT} = 0.75 \cdot d_{NTF}$

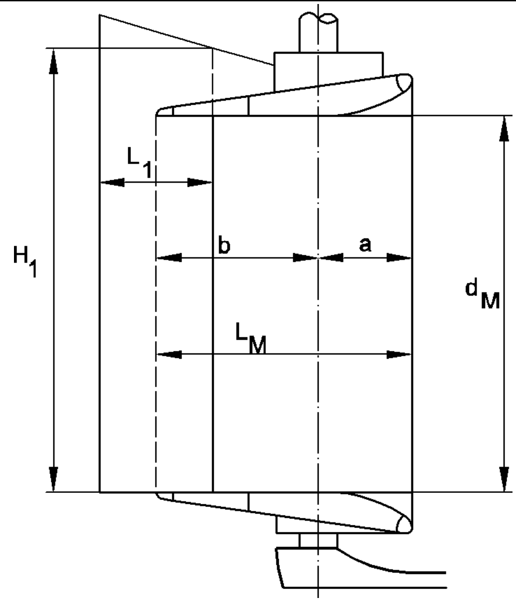


Figure 1.9.1 Geometrical parameters of the nozzle

1.9.4 Pintles

The diameter of the pintles shall not be less than the value obtained [mm] from the following formula:

$$d_A = \sqrt{k_1}\left(30 + \frac{\sqrt{S_{AV}} \cdot 0.19 \cdot V_{AV}}{0.54 \cdot V_{AV} + 3}\right)$$

S_{AV} is as defined in [1.9.3]

The length/diameter ratio of the pintle shall not be less than 1 and not to be greater than 1.2. Smaller values of h_A may be accepted provided that the pressure on the gudgeon bearing p_F is in compliance with the following formula:

$p_F \leq p_{F,ALL}$

p_F = mean bearing pressure acting on the gudgeon in N/mm² from the following formula:

$$= \frac{0.6 \cdot S'}{d'_A \cdot h'_A}$$

S' = the greater of the values S_{AV} and S_{AD} in N defined in [1.9.3]

d'_A = actual pintle diameter in mm

h'_A = actual bearing length of pintle in mm

$p_{F,ALL}$ = allowable bearing pressure in N/mm² defined in Table 1.6.1

1.9.5 Nozzle coupling

- Diameter of coupling bolts:

  The diameter of the coupling bolts shall not be less than the value obtained in mm from the following formula:

$$d_B = 0.62 \cdot \sqrt{\frac{d_{NTF}^3 \cdot k_{1B}}{n_B \cdot e_M \cdot k_{1S}}}$$

d_{NTF} = diameter of the nozzle stock in mm defined in[1.9.3]

k_{1S} = material factor k_1 for the steel used for the stock

k_{1B} = material factor k_1 for the steel used for the bolts

e_M = mean distance in mm from the bolt axles to the longitudinal axis through the coupling center(i.e.the center of the bolt system)

n_B = total number of bolts, which shall not be less than:

a. 4 if $d_{NTF} \leq 75$ mm
b. 6 if $d_{NTF} > 75$ mm

Non-fitted bolts may be used provided that, in way of the mating plane of the coupling flanges, a key is fitted having a section of (0.25 · d_{NT} · x · 0.10 · d_{NT}) in mm^2, where d_{NT} is defined in [1.9.3], and keyways in both the coupling flanges, and provided that at least two of the coupling bolts are fitted bolts.

The distance from the bolt axes to the external edge of the coupling flange shall not be less than 1.2 · d_B.

- Thickness of coupling flange:

  The thickness of the coupling flange shall not be less than the value obtained in mm from the following formula:

$$t_p = d_B \cdot \sqrt{\frac{k_{1F}}{k_{1B}}}$$

d_B = bolt diameter in mm defined in [1.9.5]
k_{1B} = material factor k_1 for the steel used for the bolts
k_{1F} = material factor k_1 for the steel used for the coupling flange

- Push-up length of cone couplings with hydraulic arrangements for assembling and disassembling the coupling:

  It shall be checked that the push-up length Δ_E of the nozzle stock tapered part into the boss is in compliance with the following formula:

$$\Delta_0 \leq \Delta_E \leq \Delta_1$$

Δ_0 = the greater of:

$$6.2 \frac{M_{TR} \cdot \eta \cdot \gamma \cdot 10^{-3}}{c \cdot d_M \cdot t_s \cdot \mu_A \cdot \beta}$$

and

$$16 \frac{M_{TR} \cdot \eta \cdot \gamma \cdot 10^{-3}}{c \cdot t_s^2 \cdot \beta} \sqrt{\frac{d_{1L}^6 - d_{1S}^6}{d_{1S}^6}}$$

d_{NTF}, d_{NT} = nozzle stock diameter in mm to be obtained from the formula in [1.9.3] considering $k_1 = 1$

η, c, β, d_M, d_E, μ_A, μ, γ = defined in [1.5.2]

t_S,d_U,d_0 = defined in Figure 1.5.1

R_{eH} = defined in [1.2.4]

- Locking device

  A suitable locking device is to be provided to prevent the accidental loosening of nuts.

1.10 Azimuth propulsion system

1.10.1 General

- Arrangement

  The azimuth propulsion system is constituted by the following sub-systems (see Figure 1.10.1):

  a. steering unit
  b. bearing
  c. hull supports
  d. rudder part of the system
  e. pod, which contains the electric motor in the case of a podded propulsion system

- Application:

  The following requirements apply to the scantlings of the hull supports, the rudder part and the pod. The steering unit and the bearing are to comply with the requirements in Pt 4 Ch 6 Sec 1.

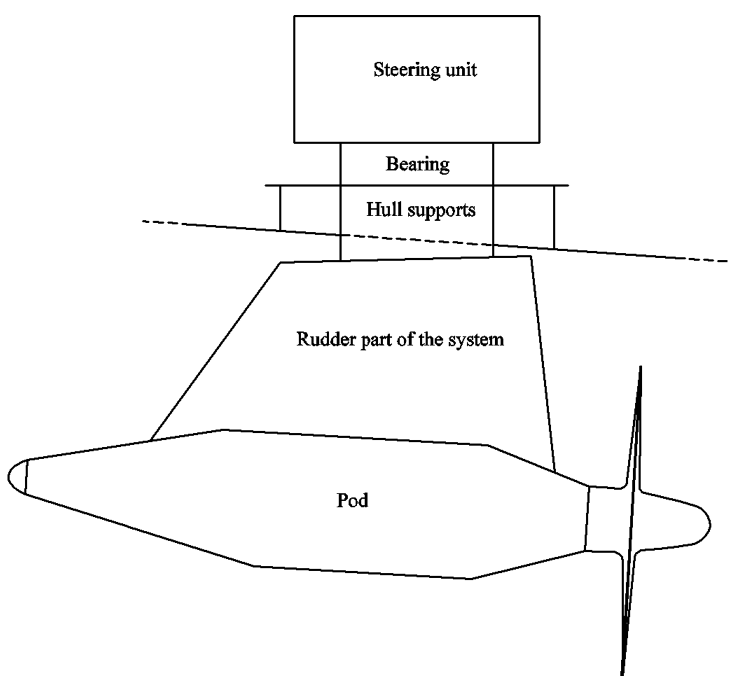


Figure 1.10.1 Azimuth propulsion system

- Operating conditions:

  The maximum angle at which the azimuth propulsion system can be oriented on each side when the vessel navigates at its maximum speed, shall be specified by the designer. Such maximum angle is generally to be less than 35° on each side.

  In general, orientations greater than this maximum angle may be considered by INTLREG for azimuth propulsion systems during maneuvers, provided that the orientation values together with the relevant speed values are considered and confirmed by INTLREG.

1.10.2 Arrangement

- Plans to be submitted

  In addition to the plans showing the structural arrangement of the pod and the rudder part of the system, the plans showing the arrangement of the azimuth propulsion system supports shall be submitted to the Society. The scantlings of the supports and the maximum loads which act on the supports shall be specified in these drawings.
- Locking device:

  The azimuth propulsion system shall be mechanically lockable in a fixed position, in order to avoid rotations of the system and propulsion in undesirable directions in the event of damage.

1.10.3 Primary supporting members

- Analysis criteria:

  The scantlings of primary supporting members of the azimuth propulsion system shall be obtained through direct calculations, to be carried out according to the following requirements:
  a. the structural model is to include the pod, the rudder part of the azimuth propulsion system, the bearing and the hull supports
  b. the boundary conditions are to represent the connections of the azimuth propulsion system to the hull structures
  c. the loads to be applied are those defined in [1.10.3]

  The direct calculation analyses (structural model, load and stress calculation, strength checks) carried out by the designer shall be submitted to the Society for information.
- Loads:

  The following loads shall be considered in the direct calculation of the primary supporting members of the azimuth propulsion system:
  a. gravity loads
  b. buoyancy
  c. maximum loads calculated for an orientation of the system equal to the maximum angle at which the azimuth propulsion system can be oriented on each side when the vessel navigates at its maximum speed
  d. maximum loads calculated for the possible orientations of the system greater than the maximum angle at the relevant speed .refer [1.10.3]
  e. maximum loads calculated for the crash stop of the vessel obtained through inversion of the propeller rotation
  f. maximum loads calculated for the crash stop of the vessel obtained through a 180° rotation of the pod

- Strength check:

It is to be checked that the Von Mises equivalent stress σ_E in primary supporting members, calculated in N/ mm^2 for the load cases defined in [1.10.3], complies with the following formula:

$$\sigma_E \le \sigma_{ALL}$$

σ_{ALL} = allowable stress in N/mm^2 to be taken equal to the lesser of the following values:

a. $0.275 \cdot R_m$

b. $0.55 \cdot R_{eH}$

R_m = tensile strength in N/mm^2 of the material, defined in Pt 2 of Rules for Classification of Ships

R_{eH} = minimum yield stress in N/mm^2 of the material, defined in Pt 2 of Rules for Classification of Ships

1.10.4 Hull supports of the azimuth propulsion system

- Analysis criteria:

  The scantlings of hull support of the azimuth propulsion system shall be obtained through direct calculations, to be carried out in accordance with the requirements in [1.10.3]

- Loads:

  The loads to be considered in the direct calculation of the hull supports of the azimuth propulsion system are those specified in .[1.10.3]

- Strength check:

  It shall be checked that the Von Mises equivalent stress σ_E in hull supports in N/mm^2 calculated for the load cases defined in [1.10.3], complies with the following formula:

$$\sigma_E \le \sigma_{ALL}$$

σ_{ALL} = allowable stress in N/mm^2 equal to:

σ_{ALL} = 65 / k

k = material factor defined in Ch 4 Sec [1.2]

Values of σ_E greater than σ_{ALL} may be accepted by the Society on a case-by-case basis, depending on the localization of σ_E and on the type of direct calculation analysis.

SECTION 2 BULWARKS AND GUARD RAILS

Contents

2.1 General

The following requirements apply to the arrangement and scantlings of bulwarks and guard rails provided at the boundaries of the main deck and superstructure decks.

2.2 Bulwark

2.2.1 General

On all cargo vessels, except pushed barges, bulwarks shall be fitted in way of the fore and aft ship, extending from the stem to the forward end of the foremost hatchway (forward cargo tank on tankers) and from the stern to the forward end of the aft deckhouse.

Between these two areas, a foot guard shall be fitted which is to rise at least 50 mm above the weather deck.

2.2.2 Height

- Cargo carriers

  The bulwark is to be at least 700 mm high. This value may be required to be increased in way of the stem.
- Passenger vessels:

  On passenger vessels, the bulwarks or guard rails are to be at least 1000 mm high on the decks open to passengers. In way of the after deckhouse, a similar height is to be arranged.

  Openings and equipment for embarking or disembarking, and openings for loading or unloading, shall be such that they can be secured.

2.2.3 Thickness

The bulwark gross thickness in mm shall not be less than:

a. $L \leq 30$ m: $t = 4$

b. $30 \text{ m} < L \leq 90$ m: $t = 5$

c. $L > 90$ m: $t = 6$

Bulwarks shall be aligned with the beam located below or connected to them by means of local transverse stiffeners.

Plate bulwarks shall be supported either by stays or plate brackets spaced not more than 2 m apart.

At their upper part, bulwarks shall be fitted with an efficient section acting as a handrail and supported by means of stays located, as far as practicable, in way of the beams.

2.3 Guard rails

In general, the guard rails shall be built in compliance with any nationally or internationally recognized standard.

In case the bulwark height is less than the required guard rail height, a guard rail shall be placed on top of the bulwark.

SECTION 3 PROPELLER SHAFT BRACKETS

Contents

3.1 Symbols

F_C = force in kN

$$= \left(\frac{2\pi N}{60}\right)^2 \cdot R_p \cdot m$$

m = mass of a propeller blade in t

N = number of revolutions per minute of the propeller

R_P = distance in m of the center of gravity of a blade in relation to the rotation axis of the propeller

σ_{ALL} = allowable stress in N/mm^2

= 70

w_A = section modulus in cm^3 of the arm at the level of the connection to the hull with respect to a transverse axis

A = sectional area in cm^2 of the arm

A_S = shear sectional area in cm^2 of the arm

d_P = propeller shaft diameter in mm measured inside the liner if any

3.2 General

3.2.1 Arrangement

Propeller shafting is either enclosed in bossing or independent of the main hull and supported by shaft brackets.

3.2.2 Strength check

The strength check shall be carried out according to Sec 3, Sec 4 or Sec 5, as applicable.

3.2.3 Vibration analysis

Remark:

A vibration analysis according to Pt 4 Ch1 Sec [2.5]& [2.6] is recommended to be performed for single-arm propeller shaft brackets.

3.3 Double arm propeller shaft brackets

3.3.1 General

Both arms of detached propeller brackets are to form an angle α to each other that differs from the angle between propeller blades. Where 3- or 5-bladed propellers are fitted, it is recommended that the angle α should be approximately 90°. Where 4-bladed propellers are fitted, the angle α should be approximately 70° or 110°.

Where possible, the axes of the arms should intersect in the axis of the propeller shaft. Exceptions to this will be considered by INTLREG on a case-by-case basis.

- Scantlings of arms:

  The moment in the arm in kN·m shall be obtained from the following formula:

$$M = \frac{F_C}{\sin\alpha} \cdot \left(\frac{L \cdot d_1 \cdot \cos\beta}{l} + L - l\right)$$

α = angle between the two arms

β = angle defined in Figure 1

d_1 = distance in m defined in Figure 3.3.1

L, ℓ = lengths in m defined in Figure 3.3.2

It shall be checked that the bending stress σ_F, the compressive stress σ_N and the shear stress τ are in compliance with the following formula:

$$\sqrt{(\sigma_F + \sigma_N)^2 + 3 \cdot \tau^2} \leq \sigma_{ALL}$$

$$\sigma_F = \frac{M}{w_A} \cdot 10^3$$

$$\sigma_N = 10 \cdot F_C \cdot \frac{L \sin\beta}{A \cdot l \cdot \sin\alpha}$$

$$\tau = 10 \cdot F_C \cdot \frac{L \cdot \cos\beta}{A_S \cdot l \cdot \sin\alpha}$$

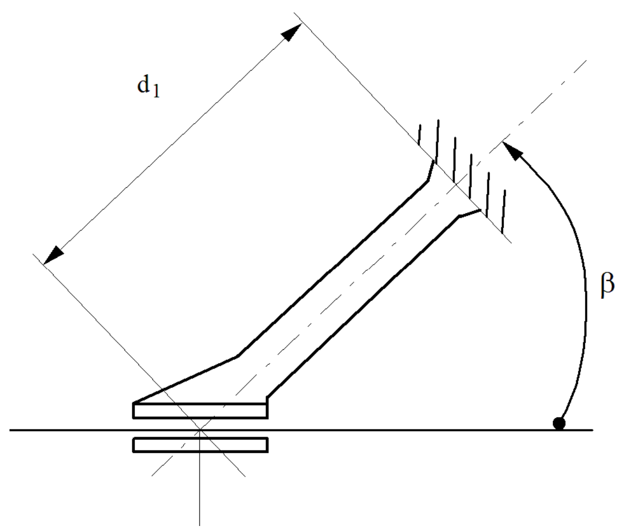


Figure 3.3.1 Angle β and length d_1

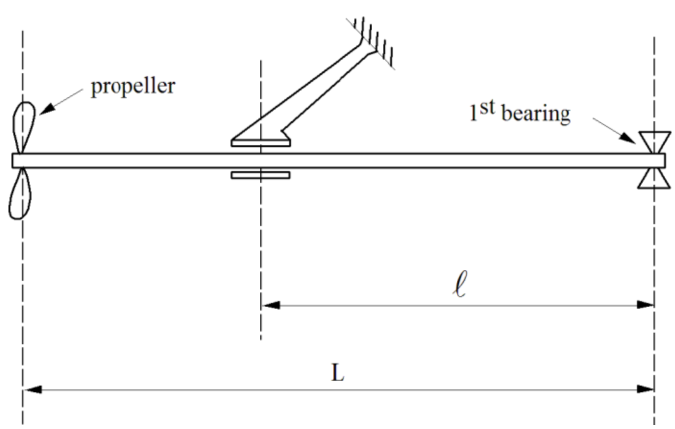


Figure 3.3.2 Lengths L and ℓ

- Scantlings of propeller shaft bossing:

  The length of the propeller shaft bossing shall not be less than the length of the aft stern tube bearing bushes (refer Pt 4 Ch 1 Sec.[2.3.6.2]).

  The thickness of the propeller shaft bossing shall not be less than 0.33 · d_P.

- Bracket arm attachments:

  The bracket arms are to penetrate the hull plating and be connected to deep floors or girders of increased thickness. Moreover, in way of the attachments, the shell plating is to be increased in thickness by 50 % or fitted with a doubling plate of same thickness, and suitably stiffened.

  The securing of the arms to the hull structure is to prevent any displacement of the brackets relative to the hull.

3.4 Single arm propeller shaft brackets

3.4.1 Scantlings

This type of propeller shaft bracket consists of one arm.

- Scantlings of arms

  The moment in kN·m shall be obtained from the following formula:

$$M = \frac{d_2 \cdot F_c \cdot L}{l}$$

d_2 = length of the arm in m measured between the propeller shaft axis and the hull

L, ℓ = lengths in m defined in Figure 2

It is to be checked that the bending stress σ_F and the shear stress τ are in compliance with the following formula:

$$\sqrt{\sigma_F^2 + 3\tau^2} \leq \sigma_{ALL} \sigma_F = \frac{M}{w_A} \cdot 10^3$$

$$\tau = 10 \cdot F_C \cdot \frac{L}{A_S \cdot l}$$

- Scantlings of propeller shaft bossing:

  The length of the propeller shaft bossing shall not be less than the length of the aft stern tube bearing bushes (refer Pt 4 Ch 1 Sec [2.3.6.2]).

  The thickness of the propeller shaft bossing shall not be less than 0.33 · d_P.

- Bracket arm attachments:

  The connection of bracket arms to the hull structure is to comply with [3.4.1]

3.5 Bossed propeller shaft brackets

3.5.1 General

Where bossed propeller shaft brackets are fitted, their scantlings are to be considered by INTLREG on a case-by-case basis.

3.5.2 Scantling of the boss

The length of the boss is to be not less than the length of the aft stern tube bearing bushes (refer Pt 4 Ch1 Sec [2.3.6.2]).

The thickness of the boss in mm is to be not less than $0.33 \cdot dP$. The aft end of the bossing shall be adequately supported.

3.5.3 Scantling of the end supports

The scantlings of end supports are to be specially considered. Supports shall be adequately designed to transmit the loads to the main structure.

End supports shall be connected to at least two deep floors of increased thickness or connected to each other within the vessel.

3.5.4 Stiffening of the boss plating

Stiffening of the boss plating shall be specially considered. At the aft end, transverse diaphragms shall be fitted at every frame and connected to floors of increased scantlings.

At the fore end, web frames spaced not more than four frames apart shall be fitted.

SECTION 4 EQUIPMENT

Contents

4.1 Symbols

P = required bow anchor weight in kg
P_i = increased required bow anchor weight in kg
L_{OA} = length over all of the vessel in m
B = breadth in m defined in Ch 1 Sec.[1.1]
T = draught in m defined in Ch 1 Sec.[1.1]
R = minimum breaking load of anchor chain cable in kN
R_S = minimum breaking load of mooring cables in kN

4.2 General

4.2.1 General requirements

In the following, the requirements for equipment (anchors, chain cables) are specified depending on the range of navigation **IW (0)**, **IW (0.6)**, **IW (1.2)** and **IW (2)** defined in Pt 1 of the Rules

The specification of tow line and mooring lines is given as a guidance but are not required as a condition of classification.

Vessels built under the Society's supervision which are to have character 7 stated in their certificate and in the register book shall be equipped with anchors and chain cables complying with SHIP Pt.2 - Materials and welding. Further, respective testing shall be carried out in the presence of asurveyor.

INTLREG, taking into account the conditions on the river concerned, may consent to a reduction in equipment for vessel intended for use only in a certain river system or area of inland water provided that a note of this inland water system or inland water is appended to the character ofclassification.

- Barges to be carried aboard sea going ships
  Barges to be carried aboard sea going ships may be exempted from the anchor equipment requirements.

4.3 Anchors

4.3.1 General

Anchors shall be of an approved type.
Cast iron anchors shall not be permitted.
The weight of the anchors shall be started on the anchor in relief in a durable manner.
Windlasses shall be arranged for handling of anchors having a weight in excess of 50 kg.

4.3.2 Bow anchors

- Cargo carriers:
  The total weight P of the bow anchors of cargo carriers shall be calculated by the following formula:

$$P = k \cdot B \cdot T$$

$$k = c \cdot \sqrt{\frac{L_{OA}}{8 \cdot B}}$$

= c for pushed barges

c = coefficient defined in Table 4.3.1.

Table 4.3.1 Coefficient c	
Deadweight	**Coefficient c**
≤ 400 t	45
> 400 t ≤ 650 t	55
> 650 t ≤ 1000 t	65
> 1000 t	70

- Passenger vessels and other vessels without deadweight measurement:

  Passenger vessels and vessels not intended for the carriage of goods, apart from pushers, shall be fitted with bow anchors whose total weight P is obtained from the following formula:

  $$P = k \cdot B \cdot T$$

  k = coefficient corresponding to 3.2.1 but where, in order to obtain the value of the empirical coefficient c, the maximum displacement in m^3 shall be taken instead of the deadweight tonnage

- Increased bow anchor weight:
  For passenger vessels and for vessels having a large windage area (container vessels) it is recommended to increase the bow anchor weight as follows:
  $P_i = P + 4 \cdot A_f$
  A_f = transverse profile view (windage area) of the hull above waterline at the draught T in m^2.
  For calculating the area A_f all superstructures, deckhouses and cargoes (e.g. containers) having a breadth greater than B/4 are to be taken into account.

  For vessels with range of navigating in **IW(0)** and **IW(0.6)**, where the current velocity is lower than 6 km/h, the anchor weights according to[4.3.1] to[4.3.3] may be reduced by 13 %.

4.3.3 Stern anchors
The vessels referred to in [3.2.1] shall be fitted with stern anchors whose total weight is equal to 25 % of the weight P.

Vessels whose maximum length exceeds 86 m shall, however, be fitted with stern anchors whose total weight is equal to 50 % of the weight P or P_i calculated in accordance with - [4.3.1] to[4.3.3]

- Pushers:

Vessels intended to propel rigid convoys not more than 86 m in length shall be fitted with stern anchors whose total weight is equal to 25 % of the maximum weight P calculated in accordance with [4.3.2] for the largest formation considered as a nautical unit.

Vessels intended to propel downstream rigid convoys that are longer than 86 m shall be fitted with stern anchors whose total weight equals 50 % of the greatest weight P calculated in accordance with 3.2.1 for the largest formation considered as a nautical unit.

The following vessels are exempted from the stern anchor requirement:

a. vessels for which the stern anchor weight will be less than 150 kg
b. pushed lighters

4.3.4 Weight reduction

The anchor weights established in accordance with [4.3.1] to [4.3.4]may be reduced for certain special anchors. The following types of anchors have so far been recognized by the Society as "high-holding- power anchors"; refer Table 4.3.2.

4.3.5 Number of anchors

The total weight P specified for bow anchors may be distributed among one or two anchors. It may be reduced by 15 % where the vessel is equipped with only a single bow anchor and the hawse pipe is located amidships.

The required total weight of stern anchors for pushers and vessels whose maximum length exceeds 86 m may be distributed between one or two anchors.
The weight of the lightest anchor should be not less than 45 % of that total weight.

Table 4.3.2 Recognized types of anchors

Type of anchors	Weight reduction
HA – DU	30 %
D’Hone Special	30 %
Pool 1 (hollow)	35 %
Pool 2 (solid)	40 %
De Biesbosch – Danforth	50 %
Vicinay – Danforth	50 %
Vicinay AC 14	25 %
Vicinay Type 1	45 %
Vicinay Type 2	45 %
Vicinay Type 3	40 %
Stockes	35 %
D’Hone – Danforth	50 %
Schmitt high holding anchor	40 %
SHI high holding anchor, type ST (standard)	30 %

SHI high holding anchor, type FB (fully balanced)	30 %
Klinsmann anchor	30 %
HA-DU-POWER Anchor	50 %

4.4 Chain cables

4.4.1 General

Short-link or stud-link chain cables may be used as anchor chain cables.

4.4.2 Minimum breaking loads

The minimum breaking load of chain cables shall be calculated by the formulae given in Table 4.4.1. For the breaking loads of short-link chains and stud-link chains, refer Table 4.6.1 and Table 4.6.2, respectively.

Where the anchors have a weight greater than that required in [4.3.1] to [4.3.4] the breaking load of the anchor chain cable shall be determined as a function of the actual anchor weight.

Table 4.4.1 Minimum breaking loads R of chain cables

Anchor weight in kg	**R in kN**
≤ 500	$R = 0.35 \cdot P'$
> 500 and ≤ 2000	$R = P' \cdot \left(0.35 - \frac{P' - 500}{15000}\right)$
> 2000	$R = 0.25 \cdot P'$
P' = required weight of each anchor determined in accordance with 3.2, 3.3 and 3.5	

The fittings between anchor and chain shall withstand a tensile load 20 % higher than the tensile strength of the corresponding chain.

4.4.3 Length of chain cables

- Bow anchor chain cables:

  For the minimum length of bow anchor chain cables, refer Table 4.4.2.

Table 4.4.2 Minimum length of bow anchor chain cables

Overall length L_{OA} of the vessel in m	Minimum length of chain cables in m	
	IW(0) to **IW(0.6)**	**IW(1.2)** to **IW(2)**
< 30	$\ell = 40$	$\ell = L_{OA} + 10$
≥ 30 and ≤ 50	$\ell = L_{OA} + 10$	
> 50	$\ell = 60$	

- Stern anchor chain cables

  The length of stern anchor chain cables shall not be less than 40 m. Can this be known at the design/ outfitting stage of the vessel they shall be equipped with a stern anchor chain of not less than 60 m in length.

- Steel wire ropes:

Case by case steel wire ropes may be accepted instead of anchor chain cables. The wire ropes are to have at least the same breaking strength as the required anchor chain cables but shall be 20 % longer.

4.5 Mooring and towing equipment

4.5.1 Ropes

Steel wire ropes as well as fiber ropes from natural or synthetic fibers or ropes consisting of steel wires and fiber strands should be used for all ropes and cables.

During loading and unloading of tank vessels carrying inflammable liquids steel wire ropes only shall be used for mooring purposes.

Ropes and cables should preferably be of the following type:

a. × 24 wires + 7 fiber cores for towing ropes and mooring lines
b. × 37 wires + 1 fiber core for warps

- Pushed barges:

  Pushed barges shall be equipped with at least four wire ropes having a theoretical breaking load of 440 · kN instead of the towing ropes.

- Mooring cables:

  Dimensions of mooring cables should be at least as defined in Table 4.5.1 and Table 4.5.2.

Table 4.5.1 Mooring cables	
Mooring cable	**Minimum length of cable in m**
1st cable	ℓ' = lesser of ℓ_1 and 100m $\ell_1 = L_{OA} + 20$
2nd cable	$\ell'' = 2/3 \cdot \ell'$
3rd cable 1)	$\ell'' = 1/3 \cdot \ell'$
1) This cable is not required on board of vessels whose L_{OA} is less than 20 m.	

Table 4.5.2 Minimum breaking load R_S of mooring	
$L_{OA} \cdot B \cdot T$	R_S in kN
≤ 1000 m^3	$R_S = 60 + \frac{L_{OA} \cdot B \cdot T}{10}$
> 1000 m^3	$R_S = 60 + \frac{L_{OA} \cdot B \cdot T}{100}$

- Towing cables:

  Self-propelled barges and pushers that are also able to tow shall be equipped with an at least 100 m long towing cable whose tensile strength in kN is not less than one quarter of the total power in kW of the power plant(s).

  Tugs are to be equipped with a number of cables that are suitable for their operation. However, the most important cable shall be at least 100 m long and have a tensile strength in kN not less than one third of the total power in kW of the power plant(s).

4.5.2 Bollards

Every vessel shall be equipped with one double bollard each on the fore and after body on port and starboard side. In between, depending on the vessel's size, one to three single bollards shall be arranged on either side of the vessel.

Remark:
For larger vessels (as from L = 70 m) it is recommended to mount a triple bollard on the fore body and two double bollards on the after body on port and starboard side.

The bollards shall be led through the deck and below be attached to a horizontal plate spaced at least one bollard diameter from the deck. This plate shall be of the same thickness as the bollard wall and

shall be connected to the side wall and adjacent beam knees. Should this be impossible (through the deck connection), the bollards shall be constrained in a bollard seat on deck.

4.6 Hawse pipes and chain lockers

4.6.1 Arrangements

Hawse pipes shall be of substantial construction. Their position and slope shall be arranged to facilitate housing and dropping of the anchors and avoid damage to the hull during these operations. The parts on which the chains bear shall be rounded to a suitable radius.

The fore ship of the vessel shall be arranged in such a way that the anchors do not protrude beyond the side shell.

All mooring units and accessories, such as timbler, riding and trip stoppers, shall be securely fastened to the Surveyor's satisfaction.

Where two chains are used, the chain locker shall be divided into two compartments, each capable of housing the full length of one line.

4.6.2 Hawse pipe scantlings

The gross thickness of the hawse pipes shall not be less than:

a. for t_0 <10 mm

t = lower of $t_0 + 2$ and 10

b. for $t_0 \geq 10$ mm

$t = t_0$

t_0 = gross thickness of adjacent shell plating in mm

Table 4.6.1 Breaking loads in kN, for short-link chain cables

Chain diameter in mm	Grade K1		Grade K2		Grade K3	
	Proof load	Breaking load	Proof load	Breaking load	Proof load	Breaking load
10	20	40	28	56	40	80
13	32	63	45	90	63	125
16	50	100	71	140	100	200
18	63	125	90	180	125	250
20	80	160	110	220	160	320
23	100	200	140	280	200	400

26	125	250	180	360	250	500
28	140	280	200	400	280	560
30	180	360	250	500	360	710
33	200	400	280	560	400	800
36	250	500	360	710	500	1000
39	280	560	400	800	560	1100
42	320	630	450	900	630	1250
Grades K1, K2 and K3 are equivalent to grades Q1, Q2 and Q3						

Table 4.6.2 Breaking loads in kN for stud-link chain cables

Chain diameter in mm	Grade K1		Grade K2		Grade K3	
	Proof load	Breaking load	Proof load	Breaking load	Proof load	Breaking load
12.5	46	66	66	92	92	132
14	58	82	82	116	116	165
16	76	107	107	150	150	216
17.5	89	127	127	179	179	256
19	105	150	150	211	211	301
20.5	123	175	175	244	244	349
22	140	200	200	280	280	401
24	167	237	237	332	332	476
26	194	278	278	389	389	556
28	225	321	321	449	449	642
30	257	368	368	514	514	735
32	291	417	417	583	583	833
34	328	468	468	655	655	937
36	366	523	523	732	732	1050
38	406	581	581	812	812	1160
40	448	640	640	896	896	1280
42	492	703	703	981	981	1400
44	538	769	769	1080	1080	1540
46	585	837	837	1170	1170	1680
48	635	908	908	1270	1270	1810
Grades K1, K2 and K3 are equivalent to grades Q1, Q2 and Q3, respectively.						

SECTION 5 CRANES AND BUNKER MASTS

Contents

5.1 General

5.1.1 Application

The lifting appliances are not covered by classification. Therefore, the following rules shall be considered as recommendations. However, they are to comply with national and/or international regulations.

The fixed parts of lifting appliances, considered as an integral part of the hull, are the structures permanently connected by welding to the vessel's hull (for instance crane pedestals, masts, derrick heel seating, etc., excluding cranes, derrick booms, ropes, rigging accessories, and, generally, any dismountable parts). The shrouds of masts embedded in the vessel's structure are considered as fixed parts.

The fixed parts of lifting appliances and their connections to the vessel's structure are covered by classification, even when the certification of lifting appliances is not required.

5.1.2 Arrangement

It shall be possible to lower the crane boom or the derrick structure and to secure them to the vessel during the voyage.

5.2 Hull girder strength

5.2.1 General

The hull girder strength shall be checked when the lifting appliance is operated, taking into account the various loading conditions considered, through criteria to be agreed with INTLREG.

5.3 Hull scantlings

5.3.1 Loads transmitted by the lifting appliances

The forces and moments transmitted by the lifting appliances to the vessel's structures, during both lifting service and navigation, shall be submitted to INTLREG.

5.3.2 Vessel's structures

The vessel's structures, subjected to the forces transmitted by the lifting appliances, shall be reinforced to the Society's satisfaction.