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Part 4
Hull Outfitting and Equipment

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CHANGES HISTORY

Refer Changes history in Part 1

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L = Rule length in m
B = Rule breadth in m
D_R = Rule depth in m
T = Rule draught in m
Δ = Rule displacement in t
C_B = Rule block coefficient
V = maximum service speed in knots on draught T.

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4.1.1 The use of asbestos is prohibited.Also refer Part 5A/Ch 1/Sect [4.7]

CHAPTER 2 STERNFRAMES, RUDDERS AND STEERING

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SECTION 1 GENERAL

Contents

1.1. Introduction

1.1.1 .A suitable steering system capable of steering the ship at maximum ahead speed shall be provided.

1.1.2 Steering shall be accomplished by use of rudders, foils, flaps, steerable propellers or jets, yaw control ports or side thrusters, differential propulsive thrust, variable geometry of the vessel or its lift system components, or by any combination of these devices.

1.1.3 Details for steering and rudder. Refer Pt 5A Ch 6 Sec 1-

1.1.4 .In case of Steering by waterjets or thrusters ,refer Pt5A/Ch 7

1.2 Definitions

1.2.1 Maximum ahead service speed is the maximum service speed V_{str}. The speed shall be specified by designer and with consideration to necessary steering gear capacity. V_{str} may be equal to or higher than maximum service speed with the ship at summer load waterline, V.

1.2.2 Maximum astern speed is the speed which it is estimated the ship can attain at the designed maximum astern power at the deepest seagoing draught.

1.2.3 Types of Rudder are detailed in Figure 2.1.1

1.2.4 Symbols:

f_1 = material factor
p_m = maximum bearing surface pressure
F_R = design rudder force
M_{TR}= design rudder torque
A = total area in m^2 of rudder blade
H = mean rudder height in m.

1.3. Documents

1.3.1 Documentation shall be submitted as required by Table 2.1.1

Table 2.1.1 Documentation requirements

Object	*Documentation type*	*Additional description*	*For approval (AP) or For information (FI)*
Rudder arrangement	Arrangement plan	Covering rudders, propeller outlines, actuators, stocks, horns, stoppers and bearing lubrication system. Specify maximum speed ahead and aft, and Ice Class when applicable.	FI
	Procedure	Mounting and dismounting or rudder (including flaps as a detached component), rudder stock and pintles.	FI
	Procedure	Measurement of bearing clearances	FI
	Maintenance manual	Flap rudders: Hinges, link systems and criteria for allowable bearing clearances.	FI
	Data sheet	Non-conventional rudder designs: Torque characteristics (torque versus rudder angle in homogeneous water stream).	FI
	Calculation report*	Expected life time of bearings subjected to extraordinary wear rate due to dynamic positioning.	AP
Stern frame, sole	Stern frame, sole		AP
Rudder blades	Structural drawing	Including details of bearings, shafts and pintles.	AP
Rudder stocks	Structural drawing	Including details of connections, bolts and keys.	AP
Propeller nozzles	Structural drawing	Including details of bearings, shafts and pintles.	AP
Propeller shaft brackets	Structural drawing	Including details of connections, bolts and keys.	AP
Rudder and steering gear supporting structures	Structural drawing	Including fastening arrangements (bolts, cocking and side stoppers).	AP

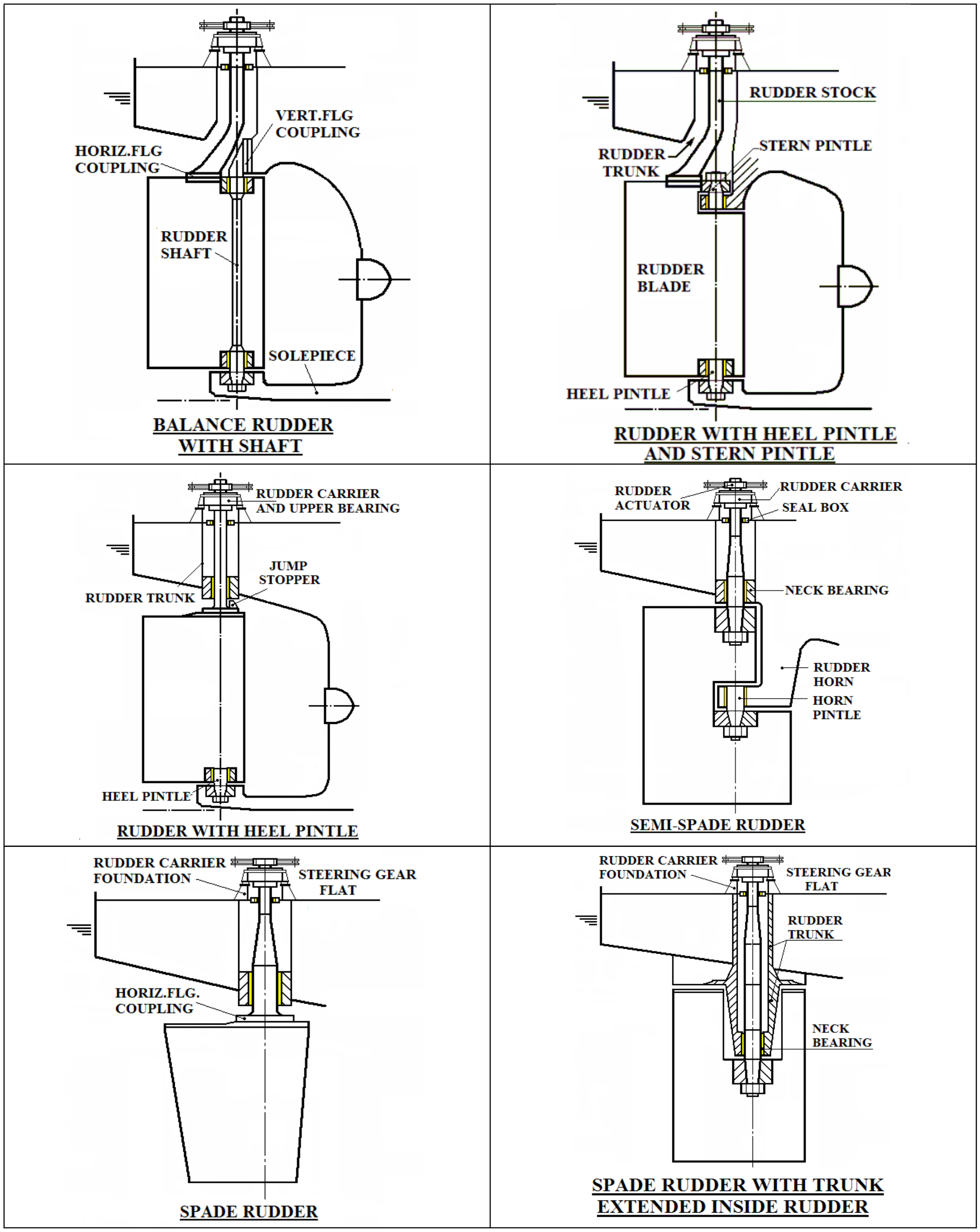


Figure 2.1.1: Types of rudders

SECTION 2 MATERIALS

Contents

2.1 Plates and sections

2.1.1 Material for plates and stern frames, rudders, rudder horns and shaft brackets are in general not to be of lower grades as given in Table 2.2.1.

Table 2.2.1: Plate material grades

Thickness in mm	Normal strength structural steel	High strength structural steel
t ≤20	A	AH
20 < t ≤25	B	AH
25 <t ≤40	D	DH
40 < t ≤150	E	EH

For rudder and rudder body plates which are subjected to stress concentrations (e.g. in way of lower support of semi-spade rudders or at upper part of spade rudders) Class III as given in Pt 2 Ch.2 Sec.2 Table 2.1.2 shall be applied.

2.1.2 The material factor k included in the various formulae for structure shall be taken as given Pt 3 Ch 2 Table 2.2.1.

2.2 Forgings and castings

2.2.1 Rudder stocks, pintles, coupling bolts, keys, stern frames, rudder horns and rudder members shall be made of rolled, forged or cast carbon manganese or alloy steel in accordance with Pt 2.

Remark: *Rudder stocks and pintles should be of weldable quality in order to obtain satisfactory weld ability for any future repairs by welding in service. Note that forgings and castings shall be Charpy tested.*

The minimum yield stress for rudder stocks, pintles, keys and bolts shall not be less than 200 N/mm^2

2.2.2 With special considerations Nodular cast iron shall be accepted in certain parts . Materials with minimum specified tensile strength between 400 N/mm^2 to 900 N/mm^2 will normally accepted in rudder stocks, shafts or pintles, keys and bolts.

2.2.3 The material factor k for forgings (including rolled round bars) and castings may be taken as

$$k = \left(\frac{\sigma_f}{235}\right)^a$$

σ_f= minimum upper yield stress in N/mm^2, not to be taken greater than 70% of the ultimate tensile strength.
If not specified on the drawings, σ_f is taken as 50% of the ultimate tensile strength.

a = 0.75 for σ_f> 235

= 1.0 for σ_f< 235

2.2.4 Before significant reductions in rudder stock diameter due to the application of steels with yield stresses exceeding 235 N/mm^2 are granted, INTLREG may require the evaluation of the rudder stock deformations. Large deformations should be avoided in order to avoid excessive edge pressures in way of bearings. The slope of the stock should be related to the bearing clearance, refer Sect {7.4.5] of this chapter

2.3 Bearing materials

2.3.1 Bearing materials for bushings shall be stainless steel, bronze, white metal, synthetic material or lignum vitae. Stainless steel or bronze bushings shall be used in an approved combination with steel or bronze liners on the axle, pintle or stock. The minimum difference in hardness of bushing and liners shall be 65 Brinell. 13% Chromium steel shall be avoided.

2.3.2 Synthetic bearing bushing materials shall be of an approved type. For this type of bushing, and have to provide adequate supply of lubrication to the bearing for the purpose of cooling/lubrication

2.3.3 For maximum surface pressure p_m Refer Table 2.2.2. Higher values than given in the Table may be taken in accordance with the maker's specification if they are verified by tests and recorded in respective type approval certificate.

Table 2.2.2: Bearing surface pressures

Bearing material	**p_m (kN/m^2)**
Lignum vitae	2500
White metal, oil lubricated	4500
Synthetic material with hardness between 60 and 70 Shore D [1)]	5500 [2)]
Steel [3)] and bronze and hot-pressed bronze-graphite materials	7000

1) Indentation hardness test at 23°C and with 50% moisture, according to a recognized standard
2) Surface pressures exceeding 5.5 N/mm^2 may be accepted in accordance with bearing manufacturer's specification and tests, but in no case more than 10 N/mm^2
3) Stainless and wear-resistant steel in an approved combination with stock liner

2.4 Material certificates

- INTLREG material certificate will be required for
- Stern frame structural parts
- Rudder structural parts
- Rudder shaft or pintles
- Rudder stock
- Rudder carrier
- Bolts for flanged couplings.

Works certificate (W) from an approved manufacturer may be accepted for:

- Bolts
- Stoppers.

2.5 Heat treatment

2.5.1 Nodular cast iron and cast steel parts for transmission of rudder torque by means of conical connections shall be stress relieved.

SECTION 3 ARRANGEMENT AND DETAILS

Contents

3.1 Sternframes and rudders

3.1.1 Types of rudder arrangements are shown in Fig.2.1.1. Other combinations of couplings and bearings shall be applied.

3.1.2 The rudder shall be arranged prevention of lifting and accidental unshipping and limiting vertical movement in case of unexpected load.

3.1.3 Effective means shall be provided for supporting the weight of the rudder without excessive bearing pressure, e.g. by 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.

3.1.4 In rudder trunks which are open to the sea, a seal or stuffing box shall be fitted above the deepest load waterline, 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 are to be provided.

3.1.5 Vibration analysis

Remark: *Vibration analysis should be considered for semi-spade rudders.*

The lowest natural frequencies will normally fall in a frequency span which includes the blade passing frequency of a propeller. Particularly a coupled mode where torsion of rudder stock and bending of rudder horn are dominating may result in increased dynamic stresses in way of the lower pintle bearing.

The natural frequencies will mainly depend on the torsion stiffness of the rudder stock, the bending stiffness of the rudder horn and the distance between the center of gravity of rudder and its rotational axis. The size of the rudder will also govern the frequency range in which these natural modes will fall. It is recommended to keep the lowest fundamental modes of a rudder away from the blade passing frequency in the full speed range. Normally it may not be possible to keep all the modes above the blade passing frequency. Thus it will be necessary to apply a method to determine the natural frequencies of a rudder either by means of Finite Element Analyses or other reliable methods based on analytical approach/experience

3.1.6 Unbalanced rudders are subject to special consideration with respect to type of steering gear and risk of an unexpected and uncontrolled sudden large movement of rudder causing severe change of ship's pre-set course. Refer Pt.5A Ch.6

Remark:

A rudder shall be considered over-balanced, when balanced portion exceed 30% in any actual load condition. Special rudder types, such as flap rudders, are subject to special consideration.

SECTION 4 DESIGN LOADS AND STRESS ANALYSIS

Contents

4.1 Rudder force and rudder torque, general

4.1.1 The rudder force upon which the rudder scantlings shall be based shall be determined from the following formula:

$$F_R = 0.044\, k_1 k_2 k_3\, A\, {V_{str}}^2 \qquad \text{(kN)}$$

A = area of rudder blade in m^2, including area of flap.

= vertical projected area of nozzle rudder

k_1 = coefficient depending on rudder profile type (refer Fig.2.4.1):

Table 2.4.1 Rudder profile type - coefficient		
Profile type	*Ahead*	*Astern*
NACA - Göttingen	1.10	0.80
Hollow profile [a)]	1.35	0.90
Flatsided	1.10	0.90
Profile with fish tail	1.40	0.80
Rudder with flap	1.70	To be specially considered. If not known: 1.30
Nozzle rudder	1.90	1.50
Mixed profiles (e. g. HSVA)	1.21	0.90
a) Profile where the width somewhere along the length is 75% or less of the width of a flat side profile with same nose radius and a straight line tangent to after end		

k_2 = coefficient depending on rudder/nozzle arrangement

= 1.0 in general

= 0.8 for rudders which at no angle of helm work in the propeller slip stream

= 1.15 for rudders behind a fixed propeller nozzle

k_3 = $\frac{H^2}{A_t} + 2$ not to be taken greater than 4

H = mean height in m of the rudder area. Mean height and mean breadth B of rudder area to be calculated as shown in Fig.2.4.2

A_t = total area of rudder blade in m^2 including area of flap and area of rudder post or rudder horn, if any, within the height H

V_{str} = service speed as defined in Sect [1.2.1] of this chapter

When the speed is less than 10 knots, Vstr shall be replaced by the expression:

$V_{min} = \frac{V_{str}+20}{3}$

For the astern condition, the maximum astern speed shall be used, however, in no case less than:

$$V_{astern} = 0.5\ V_{str} \text{ or min. 5 knots}$$

4.1.2 The rule rudder torque shall be calculated for both the ahead and astern condition according to the formula:

$$M_{TR} = |F_R \cdot x_e| \quad (kNm)$$

$$= \text{minimum } 0.1\ F_R\ B$$

F_R = as given in 4.1.1 for ahead and astern conditions

$x_e = B\ (\alpha - k)$ (m)

B = mean breadth of rudder area, Refer Fig.2.4.2

α = 0.33 for ahead condition

= 0.66 for astern condition (general)

= 0.75 for astern condition (hollow profiles).

For flap rudders or other high lift rudders α will be specially considered. If not known, α = 0.40 may be used for ahead conditions

$$k = \frac{A_F}{A}$$

A_F = area in m^2 of the portion of the rudder blade area situated ahead of the center line of the rudder stock

A = rudder blade area as given in [4.1.1]

For special rudder designs (such as flap rudders) direct calculations of rudder torque, supported by measurements on similar rudders, may be considered as basis for rudder torque estimation.

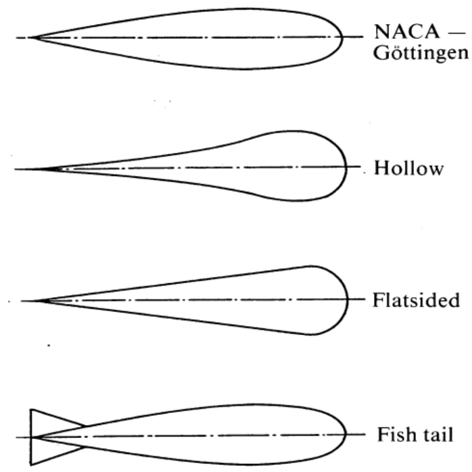


Figure 2.4.1: Rudder profiles

4.2 Rudders with stepped contours

4.2.1 The total rudder force F_R shall be calculated according to Sect [4.1.1], with height and area taken for the whole rudder.

4.2.2 The pressure distribution over the rudder area shall be determined by dividing the rudder into relevant rectangular or trapezoidal areas, Refer e.g. Fig.2.4.3. The rule rudder torque may be determined by:

$$M_{TR} = \sum_{i=1}^{n}(F_{Ri} \times x_{ei}) \quad \text{(kNm)}$$

$$= \text{minimum } 0.1\, F_R\, x_{em}$$

n = number of parts

i = integer

$$F_{Ri} = \frac{A_i}{A} F_R$$

$x_{ei} = B_i\ (\alpha - k_i)$

$$x_{em} = \sum_{i=1}^{n} \frac{(A_i B_i)}{A}$$

A_i = partial area in m^2

B_i = mean breadth of part area, see Fig.2.4.2

α = as given in Sect [4.1.2]

For parts of a rudder behind a fixed structure such as a rudder horn:

α = 0.25 for ahead condition

= 0.55 for astern condition

$$k_i = \frac{A_{iF}}{A_i}$$

A_{iF} = rudder part area forward of rudder stock center line, Refer Fig.2.4.3
F_R and A as given in Sect [4.1.1].

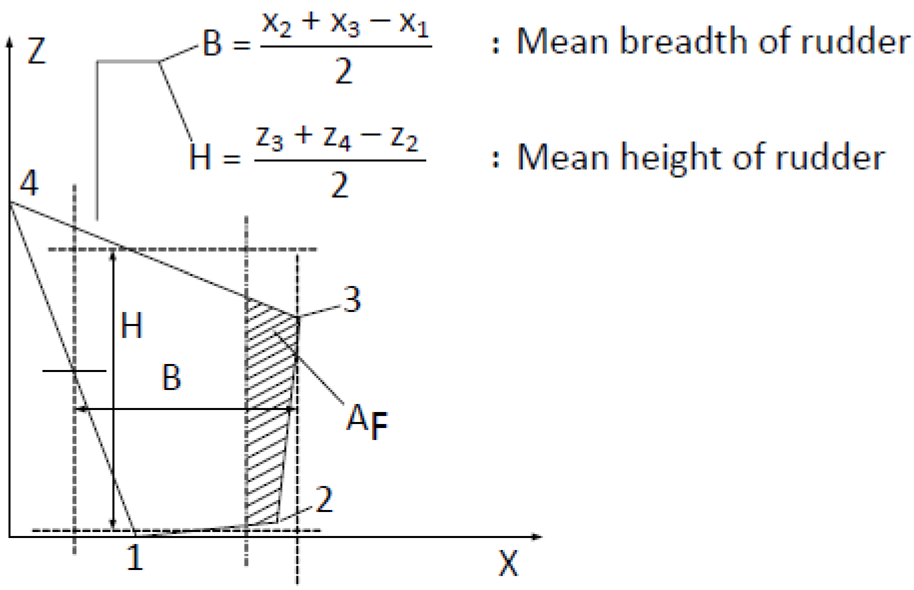


Figure 2.4.2 Rudder dimensions

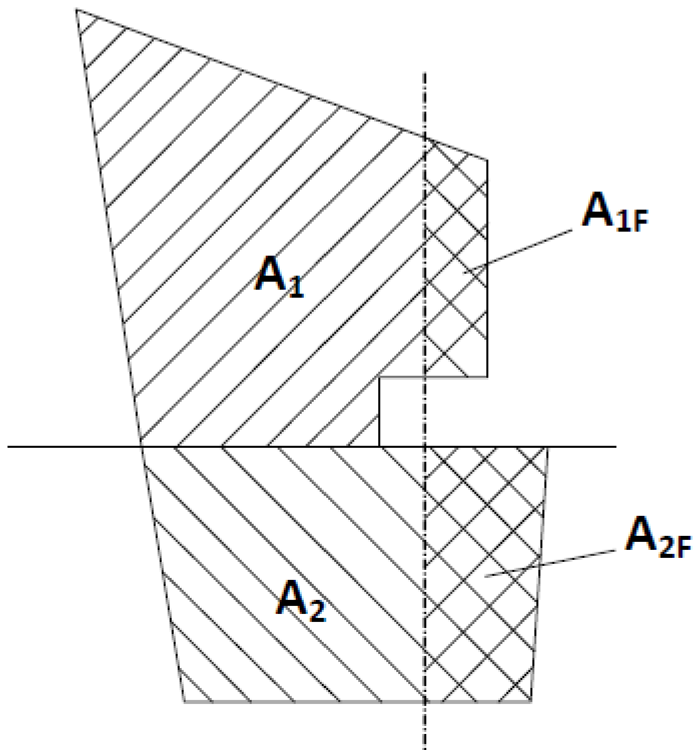


Figure 2.4.3 Rudder area distribution

4.3 Stress analysis

4.3.1 The rudder force and resulting rudder torque as given in sect [4.1] and [4.2], causes bending moments and shear forces in the rudder body, bending moments and torques in the rudder stock, supporting forces in pintle bearings and rudder stock bearings and bending moments, shear forces and torques in rudder horns and heel pieces.

The bending moments, shear forces and torques as well as the reaction forces shall be determined by a direct calculation or by approximate simplified formulae as given in the following.

For rudders supported by sole pieces or rudder horns, these structures shall be included in the calculation model in order to account for the elastic support of the rudder body. For rudder systems with flap, the force by the support of the flap mechanism on the rudder shall be included in the calculation model. In general, only the component of the support force that is perpendicular to the plane of the rudder need be considered.

4.3.2 Allowable stresses for the various strength members are given in subsections 5 to 10.

For evaluation of angular deflections, refer [2.2.4], [7.2.1] and [7.4.5].

SECTION 5 STERNFRAMES, SOLE PIECES, RUDDER HORNS AND RUDDER TRUNKS

Contents

5.1 General

5.1.1 Stern frames and rudder horns shall be effectively attached to the surrounding hull structures. In particular the stern bearing or vertical coupling flange for rudder axle shall be appropriately attached to the transom floor adjacent to the rudder stock.

For semi-spade and spade rudder arrangements structural continuity in the transverse as well as the longitudinal direction shall be specially observed.

5.1.2 Cast steel stern frames and welded stern frames shall be strengthened by transverse webs.

Castings shall be of simple design, and sudden changes of section shall be avoided. Where shell plating, floors or other structural parts are welded to the sternframe, there shall be a gradual thickness reduction towards the joint.

5.1.3 Depending on casting facilities, larger cast steel propeller posts shall be made in two or more pieces. Sufficient strength shall be maintained at connections. The plates of welded propeller posts shall be welded to a suitable steel bar at the after end of the propeller post

5.1.4 Stresses determined by direct calculations as indicated in [4.3] are normally not to exceed the following values:

- Normal stress: $\sigma = 80\ f_1$ (N/mm2)
- Shear stress: $\tau = 50\ f_1$ (N/mm2)
- Equivalent stress: $\sigma_e = 120\ f_1$ (N/mm2)

$$\sigma_e = \sqrt{{\sigma_1}^2 + {\sigma_2}^2 - \sigma_1\sigma_2 + 3\tau^2}$$

5.2 Propeller posts

5.2.1 The boss thickness at the bore for the stern tube shall not be less than:

$$t = 5\sqrt{d_p - 60} \quad \text{(mm)}$$

d = diameter of propeller shaft in mm.

5.2.2 The scantlings of fabricated propeller posts shall not be less than:

$$l = 53\sqrt{L} \quad \text{(mm)}$$

$$b = 37\sqrt{L} \quad \text{(mm)}$$

$$t = \frac{2.4\sqrt{L}}{\sqrt{f_1}} \quad \text{(mm)}$$

l, b and t are as shown in Fig. 2.5.1 Alt. I.

Where the section adopted differs from the above, the section modulus about the longitudinal axis shall not be less than:

$$Z_w = \frac{1.35\sqrt{L}}{f_1} \quad (\text{cm}^3)$$

5.2.3 The scantlings of cast steel propeller posts shall not be less than:

$$l = 40\sqrt{L} \text{ (mm)}$$

$$b = 30\sqrt{L} \text{ (mm)}$$

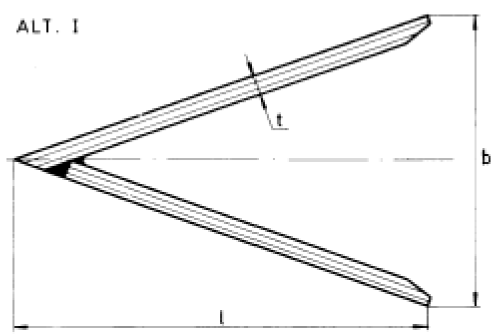
$$t_1 = \frac{3\sqrt{L}}{\sqrt{f_1}} \text{ (mm)}$$

$$t_2 = \frac{3.7\sqrt{L}}{\sqrt{f_1}} \text{ (mm)}$$

l, b, t_1 and t_2 are as shown in Fig.2.5.1 Alt. II.
Where the section adopted differs from the above, the section modulus about the longitudinal axis shall not be less than:

$$Z_2 = \frac{1.3\, L\sqrt{L}}{\sqrt{f_1}} \text{ (cm}^3\text{)}$$

When calculating the section modulus, adjoining shell plates within a width equal to $53\sqrt{L}$ from the after end of the post may be included.



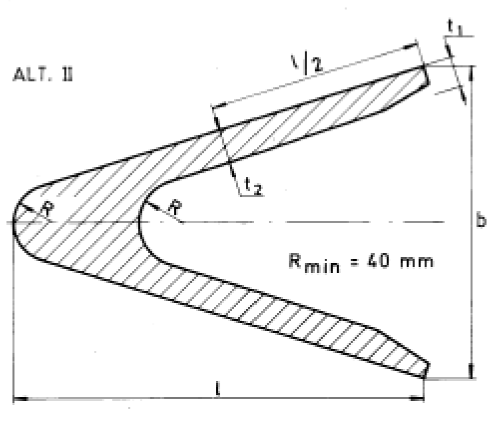


Figure 2.5.1 Propeller posts

5.3 Sole pieces

5.3.1 The sole piece shall be sloped in order to avoid pressure from keel blocks when docking. The sole piece shall extend forward of the after edge of the propeller boss, for sufficient number of frame spaces to provide adequate fixation at the connection with deep floors of the aft ship structure. The cross section of this extended part may be gradually reduced to the cross section necessary for an efficient connection to the plate keel.

5.3.2 The section modulus requirement of the sole piece about a vertical axis abaft the forward edge of the propeller post is given by:

$$Z_l = \frac{6.25 F_R\, l_s}{f_1} \text{ (cm}^3\text{)}$$

*l*s = distance in m from the center line of the rudder stock to the section in question. *l*s shall not be taken less than half the free length of the sole piece.

5.3.3 If direct stress analysis is carried out, the nominal bending stress in the sole piece shall not exceed:

$$\sigma = 115\, f_1$$

5.3.4 The section modulus of the sole piece about a horizontal axis abaft the forward edge of the propeller post shall not be to be less than:

$$Z_2 = \frac{Z_1}{2} \text{ (cm}^3\text{)}$$

5.3.5 The sectional area of the sole piece shall not be less than:

$$A_s = \frac{0.1\, F_R}{f_1} \text{ (cm}^2\text{)}$$

5.4 Rudder horns

5.4.1 The section modulus requirement of the rudder horn about a longitudinal axis is given by:

$$Z = \frac{15\, M_V l_h}{y_h f_1} \text{ (cm}^3\text{)}$$

$$M_v = \sum_{i=1}^{n} F_{Ri} y_{ei}$$

l_h = vertical distance in m from the middle of the horn pintle bearing to the section in question
y_h = vertical distance in m from the middle of the rule pintle bearing to the middle of the neck bearing
F_{Ri} = part of rudder force acting on the i-th part of the rudder area, refer [4.2.2]
y_{ei} = vertical distance in m from the centroid of the i-th part of the rudder area to the middle of the neck bearing
n = number of rudder parts
For the straight part of the rudder horn the section modulus may be taken for the total sectional area of the horn.

When the connection between the rudder horn and the hull structure is designed as a curved transition into the hull plating, the section modulus requirement as given above shall be satisfied by the transverse web plates as follows:

$$Z_w = \frac{\sum_{i=1}^{n} {b_i}^3 t_i}{6000 b_{max}} \geq 0.45\, Z$$

n = number of transverse webs
b_i = effective breadth in mm of web no. i. (including the flange thickness)
t_i = thickness in mm of web no. i
b_{max} = largest b_i

Z, b_i and b_{max} shall be taken at a horizontal section 0.7 r above the point where the curved transition starts (r = radius of curved part, Refer Fig. 2.5.2).
The formula for Z_W is based on the material in web plates and shell plate being of the same strength.

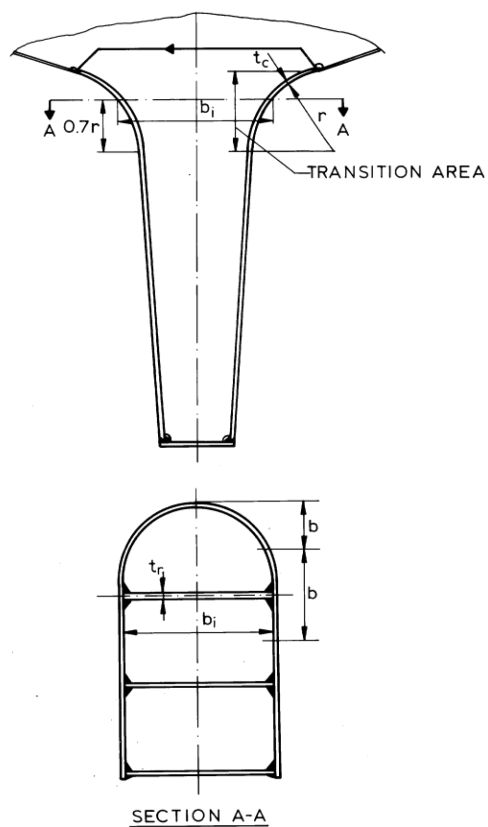


Figure 2.5.2 Curved plate transition rudder horn/shell plating

For a cast rudder horn any vertical extension of the side plating (Refer Fig.2.5.3) may be included in the section modulus.

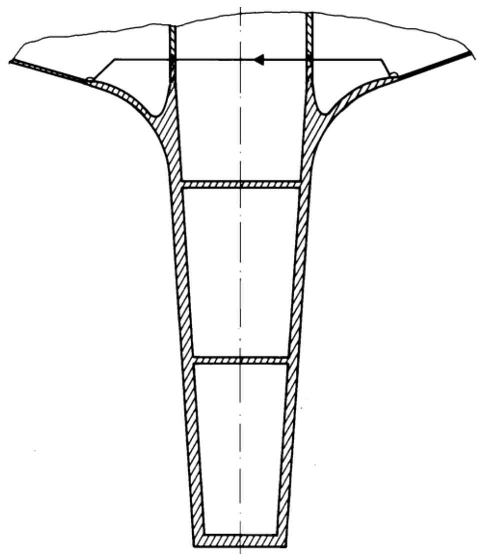


Figure 2.5.3 Curved cast transition rudder horn/shell plating

5.4.2 The rudder horn thickness shall not be less than the greater of:

$$t = 2.4\sqrt{\frac{L}{f_1}}\ \text{(mm)}$$

and

$$t = \frac{110\ kF_R e_h}{f_1 A_S}\ \text{(mm)}$$

$$k = \frac{50}{\sqrt{4000 - 1500(Z/Z_A)^2}}$$

e_h = horizontal projected distance in m from the center line of the horn pintle to the centroid of A_S

A_s = area in cm^2 in horizontal section enclosed by the horn.

For a curved transition between horn plating and shell plating the thickness of the transition zone plate shall not be less than:

$$t_c = \frac{0.15(s-40)^2}{r}\frac{Z}{Z_A}\ \text{(mm)}$$

s= horizontal projected distance in m from the center line of the horn pintle to the centroid of A_S

r = area in cm^{2}in horizontal section enclosed by the horn.

Z_A = horizontal projected distance in m from the center line of the horn pintle to the centroid of A_S

Z = area in cm^2 in horizontal section enclosed by the horn.

5.4.3 The vertical parts of the rudder horn participating in the strength against transverse shear shall have a total area in horizontal section given by:

$$A_w = C\frac{0.3\,F_R}{f_1}\ (\text{cm}^2)$$

$$C = \left(1 + \frac{(A+A_H)A_H}{A^2}\right) \text{ at the upper end of horn}$$

= 0.1 at lower end

A_H = area of horn in m^2. At intermediate sections A_H should be taken for part of horn below section

A = total area of rudder in m^2.

In a curved transition zone, the thickness of the transverse web plates shall not be less than:

$$t_r = 0.8\,t_c$$

t_c = thickness of curved plate

In the transition zone the curved shell plate shall be welded to the web plates by full penetration weld or by a fillet weld with throat thickness not less than:

$$t = 0.55 f_1\,t_r$$

5.4.4 A direct stress analysis of the rudder horn, if carried out, shall be based on a finite element method.

For a curved transition to the hull structure the maximum allowable normal and equivalent stresses as given in 5.1.4, may in the curved plate be increased to:

$$\sigma = 120\ f_1\ \text{N/mm2}$$
$$\sigma_e = 180\ f_1\ \text{N/mm2}$$

A fine-mesh finite element calculation will be considered as an acceptable method.
In the web plates the normal stresses should not exceed $\sigma = 130\ f_1$ N/mm^2.

5.4.5 For a curved transition between the horn side plating and the shell plating, the side plate thicknesses given in [5.4.1] to [5.4.4] shall be extended to the upper tangent line of the curved part. The transverse web thicknesses shall be kept to the same level and shall be welded to the floors above. No notches, scallops or other openings shall be taken in the transition area.

The alternative design shall carry the side plating of the rudder horn through the shell plate and connect it to longitudinal girders. Brackets or stringer shall be fitted internally in horn, in

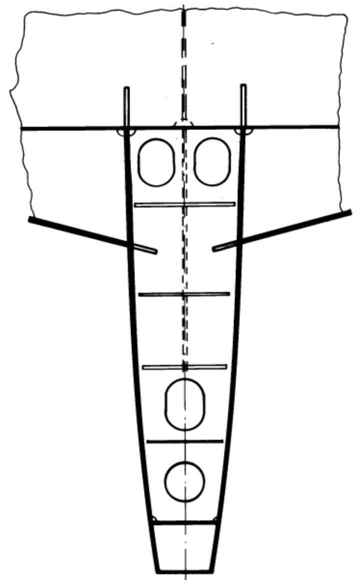


Figure 2.5.4 Shell plating connected to longitudinal girders in line with rudder horn sides

line with outside shell plate, as shown in Fig.2.5.4. The weld at the connection between the rudder horn plating and the side shell shall be full penetration. The welding radius shall be as large as practicable and may be obtained by grinding.

For both design, transverse webs of the rudder horn shall be led into the hull up to the next deck in a sufficient number and shall be of adequate thickness. The transverse webs shall be connected to/supported by transverse floors with a thickness not less than 75% of the rudder horn web plate thickness. The center line bulkhead (wash-bulkhead) in the after peak shall be connected to the rudder horn.

5.4.6 The lower end of the rudder horn shall be covered by a horizontal plate with thickness not less than the side plating.

5.5 Rudder trunk

5.5.1 Materials, welding and connection to hull

This requirement applies to both trunk configurations (extending or not below stern frame).

The steel used for the rudder trunk shall be of weldable quality, with a carbon content not exceeding 0.23% on ladle analysis and a carbon equivalent C_{EQ}, as defined in Pt.2 Ch.1 [3.3.1] not exceeding 0.41.

Plating materials for rudder trunks are in general not to be of lower grades than corresponding to Class III as given in Pt.3 Ch.2 Sec 2 table 2.2.2

The weld at the connection between the rudder trunk and the shell or the bottom of the skeg shall be full penetration.

The fillet shoulder radius r, in mm, (refer Fig. 2.5.5) shall be as large as practicable and shall comply with the following formulae:

$r = 60$ when $\sigma \geq 40 f_1$ N/mm^2

$r = 0.1 d_S$, without being less than 30 when $\sigma < 40 f_1$ N/mm^2

where:

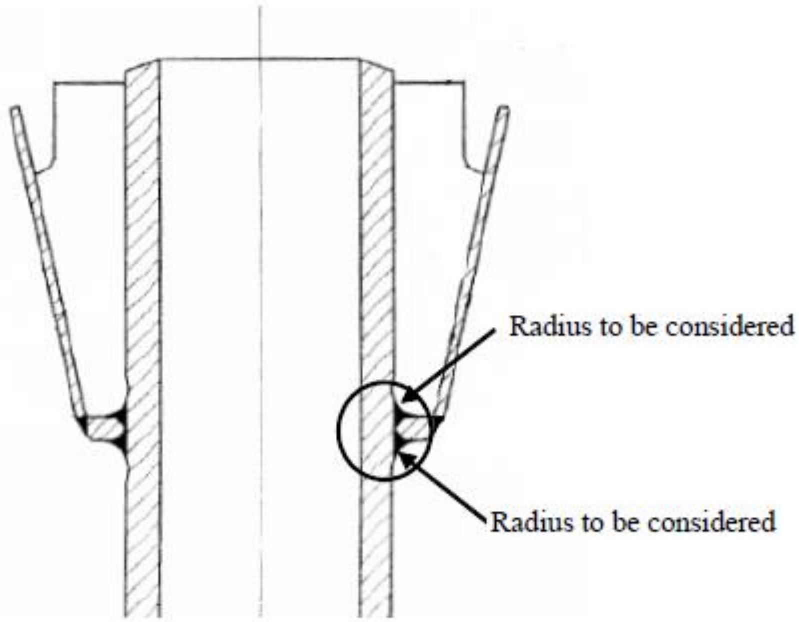


Fig. 2.5.5 Fillet shoulder radius

d_S = rudder stock diameter axis defined in 7.2.1

σ = bending stress in the rudder trunk in N/mm^2

The radius may be obtained by grinding. If disk grinding is carried out, score marks shall be avoided in the direction of the weld. The radius shall be checked with a template for accuracy. Four profiles at least shall be checked. A report shall be submitted to the Surveyor.

Rudder trunks comprising of materials other than steel shall be specially considered.

5.5.2 Scantlings

Where the rudder stock is arranged in a trunk in such a way that the trunk is stressed by forces due to rudder action, the scantlings of the trunk are to be such that:

- the equivalent stress due to bending and shear does not exceed 0.35 σ_f,
- the bending stress on welded rudder trunk is to be in compliance with the following formula:

$$\sigma \leq 80 f_1 \text{ N/mm}^2$$

σ = bending stress in the rudder trunk in N/mm^2.

σ_f = yield stress in N/mm^2 of the material used

For calculation of bending stress, the span to be considered is the distance between the mid-height of the lower rudder stock bearing and the point where the trunk is clamped into the shell or the bottom of the skeg.

SECTION 6 RUDDERS

Contents

6.1 General arrangement and details

6.1.1 Rudders shall be double plate type with internal vertical and horizontal web plates.

The rudder body shall be stiffened by horizontal and vertical webs enabling it to act as a girder in bending.

Single plate rudders may be applied to smaller vessels of special design and with service restrictions, refer [6.6]

6.1.2 All rudder bearings wear shall be measured without lifting or unshipping the rudder.

Remark*:* *In case cover plates are permanently welded to the side plating, it is recommended to arrange peep holes for inspection of securing of nuts and pintles.*

6.1.3 The following detail requirements apply to semi-spade rudders in way of the rudder horn recess:

- the radii in the rudder plating in way of the recess shall not be less than 5 times the plate thickness, but in no case less than 100 mm
- welding in side plate shall be avoided in or at the end of the radii
- edges of side plate and weld adjacent to radii shall be ground smooth.

Remark:

Edge preparation and the performance of coating are of importance for the fatigue life of the rudder.

6.1.4 Plate edges at openings in rudder side plating shall be ground smooth. Cover plates shall be arranged with rounded corners and are not to be welded directly to cast parts.

6.1.5 Means for draining the rudder completely after pressure testing or possible leakages shall be provided. Drain plugs shall be fitted with efficient packing.

6.2 Rudder plating

6.2.1 The thickness requirement of side, top and bottom plating is given by:

$$t = \frac{5.5}{\sqrt{f_1}} k_a s \sqrt{T + \frac{0.1 F_R}{A}} + 2.5 \text{ (mm)}$$

$$k_a = \sqrt{1.1 - 0.5\left(\frac{s}{b}\right)^2}, \text{ maximum 1.0}$$

s = the smaller of the distances between the horizontal or the vertical web plates in m
b = the larger of the distances between the horizontal or the vertical web plates in m.

In no case the thickness shall be less than the minimum side plate thickness as given in Pt 3 Ch 7 Sec [3.1.1]

6.3 Rudder bending

6.3.1 Bending moments in the rudder shall be determined by direct calculations as indicated in [4.3].

For some common rudder types the following approximate formulae may be applied:

- For balanced rudders with heel support:
  M_{max} = 0.125 F_R H (kNm)

- For semi-spade rudders at the horn pintle:

$$M = \frac{F_R A_1 h_s}{A} \text{ (kNm)}$$

- For spade rudders:

$$M_{max} = \frac{F_R A_1 h_s}{A} \text{ (kNm)}$$

A_1 = area in m^2 of the rudder part below the cross-section in question
h_s = vertical distance in m from the centroid of the rudder area A1 to the section in question.

6.3.2 The nominal bending stress distribution in the rudder may normally be determined based on an effective section modulus to be estimated for side plating and web plates within 40% of the net length (cut-outs or openings deducted) of the rudder profile.

At the top of the rudder, the actual section modulus of the cross-section of the structure of the rudder blade, which is connected with the solid part where the rudderstock is housed, is to be calculated with respect to the symmetrical axis of the rudder.
The breadth of the rudder plating to be considered for the calculation of this actual section modulus is to be not greater than that obtained from the following formula:

$$b = s_v + 2\frac{H_s}{m} \text{ (m)}$$

s_v = Spacing between the two vertical webs [m]
m = Coefficient to be taken, in general, equal to 3.
H_x = Vertical distance between the considered section and the upper end of the solid part.
Where openings for access to the rudder stock nut are not closed by a full penetration welded plate, they shall be deducted.

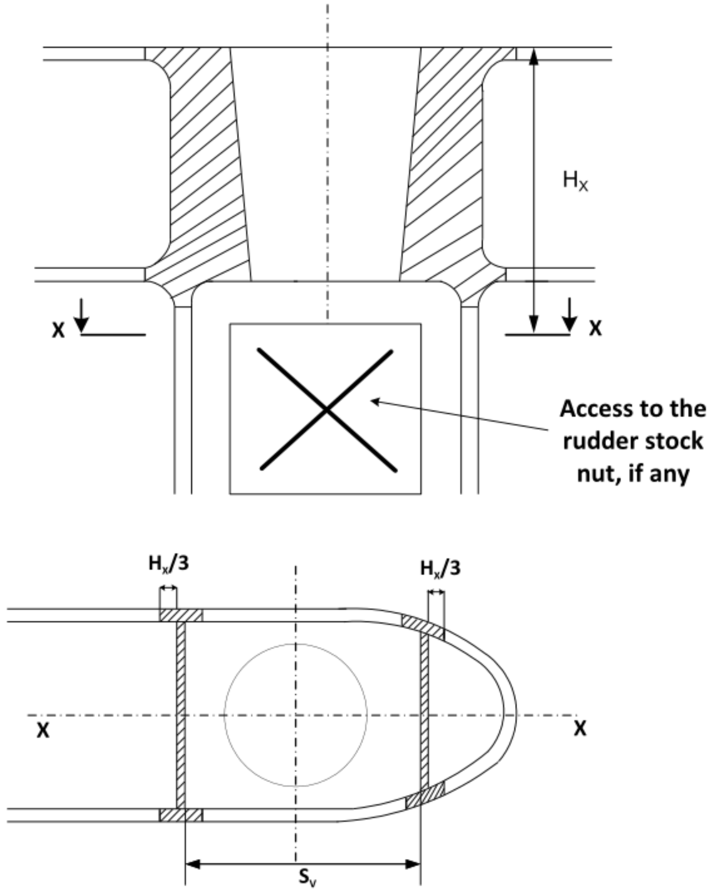


Figure 2.6.1 Cross section of the connection between rudder blade structure and rudder stock housing

Special attention to be paid to open flange couplings on the rudder. The external transverse brackets will normally have to be supplied with heavy flanges to obtain the necessary section modulus of the rudder immediately below the flange.

As an alternative the bending stress distribution in the rudder may be determined by a finite element calculation.

6.3.3 Nominal bending stresses calculated as given in Sect [6.3.1] and [6.3.2] shall not exceed:

σ = 110 f_1 N/mm^2 in general

= 75 N/mm^2 in way of the recess for the rudder horn pintle on semi-spade rudders.

In case of openings in side plate for access to cone coupling or pintle nut, σ= 90 f_1 (N/mm^2) to be applied when the corner radius is greater than 0.15 *l* (*l* = length of opening), σ= 60 f_1 (N/mm^2) when the radius is smaller.

6.4 Web plates

6.4.1 The thickness of vertical and horizontal webs shall not be less than 70% of the thickness requirement given in Sect [6.2] in no case less than 8 mm.

6.4.2 The total web area requirement for the vertical webs is given by:

$$A_w = \frac{P}{5f_1}\ (\mathrm{cm}^2)$$

$$P = \left(0.6 - \frac{h_1}{H}\right) F_R \text{ for balanced rudder with heel support}$$

$$= \frac{h_2}{H} F_R \text{ for spade rudder or lower part of semi-spade ruder}$$

h_1 = height in m of the smaller of rudder parts below or above the cross-section in question
h_2 = height in m of the rudder part below the cross section in question.
Shear stresses in web plates determined by direct stress calculations shall not exceed:
$\tau = 50\ f_1$ (N/mm^2)
Equivalent stress shall not exceed:

$$\sigma_e = \sqrt{{\sigma_b}^2 + 3\tau^2}$$

= 120 f_1 N/mm^{2}in rudder-blades without cut-outs
= 100 f_1 N/mm^{2}in rudder-blades with cut-outs.

6.5 Connections of rudder blade structure with solid parts

6.5.1 Solid parts in forged or cast steel, which house the rudder stock or the pintle, are normally to be provided with protrusions.

These protrusions are not required when the web plate thickness is less than:

- 10 mm for web plates welded to the solid part on which the lower pintle of a semi-spade rudder is housed and for vertical web plates welded to the solid part of the rudder stock coupling of spade rudders
- 20 mm for other web plates.

6.5.2 The solid parts are in general to be connected to the rudder structure by means of two horizontal web plates and two vertical web plates.

6.5.3 Minimum section modulus of the connection with the rudder stock housing

The section modulus of the cross-section of the structure of the rudder blade, in cm3, formed by vertical web plates and rudder plating, which is connected with the solid part where the rudder stock is housed shall not be less than:

$$W_s = c_s {d_s}^3 \left(\frac{H_E - H_X}{H_E}\right)^2 \frac{k}{k_s} 10^{-4}$$

Where:

c_s = coefficient, to be taken equal to:
= 1.0 if there is no opening in the rudder plating or if such openings are closed by a full penetration welded plate
= 1.5 if there is an opening in the considered cross-section of the rudder
d_s = rudder stock diameter, in mm
H_E = vertical distance between the lower edge of the rudder blade and the upper edge of the solid part, in m

H_x = vertical distance between the considered cross-section and the upper edge of the solid part, in m
f_{1b} = material factor for the rudder blade plating
f_{1s} = material factor for the rudder stock

The actual section modulus of the cross-section of the structure of the rudder blade shall be calculated with respect to the symmetrical axis of the rudder.

The breadth of the rudder plating, in m, considered for the calculation of section modulus shall be as per Sect [6.3.2]

6.5.4 The thickness of the horizontal web plates connected to the solid parts, in mm, as well as that of the rudder blade plating between these webs, shall not be less than the greater of the following values:

t_H = 1.2 t [mm]
t_H = $0.045\ d^2/s_H$ [mm]

t = required thickness of the rudder plating, in mm, as defined in Sect [6.2.1]
d = diameter, in mm, to be taken equal to:
= d_S, as per 7.2.1, for the solid part housing the rudder stock
= d_p, as per 7.4.3 for the solid part housing the pintle
s_H = spacing between the two horizontal web plates, in [mm]

The increased thickness of the horizontal webs is to extend fore and aft of the solid part at least to the next vertical web.

6.5.5 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 shall not be less than the values obtained, in mm, from the following table.

Type of rudder	*Thickness of vertical web plates, in mm*		*Thickness of rudder plating, in mm*	
	Rudder blade without opening	Rudder blade with opening	Rudder blade without opening	Area with opening
Rudder supported by sole piece	1.2 t	1.6 t	1.2 t	1.4 t
Semi-spade and spade rudders	1.4 t	2.0 t	1.3 t	1.6 t
t = required thickness of the rudder plating, in mm, as defined in Sect [6.2.1]				

The increased thickness shall extend below the solid piece at least to the next horizontal web.

6.6 Single plate rudders

6.6.1 Main piece diameter

The main piece diameter is calculated according to Sect [7.2.1]. For spade rudders the lower third may taper down to 0.75 times stock diameter.
When calculating the rudder force F_R as given in Sect [4.1.1] the factor k_1 is to be taken equal to 1.0 for both the ahead and the astern condition.

6.6.2 Blade thickness

The blade thickness shall not be less than:

$$t_b = \frac{1.5\, s\, V}{\sqrt{f_1}} + 2.5 \text{ (mm)}$$

s = spacing of stiffening arms in meters, not to exceed 1 m
V = speed in knots, refer Sect [4.1.1].

6.6.3 Arms

The thickness of the arms shall not be less than the blade thickness:

$t_a = t_b$

The section modulus shall not be less than:

$$Z_a = \frac{0.5 s {C_1}^2 V^2}{f_1} \text{ (cm}^3\text{)}$$

C_1= horizontal distance from the aft edge of the rudder to the center line of the rudder stock in meters.

SECTION 7 RUDDER STOCKS AND SHAFTS

Contents

7.1 General

7.1.1 Stresses determined by direct calculations as indicated in Sect [4.3] are normally to give equivalent stress σ_e not exceeding 118 f_1 N/mm2 and shear stress τ not exceeding 68 f_1 N/mm2 The equivalent stress for axles in combined bending and torsion may be taken as:

$$\sigma_e = \sqrt{\sigma^2 + 3\tau^2}$$

σ = bending stress in N/mm^2
τ = torsional stress in N/mm^2.

7.1.2 The requirements to diameters are applicable regardless of liner. Both ahead and astern conditions shall be considered.

7.1.3 A rudder stock cone coupling connection without hydraulic arrangement for mounting and dismounting shall not be applied for spade rudders.

7.1.4 An effective sealing shall be provided at each end of the cone coupling.

7.2 Rudder stock with couplings

7.2.1 The diameter requirement is given by:

$$d_s = 42k_b \left(\frac{M_{TR}}{f_1}\right)^{\frac{1}{3}} \text{ (mm)}$$

k_b = 1 above the rudder carrier, except where the rudder stock is subjected to bending moment induced by the rudder actuator (bearing arrangement versus rudder stock bending deflections, or actuator forces acting on tiller)

$= \left(1 + \frac{4}{3}\left(\frac{M_B}{M_{TR}}\right)^2\right)^{\frac{1}{6}}$ at arbitrary cross section

M_B = calculated bending moment in kNm at the section in question.

$M_B = F_R \cdot h_s$ (kNm) - at neck bearing for spade rudder.

For other rudder types M_B may generally be based on direct calculation of bending moment distribution. At neck bearing for semi-spade rudder M_B is not to be taken less than 0.5 M_B as given in formula below.
If direct calculations of bending moment distribution are not carried out, M_B at the neck bearing or the rudder coupling may be taken as follows:

- for balanced rudder with heel support:

$$M_B = \frac{F_R H}{7} \text{ (kNm)}$$

- for semi-spade rudder:

$$M_B = \frac{F_R H}{17} \text{ (kNm)}$$

h_s= vertical distance in m from the centroid of the rudder area to the middle of the neck bearing or the coupling.

For rudders where the neck bearing is mounted on a trunk extending into the rudder, hs is not to be taken less than H/6.
At the bearing above neck bearing $M_B = 0$, except as follows:

- for rotary vane type actuators with two rotor bearings, which allow only small free deflections, calculation of bending moment influence may be required if bending deflection in way of upper bearing, for the design rudder force F_R, exceeds two times the diametrical bearing clearances. In lieu of a direct calculation, the deflection of the rudder stock between the rotor bearings, δ_{ub} may be taken equal to:

$$\delta_{ub} = \frac{10^5 l h_{ub} M_B}{6\, E I_a}$$

Ia = moment of inertia of rudder stock in cm^4
$l = l_a - h_f$ for arrangements with upper pintle bearing
$l = l_a$ for arrangements with neck bearing
l_a = distance in m from mid-height of neck bearing or upper pintle bearing, as applicable, to mid-height of upper stock bearing
h_f = distance in m from upper end of rudder to mid-height neck bearing
hub= center distance of the rotor bearings in mm

- for actuator force induced bending moment the greater of the following:

$M_{BU} = F_{des}\ h_A$ (kNm)

or

$M_{BU} = F_{MTR}\ h_A$ (kNm)

h_A = vertical distance between force and bearing center
F_{MTR}= net radial force on rudder stock in way of actuator, with actuator(s) working at a pressure corresponding to rule rudder torque, M_{TR}.
M_{BU} = bending moment at bearing above neck bearing
F_{des} = radial force induced by actuator at design pressure.

Minimum diameter of the rudder stock between the neck and the bearing above shall not be less than if tapered with k_b=1.0 at the second bearing.

In steering systems with more than one rudder where the torque from one actuator can be transferred to another, for instance by means of a connecting rod, the rudders stock shall not be permanently damaged when exposed to the sum of actuating loads (actuators working at design pressure)

7.2.2 For coupling between stock and rudder a key shall be provided when dry fitting is applied. Tapered cone connections between rudder stock and rudder shall have strength equivalent to that required for rudder stock with respect to transmission of torque and bending moments as relevant and shall comply with the following (refer Fig. 2.7.1)

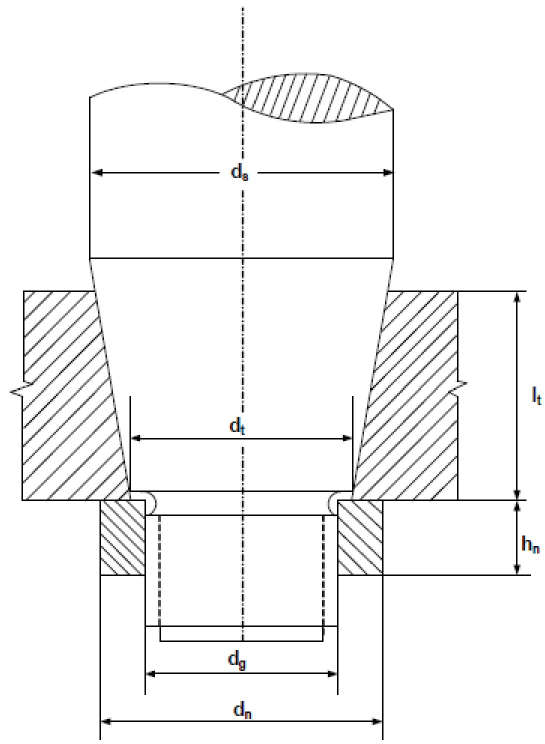


Figure 2.7.1 Cone Coupling

	Dry fitting with key	Oil injection (1)
Length/diameter ratio (l_t/d_s)	≥ 1.5	≥ 1.2
Hub/shaft diameter ratio (D/d_s)	≥ 1.5	≥ 1.25
Taper of cone	1:8-1:12	1: ≥ 12 (2)
Contact surface roughness in micron (R_A)	Maximum 3.5	Maximum 1.6
(1) The design shall enable escape of the oil from between the mating surfaces (2) Tapering 1:$\geq$ 15 is recommended for higher tolerance for push-up length		

- contact area minimum 70% evenly distributed .refer Sect [10.2] for control and testing)
- the connection shall be secured by a nut which is properly locked to the shaft.

7.2.3 Connection between rudder stock and steering gear to be according to Pt 5A Ch 6,Sect 4

7.2.4 Where the tapered end of the rudder stock is shrink fitted to the rudder, with hydraulic arrangement for mounting and dismounting (with oil injection and hydraulic nut), the necessary push-up length and push-up force shall be based on the following:

a. Push-up pressure

The push-up pressure shall be less than the greater of the two following values:

$$P_{req1} = \frac{2Q_F}{{d_m}^2 l\pi\mu_0}\, 10^3 \text{ (N/mm}^2\text{)}$$

$$P_{req2} = \frac{6M_b}{l^2 d_m}\, 10^6 \text{ (N/mm}^2\text{)}$$

Where:

Q_F= design yield moment of rudder stock, as defined in Sect [7.2.5], in Nm
d_m = mean cone diameter in mm
l = cone length in mm
μ_0 = frictional coefficient, equal to 0.15
M_b= bending moment in the cone coupling (e.g. in case of spade rudders), in kNm

It shall be proven by the designer that the push-up pressure does not exceed the permissible surface pressure in the cone. The permissible surface pressure, in N/mm², shall be determined by the following formula:

$$p_{perm} = \frac{0.8\, R_{eH}\left(1-\alpha^2\right)}{\sqrt{3+\alpha^4}} \text{ (N/mm}^2\text{)}$$

where:

R_{eH} = minimum yield stress of the material of the gudgeon in N/mm^2
α= d_m/d_a
d_m = diameter, in mm
d_a = outer diameter of the gudgeon to be not less than 1.5 dm, in mm

b. Push-up length
The push-up length Δ*l*, in mm, is to comply with the following formula:

$$\Delta l_1 \leq \Delta l \leq \Delta l_2$$

where:

$$\Delta l_1 = \frac{p_{req} d_m}{E\left(\frac{1-\alpha^2}{2}\right)c} + \frac{0.8\, R_{tm}}{c} \text{ (mm)}$$

$$\Delta l_2 = \frac{1.6\, R_{eH} d_m}{Ec\sqrt{3+\alpha^4}} + \frac{0.8\, R_{tm}}{c} \text{ (mm)}$$

R_{tm} = mean roughness, in mm taken equal to 0.01
c = taper of cone according to Sect [7.2.2]

Notwithstanding the above, the push-up length shall not be less than 2 mm.

c. Push-up force

Remark: *In case of hydraulic pressure connections, the required push-up force P_e, in N, for the cone may be determined by the following formula:*

$$P_e = P_{req} d_m \pi l \frac{c}{2} + 0.02$$

The value 0.02 is a reference for the friction coefficient using oil pressure. It varies and depends on the mechanical treatment and roughness of the details to be fixed. Where due to the fitting procedure a partial push-up effect caused by the rudder weight is given, this may be taken into account when fixing the required push-up length, subject to approval by the Society.

7.2.5 .This design of key enable transmission of rudder torque and eliminate mutual movements between stock and hub

The key shall be considered as a securing device.
For calculation of required push-up length (δ), Refer Sect [7.2.4] a), b) and c) where p_T is given with T_{fr}= 1.5 M_{TR}.
Any constrain to obtain the required push-up length (δ), then take care in fitting of the key to tight fit (no free sideways play between key and key-way). In this case T_{fr} may be taken as
T_{fr} = 0.5 M_{TR}.
Tapered key-fitting shall comply with the following:

a) Key-ways shall not be placed in areas with high bending stresses in the rudderstock and shall be provided with sufficient fillet radii (r):

$$r \geq 0.01\, d_s$$

b) For couplings between stock and rudder a key shall be provided, the shear area of which, in cm^2, shall not be less than:

$$a_s = \frac{17.55 Q_F}{d_k \sigma_{F1}}$$

where:
Q_F= design yield moment of rudder stock, in Nm
Q_F = 0.2664 d_t^3 f_1

If the actual diameter d_{ta} is greater than the calculated diameter d_t, the diameter d_{ta} shall be used. However, dt_a applied to the above formula need not be taken greater than 1.145 d_t

d_t = stock diameter required for transfer of torque, in mm. To be calculated according to 7.2.1 with k_b=1

d_k = mean diameter of the conical part of the rudder stock, in mm, at the key

σ_{F1} = minimum yield stress of the key material, in N/mm^2

The effective surface area, in cm^2, of the key (without rounded edges) between key and rudder stock or cone coupling shall not be less than:

$$a_k = \frac{5 Q_F}{d_k \sigma_{F2}}$$

where:

σ_{F2}= minimum yield stress of the key, stock or coupling material, in N/mm^2, whichever is less.

c) The height/width ratio of the key shall be:

$$\frac{h}{b} \leq 0.6$$

h = height (thickness) of the key
b = width of the key.

Where necessary tapered connections shall be provided with suitable means (e.g. oil grooves and bores to connect hydraulic injection oil pump) to facilitate dismantling of the hub.
The dimensions at the slugging nut shall not be less than: (ref Fig. 2.7.1):

- external thread diameter:
  $d_g = 0.65\ d_s$
- height of nut:
  $h_n = 0.6\ d_g$
- outer diameter of nut:
  $d_n = 1.2\ d_t$ or $d_n = 1.5\ d_g$ whichever is the greater.

7.2.6 Where the rudderstock is connected to the rudder by horizontal flange coupling the following requirements shall be complied with:

a) At least 6 tight fitted coupling bolts shall be used.

b) The shear diameter of coupling bolts shall not be less than:

$$d_b = 0.62\sqrt{\frac{{d_s}^3 f_{ms}}{n\, e f_{mb}}}\ \text{(mm)}$$

d_s = rule diameter as given in Sect [7.2.1] for the rudder stock at coupling flange.

For rudder stocks with a slanted lower part, ds shall be determined with $M_{TR} = M_{TRf}$, where M_{TRf} is given as: $M_{TRf} = M_{TR} + y_l\, M_B/l$, where M_B denotes the bending moment of the stock at the coupling flange according to 201, l denotes the vertical distance from the upper bearing to the flange attachment to the rudder, and y_l denotes the longitudinal distance, if any, from the rudder axis to the center of the coupling bolt system

n = number of coupling bolts
e = mean distance in mm from the center of bolts to the center of the bolt system
f_{ms} = material factor (f_1) for rudder stock
f_{mb}=material factor (f_1) for bolts.

c) Nuts and bolts shall be securely fastened by split pins or other efficient means.

d) If the coupling is subjected to bending stresses, the mean distance a from the center of the bolts to the longitudinal center line of the coupling shall not be less than 0.6 d_s. Further, bolt pre-stress in shear part of bolt shall normally be in the range of 60 f_{mb} to 120 f_{mb}. In the minimum section of the bolt, pre-stress shall not exceed 165 f_{mb}.

e) The width of material outside the bolt holes shall not be less than 0.67 d_b.

f) The thickness of coupling flanges shall not be less than:

$$t = k_r \sqrt{\frac{\beta M_B}{a\, f_{mf}}} \text{ (mm)}$$

at the root section, however, not less than 0.25 d_s. Away from the root section the flange thickness may be evenly tapered down to 0.25 d_s in way of the clamping bolts.
f_{mf} = material factor (f_1) for flange,
M_B = bending moment in kNm at coupling
a = mean distance from center of bolts to the longitudinal center line of the coupling, in mm
d = diameter as built of rudder stock for stock flange, breadth of rudder for rudder flange, both in mm
β= factor to be taken from the following table:

d/a	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6
β	1.8	1.5	1.25	1	0.8	0.6	0.45	0.35	0.25

β shall not be taken less than 0.25 when d/a is greater than 1.6.
k_r is determined according to the following table:

Table of k_r			
k_f	0.5	0.4	0.3
k_r	70	75	84

$$k_f = \frac{r_f}{a - 0.5\, d}$$

r_f = radius of fillet, not to be taken less than 0.3 (*a* – 0.5*d*).

Remark:

The mean distance from center of bolts to the longitudinal centerline of the coupling, a, may in general be taken as:

$$a = \frac{\sum_n y_i}{n}$$

The mean distance, e, from the center of bolts to the center of the bolt system may in general be taken as:

$$e = \frac{\sum_n \sqrt{(x_i - x_0)^2 + {y_i}^2}}{n}$$

$$x_0 = \frac{\sum_n x_i}{n}$$

n = number of bolts.
y_i = distance from the longitudinal centerline of the rudder to the center of bolt i.
x_i = longitudinal distance from, e.g. the rudder axis to the center of bolt i.

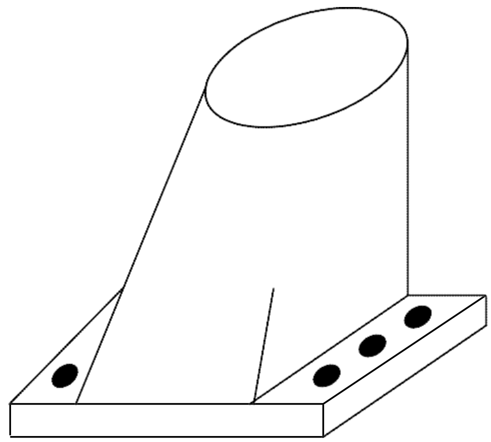
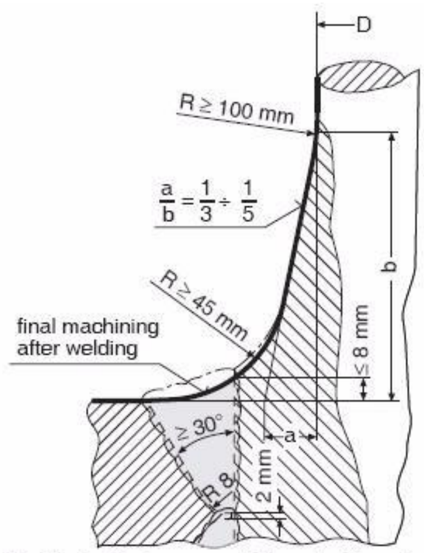


Figure 2.7.2 Rudder stock / flange

7.2.7 The welded joint between the rudder stock and the flange shall be made in accordance with Fig.2.7.3 or equivalent.



Welded joint between rudder stock and coupling flange

Figure 2.7.3 Welded joint between rudder stock and coupling flange

7.3 Rudder shaft

7.3.1 At the lower bearing, the rudder shaft diameter shall not be less than:

$$d_l = 39\left(\frac{F_R c(l-c)}{l f_1}\right)^{1/3} \text{ (mm)}$$

$$c = \frac{a+b}{2}$$

a and b are given in Fig.2.7.4 in m.

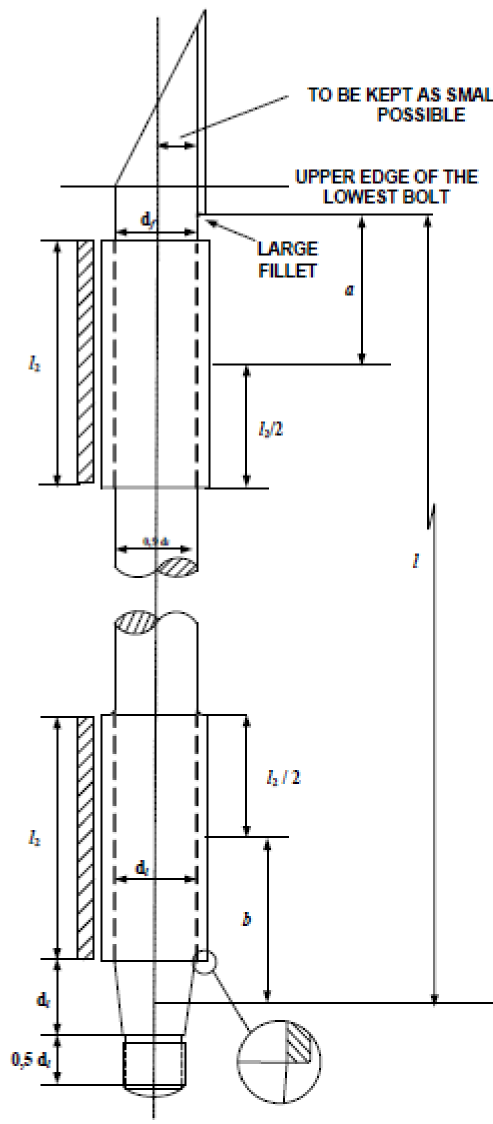


Fig. 2.7.4 Rudder shaft

The diameter df below the coupling flange shall be 10% greater than d_l. If, however, the rudder shaft is protected by a corrosion-resistant composition above the upper bearing, d_f may be equal to d_l.

7.3.2 The taper, nut, etc. at lower end of rudder shafts, shall be taken as for rudder stock given in Sect [7.2.2]

7.3.3 The scantlings of the vertical coupling at the upper end of the rudder shaft shall be as required for horizontal rudder couplings in Sect [7.2.6], inserting the shaft d_l instead of the stock diameter d_s in the formula for bolt diameter.

7.4 Bearings and pintles

7.4.1 The height of bearing surfaces shall not be greater than:

$$h_b = 1.2\ d_{sl}\ \text{(mm)}$$

d_{sl} = diameter in mm of rudder shaft or pintle measured on the outside of liners.

Bearing arrangements with a height of the bearing greater than above, may be accepted based on direct calculations provided by the designer showing acceptable clearances at the upper and lower edges of the bearing.

7.4.2 The bearing surface area shall not be less than:

$$A_B = h_b d_{sl} = \frac{P}{p_m} 10^6\ \text{(mm}^2\text{)}$$

h_b and d_{sl} = as given in [7.4.1]

P = calculated reaction force in kN at the bearing in question
pm = maximum surface pressure as given in Sect [2.3.3].

If direct calculations of reaction forces are not carried out, P at various bearings may be taken as given in the following (note that values given for stern pintle or neck bearing in semi-spade rudders are minimum values):

a) For balanced rudder with heel support:
- $P = 0.6\ F_R$ (kN) at heel pintle bearing
- $P = 0.7\ F_R$ (kN) at stern pintle or neck bearing
- $P = 0.1\ F_R$ (kN) at upper bearing.

b) For semi-spade rudder (The horn pintle bearing is assumed to be situated not more than 0.1 H above or below the center of the rudder area):

- $P = 1.1\ F_R$ (kN) at horn pintle bearing
- $P_{min} = 0.4\ F_R$ (kN) at stern pintle or $0.3\ F_R$ (kN) at neck bearing
- $P = 0.1\ F_R$ (kN) at upper bearing.

c) For spade rudder:
- $P = \frac{h_1+h_2}{h_2} F_R$ (kN) at neck bearing
- $P = \frac{h_1}{h_2} F_R$ (kN) at upper bearing

h_1 = vertical distance from the centroid of rudder area to the middle of the neck bearing
h_2 = vertical distance from the middle of the neck bearing to the middle of the upper bearing. H = as defined in Sect [4.1.1]

d) Upper bearing:
P shall not be taken less than specified in a), b) or c)
For ram type actuator, P shall be calculated considering reaction force induced by one ram.

7.4.3 The diameter of pintles shall not be less than:

$$d_p = 11\sqrt{\frac{P}{f_1}} \text{ (mm)}$$

P = as given in 7.4.2

7.4.4 The thickness of any bushings in rudder bearings shall not be less than:

$$t_v = 0.32\sqrt{P} \text{ (mm)}$$

- minimum 8 mm for steel and bronze
- maker's specification for synthetic materials
- minimum 22 mm for Lignum Vitae
- other materials shall be especially considered.
- P = as given in Sect [7.4.2]

The bushing shall be effectively secured to the bearing.

Remarks:

Bushing fitted by means of shrink fitting alone is not considered effectively secured. Additional physical stoppers need to be arranged to prevent the bushing from accidentally rotating or shifting in vertical direction.

The thickness of bearing material outside of the bushing shall not be less than:

For balanced rudder or semi-spade rudders:

$$t = 1.7\sqrt{\frac{P}{f_1}} \text{ (mm)}$$

For spade rudders:

$$t = 2.0\sqrt{\frac{P}{f_1}} \text{ (mm)}$$

Reduced thickness may be accepted based on direct analysis.

P = as given in Sect [7.4.2]

7.4.5 With metal bearings the clearance on the diameter is normally not to be less than:

$0.01 \quad d_b + 1.0$ (mm)

d_b = inner diameter in mm of the bushing.

For non-metallic bearing material , the bearing clearance shall be specially determined considering the materials' swelling and thermal expansion properties. This clearance shall not be taken less than 1.5 mm on the bearing diameter unless a smaller clearance is supported by the manufacturer's recommendation and there is documented evidence of satisfactory service history with reduced clearance.

The clearance should be related to the calculated angular deflection over the bearing length e.g. neck bearing of spade rudder.
For pressure-lubricated bearings, the clearance will be especially considered.

7.4.6 Pintles shall have a conical attachment to the gudgeons.

The conical pintle connection shall comply with the following:

	Dry fitting (1)	Oil injection (2)
Length/diameter ratio (l_t/d_s)	≥ 1.0	≥ 1.0
Hub/ pintle diameter ratio (D/d_s)	≥ 1.5	≥ 1.5
Taper of cone	1:8-1:12	1: ≥ 12
Contact surface roughness in micron (R_A)	Maximum 3.5	Maximum 1.6
(1) Slugging nut to be provided in accordance with Sect [7.2.5] (2) The design shall enable escape of the oil from between the mating surfaces		

An effective sealing against sea water shall be provided at both ends of the cone.
Contact area shall be minimum 70% evenly distributed (Refer Sect [10.2] for control and testing).
The connection shall be secured by a nut which is properly locked to the pintle.
The required push-up pressure for pintle bearings, in N/mm², is to be determined by the following formula:

$$P_{req} = 400 \frac{P d_0}{{d_m}^2 l} \text{ N/mm}^2$$

where:

P = Supporting force in the pintle bearing, in kN
d_0 = Pintle diameter, in mm

The push up length is to be calculated similarly as in Sect [7.2.4] using required push-up pressure and properties for the pintle bearing.

SECTION 8 PROPELLER NOZZLES

Contents

8.1 General

8.1.1 The following requirements are applicable to fixed and steering nozzles.

Remark:
The scantlings and arrangement of large propeller nozzles should be specially considered with respect to exciting frequencies from the propeller.

8.2 Plating

8.2.1 The thickness of the nozzle shell plating in the propeller zone shall not be less than:

$$t = 10 + 3k_a\, s\sqrt{\frac{N}{f_1}} \text{ (mm)}$$

where:

N = 0.01 P_SD, need not be taken greater than 100
P_S= maximum continuous output (kW) delivered to the propeller
D = inner diameter (m) of nozzle
s = distance in m between ring webs, shall not be taken less than 0.35 meters in the formula
k_a = aspect ratio correction as given in 6.2.1, to be applied when longitudinal stiffeners.

The thickness in zone I and II shall not be less than 0.7 t and in zone III not less than 0.6 t, corrected for spacing 's'.

The propeller zone shall be taken minimum 0.25 b (where b = length of nozzle). For steering nozzles the propeller zone shall cover the variations in propeller position.

On the outer side of the nozzle, zone II shall extend beyond the aftermost ring web.

8.2.2 The thickness of ring webs and fore and aft webs shall not be taken less than 0.6 t. They shall be increased in thickness in way of nozzle supports.

8.2.3 If the ship is reinforced according to an ice class notation, the part of the outer shell of the nozzle which is situated within the ice belt shall have a plate thickness not less than corresponding to the ice class requirement for the after part of the ship.

Remark:
In order to prevent corrosion and erosion of the inner surface of the nozzle, application of a corrosion resistant material in the propeller zone is recommended. All but welds should be ground smooth. When a corrosion resistant material is used, the plate thickness may be reduced by 15%.

8.3 Nozzle ring stiffness

8.3.1 In order to obtain a satisfactory stiffness of the nozzle ring the following requirement shall be fulfilled:

$$I = 2.8\, k\, b\, D^3\, V^2 \text{ (cm}^4\text{)}$$

I = moment of inertia of nozzle section about the neutral axis parallel to center line

$$k = \frac{28\,b}{\sqrt{D\,t_m}(n+1)}$$

t_m = mean thickness of nozzle inner and outer shell plating (mm), in propeller plane
b = length of nozzle, Refer Fig.2.8.1, in m
D = as given in [8.2.1]
V = maximum service speed (knots)
n = number of ring webs.

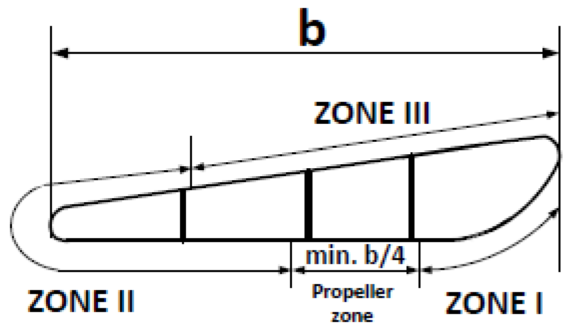


Figure 2.8.1 Section through nozzle ring

8.3.2 If the ship is reinforced according to an ice class notation the parameter V for the requirement in 8.3.1 shall not be taken less than:

V = 14, 15, 16 and 17 knots for ice class **1C**, **1B**, **1A** and **1A***, respectively.

8.4 Welding

8.4.1 The inner shell plate shall be welded to the ring webs with double continuous fillet welding.

8.4.2 The outer shell plate is as far as possible to be welded continuously to the ring webs. Slot welding may be accepted on the following conditions:

If the web spacing ‘s’ ≤ 350 mm all welds to outer plating may be slot welds. If the web spacing s > 350 mm at least two ring webs shall be welded continuously to the outer shell. A continuous weld according to Fig. 2.10.1 may be accepted.

8.5 Supports

8.5.1 The nozzle shall be supported by at least two supports. The web plates and shell plates of the support structure shall be in line with web plates in the nozzle.

SECTION 9 PROPELLER SHAFT BRACKETS

Contents

9.1 General

9.1.1 The following requirements are applicable to propeller shaft brackets having two struts to support the propeller tail shaft boss. The struts may be of solid or welded type.

9.1.2 The angle between the struts shall not be less than 50 degrees.

9.2 Arrangement

9.2.1 Solid struts shall be carried continuously through the shell plating and shall be given satisfactory support by the internal ship structure.

9.2.2 Welded struts may be welded to the shell plating. The shell plating shall be reinforced, and internal brackets in line with strut plating shall be fitted. If the struts are built with a longitudinal center plate, this plate shall be carried continuously through the shell plating. The struts shall be well rounded at fore and aft end at the transition to the hull.

9.2.3 The propeller shaft boss shall have well rounded fore and aft brackets at the connection to the struts.

9.2.4 The strut structure inside the shell shall terminate within a compartment of limited volume to reduce the effect of flooding in case of damage.

9.3 Struts

9.3.1 Solid or built-up struts of propeller shaft brackets shall comply with the following requirements:

$$h = 0.4\ d\ (mm)$$
$$A = 0.4\ d^2\ (mm^2)$$
$$W = 0.12\ d^3\ (mm^3)$$

A = area of strut section
W = section modulus of section. W shall be calculated with reference to the neutral axis Y-Y as indicated on Fig. 2.9.1

h = the greatest thickness of the section
d = Propeller shaft diameter in mm.
The diameter refers to shaft made of steel with a minimum specified tensile strength of 430 N/mm^2

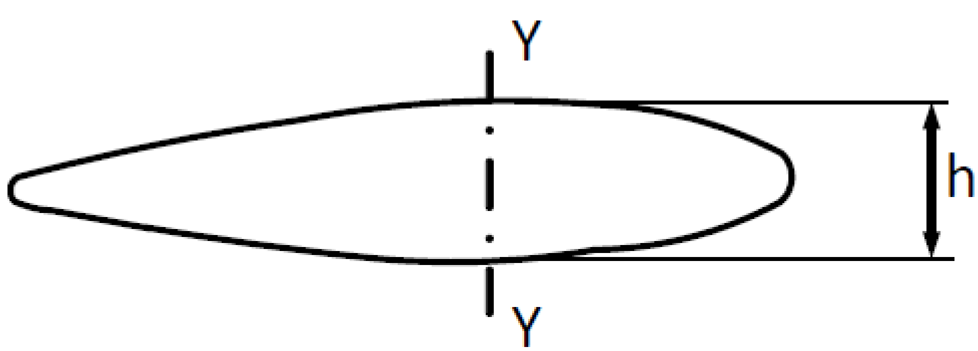


Figure 2.9.1 Strut section

SECTION 10 WELDING, MOUNTING AND TESTING

Contents

10.1 Welding

10.1.1 Welds between plates and heavy pieces (cast or very thick plating) shall be made as full penetration welds. In way of highly stressed areas e.g. cut-out semi-spade rudder and upper part of spade rudder, cast or welding on ribs shall be arranged.

10.1.2 Two sided full penetration welding shall normally be arranged. Where back welding is impossible welding shall be performed against ceramic backing bar or equivalent. Steel backing bars may be used and are to be continuously welded on one side to the heavy piece.

10.1.3 Webs shall be connected to the side plates in accordance with Pt 3 Ch 11. Weld factor C to be used is 0.43

10.1.4 Slot-welding shall be limited as far as possible. Slot welding is not acceptable in areas with large in plane stresses transversely to the slots or in way of cut-out areas of semi-spade rudders

Continuous slot welds as shown in Fig 2.10.1 might be accepted in lieu of slot welds.

When slot welding is applied, slots of minimum length 75 mm and a breadth of 2 t (where t = rudder plate thickness), with a maximum distance of 125 mm between ends of slots, will be accepted. Slots shall not be filled with weld

10.2 Rudders and rudder stock connections

10.2.1 Contact area of conical connections shall be (minimum 70%) verified by means of paint test in presence of the surveyor.

10.2.2 Test push-up followed by control of contact area may be required before final assembly for conical keyless connections intended for injection fitting, if calculations are considered inaccurate due to a nonsymmetric design or other relevant reasons. Push-up length during test push-up shall not be less than final pushup length.

10.3 Testing of stern frames and rudders

10.3.1 Built stern frames and rudders with closed sections shall be leak tested on completion.

Remarks:
Rudder and rudder horn is defined as critical area and at least 20% of the welded length is subject to non destructive testing (Ref. Pt 2 Ch 5).However, it is recommended that highly stressed welds between plates and heavy pieces are subject to 100 % examination with a corresponding reduction in the extent of less critical weld connections.

10.4 Mounting of rudder

10.4.1 For rudder with continuous shaft, it shall be checked that the rudder shaft has the right position in relation to the upper coupling, both longitudinally and transversely, when the lower tapered part of the rudder axle bears hard at the heel. The rudder shaft shall be securely fastened at the heel before the coupling bolts at the upper end are fitted.

10.4.2 Before final mounting of rudder pintles, the contact between conical surfaces of pintles and their housings shall be checked by marking with Prussian blue or by similar method. When mounting the pintles, care shall be taken to ensure that packings will not obstruct the contact between mating surfaces. The pintle and its nut shall be so secured that they cannot move relatively to each other.

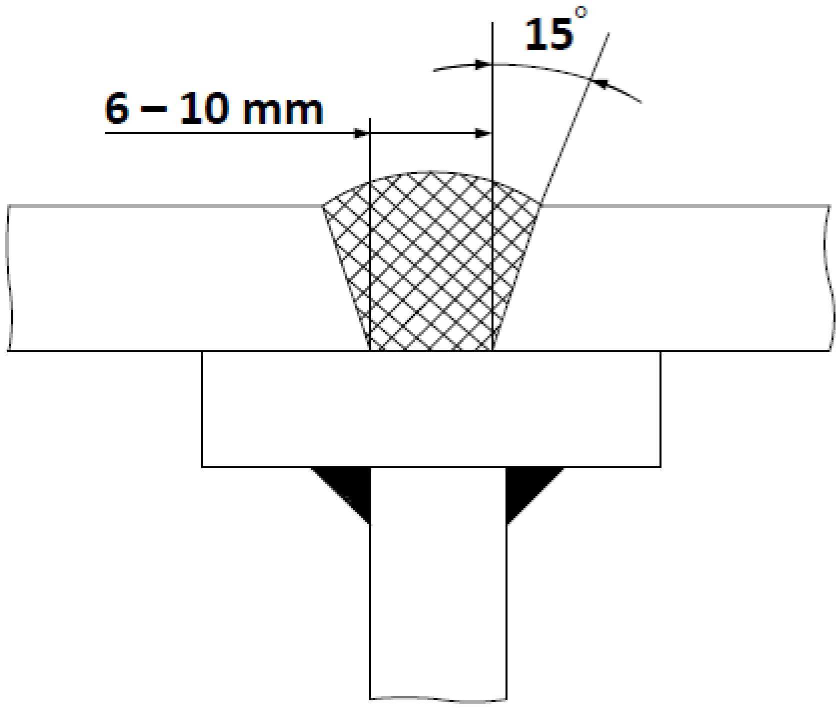


Fig. 2.10.1 Connection shell plate/ring web

CHAPTER 3 ANCHORING AND MOORING EQUIPMENT

CONTENTS

SECTION 1 GENERAL

Contents

1.1. Introduction

1.1.1. This section applicable to equipment and installation for anchoring and mooring.

1.1.2. Classification not applicable to tow and mooring lines, but lengths and breaking strength are given in the equipment tables as guidance. If voluntary certification of such equipment is requested, it shall be carried out in accordance with Ch. 3 Sec 7.

1.2. Documentation requirement

1.2.1 Documentation shall be submitted as required by Table 3.1.1

Table 3.1.1 Documentation requirements

Object	*Documentation type*	*Additional description*	*For approval (AP) or For information (FI)*
Anchoring and mooring arrangement	Arrangement plan	Including design loads	FI
	Equipment list	For windlasses, anchors, grade of anchor chain, type and breaking load of chain, wire and fiber ropes	AP
	Equipment number calculation		AP
Anchors	Design criteria	Applicable if different from standard or previously approved design	FI
	Detailed drawing		AP
	Design analysis		FI
Anchor chain stoppers	Design criteria		FI
	Assembly or arrangement drawing		FI
	Detailed drawing		AP
	Design analysis		FI
Anchor windlasses	Design criteria		FI
	Assembly or arrangement drawing		FI
	Design analysis		FI
	NDT plan		AP
	Detailed drawing	Cable lifter, drum, shaft, gear, brake, clutch and frame	AP

1.3. Certification

1.3.1 INTLREG product certificates will be required for the following items:

- Anchor
- Anchor lines – anchor chains including accessories, e.g. swivels
- Anchor chain joining shackles
- Anchor windlass

1.3.2 INTLREG material certificates will be required for the following items:

- Anchors,– anchor chains including accessories, e.g. swivels, anchor chain joining shackles
- Components of anchor windlass – Cable lifter, drum, shaft, clutch, brake and gear

1.3.3 Works material certificates from an approved manufacturer shall normally be accepted for:

- anchor windlass frame
- steel wire ropes
- Fiber ropes

1.4. Assumptions

1.4.1 The anchoring equipment required is the minimum considered necessary for temporary mooring of a vessel in moderate sea conditions when the vessel is awaiting berth, tide, etc. The equipment is not designed to hold a vessel off fully exposed coasts in rough weather or for frequent anchoring operations in open sea. In such conditions the loads on the anchoring equipment will increase to such a degree that its components may be damaged or lost owing to the high energy forces generated.

Remarks:
If the intended service of the vessel is such that frequent anchoring in open sea is expected, it is advised that the size of anchors and chains is increased above the rule requirements and taking into account the dynamic forces imposed by the vessel moving in heavy seas. The Equipment Numeral (EN) formula for required anchoring equipment is based on an assumed current speed of 2.5 m/s, wind speed of 25 m/s and a scope of chain cable between 6 and 10, the scope being the ratio between length of chain paid out and water depth.

1.4.2 The anchoring equipment required by the Rules are designed to hold a vessel in good holding ground in conditions such as to avoid dragging of the anchor. In case of poor holding ground the holding power of the anchors will be significantly reduced.

1.4.3 It is assumed that under normal circumstances the vessel will use only one bower anchor and chain cable at a time.

SECTION 2 STRUCTURAL ARRANGEMENT FOR ANCHORING EQUIPMENT

Contents

2.1. General

2.1.1. The anchors are normally to be housed in hawse pipes of required size and intended to prevent movement of anchor and chain due to wave action.

The arrangements shall provide an easy lead of the chain cable from the windlass to the anchors. After release of the brake for anchor, the anchor starts falling immediately by its own weight. There shall be chafing lips at the upper and lower ends of hawse pipes. The radius of curvature shall be such that at least 3 links of chain will bear simultaneously on the rounded parts at the upper and lower ends of the hawse pipes in those areas where the chain cable is supported during paying out and hoisting and when the vessel is lying at anchor. Alternatively, roller fairleads of suitable design may be fitted.

If hawse pipes are not fitted, alternative arrangements will be specially considered.

2.1.2. The shell plating in way of the hawse pipes shall be increased in thickness and the framing reinforced as necessary to ensure a rigid fastening of the hawse pipes to the hull.

Remark*:*

The diameter ratio, D/d, between the curvature of the rounded parts at lower end of anchor pocket, hawse pipe or bell mouth and the anchor chain cable shall be minimum 6.

2.1.3. Ships provided with a bulbous bow, and where it is not possible to obtain enough clearance between shell plating and anchors during anchor handling, local reinforcements of bulbous bow shall be provided as necessary

2.1.4. The chain locker shall have sufficient capacity and a suitable form to provide a proper stowage of the chain cable, and an easy direct lead for the cable into the spurling pipes, when the cable is fully stowed. Port and starboard cables shall have separate spaces. If 3 bower anchors and 3 hawse pipes are used, there shall be 3 separate spaces. Spurling pipes and chain lockers shall be watertight up to the weather deck.

Remark:
Bulkheads separating adjacent chain lockers are need not be watertight.

Where means of access are provided, they shall be closed by a substantial cover and secured by closely spaced bolts.

Where a means of access to spurling pipes or cable lockers is located below the weather deck, the access cover and its securing arrangements are to be in accordance with recognized standards or equivalent for watertight manhole covers (refer Remark 3 below). For the securing mechanism of access cover, butterfly nuts and/or hinged bolts are prohibited.

Spurling pipes through which anchor cables are led shall be provided with permanently attached closing appliances to minimize water ingress. Drainage facilities for the chain locker shall be provided.

Provisions shall be made for securing the inboard ends of chain to the structure. This attachment shall be able to withstand a force of not less than 15% nor more than 30% of the minimum breaking strength of the chain cable. The fastening of the chain to the ship shall be made in such a way that in case of emergency when anchor and chain have to be sacrificed, the chain can be readily made to slip from an accessible position outside the chain locker.

Remark 1:

The spurling pipe is the pipe between the chain locker and the weather deck.

Remark 2:

The emergency release of the chain dead end should consequently be arranged watertight or above the weather deck.

Remark 3:

Regarding permanently attached appliances.

Examples of the recognized standards are such as:

i) ISO 5894-1999

ii) China: GB 11628-1989 Ship Manhole Cover

iii) India: IS 15876-2009 "Ships and Marine Technology manholes with bolted covers"

iv) Japan: JIS F2304, "Ship's Manholes" and JIS F2329, "Marine Small Size Manhole"

v) Korea: KSV 2339:2006 and KS VISO5894

vi) Norway: NS 6260:1985 to NS 6266:1985

vii) Russia: GOST 2021-90 "Ship's steel manholes. Specifications".

(Ref: IACS UR L4 Rev.3)

2.1.5. The windlass and chain stoppers shall be efficiently bedded to the deck. The deck plating in way of windlass and chain stopper shall be increased in thickness and supported by pillars carried down to rigid structures. Refer Ch 5 Sec 2

SECTION 3 EQUIPMENT SPECIFICATION

Contents

3.1. Equipment number

3.1.1. The equipment number is given by the formula:

$$EN = \Delta^{2/3} + 2BH + 0.1A$$

H = effective height in m from the summer load waterline to the top of the uppermost deckhouse, to be measured as follows

$$H = a + \Sigma\, h_i$$

a = distance in m from summer load waterline amidships to the upper deck at side

h_i= height in m on the centerline of each tier of houses having a breadth greater than B/4. For the lowest tier, hi shall be measured at Centre line from the upper deck, or from a notional deck line where there is local discontinuity in the upper deck

A = area in m^2 in profile view of the hull, superstructures and houses above the summer load waterline, which is within L of the ship. Houses of breadth less than B/4 shall be disregarded.

In the calculation of $\Sigma\, h_i$ and A sheer and trim shall be ignored.

Windscreens or bulwarks more than 1.5 m in height shall be regarded as parts of superstructures and of houses when determining H and A. The total area of the mentioned items measured from the deck, shall be included.

Remark:

According to IACS UR A1, the height of the hatch coamings and that of any deck cargo, such as containers, may be disregarded when determining h and A.

3.1.2. For a barge rigidly connected to a push-tug the equipment number shall be calculated for the combination regarded as one unit.

Table 3.3.1: Equipment, general

Equipment number	Equipment letter	Stockless bower anchors		Stud-link chain cables				Towline (guidance)		Mooring lines [1)] (guidance)		
				Total length	Diameter and steel grades			Steel or fibre ropes		Steel or fibre ropes		
		Number	Mass per anchor kg	m	1 mm	2 mm	3 mm	Minimum length m	Minimum breaking strength kN	Number	Length of each m	Minimum breaking strength kN
30 to 49	a_0	2	120	192.5	12.5	-	-	170	88.5	2	80	32
50 to 69	a	2	180	220	14	12.5	-	180	98.0	3	80	34
70 to 89	b	2	240	220	16	14	-	180	98.0	3	100	37
90 to 109	c	2	300	247.5	17.5	16	-	180	98.0	3	110	39
110 to 129	d	2	360	247.5	19	17.5	-	180	98	3	110	44
130 to 149	e	2	420	275	20.5	17.5	-	180	98	3	120	49
150 to 174	f	2	480	275	22	19	-	180	98	3	120	54
175 to 204	g	2	570	302.5	24	20.5	-	180	112	3	120	59
205 to 239	h	2	660	302.5	26	22	20.5	180	129	4	120	64
240 to 279	i	2	780	330	28	24	22	180	150	4	120	69
280 to 319	j	2	900	357.5	30	26	24	180	174	4	140	74
320 to 359	k	2	1020	357.5	32	28	24	180	207	4	140	78
360 to 399	l	2	1140	385	34	30	26	180	224	4	140	88
400 to 449	m	2	1290	385	36	32	28	180	250	4	140	98
450 to 499	n	2	1440	412.5	38	34	30	180	277	4	140	108
500 to 549	o	2	1590	412.5	40	34	30	190	306	4	160	123
550 to 599	p	2	1740	440	42	36	32	190	338	4	160	132
600 to 659	q	2	1920	440	44	38	34	190	371	4	160	147
660 to 719	r	2	2100	440	46	40	36	190	406	4	160	157
720 to 779	s	2	2280	467.5	48	42	36	190	441	4	170	172
780 to 839	t	2	2460	467.5	50	44	38	190	480	4	170	186
840 to 909	u	2	2640	467.5	52	46	40	190	518	4	170	201
910 to 979	v	2	2850	495	54	48	42	190	559	4	170	216
980 to 1059	w	2	3060	495	56	50	44	200	603	4	180	230
1060 to 1139	x	2	3300	495	58	50	46	200	647	4	180	250
1140 to 1219	y	2	3540	522.5	60	52	46	200	691	4	180	270
1220 to 1299	z	2	3780	522.5	62	54	48	200	738	4	180	284
1300 to 1389	A	2	4050	522.5	64	56	50	200	786	4	180	309
1390 to1479	B	2	4320	550	66	58	50	200	836	4	180	324
1480 to 1569	C	2	4590	550	68	60	52	220	888	5	190	324
1570 to 1669	D	2	4890	550	70	62	54	220	941	5	190	333
1670 to 1789	E	2	5250	577.5	73	64	56	220	1024	5	190	353
1790 to 1929	F	2	5610	577.5	76	66	58	220	1109	5	190	378
1930 to 2079	G	2	6000	577.5	78	68	60	220	1168	5	190	402

Table 3.3.1: Contd..

2080 to 2229 2230 to 2379 2380 to 2529	H I J	2 2 2	6450 6900 7350	605 605 605	81 84 87	70 73 76	62 64 66	240 240 240	1259 1356 1453	5 5 5	200 200 200	422 451 480
2530 to 2699 2700 to 2869 2870 to 3039	K L M	2 2 2	7800 8300 8700	632. 5 632. 5 632. 5	90 92 95	78 81 84	68 70 73	260 260 260	1471 1471 1471	6 6 6	200 200 200	480 490 500
3040 to 3209 3210 to 3399 3400 to 3599	N O P	2 2 2	9300 9900 1050 0	660 660 660	97 10 0 10 2	84 87 90	76 78 78	280 280 280	1471 1471 1471	6 6 6	200 200 200	520 554 588
3600 to 3799 3800 to 3999 4000 to 4199	Q R S	2 2 2	1110 0 1170 0 1230 0	687. 5 687. 5 687. 5	10 5 10 7 11 1	92 95 97	81 84 87	300 300 300	1471 1471 1471	6 6 7	200 200 200	618 647 647
4200 to 4399 4400 to 4599 4600 to 4799	T U V	2 2 2	1290 0 1350 0 1410 0	715 715 715	11 4 11 7 12 0	10 0 10 2 10 5	87 90 92	300 300 300	1471 1471 1471	7 7 7	200 200 200	657 667 677
2080 to 2229 2230 to 2379 2380 to 2529	H I J	2 2 2	6450 6900 7350	605 605 605	81 84 87	70 73 76	62 64 66	240 240 240	1259 1356 1453	5 5 5	200 200 200	422 451 480
2530 to 2699 2700 to 2869 2870 to 3039	K L M	2 2 2	780 0 830 0 870 0	632. 5 632. 5 632. 5	90 92 95	78 81 84	68 70 73	260 260 260	1471 1471 1471	6 6 6	200 200 200	480 490 500
3040 to 3209 3210 to 3399 3400 to 3599	N O P	2 2 2	930 0 990 0 105 00	660 660 660	97 10 0 10 2	84 87 90	76 78 78	280 280 280	1471 1471 1471	6 6 6	200 200 200	520 554 588
3600 to 3799 3800 to 3999 4000 to 4199	Q R S	2 2 2	111 00 117 00 123 00	687. 5 687. 5 687. 5	10 5 10 7 11 1	92 95 97	81 84 87	300 300 300	1471 1471 1471	6 6 7	200 200 200	618 647 647
4200 to 4399 4400 to 4599 4600 to 4799	T U V	2 2 2	129 00 135 00 141 00	715 715 715	11 4 11 7 12 0	10 0 10 2 10 5	87 90 92	300 300 300	1471 1471 1471	7 7 7	200 200 200	657 667 677
4800 to 4999 5000 to 5199 5200 to 5499	W X Y	2 2 2	147 00 154 00 161 00	742. 5 742. 5 742. 5	12 2 12 4 12 7	10 7 11 1 11 1	95 97 97	300 300 300	1471 1471 1471	7 8 8	200 200 200	686 686 696
5500 to 5799 5800 to 6099 6100 to 6499	Z A* B*	2 2 2	169 00 178 00 188 00	742. 5 742. 5 742. 5	13 0 13 2 13 7	11 4 11 7 12 0	100 102 107	300 300 300	1471 1471 1471	8 8 9	200 200 200	706 706 716

Table 3.3.1: Contd..

6500 to 6899	C*	2	20000	770	-	124	111	300	1471	9	200	726
6900 to 7399	D*	2	21500	770	-	127	114	300	1471	10	200	726
7400 to 7899	E*	2	23000	770	-	132	117	300	1471	11	200	726
7900 to 8399	F*	2	24500	770	-	137	122	300	1471	11	200	735
8400 to 8899	G*	2	26000	770	-	142	127	300	1471	12	200	735
8900 to 9399	H*	2	27500	770	-	147	132	300	1471	13	200	735
9400 to 9999	I*	2	29000	770	-	152	132	300	1471	14	200	735
10000 to 10699	J*	2	31000	770	-	-	137	-	-	15	200	735
10700 to 11499	K*	2	33000	770	-	-	142	-	-	16	200	735
11500 to 12399	L*	2	35500	770	-	-	147	-	-	17	200	735
12400 to 13399	M*	2	38500	770	-	-	152	-	-	18	200	735
13400 to 14599	N*	2	42000	770	-	-	157	-	-	19	200	735
14600 to 16000	O*	2	46000	770	-	-	162	-	-	21	200	735

[1)] *For individual mooring lines with breaking force above 490 kN according to the table, the strength may be reduced by the corresponding increase of the number of mooring lines and vice versa. The total breaking force of all mooring lines on board should not be less than according to the table. However, the number of mooring should not be less than 6, and no line should have a breaking force less than 490 kN.*

3.2. Equipment tables

3.2.1. The equipment is in general to be in accordance with the requirements given in Table 3.3.1. The two bower anchors and their cables shall be connected and stowed in position ready for use. The total length of chain cable required shall be equally divided between the two anchors. The towline and the mooring lines are given as guidance only, representing a minimum standard, and shall not be considered as conditions of class.

Remark:

If anchor chain total length is an uneven number of shackles, no more than one standard shackle (27.5 m) difference in length is allowed between the two anchors.

3.2.2. For fishing vessels, the equipment shall be in accordance with the requirements given in Table 3.3.2. When the equipment number is larger than 720, Table 3.3.1 should be applied.

3.2.3. Unmanned barges are only to have equipment consisting of 2 mooring lines with length as required by Table 3.3.1.

3.2.4. For ships and manned barges with restricted service the equipment specified in Table 3.3.1 and 3.3.2 may be reduced in accordance with Table 3.3.3. No reductions are given for class notations **R250** and **R100**.

3.2.5. For ships and manned barges with equipment number EN less than 205 and fishing vessels with EN less than 500 the anchor and chain equipment specified in Table 3.3.1 and 3.3.2 may be reduced, on application from the Owners, based upon a special consideration of the intended service area of the vessel. The reduction shall not be more than given for the service notation R10 in Table 3.3.3. In such cases a minus sign will be given in brackets after the equipment letter for the vessel in the “Register of vessels classed with INTLREG”

Table 3.3.2: Equipment for fishing vessels and sealers

Equipment number	Equipment letter	Stockless bower anchors		Stud-link chain cables			Towline (guidance)		Mooring lines (guidance)		
		Number	Mass per Anchor	Total length	Diameter and steel grades		Steel or fibre ropes		Steel or fibre ropes		
					1 mm	2 mm	Minimum Length	Minimum breaking strength	Number	Length of each	Minimum breaking strength
			kg	m			m	kN		m	kN
30 to 39	a_0f_1	*2*	80	165	11	-	-	-	2	50	29
40 to 49	a_0f_2	*2*	100	192.5	11	-	-	-	2	60	29
50 to 59	af_1	*2*	120	192.5	12.5	-	180	98	3	80	34
60 to 69	af_2	*2*	140	192.	12.5	-	180	98	3	80	34
70 to 79	bf_1	*2*	160	220	14	12.5	180	98	3	100	37
80 to 89	bf_2	*2*	180	220	14	12.5	180	98	3	100	37
90 to 99	cf_1	*2*	210	220	16	14	180	98	3	110	39
100 to 109	cf_2	*2*	240	220	16	14	180	98	3	110	39
110 to 119	df_1	*2*	270	247.5	17.5	16	180	98	3	110	44
120 to 129	df_2	*2*	300	247.5	17.5	16	180	98	3	110	44
130 to 139	ef_1	*2*	340	275	19	17.5	180	98	3	120	49
140 to 149	ef_2	*2*	390	275	19	17.5	180	98	3	120	49
150 to 174	f	*2*	480	275	22	19	180	98	3	120	54
175 to 204	g	*2*	570	302.5	24	20.5	180	112	3	120	59
205 to 239	h	*2*	660	302.5	26	22	180	129	4	120	64
240 to 279	i	*2*	780	330	28	24	180	150	4	120	69
280 to 319	j	*2*	900	357.5	30	26	180	174	4	140	74
320 to 359	k	*2*	1020	357.5	32	28	180	207	4	140	78
360 to 399	l	*2*	1140	385	34	30	180	224	4	140	88
400 to 449	m	*2*	1290	385	36	32	180	250	4	140	98
450 to 499	n	*2*	1440	412.5	38	34	180	277	4	140	108
500 to 549	o	*2*	1590	412.5	40	34	190	306	4	160	123
550 to 599	p	*2*	1740	440	42	36	190	338	4	160	132
600 to 659	q	*2*	1920	440	44	38	190	371	4	160	147
660 to 720	r	*2*	2100	440	46	40	190	406	4	160	157

Table 3.3.3: Equipment reductions for service restriction notations. (Refer Table 3.3.1)

Class notation	Stockless bower anchors		Stud-link chain cables	
	Number	Mass change per anchor	Length reduction	Diameter
R100 in summer R20 in winter R10 in summer R0	2 2 2 2	- 10% - 20% - 30% - 40%	No red. No red. - 20% - 30%	No red. No red. - 10% - 20%
Alternatively:				
R20 R10 R0	1 1 1	+40% No change - 20%	- 40% - 50% - 60%	No red. No red. - 10%

SECTION 4 ANCHORS

Contents

4.1 General

4.1.1 Anchor types dealt with are:

- Ordinary stockless bower anchor
- Ordinary stocked bower anchor
- H.H.P. ("High Holding Power") anchor
- S.H.H.P. ("Super High Holding Power") anchor.

4.1.2 The minimum mass of ordinary stockless bower anchors given in Sec 3. The mass of individual anchors may vary by 7% of the table value, provided that the total mass of anchors is not less than would have been required for anchors of equal mass. The minimum mass of the head shall be 60% of the table value.

4.1.3 The mass of stocked bower anchor, the stock not included, shall not be less than 80% of the table-value for ordinary stockless bower anchors. The mass of the stock shall be 25% of the total mass of the anchor including the shackle, etc., but excluding the stock.

4.1.4 For anchors approved as H.H.P. anchors, the mass shall not be less than 75% of the requirements given in Sec 3. In such cases the letter **r** will follow the equipment letter entered in the "Register of vessels classed with INTLREG".

4.1.5 For anchors approved as S.H.H.P. anchors, the mass shall not be less than 50% of the requirements given in Sec 3. In such cases the letter **rs** will follow the equipment letter entered in the "Register of vessels classed with INTLREG".

4.1.6 The use of S.H.H.P. anchors is limited to vessels with service restriction notation **R100** or stricter.

4.1.7 The maximum mass of S.H.H.P. anchor is 1500 kg.

4.2 Materials

4.2.1 Anchor heads may be cast, forged or fabricated from plate materials. Shanks and shackles may be cast or forged.

4.2.2 The materials shall comply with relevant specification given in Pt.2. Plate material in welded anchors shall be of the grades as given in Sec [6.2] Table 3.6.3 of this chapter

4.2.3 Anchors made of nodular cast iron may be accepted in small dimensions subject to special approval of the manufacturer.

4.2.4 Fabricated anchors shall be manufactured in accordance with approved welding procedures using approved welding consumables and carried out by qualified welders.

4.3 Anchor shackle

4.3.1 The diameter of the shackle leg is normally not to be less than:

$$d_s = 1.4\, d_c$$

d_c = required diameter of stud chain cable with tensile strength equal to the shackle material, refer Table 3.3.1 or 3.3.2 . For shackle material different from the steel grades 1, 2 and 3, linear interpolation between table values of d_c will normally be accepted.

4.3.2 The diameter of the shackle pin is normally not to be less than the greater of

$$d_P = 1.5\, d_C$$

$$d_P = 0.7\, l_P$$

d_C= as given in [4.3.1] above

l_P = free length of pin. It is assumed that materials of the same tensile strength are used in shackle body and pin. For different materials d_P will be specially considered

4.4 Manufacturing

4.4.1 If not otherwise specified on standards or on drawings demonstrated to be appropriate, the following assembly and fitting tolerance shall be applied.

The clearance either side of the shank within the shackle jaws shall be no more than;
3 mm for small anchors up to 3 tonnes weight,
4 mm for anchors up to 5 tonnes weight,
6 mm for anchors up to 7 tonnes weight and
12 mm for larger anchors.

The shackle pin shall be a push fit in the eyes of the shackle, which shall be chamfered on the outside to ensure a good tightness when the pin is clenched over on fitting.

The shackle pin to hole tolerances shall be no more than 0.5 mm for pins up to 57 mm and 1.0 mm for pins of larger diameter.

The trunnion pin shall be a snug fit within the chamber and be long enough to prevent horizontal movement. The gap shall be no more than 1% of the chamber length.

The lateral movement of the shank is not to exceed 3 degrees, refer Figure 3.4.1

4.4.2 Securing of the anchor pin, shackle pin or swivel nut by welding shall be done in accordance with a qualified welding procedure.

4.5 Testing

4.5.1 The following shall be subjected to proof testing in a machine specially approved for this purpose:

Ordinary anchors with a mass more than 75 kg, or
H.H.P. anchors with a mass more than 56 kg, or
S.H.H.P. anchors with a mass more than 38 kg.

4.5.2 The proof test load shall be as given in Table 3.4.1, depends on the mass of equivalent anchor, defined as follows:

- Total mass of ordinary stockless anchors.
- Mass of ordinary stocked anchors excluding the stock.
- 4/3 of the total mass of H.H.P. anchors
- 2 times of the total mass of S.H.H.P. anchors.

For intermediate values of mass, the test load shall be determined by linear interpolation.

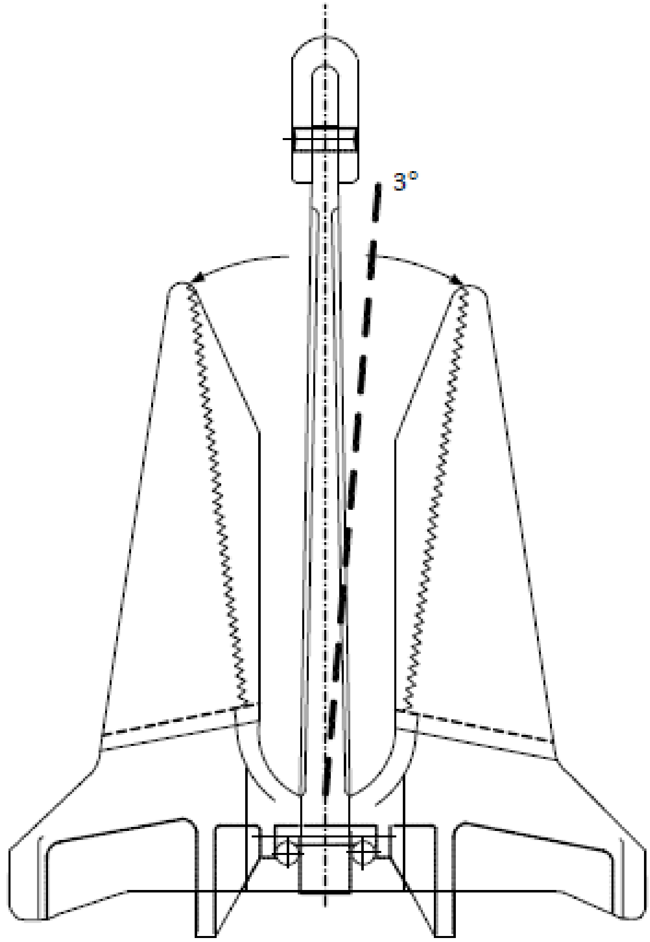


Figure 3.4.1: Allowable lateral movement of shank

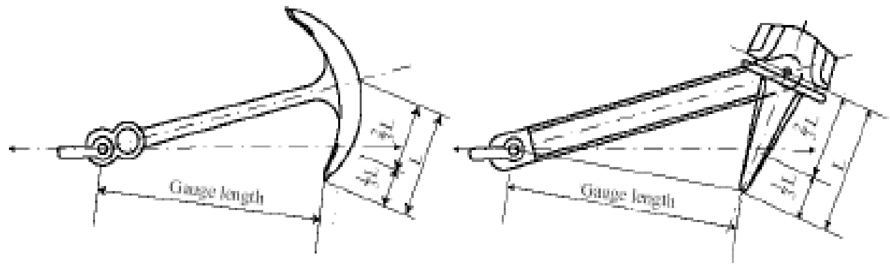
4.5.3 The proof load shall be applied on the arm or on the palm at a distance from the extremity of the bill equal to 1/3 of the distance between it and the Centre of the crown. The anchor shackle may be tested with the anchor.

4.5.4 In case of stockless anchors, both arms shall be tested simultaneously, first on one side of the shank and then on the other side.

In case of stocked anchors, each arm shall be tested individually.

4.5.5 The anchors shall withstand the specified proof load without showing signs of injurious defects. This shall be confirmed by visual inspection and NDT after proof load testing of anchor. For all types of anchors, by using magnetic particle testing (MT) or penetrant testing (PT) high stress areas shall be checked. The welds of fabricated anchors (if relevant) are in addition subject to MT.

4.5.6 In every test the difference between the gauge lengths (as shown in figures) where one-tenth of the required load was applied first and where the load has been reduced to one-tenth of the required load from the full load may be permitted not to exceed one percent (1%).



Stocked Anchor Stockless Anchor

Figure 3.4.2: Gauge length

4.6 Additional requirements for H.H.P. and S.H.H.P. anchors

4.6.1 H.H.P. and S.H.H.P. anchors are designed for effective hold of the seabed irrespective of the angle or position at which they first settle on the seabed after dropping from a normal type of hawse pipe. In case of doubt, a demonstration of these abilities may be required.

4.6.2 The design approval of H.H.P. and S.H.H.P. anchors are normally given as a type approval and the anchors are listed in the Register of Type Approved "Structural Equipment, Containers, Cargo Handling and Securing Equipment". The design approval of H.H.P. anchors is normally given as a type approval, and the anchors are listed in the "Register of Type Approved: Containers, Cargo Handling, Lifting Appliances and Miscellaneous Equipment."

4.6.3 H.H.P. anchors for which approval is sought shall be tested on sea bed to show that they have a holding power per unit of mass at least twice that of an ordinary stockless bower anchor. The mean value of three tests (for each anchor and nature of sea bed, ref. 4.6.8 shall form the basis for holding power)

4.6.4 S.H.H.P. anchors for which approval is sought shall be tested on sea bed to show that they have a holding power per unit of mass at least 4 times that of an ordinary stockless bower anchor. The mean value of three tests (for each anchor and nature of sea bed, ref. 4.6.8 shall form the basis for holding power.

4.6.5 If approval is sought for a range of H.H.P. anchor sizes, at least two sizes shall be tested. The mass of the larger anchor to be tested shall not be less than 1/10 of that of the largest anchor for which approval is sought. The smaller of the two anchors to be tested shall have a mass not less than 1/10 of that of the larger.

4.6.6 If approval is sought for a range of S.H.H.P. anchor sizes, at least three sizes shall be tested, indicative of the bottom, middle and top of the mass range.

4.6.7 Each test shall comprise a comparison between at least two anchors, one ordinary stockless bower anchor and one H.H.P. or S.H.H.P. anchor. The mass of the anchors shall be as equal as possible.

4.6.8 The tests shall be conducted on at least 3 different types of bottom, which normally shall be: soft mud or silt, sand or gravel, and hard clay or similar compacted material.

4.6.9 The tests are normally to be carried out by means of a tug. The pull shall be measured by dynamometer or determined from recently verified curves of the tug's bollard pull as function of propeller r.p.m.

The diameter of the chain cables connected to the anchors shall be as required for the equipment letter in question. During the test the length of the chain cable on each anchor shall be sufficient to obtain an approximately horizontal pull on the anchor. Normally, a horizontal distance between anchor and tug equal to 10 times the water depth will be sufficient.

4.7 Identification

4.7.1 The following marks shall be stamped on one side of the anchor:

- Mass of anchor (excluding possible stock)
- H.H.P. when approved as high holding power anchor
- S.H.H.P. when approved as super high holding power anchor
- Certificate No.
- Date of test
- INTLREG stamp
- Manufacturer's mark
- Additionally, the unique cast identification shall be cast on the shank and the fluke

Table 3.4.1: Proof test load for anchors

Mass of anchor kg	Proof test load kN	Mass of anchor kg	Proof test load kN	Mass of anchor kg	Proof test load kN	Mass of anchor kg	Proof test load kN	Mass of anchor kg	Proof test load kN	Mass of anchor kg	Proof test load kN
50	23.2	550	125	2200	376	4800	645	7800	861	17500	1390
55	25.2	600	132	2300	388	4900	653	8000	877	18000	1410
60	27.1	650	140	2400	401	5000	661	8200	892	18500	1440
65	28.9	700	149	2500	414	5100	669	8400	908	19000	1470
70	30.7	750	158	2600	427	5200	677	8600	922	19500	1490
75	32.4	800	166	2700	438	5300	685	8800	936	20000	1520
80	33.9	850	175	2800	450	5400	691	9000	949	21000	1570
90	36.3	900	182	2900	462	5500	699	9200	961	22000	1620
100	39.1	950	191	3000	474	5600	706	9400	975	23000	1670
120	44.3	1000	199	3100	484	5700	713	9600	987	24000	1720
140	49.1	1050	208	3200	495	5800	721	9800	999	25000	1770
160	53.3	1100	216	3300	506	5900	728	10000	1010	26000	1800
180	57.4	1150	224	3400	517	6000	735	10500	1040	27000	1850
200	61.3	1200	231	3500	528	6100	740	11000	1070	28000	1900
225	66.8	1250	239	3600	537	6200	747	11500	1090	29000	1940
250	70.4	1300	247	3700	547	6300	754	12000	1110	30000	1990
275	74.9	1350	255	3800	557	6400	760	12500	1130	31000	2030
300	79.6	1400	262	3900	567	6500	767	13000	1160	32000	2070
325	84.2	1450	270	4000	577	6600	773	13500	1180	34000	2160
350	88.8	1500	278	4100	586	6700	779	14000	1210	36000	2250
375	93.4	1600	292	4200	595	6800	786	14500	1230	38000	2330
400	97.9	1700	307	4300	604	6900	795	15000	1260	40000	2410
425	103	1800	321	4400	613	7000	804	15500	1270	42000	2490
450	107	1900	335	4500	622	7200	818	16000	1300	44000	2570
475	112	2000	349	4600	631	7400	832	16500	1330	46000	2650
500	116	2100	362	4700	638	7600	845	17000	1360	48000	2730

SECTION 5 ANCHOR CHAIN CABLES

Contents

5.1. General requirements

5.1.1. Chain cables and accessories shall be designed according to a recognized standard, such as ISO 1704. A length of chain cable shall measure not more than 27.5 m and shall comprise an odd number of links. Where designs do not comply with this, drawings giving details of the design shall be submitted for approval.

5.1.2. The form and proportion of links and accessories together with examples of connections of links, shackles and swivels are shown in Figure 3.5.1. Other design solutions, e.g. short link chain cable or steel wire rope may be accepted after special consideration.

5.1.3. The diameter of stud link chain cable shall not be less than given in Sec 3. If ordinary short link chain cable is accepted instead of stud link chain cable at least the same proof load will normally be required. For fishing vessels with equipment number $EN \leq 110$, the diameter shall be at least 20% in excess of the table value for the chain grades used.

5.1.4. Chain grade 1 shall normally not be used in association with H.H.P. or S.H.H.P. anchors.

5.1.5. Chain grade 3 shall not be used for chain diameter less than 20.5 mm.

5.1.6. Ships equipped with chain cable grades 2 or 3 will have the letters **s** or **sh**, respectively, added to the equipment letter.

5.1.7. Steel wire rope instead of stud link chain cable may be accepted for vessels of special design or operation, for vessels with restricted services and for fishing vessels. The acceptance will be based on a case-by-case evaluation, including consideration of operational and safety aspects.

If steel wire rope is accepted, the following shall be fulfilled:

- The steel wire rope shall have at least the same breaking strength as the stud link chain cable
- A length of chain cable shall be fitted between the anchor and the steel wire rope. The length shall be taken as the smaller of 12.5 m and the distance between the anchor in stowed position and the winch
- The anchor weight shall be increased by 25%
- The length of the steel wire rope shall be at least 50% above the table value for the chain cable
- A corresponding “Memo to Owner” (MO) shall be issued.

Arrangements applying the steel wire ropes of trawl winches may be accepted, provided the strength of the rope is sufficient.

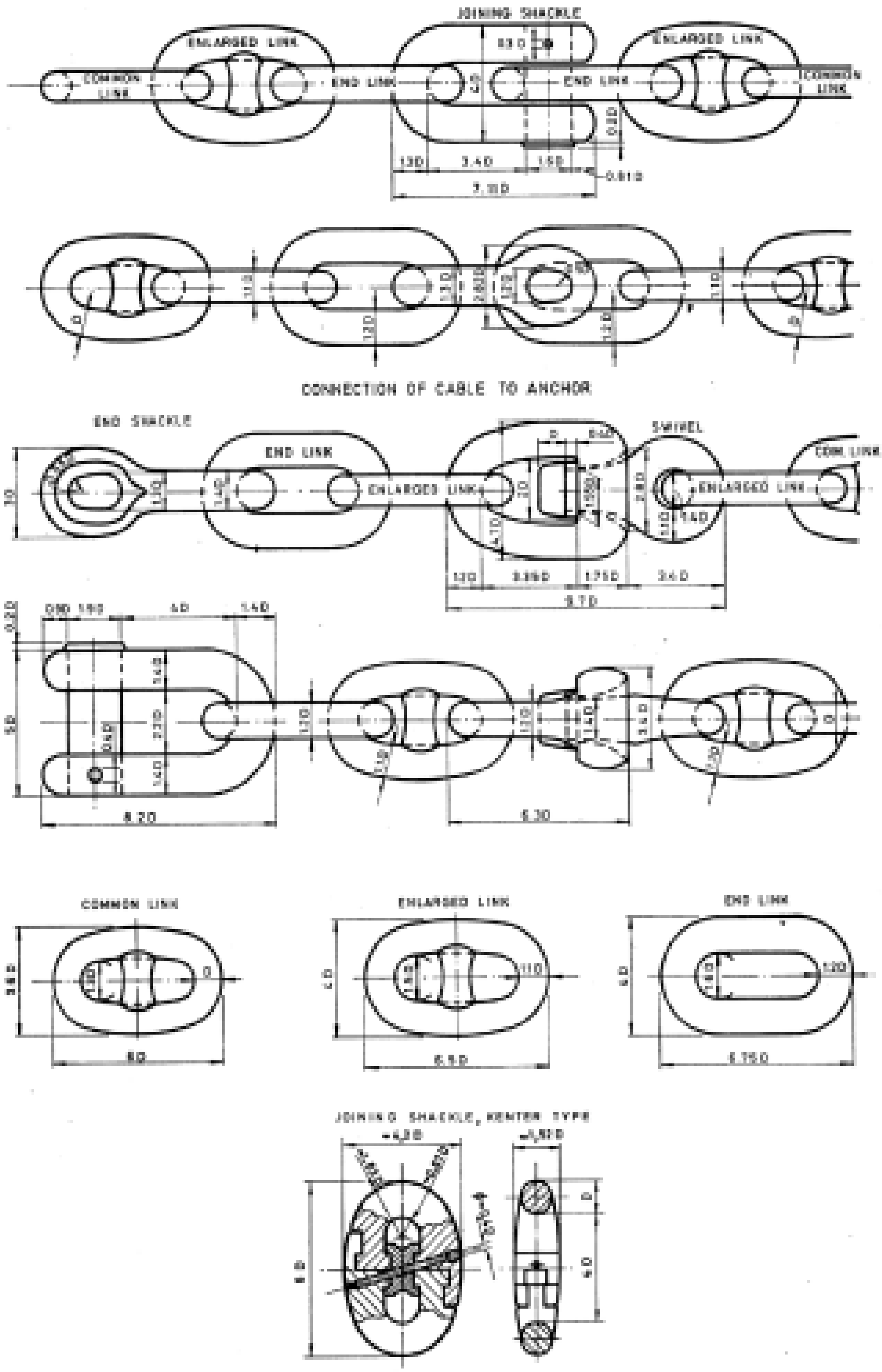


Figure 3.5.1: Standard dimensions of stud link chain cable and examples of connections
D = dc = rule diameter of chain cables

5.2. Materials and manufacture

5.2.1 Chain cables shall be made by manufacturers approved by the Society for the pertinent class of chain cable, size and method of manufacture. The pertinent type of steel, steel forgings and castings for accessories shall be made by manufacturers approved by the Society.

5.2.2 Stud link chain cables shall be manufactured by flash butt welding or, in the case of Class I and III chain cables, drop forging or casting. Pressure butt welding may also be approved for Class I and II short link chain cables provided that the nominal diameter of the chain cable does not exceed 26 mm.

5.2.3 Bar material for chain cables shall be in accordance with Pt 2 Ch 2 Sec 4. Studs for chain cable links shall be made of forged or cast steel. The carbon content in stud materials should not exceed 0.25% if studs shall be welded into the links.

5.2.4 Where studs are welded into the links this shall be completed before the chain cable is heat treated. Welding of Stud shall be made by qualified welders or operators using an approved procedure and low hydrogen consumables or processes. The stud ends must be a good fit inside the link and the weld shall be confined to the stud end opposite the flash butt weld. The full periphery of the stud end shall be welded unless otherwise approved.

5.2.5 Accessories such as shackles and swivels shall be made of forged or cast steel in accordance with the general requirements in Pt 2 Ch2 Sec 6 or Sec 7 as appropriate. Tapered locking pins for detachable components shall be made of tinned or stainless steel with a lead stopper at the thick end.

5.3. Heat treatment of Anchor Chain cables

5.3.1 Chain cables and accessories shall be supplied in one of the conditions given in Table 3.5.1. Where alternative conditions are permitted, the manufacturer shall supply chain cables and accessories only in those conditions for which he has been approved.

5.3.2 Links shall be stretched out or otherwise suitably arranged to ensure uniform heating and cooling, when heat treating in batch furnaces.

Table 3.5.1: Condition of supply for chain cables and accessories

Class	Chain cables	Accessories
Class I	As welded or Normalized	NA
Class II	As welded or Normalized [1)]	Normalized
Class III	Normalized, Normalized and Tempered, Quenched and Tempered	Normalized, Normalized and Tempered, Quenched and Tempered

NA = Not Applicable

1) Class 2 chain cables made by forging or casting shall be supplied in the normalized condition.

5.4. Proof load testing

5.4.1 Each length of chain cable and all accessories in the condition of supply shall be proof load tested and shall withstand the proof load specified in Tables 3.5.2 or 3.5.3. without fracture. Accessories shall be subjected to the proof load prescribed for the chain cable grade and size for which they are intended.

5.4.2 If a link fails during testing, the defective link shall be removed and replaced by a connecting link of an approved type and the proof test again applied. In addition, it shall be determined by examination that the probable cause of failure is not present in any of the remaining links. If a second link fails, the length shall be rejected.

5.4.3 If an accessory fail, it shall be rejected. In addition, it shall be determined by examination that the probable cause of failure is not present in any of the remaining items.

5.5. Breaking load testing

5.5.1 Breaking load test shall be carried-out in samples of chain cables and accessories and shall withstand the breaking load specified in Tables 3.5.2 or 3.5.3. Accessories shall be subjected to the breaking load prescribed for the chain cable grade and size for which they are intended. End links and enlarged links need not be tested provided that they are manufactured and heat treated with the chain cable. It will be considered acceptable if the samples show no sign of fracture after application of the minimum specified load for 30 seconds.

5.5.2 For chain cables, one sample consisting of at least three links shall be taken at the frequency given in Sect. [5.5.3] below. Sample links for testing shall be made as part of the chain cable. They may be removed prior to heat treatment provided that

- Each sample is properly identified with the chain represented, and
- Each sample is securely attached to and heat treated with the chain represented

5.5.3 For flash butt welded or drop forged chain cables, one sample shall be taken from every four lengths of 27.5 m or less. For cast link chain cables, one sample shall be taken from each heat treatment charge with a minimum of one from every four lengths of 27.5 m or less.

5.5.4 One sample item out of every test unit (batch) shall be taken in case of testing of accessories. A test unit shall consist of up to 25 items, or up to 50 in the case of Kenter shackles, of the same accessory type, grade, size and heat treatment procedure. The test unit need not necessarily be representative of each heat of steel, heat treatment charge or individual purchase order.

5.5.5 Except as provided in Sect [5.5.6] accessories that have been breaking load tested shall be discarded and not used as part of an outfit.

5.5.6 Accessories that have been breaking load tested may be used as part of an outfit provided that

- the accessory is of higher grade than the chain cable for which it is intended, e.g. grade 3 accessory of grade 2 size in grade 2 chain,
- The accessory is specially designed and approved with increased dimensions so that the breaking strength is not less than 1.4 times the break load of the chain cable for which it is intended.

5.5.7 The Society may waive the breaking load test of accessories provided that:

- The accessories are subjected to suitable non-destructive testing.
- The breaking load test has been completed satisfactorily during approval testing of the same type of accessory, and
- The tensile and impact properties of each manufacturing batch, Refer [5.5.10], are proved

5.5.8 For the purpose of waiving the breaking load test of accessories, a manufacturing batch (test unit) shall consist of up to 25 items, or up to 50 in the case of Kenter shackles, of the same type, grade, size and heat treatment charge. The test unit need not necessarily be representative of each heat of steel or individual purchase order.

5.5.9 If a chain cable sample fails, a further sample shall be cut from the same length of cable and subjected to the test. If this re-test fails, the length of cable shall be rejected. When this test is also representative of other lengths, each of the remaining lengths shall be individually tested. If one of these further tests fails, all lengths represented by the original test shall be rejected.

5.5.10 If an accessory fail, two more accessories from the same test unit shall be selected and subjected to the test. If either of these further tests fails, the test unit shall be rejected.

Table 3.5.2: Proof and breaking loads for stud link chain cables and accessories

Diameter of chain	Grade 1		Grade 2		Grade 3		Guidance
	Proof load	Breaking load	Proof load	Breaking Load	Proof Load	Breaking load	Approximate mass per m
mm	kN	kN	kN	kN	kN	kN	kg
11	36	51	51	72	72	102	
12.5	46	66	66	92	92	132	3.7
14	58	82	82	116	116	165	4.4
16	76	107	107	150	150	216	5.6
17.5	89	127	127	179	179	256	6.8
19	105	150	150	211	211	301	8.0
20.5	123	175	175	244	244	349	9.3
22	140	200	200	280	280	401	10.6
24	167	237	237	332	332	476	12.6
26	194	278	278	389	389	556	14.8
28	225	321	321	449	449	642	17.1
30	257	368	368	514	514	735	19.6
32	291	417	417	583	583	833	22.3
34	328	468	468	655	655	937	25.1
36	366	523	523	732	732	1050	28.1
38	406	581	581	812	812	1160	31.3
40	448	640	640	896	896	1280	34.7
42	492	703	703	981	981	1400	38.2
44	538	769	769	1080	1080	1540	41.9
46	585	837	837	1170	1170	1680	45.8
48	635	908	908	1280	1280	1810	49.8
50	686	981	981	1370	1370	1960	54.0
52	739	1060	1060	1480	1480	2110	58.4
54	794	1140	1140	1590	1590	2270	63.0
56	851	1220	1220	1710	1710	2430	67.8
58	909	1290	1290	1810	1810	2600	72.7
60	969	1380	1380	1940	1940	2770	77.8
62	1030	1470	1470	2060	2060	2940	83.1
64	1100	1560	1560	2190	2190	3130	88.6
66	1160	1660	1660	2310	2310	3300	94.2
68	1230	1750	1750	2450	2450	3500	100.0
70	1290	1840	1840	2580	2580	3690	106.0
73	1390	1990	1990	2790	2790	3990	115.2
76	1500	2150	2150	3010	3010	4300	124.9
78	1580	2260	2260	3160	3160	4500	131.6
81	1690	2410	2410	3380	3380	4820	142.0
84	1810	2580	2580	3610	3610	5160	152.9
87	1920	2750	2750	3850	3850	5500	164.2
90	2050	2920	2920	4090	4090	5840	176.0
92	2130	3040	3040	4260	4260	6080	184.1
95	2260	3230	3230	4510	4510	6440	196.6
97	2340	3350	3350	4680	4680	6690	205.0

100	2470	3530	3530	4940	4940	7060	218.5
102	2560	3660	3660	5120	5120	7320	227
105	2700	3860	3860	5390	5390	7700	241
107	2790	3980	3980	5570	5570	7960	250
111	2970	4250	4250	5940	5940	8480	269
114	3110	4440	4440	6230	6230	8890	284
117	3260	4650	4650	6510	6510	9300	299
120	3400	4860	4860	6810	6810	9720	314
122	3500	5000	5000	7000	7000	9990	326
124	3600	5140	5140	7200	7200	10280	335
127	3750	5350	5350	7490	7490	10710	351
130	3900	5570	5570	7800	7800	11140	367
132	4000	5720	5720	8000	8000	11420	378
137	4260	6080	6080	8510	8510	12160	408
142	4520	6450	6450	9030	9030	12910	437
147	4790	6840	6840	9560	9560	13660	470
152	5050	7220	7220	10100	10100	14430	500
157	5320	7600	7600	10640	10640	15200	530
162	5590	7990	7990	11170	11170	15970	570

Table 3.5.3: Proof and breaking loads for short link chain cables

Diameter of chain mm	Proof load kN	Breaking load kN
11	22.4	47.7
12	26.6	53.2
13	31.3	62.5
14	36.3	72.5
15	41.6	83.2
16	47.4	94.7
17	53.5	107.0
18	59.8	119.5
19	66.7	133.5
20	73.9	147.5
21	81.4	163.0
22	89.6	179.0
23	97.9	195.5
24	106.5	213
25	116.0	231
26	125.0	250
27	135.0	270
28	144.5	289
29	155.5	311
30	166.5	333
31	177.5	355
32	190.0	380
33	201	402
34	214	428
35	227	453

5.6. Mechanical testing

5.6.1 Samples of chain cables and accessories shall be tensile tested and, where applicable, impact tested in the condition of supply, as given in Table 3.5.4. and shall meet the mechanical properties specified in Table 3.5.5 . Testing of grade 1 chain cables and welded grade 2 chain cables supplied in normalized condition is not required. End links and enlarged links need not be tested provided that they are made as part of the chain and heat treated with it.

5.6.2 For chain cables, one sample link shall be taken from every four lengths of 27.5 m or less. Sample links for testing shall be made as part of the chain cable. They may be removed prior to heat treatment provided that:

5.6.3 For accessories, one sample item or separately made representative sample shall be taken from every test unit (batch). A test unit shall consist of items of the same grade, size, heat treatment charge and a single heat of steel. The test unit need not necessarily be representative of each accessory type or individual purchase order.

5.6.4 One tensile test piece and, where applicable, one or two sets of three Charpy V-notch test pieces shall be taken from each sample at a depth one third radius below the surface. Test pieces for chain cable base materials shall be taken from the side of the link opposite the weld. For Charpy V-notch test pieces, the notch shall be cut in a face of the test piece which was originally approximately perpendicular to the surface, see Figure 3.5.2. In the case of welds, the notch shall be positioned at the center of the weld.

5.6.5 The procedures used for testing and preparation of test pieces shall comply with the applicable requirements in Pt.2 Ch.2, Sec.12.

5.6.6 If the results do not meet the specified standard, the re-test procedures in Pt.2 Ch.2, Sec.12 may be adopted.

Table 3.5.4: Scope of mechanical tests for chain cables and accessories

Grades	Method of manufacture	Condition of supply	Number of test pieces per sample		
			Tensile test, base material	Charpy V-notch impact test	
				Base material	Weld
Grade 1 Cable	Flash butt welded	As welded, Normalized	-	-	-
Grade 2 Cable	Flash butt welded	As welded,	1	3	3
		Normalised	-	-	-
	Forged or cast	Normalised	1	3	-
Grade 3 Cable	Flash butt welded	Normalised, Normalised and tempered, Quenched and tempered	1	3	3
	Forged or cast		1	3	-
Grade 2 Accessory	Forged or cast	Normalised	1	3	-
Grade 3 Accessory	Forged or cast	Normalised, Normalised and tempered, Quenched and tempered	1	3	-

Table 3.5.5: Mechanical properties for chain cables and accessories

Grades	Yield stress MPa minimum	Tensile strength MPa	Elongation %minimum	Reduction of area %minimum	Charpy V-notch impact test		
					Test temperature °C	Average energy J minimum	
						Base material	Weld
Grade 2	295	490 -690	22	-	0	27	27
Grade 3	410	690 Minimum	17	40`	0	60	50

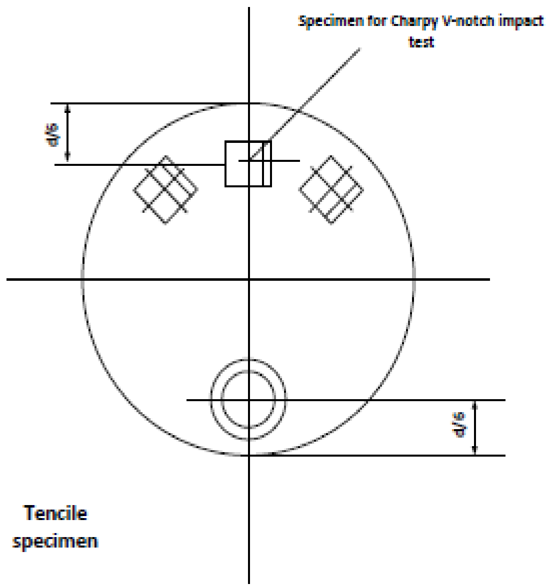


Figure 3.5.2: Position of test pieces

5.7. Inspection and dimensional tolerances

5.7.1 Surface inspection and verification of dimensions are the responsibility of the manufacturer. Acceptance by the surveyor of material later found to be defective shall not absolve the manufacturer from this responsibility.

5.7.2 All links and accessories after proof load testing shall be visually inspected and shall be free from injurious imperfections. Studs in chain cables shall be securely fastened. Minor imperfections remote from the crown may be ground off to a depth of 5% of the nominal diameter. Defective links shall be removed and replaced by connecting links of an approved type. The chain shall then be subjected to a proof load test and re inspected. Defective accessories shall be rejected.

5.7.3 entire chain cable shall be checked for length, five links at a time with an overlap of two links. The length over five links shall be minimum 22 times the nominal diameter and the maximum allowable tolerance is plus 2.5%. The measurements shall be made while the chain is loaded to about 10% of the proof load. The links held in the end blocks may be excluded from these measurements.

5.7.4 links selected from every four lengths of 27.5 m shall be checked for diameter, outside length, outside width and stud position. If one link fails to comply with the required tolerances in Sect [5.5.5] and Sect [5.5.6], measurements shall be made on a further five links in every four lengths of 27.5 m. If more than one link in a 27.5 m length fails, all the links in that length shall be measured.

5.7.5 The tolerances on chain link dimensions, except for diameter, are plus and minus 2.5%. The maximum allowable tolerance on nominal diameter measured at the crown is plus 5%. The minus tolerances on the diameter in the plane of the link at the crown are permitted to the following extent provided that the cross-sectional area at that point is at least the theoretical area of the nominal diameter

- Minus 1 mm when $d_c \leq 40$ mm
- Minus 2 mm when $40 < \mathrm{d_c} \leq 84\ \mathrm{mm}$
- Minus 3 mm when $84 < \mathrm{d_c} \leq 122\ \mathrm{mm}$
- Minus 4 mm when $\mathrm{d_c} > 122\ mm$

The cross-sectional area shall be calculated using the average of the diameter measured in the plane of the link and the diameter measured perpendicular to the plane of the link.

5.7.6 Studs shall be located in the links centrally and at right angles to the sides of the link. The maximum off Centre distance shall be 10% of the nominal diameter and the maximum deviation from the 90° position shall be 4°.

5.7.7 Chain links failing to comply with dimensional tolerances shall be removed and replaced by connecting links of an approved type. The chain shall then be subjected to a proof load test and re-inspected.

5.7.8 One accessory selected from every test unit shall be checked for diameter and other dimensions as given in ISO 1704 or as approved. The maximum allowable tolerance on nominal diameter is plus 5% and no negative tolerance is permitted. The tolerances on other dimensions are plus and minus 2.5%. If the accessory fails to comply with the required tolerances, two more accessories from the same test unit shall be selected and measured. If either of these further accessories fails, all the accessories in the test unit shall be measured. Accessories failing to comply with dimensional tolerances shall be rejected.

5.8. Identification

5.8.1 All lengths of chain cables and all accessories shall be stamped or otherwise suitably marked with the following identification marks:

- grade of chain,
- number of certificates as furnished by the surveyor,
- The Society's stamp

5.8.2 Chain cables shall be marked at both ends of each length and as indicated in Figure 3.5.3

5.8.3 Accessories that have been breaking load tested and are used as part of an outfit, as permitted in Sect [5.5.6] shall be marked with the grade of chain for which they are intended

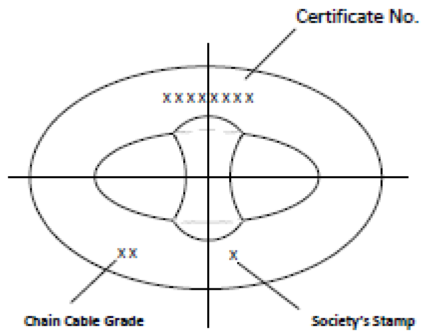


Figure 3.5.3: marking of chain cables

5.9. Certification

5.9.1 Certificates shall include the following particulars for all chain cable lengths and or accessories included in the certificate:

- Purchaser's name, order number and, if known, the vessel identification,
- Manufacturer's name,
- Description of products and dimensions,
- Grade of chain, method of manufacture, condition of supply and reference to material certificate,
- Identification marking,
- Results of proof load test, breaking load test and, where applicable, mechanical tests.

SECTION 6 WINDLASS AND CHAIN STOPPERS

Contents

6.1. General design

6.1.1. The anchors are in general operated by a specially designed windlass. For ships with length $L < 50\,m$, one of the cargo winches may be accepted as windlass, provided the requirements to the arrangement and function are satisfied.

6.1.2. The windlass shall have one cable lifter for each anchor stowed in hawse pipe. The cable lifter is normally to be connected to the driving shaft by clutch coupling and provided with brake. The number of pockets in the cable lifter shall not be less than 5. The pockets, including the groove width etc. shall be designed for the joining shackles/ kenter shackles with due attention to dimensional tolerances. only one of the cable lifters need be fitted with release coupling and brake, when the chain cable diameter is less than 26 mm,

6.1.3. Chain stoppers shall be provided for each chain cable arranged between windlass and hawse pipe. The chain cables shall reach the hawse pipes through the cable lifter only.

6.1.4. Electrically driven windlasses shall have a torque limiting device. Electric motors shall comply with the requirements of Pt 6

6.1.5. The windlass with prime mover shall be able to exert the pull specified by Table 3.6.1 directly on the cable lifter. For double windlasses the requirements apply to one side at a time.

Table 3.6.1: Lifting power

Lifting force and speed	Grade of chain		
	Grade 1	Grade 2	Grade 3
Normal lifting force for 30 min in N	36.8 d_c^2	41.7 d_c^2	46.6 d_c^2
Mean hoisting speed	9 m/min		
Maximum lifting force for 2 minutes (no speed requirement)	1.5 x normal lifting force		
d_c = diameter of chain in mm			

Sudden starting or stopping of the prime mover or anchor chain may cause stress concentrations in keyways and other stress raisers and also to dynamic effects .

6.1.6. The capacity of the windlass brake shall be sufficient for safe stopping of anchor and chain cable when paying out.

i) The windlass with brakes engaged and release coupling disengaged shall be able to withstand a static pull of 45% of the chain cable minimum breaking strength given in Table 3.5.2, without any permanent deformation of the stressed parts and without brake slip.

ii) If a chain stopper is not fitted, the windlass shall be able to withstand a static pull equal to 80% of the minimum breaking strength of the chain cable, without any permanent deformation of the stressed parts and without brake slip.

6.1.7. Calculations indicating compliance with the requirements in Sect [6.1.5] and [6.1.6] may be dispensed with when complete shop test verification shall be carried out.

6.1.8. The chain stoppers and their attachments shall be able to withstand 80% of the minimum breaking strength of the chain cable, without any permanent deformation of the stressed parts. The chain stoppers shall be so designed that additional bending of the individual link does not occur and the links are evenly supported. Bar type chain stoppers stopping the chain link from one side may be accepted after special consideration and provided that satisfactory strength is demonstrated by calculation or prototype test.

Remark:

A chain stopper designed to a recognized national or international standard may be accepted provided its service experience is considered satisfactory by the Society.

6.2. Materials

6.2.1 Cable lifter shafts and cable lifters with couplings shall be made from materials as stated in Table 3.6.2

Table 3.6.2: Material requirements		
	Chain cable diameter ≤ 46 mm	Chain cable diameter > 46 mm
Cable lifters and couplings	Nodular cast iron or special cast iron	Cast steel
Cable lifter shaft	Forged or rolled steel, cast steel	

6.2.2 Windlass and chain stoppers may be cast components or fabricated from plate materials. The material in cast components shall be cast steel or nodular cast iron with minimum 18%elongation. Plate material in welded parts shall be of category as given in Table 3.6.3

Table 3.6.3: Plate material grades		
Thickness in mm	Normal strength structural steel	High strength structural steel
$t \leq 20$	A	AH
$20 < t \leq 25$	B	AH
$25 < t \leq 40$	D	DH
$40 < t \leq 150$ [1)]	E	EH
[1)] *For plates above 40 mm joined with fillet-/partly penetration welds, Grade D will normally be accepted*		

6.3. Testing

6.3.1 The following parts shall be pressure tested before assembly:

- Housings with covers for hydraulic motors and pumps
- Hydraulic pipes
- Valves and fittings
- pressure vessels
- steam cylinders.

Test pressure for steam cylinders shall be 1.5 times the working steam pressure.

6.3.2 After completion, at least one prime mover of the windlass shall be shop tested with respect to required lifting forces and if relevant, braking forces.

If calculations have not previously been accepted, shop testing of the complete windlass shall be carried out.

6.3.3 After installation of the windlass on board, an anchoring test shall be carried out to demonstrate that the windlass with brakes etc. functions satisfactorily.

The mean speed on the chain cable when hoisting the anchor and cable shall not be less than 9 m/min. and shall be measured over two shots (55 m) of chain cable during the trial. The trial should be commenced with 3 shots (82.5 m) of chain cable fully submerged. Where the depth of water in trial areas is inadequate, consideration will be given to acceptance of equivalent simulated conditions

SECTION 7 TOWING LINES AND MOORING LINES

Contents

7.1. General

7.1.1. Steel wire ropes, shall be made by an approved manufacturer**.**

7.1.2. The number, length and breaking strength of towlines and mooring lines are given in Section 3. Note that towlines and mooring lines are given as guidance only.

7.1.3. The strands of steel wire ropes shall be made in equal lay construction (stranded in one operation), and are normally to be divided in groups as follows:

- 6x19 Group consists of 6 strands with minimum 16 and maximum 27 wires in each strand
- 6x36 Group consists of 6 strands with minimum 27 and maximum 49 wires in each strand.

Figure 3.7.1 gives examples of rope constructions. Other rope constructions may be accepted by the Society upon special consideration

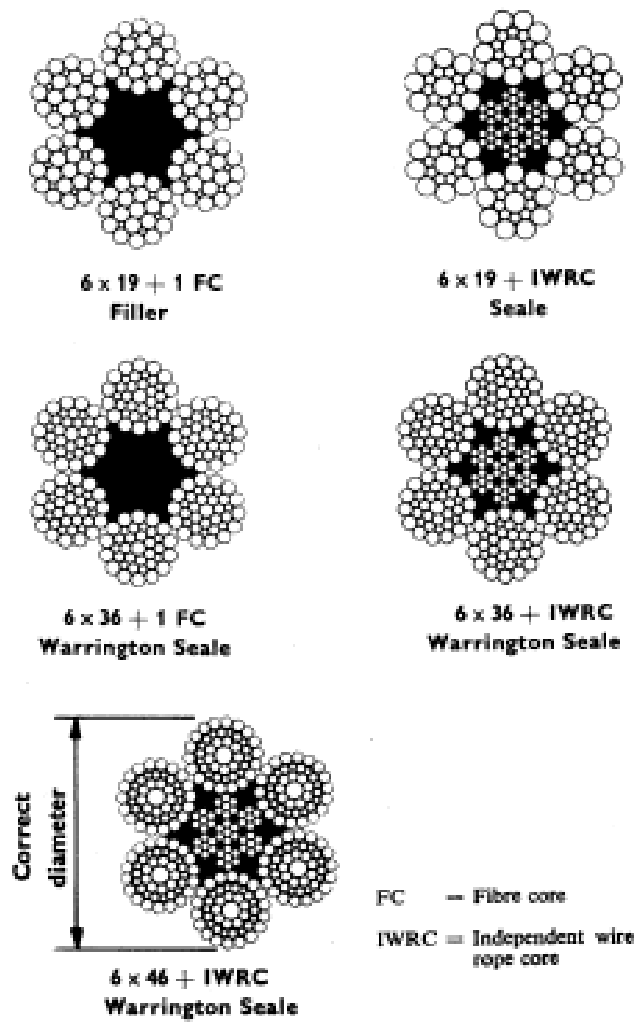


Figure 3.7.1: Constructions of steel wire ropes

7.1.4. The minimum diameter of a fibre rope is 20 mm.

7.1.5. Synthetic fibre ropes will be specially considered with respect to size, type, material and testing.

7.2. Materials

7.2.1 Towlines and mooring lines may be of steel, natural fiber or synthetic fiber construction.

7.2.2 Wire for steel wire ropes shall be made by open hearth, electric furnace, LD process or by other processes specially approved by the Society.

Normally, the tensile strength of the wires shall be 1570 N/mm^2 or 1770 N/mm^2. The wire shall be galvanized or bright (uncoated). Galvanized wire shall comply with the specifications in ISO Standard 2232.

7.2.3 The steel core shall be an independent wire rope. Normally, the wires in a steel core shall be of similar tensile strength to that of the main strand, but shall not be less than 1570 N/mm^2. The fiber core shall be manufactured from a synthetic fiber.

7.2.4 Unless otherwise stated in the approved specification, all wire ropes shall be lubricated. The lubrications shall have no injurious effect on the steel wires or on the fibers in the rope.

7.3. Testing of steel wire ropes

7.3.1 Steel wire ropes shall be tested by pulling a portion of the rope to destruction. The test length is depends on the rope diameter is given in Table 3.7.1. The breaking load of the ropes shall not be less than given in Table 3.7.2 for the dimension concerned

Table 3.7.1: Test lengths

Rope diameter in mm	Minimum test length in mm
$d \leq 6$	300
$6 < d \leq 20$	600
$d < 20$	$30 \times d$

Table 3.7.2: Test load and mass. Steel wire ropes

Construction groups	Nom. dia. mm	Minimum required breaking strength in kN				Approximate mass kg/100 m	
		1570 N/mm^2		1770 N/mm^2			
		FC	IWRC	FC	IWRC	FC	IWRC
6×19 *group*	14	102	110	115	124	72.7	82.0
	16	133	144	150	162	94.9	107
	18	168	182	190	205	120	135
	20	208	224	234	253	148	167
	22	251	272	283	306	179	202
	24	299	323	337	364	214	241
	26	351	379	396	428	251	283
	28	407	440	459	496	291	328
	30	468	505	527	569	334	376
6×19 *group* *and* 6×36 *group*	32	530	573	598	646	380	428
	36	671	725	757	817	480	542
	40	829	895	934	1 010	593	669
	44	1000	1 080	1 130	1 220	718	810
	48	1190	1 290	1 350	1 450	854	964
	52	1400	1 510	1 580	1 710	1 000	1 130
	56	1620	1 750	1 830	1 980	1 160	1 310
	60	1860	2 010	2 100	2 270	1 330	1 510
	64	-	2 290	-	2 580	-	1 710
	68	-	2 590	-	2 920	-	1 930

$6 \times 36\ group$	72	-	2 900	-	3 270	-	2 170
	76	-	3 230	-	3 640	-	2 420
	80	-	3 580	-	4 040	-	2 680
	84	-	3 950	-	4 450	-	2 950
	88	-	4 330	-	4 880	-	3 240
	92	-	4 730	-	5 340	-	3 540
	96	-	5 160	-	5 810	-	3 850
	100	-	5 590	-	6 310	-	4 180
	104	-	6 050	-	6 820	-	4 520
	108	-	6 520	-	7 360	-	4 880
	112	-	7 020	-	7 910	-	5 250
	116	-	7 530	-	8 490	-	5 630
	120	-	8 060	-	9 080	-	6 **020**
	124	-	8 600	-	9 700	-	6 430
	128	-	9 170	-	10 330	-	6 850
C = fibre core *IWRC = independent wire rope core*							

7.3.2 If facilities are not available for pulling the complete cross section of the rope to destruction, the breaking load may be determined by testing separately 10% of all wires from each strand. The breaking strength of the rope is then considered to be:

$$P = f\ t\ k\ (kN)$$

f = average breaking strength of one wire in kN

t = total number of wires

k = lay factor as given in Table 3.7.3.

Table 3.7.3 Lay factor k		
Rope construction group	Rope with FC	Rope with IWRD
6×19	0.86	0.80
6×36	0.84	0.78

7.3.3 The following individual wire tests shall be performed:

- Torsion test
- reverse bend test
- Weight and uniformity of zinc coating

These tests shall be made in accordance with and shall comply with ISO Standard 2232.

7.4. Testing of natural fibre ropes

7.4.1 Natural fibre ropes are, if possible, to be tested by pulling a piece of the rope to destruction. For qualities 1 and 2, the breaking load shall not be less than given in Table 3.7.4

Table 3.7.4: Breaking loads - natural fibre ropes

Circumference mm	Breaking load (approximately) in kN			
	Three-stranded (hawser-laid)		Four-stranded (hawser-laid)	
	Quality 1	Quality 2	Quality 1	Quality 2
64	31.6	28.2	28.2	24.9
70	37.6	33.4	33.4	29.6
76	44.8	39.8	39.8	35.3
83	52.0	46.3	46.0	41.1
89	59.5	53.1	52.8	47.1
95	68.0	60.5	60.2	53.6
102	76.4	68.0	67.0	60.2
108	85.2	75.7	75.4	67.0
114	95.4	84.7	84.7	75.2
121	105.1	93.4	93.2	82.7
127	116.1	103.1	103.1	91.6
140	139.0	123.5	123.5	109.6
152	163.9	145.5	144.5	128.5
165	190.8	169.4	169.4	150.5
178	219.7	195.3	195.3	173.3
203	282.5	251.1	250.2	222.2
229	353.3	313.9	318.9	279.0
254	433.0	384.7	383.7	340.7
279	520.2	462.1	461.5	410.2
305	617.0	548.2	547.2	486.4

7.4.2 If facilities are not available for making the above test, the Society may accept testing of a specified number of the yarns from the rope. The breaking strength of the rope will then be deduced from these tests.

7.5. Mooring Winches

7.5.1

Remark:

Each winch should be fitted with drum brakes the strength of which is sufficient to prevent unreeling of the mooring line when the rope tension is equal to 80 per cent of the breaking strength of the rope as fitted on the first layer. Where this is achieved by the winch being fitted with a pawl and ratchet or other positive locking device, then the braking mechanism shall be such that the winch drum can be released in controlled manner while the mooring line is under tension.

For powered winches the maximum hauling tension which can be applied to the mooring line (the reeled first layer) should not be less than $1/4.5$ *times the rope's breaking strength and not more than 1/3 times the rope's breaking strength. For automatic winches these figures shall apply when the winch is set on the maximum power with automatic control.*

The rendering tension which the winch can exert on the mooring line (reeled 1st layer) should not exceed 1.5 times, nor be less than 1.05 times the hauling tension for that particular power setting of the winch on automatic control. The winch shall be marked with the range of rope strength for which it is designed.

CHAPTER 4 MASTS AND RIGGING

CONTENTS

SECTION 1 GENERAL

Contents

1.1. Introduction

1.1.1. This Chapter consists of requirements to strength and support of masts, derrick posts and standing rigging

1.1.2. The derricks and the cargo handling gear are not subject to approval.

1.2. Assumptions

1.2.1. The cargo handling systems are assumed only to be operated in harbors or in sheltered waters.

1.2.2. The formulae for determining the scantlings of stayed masts, post and standing rigging are based on a symmetrical arrangement of stays and shrouds related to a vertical longitudinal plane through the mast or post. Steel wire ropes for shrouds are assumed with a modulus of elasticity equal to 7.5×10^6 N/mm^2.

1.3. Definitions

1.3.1 Symbols:

P = load in t which may be lifted by the derrick

l_d = length of derrick in m. Where the working position of the derrick is such that the angle between the Centre line of the derrick and the horizontal always exceeds 15°, l_d is taken as the greatest horizontal projection of the derrick

l_s = length of shrouds in m

l_m = length of mast in m from deck or top of mast house to hounds

H = height of derrick heel above deck or top of mast house in m

a = athwart ship distance in m from the mast to the deck attachment of shroud in question, Figure 4.1.1

c = longitudinal distance in m from the mast to the deck attachment of shroud in question, Refer Figure 4.1.1 With reference to a transverse plane through the mast, c shall be taken negative (–) for shrouds fitted on the same side as the derricks in question and positive (+) for those fitted on the opposite side

e = horizontal distance in m from the mast to the deck attachment of shroud in question, Refer Figure.4.1.1. a_0, c_0 and e_0, refer to the shrouds nearest the transverse plane through the mast. c_0 shall not be taken greater than B/4.

Σ = summation of:

a) Load functions for derricks simultaneously serving one hatch.
b) Support functions for effective shrouds when loads are as indicated in a), i.e. all shrouds forward or aft of the mast whichever is opposite to the hatch in question.
c) Load functions for derricks simultaneously working outboard.
d) Support functions for effective shrouds when loads are as indicated in c), i.e. all shrouds on one side of the ship; however the attachment to the deck shall not exceed 0.3 B forward or aft of the mast.

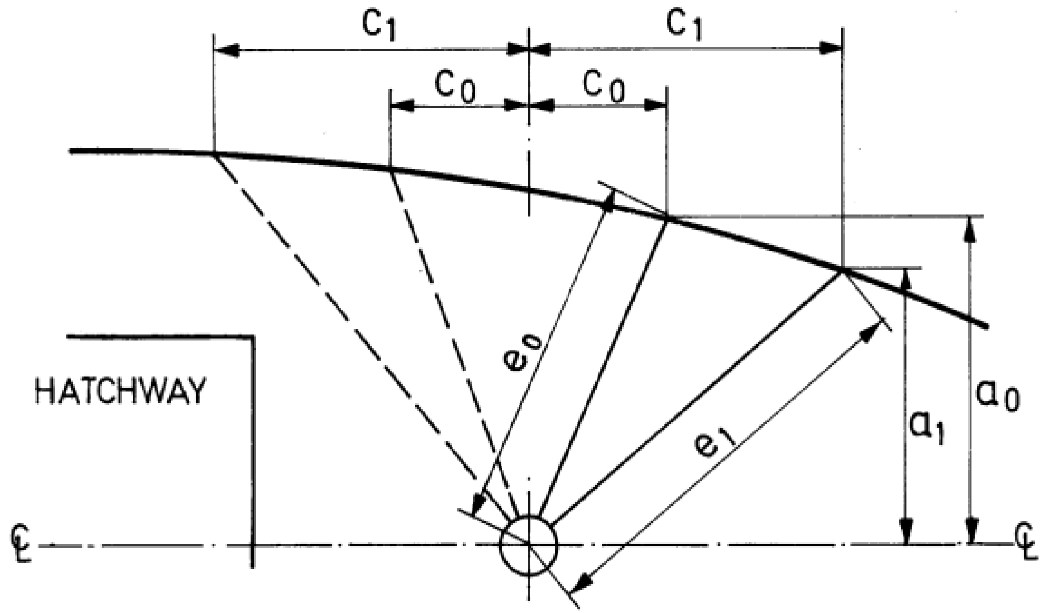


Figure 4.1.1: Arrangement of shrouds

1.4. Documentation requirements

1.4.1 Documentation shall be submitted as per Table 4.1.1

Table 4.1.1 Documentation requirements			
Object	*Documentation type*	*Additional description*	*For approval (AP) or For information (FI)*
Masts and rigging	Arrangement plan		AP
	Design criteria	Safe working load	AP
	Procedure	Information about the operation of the derrick booms, if provided, i.e. how the derricks are intended to be worked, for instance, if more than one derrick is intended to simultaneously serve one hatch. Working position for each provided derrick to be included.	FI
Masts	Detailed drawing	Including derrick posts	AP
Rigging	Detailed drawing	Including minimum breaking strength	AP

SECTION 2 MATERIALS AND WELDING

Contents

2.1 Materials

2.1.1 Selection of material grades for plates and sections shall be based on material thickness. Steel grades as given in Table 4.2.1 will normally be accepted.

Table 4.2.1: Plate material grades

Thickness in mm	Normal strength structural steel	High strength structural steel
$t \leq 20$	A	AH
$20 < t \leq 25$	B	AH
$25 < t \leq 40$	D	DH
$40 < t \leq 150$	E	EH

2.1.2 The tensile strength of wire ropes intended for shrouds and stays is normally to be minimum 1570 or 1770 N/mm^2 and maximum tensile strength is 2200 N/mm^2.

2.1.3 Material certificates for standing rigging shall be issued by the manufacturer, certifying that the delivered products are manufactured and tested according to the Rules (ref. Ch 3 Sec 7) or another approved specification.

SECTION 3 ARRANGEMENT AND SUPPORT

Contents

3.1. Masts and posts

3.1.1 Masts and posts shall be efficiently supported and connected to at least two decks or to one deck and a mast house top above. If the latter arrangement is adopted, the mast house top shall be of adequately stiffened and sufficient size. A winch house of usual size and scantlings is not considered to meet the requirements

3.2 Standing rigging

3.2.1 The mast or post shall have at least two shrouds on each side of the Centre line of the ship. To reduce torsional strains the attachment of shrouds to mast shall be carefully made.

3.2.2 At fastenings for standing rigging and for guys and topping lifts, the deck shall be securely stiffened and reinforced for the additional loading.

SECTION 4 DESIGN AND SCANTLINGS

Contents

4.1. General

4.1.1 The requirements to diameter d_0 and plate thickness t_0 for masts and posts given in the following shall be maintained for a distance not less than 1 m above the derrick heel fitting. Above this level, the diameter and the plate thickness may be gradually reduced to 0.75 d_0 and 0.75 t_0 at the hounds and thickness should not be less than is 7.5 mm.

4.1.2 Where masthead span blocks are attached to outriggers, the section modulus of the mast at the level of the outrigger shall not be less than:

$$Z_i = 120\ r\ Q\ (cm^3)$$

r = horizontal distance in m from mast to masthead span blocks on outrigger

$$Q = \sum P_d + \frac{\sum P_d}{n}\sqrt{1+\left(\frac{l_d}{l_m - H}\right)^2}\ (t)$$

$\Sigma\, P_d$ = Total load in t which may be lifted by the derricks on one side of the center line of the ship

n = 1, 2, 3 etc. for single, double and triple blocks etc., respectively

4.1.3 Masts and posts shall be increased in thickness or reinforced with doubling at the heel, deck and hounds.

4.2. Unstayed masts and posts with derricks

4.2.1 The section modulus and moment of inertia of masts and posts with derricks are not, at decks, to be less than:

$$z = 100\sum Pl_d\ (cm^3)$$

$$I = 240\frac{{l_m}^2}{l_m - H}\sum Pl_d\ (cm^4)$$

Minimum thickness of plating t = 7.5 mm.

Masts with outriggers on unusual spread will be specially considered.

4.3. Stayed masts or posts with derricks with a lifting capacity not exceeding 10 t

4.3.1 The outer diameter of masts or posts shall not be less than

$$d_0 = 140\sum (Pl_d)^{\frac{1}{3}}\ (mm)$$

4.3.2 The plate thickness of masts or posts shall not be less than:

$t_0 = 0.014 d_o$ mm, minimum 7.5 mm

4.3.3 The moment of inertia of masts or posts shall not be less than:

$$I = 240\frac{{l_m}^2}{l_m - H}\sum (Pl_d) - 1500{l_m}^3\sum\frac{{f_c}^2}{{l_s}^3}\ \alpha (cm^4)$$

$\alpha\ =\ 0.5$ for derricks with a lifting capacity of 5 t or less

= 1.0 for derricks with a lifting capacity of 10 t. Between 5 and 10 t, α is determined by linear interpolation.

$$f = \frac{V}{100q}(cm)^2$$

V = breaking strength of shrouds in N

q = tensile strength of shrouds in N/mm².

4.4. Stayed masts of posts with derricks with a lifting capacity of 10 t or more, but not exceeding 40 t

4.4.1 The required outer diameter d_0 in mm of masts or posts, measured at deck or top of mast house, is determined from the expression:

$$\frac{d_o t_o}{100} \geq 1.5 \sum P + 10{l_m}^2 F$$

t_o= plate thickness of mast in mm at diameter d_0

F = the greater of:

$$\sum \frac{f_c}{{l_s}^3} and \frac{1}{2} \sum \frac{f(1.7a + c)}{{l_3}^3}$$

4.4.2 The plate thickness of masts or posts is in no place to be less than 7.5 mm.

4.4.3 The moment of inertia of masts or posts shall not be less than:

$$I = 240 \frac{{l_m}^2}{l_m - H} \sum Pl_d - 1500{l_m}^3 G\ (cm^4)$$

G = the smaller of

$$\sum \frac{{f_c}^2}{{l_s}^3} and \frac{1}{4} \sum \frac{f(1.7a + c)^2}{{l_s}^3}$$

4.4.4 Section modulus of masts is in general not to be less than:

$$Z = 80 \frac{l_m}{l_m - H} \sum Pl_d - \frac{30000{l_m}^3 G}{d_0} (cm^3)$$

G = as defined in 4.4.3.

4.4.5 Where derricks are fitted both forward and aft of the mast, the minimum section modulus shell be $Z = 80 \frac{l_m}{l_m - H} \sum Pl_d - k^1 \frac{{l_m}^3}{d_0} \sum \frac{{f_a}^2}{{l_m}^3} (cm^3)$

$$k^1 = 24000 \left(1 + 0.25 \frac{\sum P_1 l_{d1}}{\sum P_2 l_{d2}}\right)$$

$\sum P_1 l_{d1}$ And $\sum P_2 l_{d2}$ refer to derricks on either side of a transverse plane through the mast.

$\sum P_1 l_{d1}$ Shall be the smaller of these products.

4.5. Stayed masts without derricks

4.5.1 The diameter of stayed masts without derricks shall not be less than:

$$d_0 = \frac{100 l_{m1}}{3}\ (mm)$$

$$d_1 = 0.75 d_0\ (mm)$$

d_0And d_1 are the diameter at deck and hounds respectively.

l_{m1}= length of mast in m measured from deck to hounds.

4.5.2 The plate thickness shall not be less than:

$$t = 2.5 + 0.35 l_{m1} (mm)$$

4.6. Shrouds

4.6.1 Shrouds for masts or posts with derricks shall have breaking strength not less than:

$$V = \frac{10.8 g_0 l_m \sum P l_d}{(l_m - H)(1 + \frac{c_0}{B}) \sum e}\ (kN)$$

Permanent Centre line stays may be included in $\Sigma\ e$ when relevant.

4.6.2 Shrouds for masts without derricks shall have circumference of steel wire rope with minimum 63 mm

CHAPTER 5 LIFTING APPLIANCES AND FOUNDATIONS FOR HEAVY EQUIPMENT, DECK MACHINERY AND TOWING EQUIPMENT

CONTENTS

SECTION 1 CRANE AND LIFTING APPLIANCES

Contents

1.1. Introduction

1.1.1. The requirements for strength and support of crane pedestals, support of davits, A-frames and other lifting equipment are described in this section. The requirements are generally applicable to equipment specified for safe working load (SWL) > 30 kN or resulting bending moment at hull fixation > 100 kNm.

For davit for survival craft, man over board-boat and work boat, the requirements are applicable regardless of SWL or resulting bending moment at hull fixation.

1.1.2. The following definitions shall apply for contents in this section:

- Offshore cranes are lifting appliances onboard ships and similar units intended for cargo handling outside the deck area at open sea. e.g. loading and unloading of offshore support vessels, barges etc. or from the seabed
- Shipboard cranes are lifting appliances onboard ships and similar units intended for use within harbor areas and when at sea within the cargo deck area.
- Working load (W) is Safe Working Load (SWL) plus the weight of the lifting gear (e.g. hook block).

1.1.3. Generally, design for foundations and structure supporting lifting appliances, such as A frames and Shipboard cranes, having a complex arrangement and / or complied by irregular shaped plating, should be supported by a strength analysis at an extent and content to be agreed beforehand with the Society. Calculations shall follow principles outlined in Pt 3 Ch 13.

1.2. Documentation requirements

1.2.1 Documentation shall be submitted as per Table 5.1.1

Table 5.1.1 Documentation requirements

Object	*Documentation type*	*Additional description*	*For approval (AP) or For information (FI)*
Cranes	Arrangement plan	Includes: ▪ Main dimensions ▪ Limiting positions of movable parts ▪ Location on board during operation and in parked position	FI
	Design criteria	Includes: ▪ Load charts including safe working loads and corresponding arms ▪ Dynamic coefficients ▪ Self-weights and positions of center of gravity For offshore cranes: ▪ Significant wave heights (H_s) for operation ▪ Load charts showing crane capacity at each given H_s	FI
Crane pedestals	Structural drawing		AP
Crane supporting structures	Structural drawing	Includes design loads and reaction forces: ▪ During operation ▪ In stowed position	AP
Crane stowage arrangements	Structural drawing	Including design loads and reaction forces in transit condition	AP

Crane rails	Structural drawing	Includes end buffers and their supports, rack bars and fixation bolts and pads. Including design loads and reaction forces during operation and in stowed positions	AP

1.3. Materials

1.3.1 For pedestal/posts and supporting structures to be used in harbor only, selection of category materials for plates and sections shall be based on Table 5.2.1 of Sect [2.2]

1.3.2 When a pedestal subjected to bending is not continuous through a deck plating, the following applies:

— either Z-quality material INTLREG Pt 2,Ch 1,Sect [8.10.3] and Sect 1 [1.11] shall be used
— or an ultrasonic lamination test of plate before welding, shall be carried out in tension exposed areas INTLREG Pt 2,Ch 1,Sect [8.10.3] and Sect 1 [1.11] shall be used

Remark: *Killed and fine grain treated steel grades with max. sulphur content 0.008% will normally pass the testing*

1.4. Arrangement

1.4.1 Heavily loaded crane pedestals shall preferably be supported by at least two deck levels. The supporting structure shall have continuity and allow safe access for survey of its interior. Reference is made to Figure.5.1.1. and Figure 5.1.2.

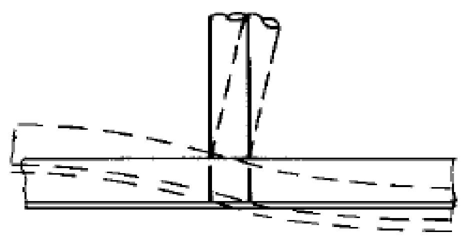


Figure 5.1.1; Not recommended

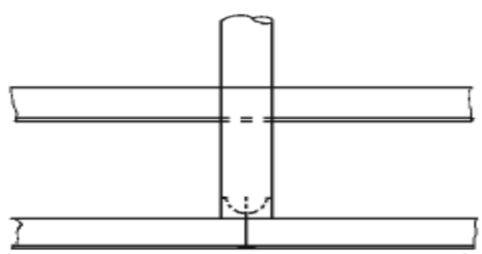


Figure 5.1.2: Recommended support

1.5. Design loads

1.5.1 The structural strength of the supporting structure (including pedestal) shall be based on a design load consisting of working load (W) multiplied by the design dynamic coefficient "ψ" (specified for the crane designer) plus the self-weight. However, the dynamic coefficient shall not be taken less than the following:

For "shipboard cranes":
- Ψ = 1.3.

For "offshore cranes":

- Ψ = 1.3 for 10 kN <W ≤ 2500 kN
- Ψ = 1.1 for W > 5000 kN

Linear interpolation shall be used for values of W between 2500 kN and 5000 kN.
For offshore cranes the design loads for the supporting structure shall be taken as the design loads for the crane multiplied with an additional offshore safety factor SF1 of 1.1.
For offshore cranes with W ≤ 2500 kN, where the operator cabin is attached above the slewing bearing, SF1 shall be taken as 1.3.
Lifting appliances fitted with shock absorbers may be specially considered.

1.5.2 Vertical and horizontal accelerations for the specified sea state a_v, a_t and a_l to be taken as a safe fraction of the extreme values given in Pt 3 Ch 4. Accelerations to be combined as indicated for deck equipment in Pt 3 Ch4.

Remark: *When the significant wave height H_S is known,*

$$C_W = \frac{2}{3} H_s$$

may be inserted in the formulae of Pt 3 Ch 4.

C_w = wave coefficient.

1.5.3 When the transit condition is considered critical,, the design loads shall normally be taken as given for idle deck equipment in Pt 3 Ch 4

For non-compact units wind and icing shall be taken into account as appropriate.
Standard ice load for North Sea winter conditions may be taken as 5 cm ice deposit on wind and weather exposed surfaces.

1.5.4 Supporting structure for survival craft and workboat davits shall be designed for a dynamic coefficient of 2.2

1.5.5 For man overboard boat davits, the supporting structure shall also be designed to withstand a horizontal towing force.

1.6. Allowable stresses

1.6.1 Allowable stresses in crane and respective structure supports shall in principle be taken as follows:

Normal stresses 160 f_1 N/mm^2

Shear stresses: 90 f_1 N/mm^2

The above also applies to supporting structures for davits, A-frames and other similar lifting devices. In way of structures subject to longitudinal hull stresses, the allowable stresses will be especially considered.

1.7. Testing

1.7.1 Upon completion of crane foundation, load test shall be carried out in the presence of an INTLREG surveyor.

SECTION 2 FOUNDATIONS FOR HEAVY EQUIPMENT, WINCHES, WINDLASSES AND OTHER PULLING ACCESSORIES

Contents

2.1. Introduction

This sub section applies to foundations and respective supporting structures for heavy equipment and deck machinery. Foundations and structures covered by in Section 3 need not comply with this section.

- Heavy equipment: equipment :where the static forces exceed 50 kN or resulting static bending moments at deck exceed 100 kNm.
- Deck machinery: winches, windlasses, chain stoppers, and other similar items, including stern rollers and shark jaws for handling chains of offshore rigs fitted on board offshore support vessels, with breaking load of the wire or chain > 150 kN, or SWL > 30 kN

Remark:

*Only windlasses, anchor chain stoppers and equipment related to additional class notations, when specifically mentioned (e.g. towing equipment for vessels with class notation **Tug**) are included in scope of classification, requiring plan approval and certification of the equipment by INTLREG.*

2.2. Documentation requirements

2.2.1 Documentation shall be submitted as per Table 5.2.1

Table 5.2.1 Documentation requirements

Object	*Documentation type*	*Additional description*	*For approval (AP) or For information (FI)*
Deck machinery supporting structure	Structural drawing	Including foundation above deck and fixation (bolts, chocks and shear stoppers).	AP
Deck equipment/machinery arrangement	Arrangement plan	Including main dimensions and design loads (SWL, equipment weight, brake rendering load and wire breaking load) and foot print loads.	FI

2.3. Design loads and allowable stresses

a) The strength of the foundations and supporting structures shall fulfil the strictest of the following requirements and found relevant. Design load to be given by the respective SWL times dynamic coefficient, " ψ", as specified by designer. " ψ", is however not to be taken less than 1.3.

b) Design load to be given by the force in the rope causing the brake to render.

c) For winches with constant tension control, design load to be taken as 1.1 times the maximum pulling force.

d) For transit condition, Refer Ch 5,Sect [1.5.3]

For the above load conditions the allowable stresses are the following:

Normal stresses: 160 f_1 N/mm^2

Shear stresses: 90 f_1 N/mm^2

e) For winches (e.g. trawl winches) where the rope/equipment can get stuck on the sea bottom or otherwise, the design load shall be equal to the breaking load of the rope.

f) For structure under windlasses and chain stoppers designed for loads as given in Ch 3 Sec 6, [6.1.6].

For the above load conditions e) and f) the allowable stresses are the following:

Normal stresses: 210 f_1 N/mm^2

Shear stresses: 120 f_1 N/mm^2

2.4. Securing requirements for fore deck windlasses

2.4.1 This subsection gives requirements for the securing of windlasses when fitted under the following three conditions:

- in ships of length greater than or equal to 80 m
- Located on an exposed deck over the forward 0.25 L.
- The distance between their base and the summer load waterline is less than 0.1 L or 22 m, whichever is lower.

2.4.2 These requirements are additional to those appertaining to the anchor and chain performance criteria.

2.4.3 When mooring winches are integrated with anchor windlass, they shall be considered as part of the windlass.

2.4.4 The following pressures and associated areas shall be applied (Refer Figure 5.2.1.):

200 kN/m^2 normal to the shaft axis and away from the forward perpendicular, over the projected area in this direction
150 kN/m^2 parallel to the shaft axis and acting both inboard and outboard separately, over the multiple of f times the projected area in this direction,

where f is defined as:

$f = 1 + B/H$, but not greater than 2.5

where:

B = width of windlass measured parallel to the shaft axis

H = overall height of windlass.

2.4.5 Forces in the bolts, chocks and stoppers securing the windlass to the deck shall be calculated. The windlass is supported by N bolt groups, each containing one or more bolts, Refer Figure 5.2.1.

2.4.6 The axial force R_i in bolt group (or bolt) *i*, positive in tension, may be calculated from:

$$R_{xi} = {P_X h_{xi} A_i}/{I_x}$$

$$R_{yi} = {P_y h_{yi} A_i}/{I_y}$$

and

$$R_i = R_{xi} + R_{yi} - R_{si}$$

Where:

$P_x =$ Force (kN) acting normal to the shaft axis

$P_y =$ Force (kN) acting parallel to the shaft axis, either inboard or outboard whichever gives the greater force in bolt group *i*

h = shaft height above the windlass mounting (cm)

x_i, y_i = x and y coordinates of bolt group i from the centroid of all N bolt groups, positive in the direction opposite to that of the applied force (cm)

A_i = Cross sectional area of all bolts in group *i* (cm²)

$I_x = \sum A_i x_i^2$ for N bolt groups

$I_y = \sum A_i y_i^2$ for N bolt groups

R_{si} = Static reaction at bolt group i, due to weight of windlass.

2.4.7 Shear forces F_{xi}, F_{yi} applied to the bolt group *i*, and the resultant combined force F_i may be calculated from:

$$F_{xi} = (P_x - \alpha g M)/N_b$$
$$F_{yi} = (P_y - \alpha g M)/N_b$$

and

$$F_i = (F_{xi}^2 + F_{yi}^2)^{0.5}$$

where α= coefficient of friction (0.5)

M = mass of windlass (tonnes)

g = gravity (9.81 m/sec²)

N_b = number of bolt groups.

2.4.8 Axial tensile and compressive forces in [2.4.6] and lateral forces in [2.4.7] shall also be considered in the design of the supporting structure.

2.4.9 Tensile axial stresses in the individual bolts in each bolt group i shall be calculated. The horizontal forces F_{xi} and F_{yi} shall normally be reacted by shear chocks. Where “fitted” bolts are designed to support these shear forces in one or both directions, the von Mises' equivalent stresses in the individual bolts shall be calculated, and compared to the stress under proof load. Where pourable resins are incorporated in the holding down arrangements, due account shall be taken in the calculations. The safety factor against bolt proof strength shall be not less than 2.0. (IACS UR S27)

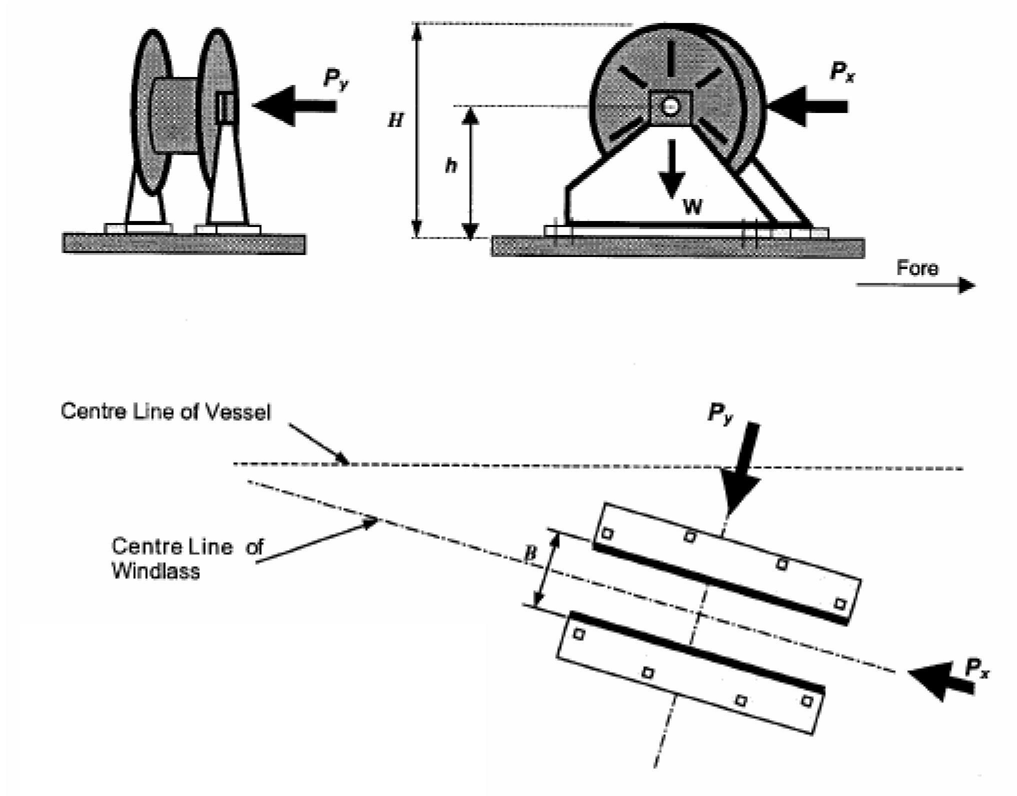
2.5. Materials

2.5.1 Selection of material grades for plates and sections shall be based on material thickness. Steel category given in Table 5.2.2 or equivalent will be accepted.

Table 5.2.2: Plate material grades

Thickness (mm)	Normal strength structural steel	High strength structural steel
t ≤ 40	A	AH
40 < t ≤150	B	AH

2.5.2 Deck doublers are generally not acceptable if tension perpendicular to deck occurs.



Note: P_y to be examined from both inboard and outboard directions separately. The sign convention for y_i to be reversed when P_y is from the opposite direction as shown.

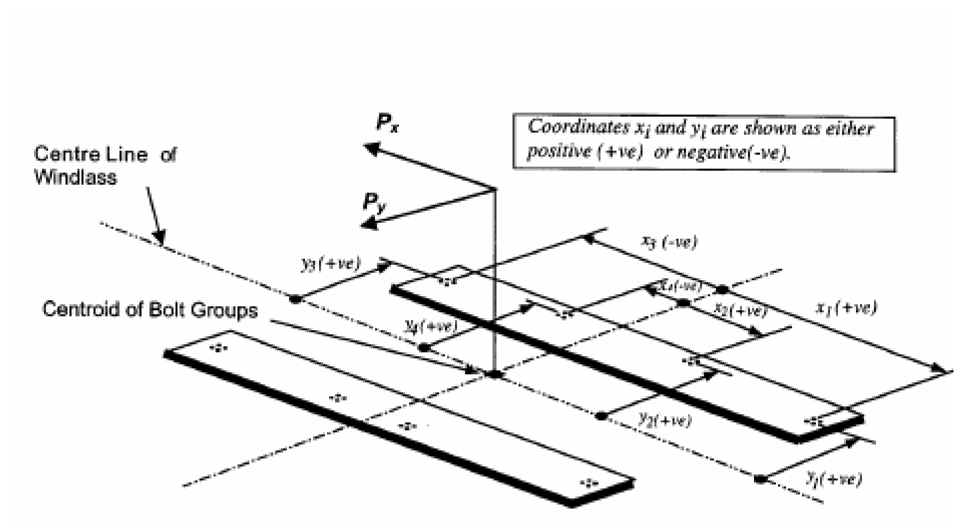


Figure.5.2.1: Direction of forces and weight

SECTION 3 SHIPBOARD FITTINGS AND SUPPORTING HULL STRUCTURES ASSOCIATED WITH TOWING AND MOORING ON CONVENTIONAL VESSELS

Contents

3.1. Introduction

3.1.1. This sub section apply to the design and construction of ship onboard fittings and respective structures supports, used for normal towing (at bow, sides and stern) and mooring operations on conventional vessels

3.1.2. For the purpose of application this section, the following definitions apply:

- Conventional vessels: New displacement-type vessels of 500 GT and above, excluding high speed craft, special purpose vessels, and offshore units of all types.
- Shipboard fittings: Those components limited to the following;
- Bollards and bitts, fairleads, stand rollers, chocks used for the normal mooring of the vessel and the similar components used for the normal towing of the vessel. The requirements in this sub section does not apply to components such as capstans, winches, etc. Any weld, bolt or equivalent device connection the shipboard fitting to the supporting structure is a part of the shipboard fitting and subject to the Industry standard applicable to this shipboard fitting. Supporting hull structures are that part of the ship on/in which the shipboard fitting is placed and which is directly subjected to the forces exerted on the shipboard fitting. The requirement in this sub-section applies to the supporting hull structure of capstans, winches, etc. used for the normal towing and mooring operations.
- Industry standard means international standard (ISO, etc.) or standards issued by national association such as DIN or JMSA, etc. which are recognized in the country where the ship is built.

3.1.3. Arrangement of emergency towing for tankers of 20 000 tonnes deadweight and above, including oil tankers, chemical tankers and gas carriers, shall comply with requirements in Pt 7B

Shipboard fittings which are part of emergency towing procedure, as required by SOLAS II-1/3-4 for passenger and cargo ships should also comply with the requirements of Sect [3.4]

3.1.4. Equipment and support structures covered by separate class notations like e.g. "**Tug**", "**Supply vessel**" and "Escort" are not covered by the below requirements but are to comply with the requirements in the respective sections.

3.2 Documentation requirements

3.2.1 Documentation shall be submitted as per Table 5.3.1

Table 5.3.1 Documentation requirements

Object	*Documentation type*	*Additional description*	*For approval (AP) or For information (FI)*
Towing and mooring arrangements	Arrangement plan	Plan providing information for each item regarding - Location on the ship - Fitting types - Dimensions - Safe working load - Maximum breaking strength of the towing and mooring lines - The purpose (mooring/harbor towing etc.) - Manner of applying the lines including limiting fleet angles	FI
Emergency towing arrangement	Arrangement plan	Plan providing information for each item regarding - Location on the ship - Fitting types - Dimensions - Safe working load - Maximum breaking strength of the towing lines - Manner of applying the towing lines including limiting fleet angles	FI
	Procedure	Covering SOLAS II-1/3-4	FI

3.2.2 For vessels with increased number of mooring lines to compensate for reduced breaking strength the “Towing and mooring arrangement plan” shall also show the number of mooring lines together with the breaking strength of each mooring line.

3.2.3 The “Towing and mooring arrangement plan” shall be available on board for the guidance of the Master.

3.3. General

3.3.1 Shipboard fittings for towing and mooring shall be located on stiffeners and /or girders, which are part of the deck structure to facilitate efficient distribution of the load. Other arrangements are accepted (for Panama chocks, etc.) if the strength is confirmed adequate for the intended service.

3.3.2 The deck strengthening beneath shipboard fittings shall be effectively arranged for any variation of direction (horizontally and vertically) of the design loads acting through the arrangement of connection to the shipboard fittings.

3.3.3 Strength calculations shall be based on net scantlings after deduction of corrosion addition. For this purpose, the total corrosion addition, t_c, in mm, for the supporting structure is normally not to be less than the following values:

- Ships covered by IACS Common Structural Rules for Bulk Carriers and Oil Tankers*:* Total corrosion additions defined in these rules

- Other ships: 2.0 mm.

3.3.4 Shipboard fittings shall be selected by the shipyard normally in accordance with an industry standard (e.g. ISO 13795 Ships and marine technology - Ship's mooring and towing fittings - Welded steel

bollards for sea-going vessels) accepted by INTLREG.

3.3.5 The design of the shipboard fitting shall be subjected to approval if it is not selected from an accepted Industry standard. The design load used to assess its strength and its attachment to the ship shall be in accordance the relevant requirements in Sect [3.4] and [3.5], for towing and mooring respectively .

3.3.6 Allowable stresses for fittings according to [3.3.5] and for all supporting structures are:

Allowable normal stress: 100% of the specified minimum yield point of the material
Allowable shear stress: 60% of the specified minimum yield point of the material
No stress concentration factors need to be taken into account.

Normal stress shall be taken as the sum of the bending and axial stress with the corresponding shear stress acting perpendicular to the normal stress.

3.3.7 SWL of each shipboard fitting used for towing or mooring shall be marked by weld bead or equivalent.

3.3.8 The method of using the towing and mooring lines shall be defined in the “Towing and mooring arrangement plan”. The acting point of the towing/ mooring forces on deck fittings shall be taken at the attachment point of a towing/ mooring line or at a change in its direction.

3.4 Towing

3.4.1 The minimum design load to be used is the following value of (a) or (b), as applicable, unless greater safe working load (SWL) of shipboard fittings is specified:

a) 1.25 times the intended maximum towing load (e.g. static bollard pull) as indicated on the “Towing and mooring arrangement plan”, for normal towing operations (e.g. in harbor / manoeuvring).

b) Table 3.3.1 is to be followed for the nominal breaking strength of the towing line for other towing service, for the ship's corresponding equipment number.

The projected area including maximum stacks of deck cargoes shall be considered in the calculation of the equipment number for the selection of the towing lines. The breaking loads of towing lines given as guidance in Table 3.3.1 is the design load to be applied to the shipboard fittings and supporting hull structure. As per the arrangement shown on the “Towing and mooring arrangements plan”, the design load shall be applied through the tow line.

3.4.2 The procedure for the application of the design load to the fittings and supporting hull structures should be taken into account, in such a way that the total load needs be less than twice the design load, i.e. no more than one turn of one line (Refer figure 5.3.1 below).

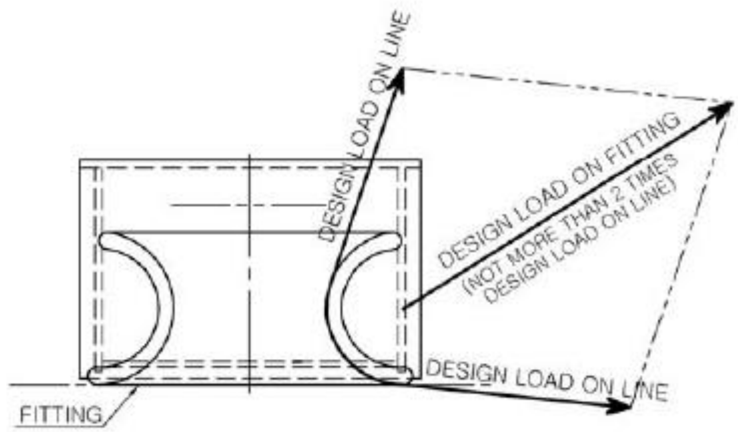


Figure 5.3.1

3.4.3 The following requirements apply to the definition of the Safe Working Load (SWL):

a) The SWL used for normal towing operations (e.g. harbor / maneuvering) is not to exceed 80% of the design load per Sect[3.4.1](a) and the SWL used for other towing operations is not to exceed the design load per .Sect [3.4.1](b) For fittings used for both normal and other towing operations, the greater of the design loads given in Sect [3.4.1]shall be used.

b) The above requirements on SWL apply for a single post basis (no more than one turn of one cable).

3.5 Mooring

3.5.1 The following will apply to definition of the design load for the mooring shipboard fittings and respective supporting hull structures,

a) The design load to be applied to the fittings and supporting hull structures shall be 1.25 times the breaking strength of the mooring line according to values given in Table 3.3.1 as guidance for the ship's corresponding equipment number, unless greater safe working load (SWL) of mooring fittings are specified by the applicant.

b) The design load to be applied to supporting hull structures for mooring winches, etc. shall be 1.25 times the intended maximum brake holding load and, for capstans, 1.25 times the maximum hauling-in force.

c) The design load shall be applied through the mooring line according to the arrangement shown on the “Towing and mooring arrangements plan”.

d) The method of application of the design load to the fittings and supporting hull structures shall be taken into account such that, the total load need not be more than twice the design load specified in 1) above, i.e.no more than one turn of one line.

e) When a specific SWL is applied for a shipboard fitting at the request of the applicant, by which the design load will be greater than the above minimum values, the strength of the fitting shall be designed using this specific design load.

f) Design load for shipboard fittings included in the emergency towing procedure required by SOLAS II-1/3- 4, shall be taken not less than strong point capacity specified in the procedure. The capacity is assumed to be not less than 1.25 times the safe working load (SWL).

For the purpose of defining breaking strength of the mooring line, its selection shall be based on equipment number calculated considering the projected area including maximum stacks of deck cargoes. The breaking loads of mooring lines given as guidance in Ch 3,Sect 3,Table 3.3.1 shall be used for determining the design load to be applied to the shipboard fittings and supporting hull structure.

3.5.2 The following requirements apply to the definition of the Safe Working Load (SWL) for the mooring fittings:

1) The SWL is not to exceed 80% of the design load given in Sect [3.5.1].
2) The above requirements on SWL apply for a single post basis (no more than one turn of one cable). (Ref: IACS UR A2)

3.6 Materials

3.6.1 The material in deck fittings and supporting structure shall be at least NVA or equivalent. Casting in mooring and towing equipment shall be of weldable quality. The material in foundation for emergency towing equipment shall comply with requirement in Ch 5,Sect [2.2.1] Table 5.2.1

CHAPTER 6 OPENINGS AND CLOSING APPLIANCES

CONTENTS

SECTION 1 GENERAL

Contents

1.1. Application

1.1.1. This Chapter covers the statutory requirements of outfitting items as per ICLL, SOLAS and other applicable regulations of IMO. This Chapter also considers the requirements for the arrangement of openings and closing appliances. The closing appliances will have strength at least corresponding to the required strength of the hull in which they are fitted.

1.1.2. This is applicable to all kinds of ships which are more than 24m in length, with the following exceptions:

- pleasure yachts not engaged in trade
- Fishing vessels.

For ships less than 24 m in length this section applies as practicable.

1.2. Definitions

1.2.1 Symbols:

L = rule length in m [1)]
B = rule breadth in m [1)]
C_B = rule block coefficient [1)]
t = thickness of plate in mm. [1)]

Z = rule section modulus in cm^3 of stiffeners and simple girders

c_f = Correction factor for aspect ratio of plate field

$$= (1.1 - 0.25s/l)^2$$

= maximum 1.0 for $s/l = 0.4$

= minimum 0.72 for $s/l = 1.0$

s = stiffener spacing in m, measured along the plating *l* = stiffener span in m, measured along the top flange of the member.

For definition of span point, Refer Pt 3 Ch 3 Sec 3, [3.1]. For curved stiffeners *l* may be taken as the cord length

S = girder span in m. For definition of span point, Refer Pt 3 Ch 3 Sec 3, [3.1]

k = material factor [2)]

t_c = corrosion allowance as specified in Pt 3 Ch 2.

w_c = section modulus correction factor in tanks, Refer Pt 3 Ch 3 Sec 3,[3.10.4]

σ = allowable bending stress in N/mm^2 due to lateral pressure

σ_s = allowable shear stress in N/mm^2 due to lateral loads

p = design pressure in kN/m^2 as given for the various structures.

1) Refer Pt 3 Ch.1 Sec.2.

2) Refer Pt 3 Ch 2 Sec 2 & 3.

1.2.2 Terms

Position

For the Regulation purpose, two positions of hatchways, doorways and ventilators are defined as follows:

Position 1 - Exposed freeboard and raised quarter decks and exposed superstructure decks which are situated forward of point located from forward perpendicular.

Position 2 - Exposed superstructure decks situated abaft a quarter of the ship's length from the forward perpendicular and located at least one standard height of superstructure above the freeboard deck.
Exposed superstructure decks situated forward of a point located a quarter of the ship's length from the forward perpendicular and located at least two standard heights of superstructure above the freeboard deck.
(ICLL Reg.13)

Freeboards greater than minimum

Where freeboards have to be increased, because of such consideration as strength, location of shell or side scuttles or other reasons, then:

a) The heights of hatchway coamings, doors sills, sills of machinery space openings, miscellaneous openings, ventilators and air pipes
b) Freeing arrangements and means for protection of crew
c) The scantlings of hatch covers
d) Windows and side scuttles

on the actual freeboard deck may be as required for a superstructure deck, provided the summer freeboard is such that the resulting draught will not be greater than that corresponding to the minimum freeboard calculated from an assumed freeboard deck situated at a distance equal to a standard superstructure height below the actual freeboard deck. Similar considerations may be given in cases of draught limitation on account of bow height.

Ship types

The basic ship types are as follows:

Type "A" Ships designed solely for the carriage of liquid cargo.

Type "B" Cargo ship other than “A”, with steel weather tight hatch covers

Type "B-100" "B-60"Cargo ship of type "B" with reduced freeboard on account of their ability to survive damage.

Type "B+" Cargo ship with increased freeboard on account of hatch cover arrangement

Weathertight means that in any sea condition of sea water doesn’t come on to the vessel.

Watertight means prevention of passage of water on the vessel at any sea conditions, for which the surrounding structure is designed.

Ro-Ro passenger ship is a passenger ship with Ro-Ro spaces or special category spaces.

Ro-Ro spaces are spaces not normally subdivided in any way and normally extending to either an entire length or the substantial length of the ship in which motor vehicles with fuel in their tanks for their own propulsion and/or goods (packaged or in bulk, in or on rail or road cars, vehicles (including road or rail tankers), trailers, containers, pallets, demountable tanks or in or on similar stowage units or other receptacles) can be loaded and unloaded normally in a horizontal direction.

Special category spaces are those enclosed spaces above or below the bulkhead deck, into and from which vehicles can be driven and to which passengers have access. Special category spaces may be accommodated on more than one deck provided that the total overall clear height for vehicles does not exceed 10 m.

***Freeboard**, freeboard deck and superstructure*, Refer Pt 3 Ch.1 Sec.2,[2.2.5]

1.3. Documentation requirements

1.3.1 Documentation shall be submitted as required by Table 6.1.1

Table 6.1.1: Documentation requirements

Object	*Documentation type*	*Additional description*	*For approval (AP) or For information (FI)*
External watertight integrity	Freeboard plan	Drawing including information about openings and closing appliances requested in Chapter II of the ICLL.	AP
Cargo hatches	Detailed drawing	Including covers and opening, closing, sealing, securing and locking devices.	AP
Shell doors and ramps (bow, side and stern as applicable	Detailed drawing	Including securing devices.	AP
	Control and monitoring system Documentation.	Shell doors control and monitoring system.	AP
	Control and monitoring system Documentation	Water leakage monitoring system.	AP
	Operation manual		AP
	Maintenance manual		AP
Service hatches	Detailed drawing		AP
Manholes	Arrangement plan		FI
Scuppers	Piping diagram		AP
Internal watertight doors	Arrangement plan	Including for each door: Size, design principle (sliding, hinged), pressure rating and fire rating. Including remote control positions.	AP
	Control and monitoring system documentation	Internal watertight doors control and monitoring system.	AP
Retractable bottom equipment	Structural drawing	Foundations including watertight boundaries.	AP
	Structural drawing	Supporting structures.	AP
	Arrangement plan	Including resulting loads acting on the supporting structures, and details of sealings.	FI
Box coolers	Structural drawing	Foundations including watertight boundaries.	AP
	Structural drawing	Supporting structures.	AP

	Arrangement plan	Including details of sealings	FI

1.4. On board documentation

1.4.1 The operation and maintenance manuals for the shell doors shall be provided on board.

1.5. Testing

1.5.1 All weather tight or watertight doors and hatch covers are to be tested.

1.5.2 For ships exclusively intended for the carriage of containers in the cargo holds, for which an exemption to the ICLL, Reg.16 (Refer Sec 5 & 6) has been granted by the Flag Administration, and which complies with the requirements given in Pt.5A, the required testing for weather tightness given in Pt.1 may be dispensed with.

1.5.3 If non-weathertight hatch covers are fitted in accordance with Sect [1.2.2], this will be noted in the main letter of approval with the implication that hose testing for weather tightness in accordance with Pt.1 will not be carried out.

1.5.4 Doors and hatch covers which are to be hydrostatic pressure tested when the ship comes to the damaged condition by the water plane occurred at the head waves during voyage. The head of water used for the pressure test shall correspond at least to the head measured from the lower edge of the door opening, at the location in which the door is to be fitted in the vessel, to the most unfavorable damaged water plane. The test to be accepted when there is no leakage through the doors or hatch covers. For large doors, above 6 m^2, it should be done the structural analysis of load bearing capacity, when these are placed with gasket seals. The pressure test of the gasket seal should evolve that it is capable of withstanding the maximum deflection faced by the structural analysis test by using theoretical or experimental analysis.

1.6. Certificate requirements

1.6.1 Certificates shall be issued as required by Table 6.1.2

Table 6.1.2: Certificate requirements

Object	Certificate type
Internal watertight doors control and monitoring system	INTLREG product certificate
Shell doors control and monitoring system	INTLREG product certificate

SECTION 2 ACCESS OPENINGS IN SUPERSTRUCTURES AND FREEBOARD DECK

Contents

2.1. Doors

2.1.1. All access openings in bulkheads at ends of enclosed superstructures shall be fitted with doors of steel or other equivalent material, permanently and strongly attached to the bulkhead, and framed, stiffened and fitted so that the whole structure is of equivalent strength to the un-pierced bulkhead and weather tight when closed. The means for securing these doors weather tight shall consist of gaskets and clamping devices or other equivalent means and shall be permanently attached to the bulkhead or to the doors themselves, and the doors shall be so arranged that they can be operated from both sides of the bulkhead.

2.1.2. Unless otherwise permitted by the Administration, doors shall open outwards to provide additional security against the impact of the sea.

2.1.3. Except as otherwise provided in these regulations, the height of the sills of access openings in bulkheads at ends of enclosed superstructures shall be at least 380 mm above the deck. (ICLL Reg.12)

2.1.4. Portable sills shall be avoided. However, in order to facilitate the loading/unloading of heavy spare parts or similar, portable sills may be fitted on the following conditions:

(a) they shall be installed before the ship leaves port; and

(b) they shall be gasketed and fastened by closely spaced through bolts.

2.1.5. a) Doors should open outwards to provide additional security against sea impact. Doors which open inwards shall be especially approved.

b) Portable sills should be avoided. However, in order to facilitate the loading/unloading of heavy spare parts or similar, portable sills may be fitted on the following conditions:

i) This must be installed before ship leaves port.

ii) Sills shall be gasketed and fastened by closely spaced through bolts.

iii) When the sills are replaced after removal the weather tight of the sills and the r doors must be checked by hose testing. The removal of dates, hose testing and replacing shall be recorded in the ship's log book.

(IACS UI LL5)

2.1.6. Weathertight doors as specified above shall be fitted in all access openings in:

- Bulkheads at ends of superstructures.
- Bulkheads of deckhouses on freeboard deck protecting openings.
- Companion ways on freeboard deck and superstructure deck.
- bulkheads of deckhouses on superstructure deck protecting openings
- Companion ways and bulkheads of deckhouse upon another deckhouse on freeboard deck protecting openings in the freeboard deck.

2.1.7. For weathertight doors the minimum required door plate thickness corresponding to lateral pressure shall be calculated by the following formula: The section modulus requirement for stiffeners is given by: assuming simply supported ends.

$$t = \frac{1.58 k_a s \sqrt{p}}{\sqrt{f_1}} \text{ (mm)}$$

the section modulus for stiffeners to be

$$Z = \frac{0.8 l^2 s \sqrt{p}}{f_1} \text{ (cm}^3\text{)}$$

2.1.8. The number of the cleats is to comply with ISO6042(1998). The cleats may be individual or centrally operated.

2.1.9. A hinged watertight door which tends to open inwards is acceptable in lieu of a weathertight door which tends to open outwards.

2.2. Sill heights

2.2.1. Openings as mentioned in Sect [2.1] are in general to have sill heights not less than 380 mm. The following openings in position 1 shall have sill heights not less than 600 mm:

- Companion ways
- Where access is not provided from above of the deck. Openings in poop front bulkhead, bulkheads at ends of mid ships, superstructures and bulkheads at ends and sides of deckhouses
- openings in forecastle end bulkhead covering entrance to space below the deck
- openings in engine casings

2.2.2. Freeboard assignment in ships based upon a flooding calculation (type A, B-60 or B-100), the sill heights for the superstructure bulkhead openings may require to be adjusted to the damage calculation waterline. In such ships were engine casings are not protected by outer structures, two weathertight doors in series are required, the sill height of the inner door should not be less than 230 mm.

Remark: *If the door to the engine room can be accessed from the deck above, inside the deck house or superstructure, then the engine casing is considered protected by outer structures. Two weather tight doors in series are not required.*

2.2.3. Openings which are used only when the ship is in harbor (for handling of spare parts, etc.), may have a reduced sill height.

2.2.4. For vessels trading in domestic waters reduced sill height may be accepted in accordance with Pt1/Ch1/sect 4

2.3. Access openings in freeboard and superstructure decks

2.3.1. Manholes and scuttles in position 1 or 2 or within superstructures other than enclosed superstructures shall be closed by substantial covers capable of being made watertight. When access doors secured by closely spaced bolts, the covers shall be permanently attached.

2.3.2. Openings in freeboard decks other than hatchways, machinery space openings, manholes and flush scuttles will be protected by an enclosed superstructure, or by a deckhouse or companion way of equivalent strength and weathertight. Opening in an exposed superstructure deck or in the top of a deckhouse on the freeboard deck which gives access to a space below the freeboard deck or a space within an enclosed superstructure shall be protected by an efficient deckhouse or companionway. Doorways in such deckhouses or companionways shall be fitted with doors complying with the requirements of Sect[2.1.1].

2.3.3. In position 1 the height above the deck sills to the doorways in companion ways shall be at least 600mm. In position 2 it shall be at least 380m

2.3.4. Regarding the requirement to protect openings in superstructures [2.3.2] above, it is considered that openings in the top of a deckhouse on a raised quarterdeck having a height equal to or greater than a standard height of raised quarterdeck shall be provided with an acceptable means of closing but need not be protected by an efficient deckhouse or companion way as defined in the regulation provided the height of the deckhouse is at least the height of a full superstructure.

2.3.5. Only those doorways in deckhouses leading to or giving access leading below, need to be fitted with doors in accordance with Sect [2.1.1]. Alternatively, if stairways within a deckhouse are enclosed within properly constructed companionways fitted with doors complying with [2.1.1], the external doors need not be weather tight. Where an opening in a superstructure deck or in the top of a deckhouse on the freeboard deck which gives access to a space below the freeboard deck or to a space within an enclosed superstructure is protected by a deckhouse, then it is considered that only those side scuttles fitted in spaces which give direct access to an open stairway need be fitted with deadlights in accordance with Ch 6 Sec 12, [12.1]. A cabin is considered to provide adequate protection against the minimal amount of water which will enter through a broken side scuttle glass fitted on the second tier.

4.1.1 In the application of Sect [2.3.1] to [2.3.2] it is understood that:

i) Where access is provided from the deck above as an alternative to access from the freeboard then the height of sills into a bridge or poop should be 380 mm. The same consideration should apply to deckhouses on the freeboard deck.

ii) Where access is not provided from above the height of the sills to doorways in a poop bridge or deckhouse on the freeboard deck should be 600 mm.

iii) Where the closing appliances of access openings in superstructures and deckhouses are not in accordance with Sect [2.1.1]., interior deck openings shall be considered exposed i.e. situated in the open deck.

(Ref: IACS UI LL8)

2.4. Strength and securing of small hatches on the exposed fore deck

2.4.1. For vessels with L > 80 m:

Exposed deck contains small hatches < 2.5 m^2over the forward 0.25 L, where the height of the exposed deck in way of the hatch is less than 0.1L or 22 m above the summer load waterline, whichever is the lesser, shall comply with [2.4.3].to [2.4.14].

(Ref: IACS UR S 26)

2.4.2. Hatches designed for use as emergency escape shall comply with these requirements, except [2.4.14]. In [2.4.7], option (iii) shall be used for emergency escapes.

2.4.3. Rectangular small steel hatch covers, the thickness of the plate, arrangement of stiffener and scantlings shall be in accordance with Table 6.2.1. And Fig 6.2.1. Stiffeners, where fitted, shall be aligned with the metal-to-metal contact points, required in [2.4.9], Refer Figure 6.2.1. Primary stiffeners shall be continuous. All stiffeners shall be welded to the inner edge stiffener, see Figure 6.2.2.

Table 6.2.1 Scantling for small steel hatch covers on the fore deck

Nominal size (mm × mm)	Cover plate thickness (mm)	Primary stiffeners	Secondary stiffeners
		Flatbar (mm × mm); number	
630 ×630	8	_	_
630 × 830	8	100 × 8; 1	_
830 × 630	8	100 × 8; 1	_
830 × 830	8	100 × 10; 1	_
1030 × 1030	8	120 × 12; 1	80 × 8; 2
1030 × 1030	8	120 ×12; 1	100 ×10; 2

2.4.4. The upper edge of hatchway coamings shall be suitably reinforced by a horizontal section, normally not more than 170 to 190 mm from the upper edge of coaming

2.4.5. For small hatch covers of circular or similar shape, the cover plate thickness and reinforcement shall be according to the requirements of Ch. 6 Sec 5.

2.4.6. For small hatch covers constructed of materials other than steel, the required

Scantlings will have to provide equivalent strength.

2.4.7. Small hatches located on exposed fore deck shall be fitted with primary securing

Devices such that hatch covers can secured in place and weather tight by means of a mechanism employing any one of the following methods:

i) Butterfly nuts tightening to forks (clamps)
ii) Quick acting cleats, or
iii) Central locking device.

For emergency escape hatches the central locking device will be a quick operable from both sides of hatch cover.

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

2.4.9. The hatch cover shall be fitted with a gasket of elastic material, will be designed to allow a metal to metal contact at a designed compression and prevent over compression of the gasket by green sea forces that may cause the securing devices to be loosened or dislodged. The metal-to-metal contacts shall be arranged close to each securing device in accordance with Fig 6.2.1. And of sufficient capacity to withstand the bearing force.

2.4.10. The primary securing method shall be designed and manufactured such that the designed compression pressure is achieved without the need of tools.

2.4.11. For a primary securing method using butterfly nuts, the (clamps) shall be of perfect strong design. They shall be designed to minimize the risk of butterfly nuts being dislodged while in use; by means of curving the forks upward, a raised surface on the free end, or a similar method. The plate thickness of unstiffened steel forks shall not be less than 16 mm. An example arrangement is shown in Figure 6.2.2.

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

2.4.13. On small hatches located between the main hatches, for example between Nos. 1 and 2, the hinges shall be placed on the fore edge, outboard edge, whichever is practicable for protection from green water in beam sea and bow quartering conditions.

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

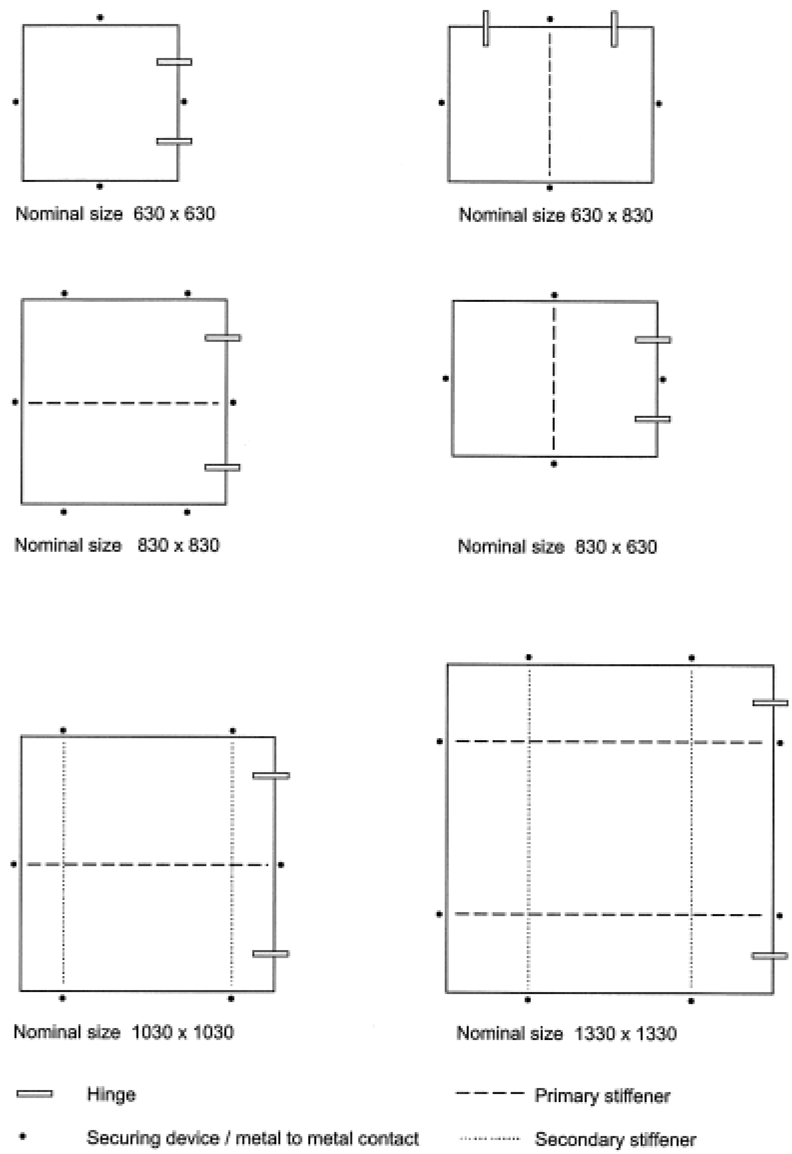
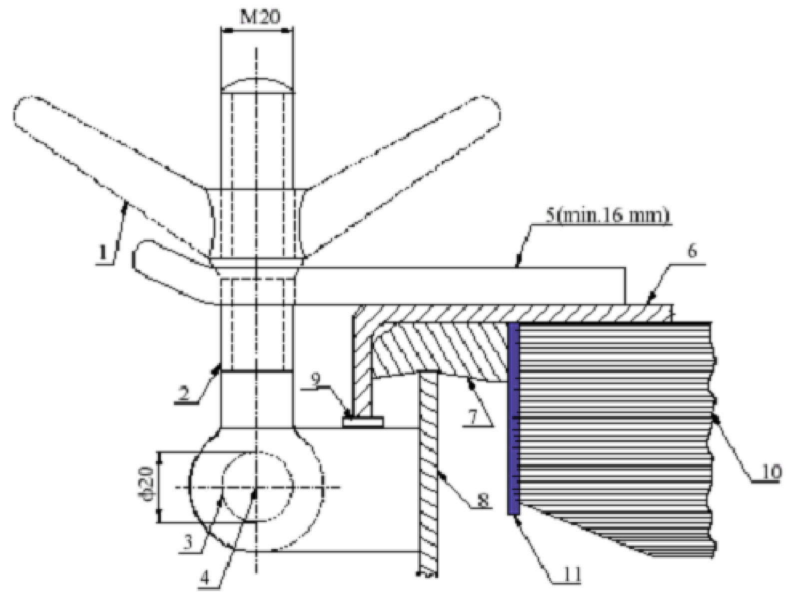


Figure 6.2.1:

Arrangement of stiffeners



1. butterfly nut
2. Bolt
3. Pin
4. Centre of pin
5. Fork (clamp) plate
6. Hatch cover
7. Gasket
8. Hatch coaming
9. Bearing pad welded on the bracket of a toggle bolt for metal and metal contact
10. Stiffener
11. Inner edge stiffener

Figure 6.2.2

Example of primary securing method

SECTION 3 SIDE AND STERN DOORS

Contents

3.1. General

3.1.1. These requirements are for cargo and service doors in the ship side (abaft the collision bulkhead) and stern area, below the freeboard deck and in enclosed superstructures. For requirements of bow doors, Refer Pt.5A.

3.1.2. The side and stern doors shall be fitted to ensure tightness and structural integrity commencement with their location and the surrounding structure. The number of such openings shall be the minimum compatible with the design and proper working of the ship. In the analysis of damage all external openings leading to compartments will be intact, which are below the final damage waterline, are required to be watertight.

3.1.3. The lower edge of any cargo or service door, if located below the freeboard deck, shall not be below line drawn parallel to the freeboard deck at side, which at its lowest point is 230 mm above the upper edge of the upper most load line. Special consideration shall be given to prevent the spread of any leakage water over the deck. A flat bar welded to the deck and provision of scuppers would be an acceptable arrangement.

3.1.4. Where the sill of any cargo or service door is below the line defined in [3.1.3], the arrangements will require to be specially considered to ascertain that the safety of the ship is in no way impaired. The fitting of a second door of equivalent strength and water tightness is one acceptable arrangement. In that case leakage detection device should be provided in the compartment between the two doors. Further, drainage of this compartment to the bilges controlled by an easily accessible screw down valve should be arranged. The outer door should preferably open outwards.

3.1.5. Doors should preferably open outwards.

3.1.6. Terms

Cleats: Devices for pre-compression of packings and steel to steel contact.

Supports: Load carrying devices designed for transfer of acting forces from door structures to hull structures.

Locking arrangement: Preventive measures ensuring that cleats and supports as applicable always remain in position when engaged.

3.2. Structural arrangement

3.2.1. Door openings in the shell shall have well rounded corners and sufficient compensation shall be arranged with web frames at sides and stringers or equivalent above and below.

3.2.2. Doors shall be adequately stiffened, and means shall be provided to prevent movement of the doors when closed. Adequate strength shall be provided in the connections of the lifting / maneuvering arms and hinges to the doors structures and to the ship structure.

3.2.3. $A \geq 12$ m^2 Doors with light opening area shall be such that the sea pressure is transferred directly to the hull coamings.

3.2.4. For doors with light opening area **A** < 12 m^2 securing bolts or similar devices may be accepted as carriers of sea pressure to the coamings, if an arrangement as required in [3.2.3] is not feasible.

3.2.5. If a door is divided into separate sections, each section shall have full strength independent of the other sections.

3.2.6. Where doors also serve as vehicle ramps, in the design of the hinges should take into account the ship angle of trim and heel, which may result in uneven loading on the hinges

3.3. Design loads

3.3.1. The design sea pressure is given by

$$p = \left(p_{dp} - (4 + 0.2k_s)h_o\right)$$

Minimum 6.25 + 0.025 L (kN/m^2)

or

$\mathrm{p} = 10h_b$, whichever is the largest

p_{dp}, k_S= as given in Pt 3 Ch 4

h_0 = Vertical distance in m from the load point to the waterline at draught T.

h_b = Vertical distance in meters from the load point to the deepest equilibrium or intermediate waterline in damaged condition, obtained from applicable damage stability calculations.

For ships with service restrictions p may be reduced with the percentages given in Pt 3 Ch4. C_W should not be reduced.

3.3.2. The design force for securing bolts and other closing devices, supporting members and surrounding structure is given by

$$F_1 = A\, p_e 10^3 + F_p \quad (N)$$

$$F_2 = F_0 + 10\, W_d + F_p \quad (N)$$

F_1 is applicable for ports opening inwards.

F_2 is applicable for ports opening outwards.

p_e = External design pressure p according to 3.3.1, minimum 25kN/m^2

F_p= total packing force in N

F_o = The greater of F_c and 5000 A (N)

F_c= accidental force (N) due to loose cargo etc., to be uniformly distributed over the area A and not to be taken less than 300 000 N.

For small doors such as bunker doors and pilot doors, the value of F_C may be appropriately reduced.

However, the value of F_C may be taken as zero, provided an additional structure such as an inner ramp way is fitted, which is capable of protecting the door from accidental forces due to loose cargo etc.

A = area of door opening (m^2) to be determined on the basis of the loaded area taking account of the direction of the pressure

W_d = mass of door (kg).

p_e = Is normally to be calculated at the midpoint of A.

Packing force shall be decided depending on type and hardness of packing. For calculation purpose, however, the packing line pressure should not be taken less than 5 N/mm^2. The packing line pressure shall be specified.

3.4. Plating

3.4.1. The thickness requirement corresponding to lateral pressure is given by:

$$t = \frac{1.58 k_a s \sqrt{p}}{\sqrt{f_1}} \text{ (mm)}$$

p = as given in Sect [3.3]. The thickness is in no case to be less than the minimum shell plate thickness.

3.4.2. The plating shall not be less than required for vehicle decks, where doors also serve as vehicle ramps.

3.5. Stiffeners

3.5.1. The required section modulus of stiffener is

$$Z = k\ 0.8\ l^2\ s\ p\ cm^3$$

(Assuming simply supported ends)

p = as given in Sect [3.3].

3.5.2. The minimum sectional area of stiffener web plate at the ends shell be A = 0.08 l s p (cm^2)

p = as given in Sect [3.3].

3.5.3. Edge stiffeners of doors shall have a moment of inertia not less than:

$$I = 8 p_l d^4 (cm^4)$$

For cover edges connected to a rigid ship structure member or adjacent door coaming.

d = distance between closing devices in m

p_l = Packing line pressure along edges in N/mm^2, Refer [3.3].

3.5.4. For edge stiffeners supporting main door stiffeners between securing devices, the moment of inertia shall be increased corresponding to the extra force.

3.5.5. Where doors also serve as vehicle ramps, the stiffener scantlings shall not be less than required for vehicle decks.

3.6. Girders

3.6.1. The section modulus requirement for simple girders assuming simply supported ends is given by:

$$Z = k\ 1.05\ S^2 bp\ \ (cm^3)$$

S = girder span in m

b = loading breadth in m

p = design pressure according to Sect [3.3].

3.6.2. The web area requirement (after deduction of cut-outs) at the girder ends is given by:

$$A = 0.08 Sbp\ k\ (cm^2)$$

S, b and p as in [3.6.1].

3.6.3. The webs of girders and stringers shall be adequately stiffened, preferably in a direction perpendicular to the shell plating.

3.6.4. The girder system shall be given sufficient stiffness to ensure integrity of the boundary support of the door. Edge girders should be sufficiently stiffened against rotation and shall have a minimum moment of inertia:

$$I = 8 p_l d^4 (cm^4)$$

d = distance between closing devices in m

p_l =Packing line pressure in N/mm^2, Refer [3.3.2].

For edge girders supporting main door girders between securing devices, the moment of inertia shall be increased in relation to the additional force.

3.7. Allowable stress

3.7.1. Girder systems with direct strength calculations

For large doors with a grillage girder system, a direct stress analysis as outlined in Pt 3 Ch 12 may be necessary. Design loads shall be as given in 3.3. And the allowable stresses are as follows:

Bending or normal stress:

$\sigma = 120\ f_1\ N/mm^2$

Shear stress:

$\tau = 80\ f_1\ N/mm^2$

Equivalent stress

$$\sigma_e = \sqrt{s^2 + 3t^2} = 150\ f_1\ \ N/mm^2$$

The material factor k shall not be taken greater than 1.39 unless a direct stress analysis with regard to relevant modes of failures (e.g. fatigue) is carried out.

3.7.2. Damage condition In general:

$\sigma = 220\ f_1$ and $\tau = 120\ f_1$

For cleats: $\sigma = 165\ f_1$ and $\tau = 110\ f_1$

3.8. Closing arrangement, general

3.8.1. Closing devices shall be easily accessible and simple to operate. Where hinges are used as closing devices, they should be well integrated into the door structure.

3.8.2. Packing material shall be of a comparatively soft type, and the supporting forces shall be carried by the steel structure only. Other types of packing will be specially considered.

3.8.3. For side or stern door opening inwards, and which becomes immersed by an equilibrium or intermediate water plane in damaged condition, the deflections of the door frame have to be documented to not affect the watertight capacity. The structural analysis has to include the flexibility of the surrounding structure. Test to be made according to Ch 6,Sect [1.5.4]

3.8.4. Flat bar or similar fastening devices for packings shall have scantlings and welds determined with simple considerations to wear and tear.

3.8.5. Devices shall be arranged for the doors to be secured in open position.

3.8.6. For closing and securing of side shell, bow and stern doors documented operating procedures shall be kept on board and posted at the appropriate places.

3.8.7. Openings in the shell plating below an equilibrium or intermediate water plane in damaged condition shall be fitted with a device that prevents unauthorized opening if they are accessible during the voyage. (2006/05 SOLAS Am/II-1/B-2/15-1)

3.9. Closing arrangement, strength

3.9.1. Side and stern doors shall be fitted with adequate means of closing and securing, commensurate with the strength of the surrounding structure.

3.9.2. The number of devices is generally to be the minimum practical whilst taking into account the requirement for redundant provision given in [3.8.6] and the available space for adequate support in the surrounding hull structure which may limit the size of each device.

3.9.3. In a calculation of the load carrying capacity of the devices**,** only supports having an effective stiffness in a given direction shall be included. The total external or internal force, as given in 3.3.2. may normally be considered as equally distributed between the devices.

However, the distribution of the total forces acting on the supports may, for doors with a complex closing arrangement, be required calculated by a direct calculation taking into account the flexibility of the door and surrounding hull structure and the position of the supports. Maximum design clearance for effective supports should normally not exceed 3 mm. In the Operating and Maintenance Manual design clearances shall be included as given in Pt.5A. Allowable normal, shear and equivalent stresses in closing and supporting elements are as given in Sect[3.6.3].

3.9.4. The nominal tensile stress in way of threads of bolts shall not exceed $105\,f_1\ \mathrm{N/mm^2}$. The arrangement of securing and supporting devices shall be such that threaded bolts do not carry support forces

3.9.5. For steel to steel bearings in closing and supporting devices, the nominal bearing pressure calculated by dividing the design force with the projected area shall not exceed $0.8\,\sigma_f$, where σ_f is the yield stress of the bearing material. For other bearing materials, the permissible bearing pressure shall be determined according to the manufacturer's specification.

3.9.6. For side and stern doors effective supports including surrounding door and hull structural members are, in the case of failure of any single support, to have sufficient capacity to withstand the total design forces. In this case the allowable stresses as given in Sect [3.6.3]. May be increased by 20%.

3.9.7. All load transmitting elements in the design load path, from the door through securing and supporting devices into the ship structure, including welded connections, shall be to the same strength standard as required for the securing and supporting devices.

3.10. Closing arrangement, system for operation and indication/monitoring

3.10.1. Cleats and support devices shall be equipped with mechanical locking arrangement (self-locking or separate arrangement) or to be of the gravity type.

3.10.2. Where hydraulic operating systems are applied, in case of failure in the hydraulic system also cleats and support devices shall remain locked in closed position.

3.10.3. Systems for opening and closing of the door, operation of cleats and support devices and, where applicable, for locking arrangement shall be interlocked in such a way that they can only operate in the proper sequence. Hydraulic operating systems shall be isolated from other circuits and to be blocked when doors and closing arrangement are in closed/locked position.

3.10.4. Signboards giving instructions to the effect that the doors shall be closed and all the closing devices locked before leaving quay side (or terminal), shall be placed at the operating panel (or for small doors at the door when no operating panel) and on the bridge, and shall be supplemented by warning indicator lights on the panel and on the bridge.

3.10.5. Doors with clear opening area greater than 6 m^2 shall be provided with an arrangement for remote control, from a convenient position above the freeboard deck of:

- The closing and opening of the doors.
- Associated cleats, support and locking devices.

For doors which are required to be equipped with a remote-control arrangement, the open/closed position of the door and every closing device (cleats, support and locking device) shall be indicated at the remote-control station. The operating panel for remote controlled doors is inaccessible to unauthori zed persons.

3.10.6. The requirements given in Sect [3.9] –apply to doors in the boundary of special category spaces or ro-ro spaces, through which such spaces may be flooded. For cargo ships, where no part of the door is below the uppermost waterline and the area of the door opening is not greater than 6 m^2, then the requirements in Sect [3.9] need not be applied.

3.10.7. To indicate that the doors are closed separate indicator lights shall be provided on each operating panel and that their cleats, support and locking devices as applicable are properly positioned. Indication panels shall be provided with a lamp test function. `` On the navigation bridge Separate indicator lights and audible alarms shall be provided to show and monitor that each of the doors is properly positioned and that cleats, support and locking devices as applicable are properly positioned. The indicator system shall show by visual indication if any of the doors are not fully closed and not fully locked and by audible alarms if securing devices become open or locking devices become unsecured.

The indication panel on the navigation bridge shall be equipped with a mode selection function "harbor/sea voyage", so arranged that audible alarm is given on the navigation bridge if the vessel leaves quay side (or terminal) with any side shell or stern door not closed or with any of the cleats, support and locking devices, as applicable, not in the correct position.
When a mechanical lock is placed inside the hydraulic cylinder operating a cleat or support, indication of the open or closed position of the cleat or support shall be made on the lock inside the cylinder.

3.10.8. The indicator and alarm system on the navigation bridge shall be designed on the fail -to-safe principle in compliance with the following:

1) The indication panel shall be provided with:
- a power failure alarm, provided for both power sources
- an earth failure alarm
- a lamp test device
- For each door, separate indications for door closed / not closed, door locked / not locked
- A dimmer (however, it shall not be possible to turn off the indicator lights completely).

2) When more limit switches are provided for each door they may be connected in series. The electrical circuits used for indicating door position shall be normally closed when the door is completely closed and completely open.

3) The electrical circuit used for indicating securing arrangements position shall be normally closed when the securing arrangements are completely locked and completely un-locked. When more limit switches are provided for each door they may be connected in series.

4) Separate circuits shall be arranged for indication of door position (closed / not closed) and for securing arrangements position (locked / not locked). Multicore cable is permitted.

5) In case of dislocation of limit switches, this shall be indicated by not closed / not locked / securing arrangement not in place - as appropriate.

3.10.9. The power supply for indicator and alarm systems shall be independent of the power supply of the operating and closing arrangements and shall be provided with a backup power supply from the emergency source of power or secure power supply, e.g. UPS (Uninterrupted Power Supply) with a minimum capacity of 30 minutes. Sensors for the indicator system shall be protected from water, ice formation and mechanical damage.

3.10.10. In case of passenger ships, a water leakage detection system with audible alarm and also television surveillance shall be arranged to provide an indication to the navigation bridge and to the engine control room of any leakage through the doors.

In case of cargo ships, a water leakage detection system with audible alarm shall be arranged to provide an indication to the navigation bridge.

3.10.11. In case of Ro-Ro passenger ships, the special category spaces and Ro-Ro spaces shall be continuously patrolled or monitored by effective means, such as television surveillance, so that any movement of vehicles in adverse weather conditions and unauthorized access by passengers thereto can be detected whilst the ship is underway.

SECTION 4 HATCHWAY COAMINGS

Contents

4.1. General

4.1.1. Side coamings of hatchways shall extend to lower edge of deck beams. Side coamings not forming part of continuous girders, are below deck to extend two frame spaces beyond the hatch ends.

4.1.2. Hatch end coamings not in line with ordinary deck transverses are below deck to extend at least three longitudinal frame spaces beyond the side coamings.

4.1.3. Continuous hatchway coamings on strength deck shall be made from steel of the same strength group as the deck plating. The same apply to non-continuous coamings effectively supported by longitudinal strength member or being an effective part of the deck girder system.

4.1.4. If the junction of hatch coamings forms a sharp corner, well rounded brackets shall be fitted towards the deck both longitudinally and transversely. The longitudinal brackets shall be welded by full penetration welding. The hatch end beam shall be given a smooth transition to the deck transverse. If the hatch end beam is replaced by a stool tank, this shall be in line with structures outside the hatch.

4.1.5. The web plate of low hatch side coamings shall be stiffened over the entire height at each frame or with a stiffener spacing of about 60 × web thickness. Tripping brackets shall be fitted on every 2nd frame.

4.1.6. Cut-outs in the top of hatch coamings are normally to be avoided. Unavoidable cut-outs shall be circular or elliptical in shape. Local reinforcements should be given a soft transition in the longitudinal direction. Unavoidable cutouts in longitudinal coaming end brackets shall be as small as possible and with edge reinforcement.

4.2. Coaming heights

4.2.1. The minimum height of coamings for hatches with weather tight covers is normally not to be less than:

600 mm in position 1

450 mm in position 2

4.2.2. Manholes and small scuttles with coaming height less than given in [4.2.1]. And flush scuttles may be allowed when they are closed by substantial watertight covers. Unless secured by closely spaced bolts, the covers shall be permanently attached.

4.2.3. Coamings with heights less than given in [4.2.1] may be accepted after special consideration of arrangement and integrity of the vessel. When such acceptance is given, the stiffness of deck girders supporting the covers is given by the following requirement to moment of inertia:

$$\mathrm{I} = \frac{7\ \mathrm{p\ b\ l}^4}{\mathrm{n}_C{}^2\ \mathrm{E}}\ 10^5\ (\mathrm{cm}^4)$$

p = design pressure for deck girder in kN/m^2

b = breadth in m of load area for deck girder

l = total length in m of hatch coaming between supports

n_c = number of cover elements along length *l* of coaming.

4.2.4. Coamings with increased height may be required on ships of type B-100 and B-60 if found necessary by the floatability calculation.

4.3. Scantlings

4.3.1. Hatchway coamings to holds are also intended to carry water ballast or oil in bulk; they must satisfy the requirements for tank bulkheads given in Pt 3 Ch 9.

4.3.2. The scantlings of coamings acting as deck girders shall have to satisfy following requirements in Pt 3 Ch 8.

4.3.3. For hatches with area larger than 12.0 m^2, the plate thickness of hatchway coamings on weather deck shall not be less than 11 mm. For hatches with area less or equal to 12.0 m^2, the plate thickness of the hatchway coamings on weather deck shall not be less than 9.0 mm.

4.3.4. Hatchway coamings of conventional design shall be stiffened by a horizontal section of substantial strength normally not more than 0.25 m from the upper edge of the coaming. Maximum spacing of Coaming brackets shell be 3 m apart. The brackets shall not end on unstiffened plating. The coamings shall be satisfactorily stiffened against buckling.

Remark: *In Position 2, the horizontal stiffening of the upper end of the coaming can normally be omitted for hatches with area less than 1.0* m^2*.*

4.3.5. Stiffeners, brackets and coamings shall be able to withstand the local forces set up by the clamping devices and/or the handling facilities necessary for securing and moving the hatch covers as well as vertical and horizontal mass forces from cargo stowed on the hatch covers, e.g. containers, Refer Ch 6 Sec 5,[5.2.]

4.3.6. The strength of the stiffeners shall also comply with the requirements given in Pt 3 Ch 7 Sec 3. Maximum stiffener spacing is 750 mm

SECTION 5 HATCH COVERS

Contents

5.1. General

5.1.1 The requirements below are valid for steel hatch covers in holds intended for dry cargo, liquid cargo and ballast and for steel hatch covers on weather decks.

5.1.2 Steel hatch covers shall be fitted to hatch openings on weather decks so as to ensure tightness consistent with operational conditions and type of cover and to give effective protection to the cargo in all sea conditions.

5.1.3 Steel hatch covers shall be fitted to openings in watertight decks inside dry cargo holds. The requirements for small access hatches, below 6 m^2 are given in Ch 6 Sec 6.

5.1.4 Requirements for small cargo tank hatch covers used for access and ventilation only, are given in Sec 8.

5.1.5 Materials for steel hatch covers shall satisfy the requirements given for hull material. Other material than steel may be used, provided the strength and stiffness of covers are equivalent to the strength and stiffness of steel covers. For aluminum alloys, Refer Pt 3 Ch 2.

5.1.6 For effective ventilation and gas freeing Tank hatch covers of closed box type construction shall be provided.

5.1.7 Hatch covers shall be mechanically lockable in open position.

5.1.8 Upon completion of installation of hatch covers, a chalk test shall be carried out for tightness.

Remark: *It is recommended that ships with steel hatch covers are supplied with an operation and maintenance manual including:*

- *Opening and closing instructions*
- *maintenance requirements for packing, securing devices and operating items*
- *cleaning instructions for the drainage system*
- *corrosion prevention instructions*
- *List of spare parts.*

5.1.9 The stiffeners and primary supporting members of the hatch covers shall be continuous over the breadth and length of the hatch covers, as far as practical. When this is impractical, sniped end connections shall not be used and appropriate arrangements shall be adopted to ensure sufficient load carrying capacity.

The spacing of primary supporting members parallel to the direction of stiffeners shall not exceed 1/3 of the span of primary supporting members, i.e. between rigid supports. When structural analysis is carried out by finite element analysis, this requirement may be waived.

5.1.10 Corrosion addition shall be included in addition to the minimum scantlings as given in Sect [5.6]. to [5.9]

For hatch covers of cargo holds on weather decks,
If $p = p_1$, the required corrosion addition t_s is given in Ch 6 Sect [5.10.1] Table 6.5.3

In all other cases, the required corrosion addition t_k is given in Pt 3 Ch 2 Sec 4.

5.2. Design loads

5.2.1 All generally applicable lateral loads on hatch covers are given in Table 6.5.1 based upon the general loads given in Pt 3 Ch 4

Table 6.5.1: Design loads

Hatch cover at	Load type	p (kN/m^2)
Weather decks 1)	Sea pressure	p_1 as given in Table 6.5.2) 2) $p_2 = a\left(p_{dp} - (4 + 0.2k_s)h_0\right)$ 3) minimum 5.0
	Deck cargo	$p_3 = (g_0 + 0.5a_v)q$
Cargo 'tweendecks	Deck cargo	$p_4 = \rho_c((g_0 + 0.5a_v)H_C$
Deck as tank top in general	Ballast or liquid cargo	$p_5 = \rho g_0 h_p + \Delta p_{dyn}$ $p_6 = \rho g_0 h_s + p_0$
Deck as tank top in tanks with breadth > 0.4 B	Ballast or liquid cargo	$p_7 = \rho g_0\left[0.67(h_s + \emptyset b) - 0.12\sqrt{H_{tk}\emptyset b_t}\right] + p_V$ 4)
Deck as tank top towards ends of tanks with length > 0.15 L	Ballast or liquid cargo	$p_8 = \rho g_0\left[0.67(h_s + \theta l) - 0.12\sqrt{H_{tk}\emptyset l_t}\right] + p_V$
Deck as tank top in tanks with unrestricted filling and with free breadth bt < 0.56B 5)	Ballast or liquid cargo	$p_9 = \rho\left(3 - \frac{B}{100}\right)b_t + p_V$ 6)
Watertight decks submerged in damaged condition 7)	Sea pressure	$p_{10} = 10\ h_b$

1) On weather decks combination of the design pressures p_2 and p_3 may be required for deck cargo with design stowage height less than 2.3 m.
2)P_1 is required only for ships complying with ICLL.
3) For ships with service restrictions, p_2 may be reduced with the percentages given in Pt 3 Ch 4. C_W should not be reduced.
4) Distribution across hatch: Maximum value at one side linearly reduced to p_V at other side.
5) For tanks with free breadth above 0.56 B the design pressure will be specially considered, Refer Pt 3 Ch 4.
6) Distribution across hatch: Maximum value constant for 0.25 b_t from one side, reduced to p_V elsewhere.
7) The strength may be calculated with allowable stresses for plating, stiffeners and girders increased by 60 F_1.

a = 1.0 for weather decks forward of 0.15 L from FP, or forward of deckhouse front, whichever is the fore most position
= 0.8 for weather decks elsewhere
P_{dp}, k_s = as given in Pt 3 Ch 4.
H_0 = Vertical distance in m from the waterline at draught T to the cover top
a_V = Vertical acceleration as given in Pt 3 Ch 4

q_{do} = deck cargo load in t/m^2, as specified.
ρ_C = dry cargo densities in t/m^3, if not otherwise specified to be taken as 0.7, Refer also Pt 3 Ch 4
ρ = density of ballast, bunker or liquid cargo in t/m^3, normally not to be less than 1.025 (i.e. $\rho\ g_0 \approx 10$)
H_C = stowage height in m of dry cargo. Normally the 'tween deck height or height to top of cargo hatchway to be used.
H_S = Vertical distance in m from the load point to top of tank, excluding smaller hatchways
H_P =Vertical distance in m from the load point to the top of air pipe
h_b =Vertical distance in meters from the load point to the deepest equilibrium waterline in damaged condition obtained from applicable damage stability calculations. The deepest equilibrium waterline in damaged condition should be indicated on the drawing of the deck in question
Δp_{dyn} = As given in Pt 3 Ch 4.
p_0 = 25 in general
= 15 in ballast holds in dry cargo vessels
= p_v, when exceeding the general value
P_V =Pressure valve opening pressure
H_{tk} = height in m of tank
b = the largest athwart ship distance in m from the load point to the tank corner at the top of tank / hold most distant from the load point
b_t = breadth in m of top of tank/hold.
l = the largest longitudinal distance in m from the load point to the tank corner at top of tank most distant from the load point
l_{tt} = Length in m of top of tank
Φ = roll angle in radians as given in Pt 3 Ch 4
θ = pitch angle in radians as given in Pt 3 Ch 4
= breadth in m of top of tank/hold

<table>
<tr><th colspan="3">Table 6.5.2: Sea pressure load p_1 for hatch covers on weather decks, required only for ships complying with ILLC</th></tr>
<tr><td rowspan="2">Position</td><td colspan="2">p_1(kN/m^2)</td></tr>
<tr><td>$\frac{x_F}{L_F} \leq 0.75$</td><td>$0.75 < \frac{x_F}{L_F} \leq 1$</td></tr>
<tr><td rowspan="6">1</td><td colspan="2">for $24\text{m} \leq \text{L}_\text{F} \leq 100$</td></tr>
<tr><td rowspan="2">$\frac{9.81}{76}.(1.5.L_F + 116)$</td><td>On the freeboard deck
$\frac{9.81}{76}.\left[(4.28\,.L_F + 28).\frac{x_F}{L_F} - 1.71.L_F + 95\right]$</td></tr>
<tr><td>upon exposed superstructure decks located at least one standard height of superstructure above the freeboard deck
$\frac{9.81}{76}.(1.5.\text{L}_\text{F} + 116)$</td></tr>
<tr><td colspan="2">for $\text{L}_\text{F} > 100\text{m}$</td></tr>
<tr><td></td><td>on freeboard deck for type B freeboard ships
$9.81.\left[(0.0296\,.L_1 + 3.04).\frac{x_F}{L_F} - 0.0222.L_1 + 1.22\right]$</td></tr>
</table>

	9.81*3.5	on freeboard deck for ships with reduced freeboard $9.81.\left[(0.1452\,.L_1 - 8.52).\frac{x_F}{L_F} - 0.1089.L_1 + 9.89\right]$
		upon exposed superstructure decks located at least one standard height of superstructure above the freeboard deck 9.81*3.5
2	for $24\text{m} \leq \text{L}_\text{F} \leq 100$	
	$\frac{9.81}{76}.(1.1\,.L_F + 87.6)$	
	or $\text{L}_\text{F} > 100m$	
	9.81*2.6	
Other than 1 and 2	9.81*2.1	
$L_F =$ *freeboard length, in m, as given in Pt 3 Ch 1 Sec 2* $X_F =$ *longitudinal co-ordinate of mid length of the hatch cover under consideration measured from aft end of length* L_F *Where two or more panels are connected by hinges, each individual panel shall be considered separately.* *L =* L_F*, but need not be taken greater than 300 m*		

5.2.2 Horizontal loads from cargo stored on hatch covers are given by:

- Total transverse force:

$$P_T = C\ a_t\ \ q\ l_h b_h\ (KN)$$

- Total longitudinal force:

$$P_L = C\ a_l\ \ q\ l_h b_h\ (KN)$$

a_t = Transverse acceleration as given in Pt 3 Ch 4
a_l = Longitudinal acceleration as given in Pt 3 Ch 4
q_{do} = deck cargo load in t/m^2, Refer Sect [5.2.1]Table 6.5.1
l_h = Length of hatch in m
b_h =Breadth of hatch in m
$b_h l_h\ q$ =Total cargo mass (M) on hatch cover in t
C = 0.5 when horizontal forces are combined with vertical forces
C = 0.67 when horizontal forces are considered alone.

If the cargo is secured (lashed etc.) to the deck outside the hatch cover, the horizontal load on covers may be reduced

5.2.3 In addition to the distributed design loads specified in [5.2.1], forces acting on hatch covers from heavy cargo units shall be considered as given in Pt 3, Ch4, Sec 3.5

Deflections and loads due to movements and thermal effects are also to be considered, Refer Sect [6.2.3]

5.2.4 Hatch covers subjected to wheel loading shall satisfy the strength requirements given in Part 7B, Ch 2, Sec 4.4.

5.3. Plating

5.3.1 The thickness corresponding to lateral pressure is given by:

$$t = \frac{15.8 k_a s \sqrt{p}}{\sqrt{\sigma}} F_p + t_c'(mm)$$

p = $p_1 - p_{10}$, whichever is relevant, as given in Table 6.5.1
F_p =1.50 in general for hatch covers on weather decks, when $p = p_1$
$= 2.375 \frac{\sigma_{top}}{\sigma_f}$, for hatch covers on weather decks, when $p = p_1$ and $\frac{\sigma_{top}}{\sigma_f} \geq 0.64$ for the attached plate flange of primary supporting members
= 1.0 in all other cases
$\sigma = 0.95\ \sigma_f\ N/mm^2$ For hatch covers on weather decks, when $p = p_1$
$= 0.58\ \sigma_f\ N/mm^2$ For hatch covers on weather decks, when $p = p_2$ or p_1
$= 0.67 \sigma_f\ N/mm^2$ In all other cases
σ_{top} = Normal stresses of hatch cover top plating in N/mm^2
$t_c' = t_s$ as given in 4.13 in mm, for hatch covers of cargo holds on weather decks, when $p = p_1$
= t_c as given in Pt 3 Ch 2 in mm, in all other cases
σ_f = minimum upper yield stress in N/mm^2. INTLREG-NS-steel may be taken as having

$$\sigma_f = 235 \frac{N}{mm^2}$$

σ_f shall not be taken greater than 70% of the ultimate tensile strength.

5.3.2 The thickness of top plating shall not be less than:

t = $10\,s + t_c'$ (mm), min. $6 + t_c'$ mm.
$t_c' = t_s$ as given in 5.10 in mm, for hatch covers of cargo holds on weather decks
= t_c as given in Pt 3 Ch 2 in mm, in all other cases

5.3.3 The thickness of bottom plating of closed box construction shall not be less than
$t = 5 + t_c'$ mm

$t_c' = t_s$ as given in 5.10. in mm, for hatch covers of cargo holds on weather decks
$= t_c$ as given in Pt 3 Ch 2 in mm, in all other cases.

5.4 Stiffeners

5.4.1 The section modulus is given by:

$$\mathrm{Z} = \frac{1000\, \mathrm{l}^2 \mathrm{spw}_c'}{\mathrm{m}\sigma} \qquad (\mathrm{cm}^3)$$

$p = p_1 - p_{10}$, whichever is relevant, as given in Table 6.5.1
m = 8 for stiffeners simply supported at both ends, or simply supported at one end and fixed at the other end

= 12 for stiffeners fixed at both ends

$\sigma = 0.8\ \sigma_f\ N/mm^2$ For hatch covers on weather decks, when $p = p_1$

$\sigma = 0.58\ \sigma_f\ N/mm^2$ For hatch covers on weather decks, when $p = p_2$ or p_3

$\sigma = 0.67\ \sigma_f\ N/mm^2$ In all other cases.

w_k' to be calculated as w_k based on following corrosion additions:

t_s as given in 4.13. in mm, for hatch covers of cargo holds on weather decks, when $p = p_1$

t_c as given in Pt 3 Ch 2 in mm, in all other cases.

Stiffeners subject to point loads from heavy cargo units Refer [4.3.6] shall be specially considered.

i. The requirements for section modulus and moment of inertia given above are valid for strength members with a constant cross section over the entire span. Design of Covers with gradually reduced Z and I towards the ends of the span shall be so that the maximum bending stresses and deflections are not increased. With a Z-reduction towards ends, the rule section modulus at middle of span shall be multiplied by a factor

$$C_1 = 1 + \frac{3.2\alpha - \beta - 0,8}{7\beta + 0,4}$$

$$\alpha = \frac{l_1}{l_0}$$

$\beta = \frac{Z_1}{Z_0}$

l_1, l_0, Z_1, and Z_0 are given in Figure 6.4.1.

C_1 Shall not be taken less than 1.0.

With an I-reduction towards ends, the rule moment of inertia shall be multiplied by a factor:
$C_2 = 1 + 8\alpha^3 \frac{1-\delta}{0,2+3\sqrt{\delta}}$

$\delta = \frac{I_1}{I_0}$

I_1 And I_0 are given in Figure 6.4.1.

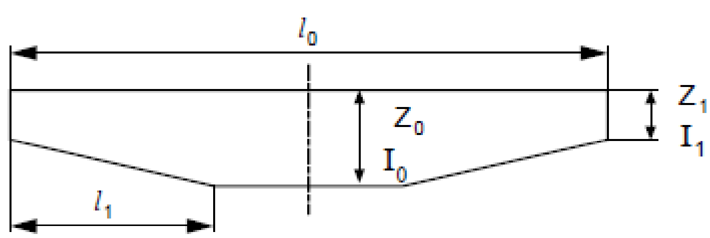


Figure 6.4.1: Hatch cover with variable cross-section

5.4.2 The web area shall not be less than:

$$A = C_3 \left(0.5 - \frac{x}{l}\right) lsp + 10h_{wb}t_k' \qquad (cm^2)$$

C_3 = 0.0925 for hatch covers on weather decks, when $p = p_1$

= 0.14 in all other cases.

x = distance in m from the end of span to section considered, and shall not be taken greater

than 0.25 l

h_{wb} = web height in m

$t_k' = t_s$ as given in 5.10. in mm, for hatch covers of cargo hold on weather decks.

$= t_k$ as given in Pt 3 Ch 2 in mm, in all other cases.

(IACS UI LL20)

5.4.3 The cover edges shall be adequately stiffened to withstand the forces imposed upon them during opening and closing of the hatches. For stiffness of cover edges, Refer [5.6]

5.4.4 Connection area and welding of stiffeners shall be in accordance with Pt 2. For covers above cargo- and ballast tanks, chain or staggered fillet welds on the tank side are not acceptable.

5.4.5 The minimum thickness of web and flange thickness shall be

t $= 5.0 + t_k'$ (mm)

$t_k' = t_s$ as given in 5.10. in mm, for hatch covers of cargo hold on weather decks.

$= t_k$ as given in Pt 3 Ch 2 in mm, in all other cases.

5.5 Girders

5.5.1 When calculating the actual Z for strength members supporting other stiffeners, the effective flange shall be determined in accordance with Pt 3 Ch 3. When the hatch cover is of closed box girder construction, the flange may be taken as 100% effective.

5.5.2 The section modulus and moment of inertia shall not be less than according to the requirement given in [5.4.1], when s is replaced by b.

b = half the sum in m of stiffener span on either side of the girder.

5.5.3 The web area at ends shall not be less than:

$A = 0.5C_3 lbp + 10\ htk'\ \ (cm^2)$

C_3 = as defined in [5.4.3]

b = as defined in [5.5.2]

h = as defined in [5.4.3]

t_k''=t_s as given in [5.4.5] in mm, for hatch covers of cargo holds on weather decks

=t_k as given in Pt 3 Ch 2 in mm, in all other cases.

At each intersection with supported members, A may be reduced by the value $0.5C_3$ s b p towards the middle of the span, s being the distance in m between supported members. A shall not be taken less than 50% of the value at ends. Web plates shall be effectively stiffened against buckling.

5.5.4 Double continuous fillet welds are normally to be used within areas with shear stress greater than75 N/mm^2, and not less than 150 mm from each end of the girder. The throat thickness of the weld attachment between web plates and flanges in these areas is normally not to be less than 0.4 t, where t = web plate thickness.

5.5.5 The breadth of the primary supporting member flange shall not be less than 40% of their depth for laterally unsupported spans greater than 3.0 m. Tripping brackets attached to the flange may be considered as a lateral support for primary supporting members. The flange outstand shall not exceed 15 times the flange thickness.

5.5.6 When structural analysis is carried out by finite element analysis in accordance with , Sect [5.7] requirements in [5.5.2]and Sect [5.5.3] may be waived

5.6 Stiffness of cover edges

5.6.1 To ensure sufficient packing pressure for the whole distance between the securing devices, the moment of inertia of the side elements of the covers shall be at least:

$$I = 6p_l a^4 (cm^4)$$

for cover edges connected to a rigid hatch coaming and

$$I = 12p_l a^4 (cm^4)$$

between cover edges of equal stiffness.

p_l = packing line pressure along edges N/mm^2, minimum 5 N/mm^2

a = spacing in m of bolts or other securing devices.

5.6.2 When determining the moment of inertia of tank cover side elements supporting primary cover stiffening elements between securing devices, the internal pressure in the tank shall be taken into consideration.

5.7 Structural analysis

5.7.1 For hatch covers of special construction or arrangement (e.g. covers constructed as a grillage, covers supported along more than two opposite edges, covers supporting other covers) a separate strength calculation may be required, in which the arrangement of girders and supports is taken into account. This is especially valid for hatch covers in open bulk carriers and combination carriers where deflections are important to tightness.

5.7.2 Load conditions shall be established in accordance with the loads given in [5.2]. For calculations

According to beam theory the following stresses will be accepted:

a) Bending stress:

$\sigma = 0.8\, \sigma_f\ N/mm^2$ For hatch covers on weather decks, when $p = p_1$

$\sigma = 0.8\, \sigma_f\ N/mm^2$ For hatch covers on weather decks, when $p = p_2$ or p_3

$\sigma = 0.8\, \sigma_f N/mm^2$In all other cases

b) Shear stress:

$\tau = 0.46\ \sigma_f N/mm^2$ For hatch covers on weather decks, when $p = p_1$

$\tau = 0.33\ \sigma_f N/mm^2$ For hatch covers on weather decks, when $p = p_2$ or p_3

$\tau = 0.37\ \sigma_f N/mm^2$ In all other cases. σ_f As defined in [5.3]

The sum of girder bending stress and local bending stress in stiffeners being part of the girder shall not exceed $0.8\ \sigma_f\ N/mm^2$

5.8 Buckling Control

5.8.1 Buckling for hatch cover plating with primary supporting members parallel to the direction of stiffeners shall be in accordance with Pt 3 Ch 14. with ψ = 1.0.

Buckling for hatch cover plating with primary supporting members perpendicular to the direction of stiffeners shall be in accordance with Pt 3 Ch 14.

Buckling for stiffeners shall be in accordance with Pt 3 Ch 14.

The critical buckling stress shall be related to the actual compressive stresses as follows:

η = 0.8 for hatch covers on weather decks, when $p = p_1$

= 0.77 for wave induced internal liquid loads and hatch covers on weather decks, when $p = p_2$= 0.87 for other loads

σ_a = actual calculated stress.

The bi-axial compression stress in the hatch cover plating, when calculated by means of finite element analysis, shall comply with the requirements in Pt 3 Ch 14..

5.8.2 For flat bar stiffeners and buckling stiffeners, the ratio h_{stf}/t_w shall not be greater than:

h_{stf} = height of stiffener in mm

t_w = net thickness of stiffener in mm. Corrosion addition given in [5.1.9] shall be considered.

5.8.3 Buckling for web panels of hatch cover primary supporting members shall be in accordance with Pt 3 Ch 14. For primary supporting members parallel to the direction of stiffeners, the actual dimensions of the panels shall be considered. For primary supporting members perpendicular to the direction of stiffeners or for hatch covers built without stiffeners, a presumed square panel of dimension d shall be taken for the determination of the stress τ_c. In such a case, the average stress τ between the values calculated at the ends of this panel shall be considered. The critical buckling stress shall be related to the actual shear stresses as follows:

$$\tau_c \geq \frac{\tau_a}{\eta} \quad (N/mm^2)$$

$\eta\ =\ 0.8\ for$ hatch covers on weather decks, when $p = p_1$

= 0.85 in all other cases

τ_a = actual calculated stress.

5.9 Deflection limit and connections between hatch cover panels

5.9.1 Load bearing connections between the hatch cover panels shall be fitted with the purpose of restricting the relative vertical displacements.
For hatch covers on weather decks, when $p = p_1$, the vertical deflection of primary supporting members shall not be more than 0.0056 l, where l is the greatest span of primary supporting members.

5.10 Corrosion addition and steel renewal

5.10.1 The corrosion allowance t_s for hatch covers of cargo holds on weather decks, when $p = p_1$, is given in table 6.5.3

Table 6.5.3: Corrosion additions ts for hatch covers of cargo holds on weather decks, when $\mathbf{p = p_1}$

Application	*Structure*	*t_s (mm)*
Weather deck hatches of Bulk Carriers, Ore Carriers and Combination Carriers	Single skin hatch covers, for all plating and stiffeners	2.0
	Double skin hatch covers, for top and bottom plating	2.0
	Double skin hatch covers, for the internal structure.	1.5
Weather deck hatches of cellular cargo holds intended for containers	Hatch covers, for all plating and stiffeners	1.0
Weather deck hatches of all other ship types	Single skin hatch covers, for all plating and stiffeners	2.0
	Double skin hatch covers, for top and bottom plating	1.5
	Double skin hatch covers, for the internal structure	1.0

The net thickness, t_{net}, is the thickness necessary to obtain the net minimum scantlings as given in 4 [5.3] to [5.9]. For single skin hatch covers and for the plating of double skin hatch covers, steel renewal is required where the gauged thickness is less than $t_{net} + 0.5\,mm$

Where the gauged thickness is within the range $t_{net} + 0.5\,mm$ and $t_{net} + 1.0 mm$, coating (applied in accordance with the coating manufacturer's requirements) or annual gauging maybe adopted as an alternative to steel renewal. Coating shall be maintained in good condition, as defined Pt 1. For the internal structure of double skin hatch covers, thickness gauging is required when hatch cover top or bottom plating renewal is to be carried out or when this is deemed necessary, at the discretion of the Society Surveyor, on the basis of the plating corrosion or deformation condition. In these cases, steel renewal for the internal structures is required where the gauged thickness is less than: t_{net}. For corrosion addition $t_s = 1.0\,mm$, it is assumed that the thickness for steel renewal is t_{net}, and the thickness for coating or annual gauging is: $t_{net} + 0.5\,mm$

SECTION 6 HATCHWAY TIGHTNESS ARRANGEMENT AND CLOSING DEVICES

Contents

6.1. General

6.1.1 The requirements below are valid for steel hatch covers in dry cargo holds, on weather decks and above tanks, with ordinary packing arrangement between hatch cover and coaming, and packing arranged for vertical packing pressure in joints between cover elements. Other packing arrangements will be specially considered.

6.1.2 Closing of hatches by portable hatch beams, covers and tarpaulins will be specially considered.

6.1.3 Packing and drainage arrangements of hatch covers for cargoes which are not sensitive to moisture from small leakages may be specially considered.

6.2. Design and tightness requirements

6.2.1 The weight of covers and any cargo stowed thereon, together with inertial forces generated by ship motions, shall be transmitted to the ship structure through steel to steel contact. This may be achieved by continuous steel to steel contact of the cover skirt plate with the ships structure or by means of defined bearing pads. A proper alignment between coaming and cover is very important in this respect.

6.2.2 The sealing shall be obtained by a continuous gasket of relatively soft, elastic material compressed to achieve the necessary weather tightness. Similar sealing shall be arranged between cross-joint elements. Where fitted, compression flat bars or angles shall be well rounded where in contact with the gasket and shall be made of a corrosion-resistant material.

6.2.3 Special consideration shall be given to the gasket and securing arrangements in ships with large relative movements between cover and ship structure or between cover elements. For such ships, relative deflections both in the vertical and the horizontal planes should be calculated and submitted with the hatch cover plans. Also vertical deflections due to thermal effects and internal pressure loads shall be considered. For ships with large deck openings as defined in Pt 3 Ch 5, the torsional deformation of the hatch opening shall be calculated based on a torsional moment

$$M_t = M_{ST} + M_{WT}$$

M_{ST}, M_{WT} as given in Pt.7B

The necessary compression of the gasket to obtain sufficient sealing shall be estimated on the basis of the vertical deflections calculated, including building/installation tolerances, seen in relation to results from compression/ leakage tests performed.

6.2.4 It is assumed that the gasket material and any gluing material used in gasket junctions or to fasten the gasket to the cover are of a quality suitable for all environmental conditions likely to be experienced by the ship, and are compatible with the cargoes carried. The material and form of gasket selected shall be considered in conjunction with the type of cover, the securing arrangement and the expected relative movement between cover and ship structure. The gasket shall be effectively secured to the cover.

6.2.5 There shall be a metallic contact between hatch cover and hull (earthing connection). If necessary, this shall be achieved by a special connection.

Remarks

1) As practical limits for the hatch opening horizontal deformations in ships with hatch openings less than given in Pt 3 Ch 5 (calculated with rule design loads) are indicated:

- *single amplitude diagonal deformation: l_d/1000*
- *bending deflection of coamings: l_c/1000*

l_d = length of hatch opening diagonal

l_c = length of side or end coaming.

2) *Deflections due to temperature differences should be checked, especially for closed (double-skin) hatch cover pontoons. The deflections should be calculated both for hot cargo (80°C) and cold air (–5°C) resulting in upward bending of pontoon corners, and for hot air (60°C) and cold cargo (0°C) resulting in upward bending of middle of pontoon and pontoon edges. Securing devices shall be given sufficient strength and pre-tension to reduce deflections to acceptable figures. Designing the pontoons as open panels (one continuous plate flange only) will normally reduce the temperature deflections effectively. Combination of loads and deflections should be based on a consideration of the probability of simultaneous occurrence.*

3) *Laboratory compression tests should be performed on test panels arranged for observing leakage for various combinations of internal liquid pressure and compression of gasket. By this a minimum compression/internal pressure curve for no leakage may be obtained. Necessary compression of gaskets may thus be estimated by adding minimum compression to maximum vertical deflections calculated.*

6.3. Securing devices in general

6.3.1 Panel hatch covers on weather decks above dry cargo holds or on top of deep tanks are in general to be secured by appropriate devices (bolts, wedges or similar) suitably spaced alongside the coamings and between cover elements. Arrangement and spacing shall be determined with due attention to the effectiveness for tightness, depending upon the type and the size of the hatch cover, as well as the stiffness of the cover edges between the securing devices, Refer [5.6]. Scantlings of securing devices are given in [5.4] to [5.7].

6.3.2 Securing means of other material than mild steel or other means than bolts shall be of strength equivalent to the requirements given in [5.4] to [5.7], and so arranged that the correct pressure on the packing between the covers and the coamings, and adjacent covers as well, is obtained. Bolts with nuts, wedges and other parts for securing the covers, shall be of reliable construction and securely attached to the hatchway coamings, decks or covers. The individual securing elements shall have approximately the same deflection characteristics. Bolts and adjusting screws shall be secured in position by appropriate means. Where rod cleats are fitted, resilient washers or cushions shall be incorporated. Where hydraulic cleating is applied, the system shall remain mechanically locked in closed position in the event of failure of the hydraulic system.

6.3.3 Spare securing elements shall be kept on board; the number depending on the total number fitted, as well as type of element, special material used, etc.

6.4. Securing arrangement for weather tight hatch covers

6.4.1 Ordinary packed hatch covers shall be secured to the coaming by a net bolt area for each bolt not less than:

$$A = \frac{1.4a}{f_{1e}} \quad (cm^2)$$

a = spacing of bolts in m

$$f_{1e} = \left(\frac{\sigma_f}{235}\right)^e$$

σ_f= minimum upper yield stress in N/mm², not to be taken greater than 70% of the ultimate tensile strength.

e = 0.75 for $\sigma_f > 235$

= 1.0 for $\sigma_f > 235$

6.4.2 Between cover and coaming and at cross-joints, a packing line pressure sufficient to obtain weather tightness shall be maintained by a bolt area as given in [5.4.1].

6.4.3 For packing line pressures exceeding 5 N/mm² the area shall be increased accordingly. The packing line pressure shall be specified.

6.4.4 The net bolt diameter shall not be less than 19 mm for hatchways exceeding 5 m² in area.

6.4.5 Closing appliances of covers to hatches on exposed decks (position 1 and 2) where reduced coaming heights are accepted Refer [4.2] will be specially considered. In this case each cover element shall be equipped with at least 2 securing devices along each side, and the maximum distance shall not exceed $\mathrm{a}_{\max} = 2.5\ \mathrm{meters}$.

6.5. Securing arrangement for deep tank or cargo oil tank hatch covers

6.5.1 In addition to the requirements given in [5.4], deep tank or cargo oil tank hatch covers have to fulfill the following requirements.

The net securing bolt area for each bolt shall not be less than

$$A = \frac{0.08a}{f_{1e}}(0.5lp + p_l) \quad (\mathrm{cm}^2)$$

a = spacing of bolts in m

l = span in m of hatch cover girder or stiffener perpendicular to coaming, if any — or distance from

cover edge to the first parallel stiffener

p =$p_4 - p_9$, whichever is relevant, as given in Table 6.5.1

$p_l =$ packing line pressure in N/mm². For calculation purpose, however, the packing pressure shall not be taken less than 5 N/mm²

$f_{1e} =$ As given in [5.4.1]

6.5.2 Between cover elements the packing line pressure shall be maintained by a net bolt area for each bolt not less than:

$$A = \frac{3a}{f_{1e}} \quad (\mathrm{cm}^2)$$

a = spacing of bolts in m.

Corrections to be applied as given in Sect [5.4.3] and [5.4.4]

6.5.3 Covers particularly calculated, as mentioned in Ch 6 Sect [5.7] shall be fitted with closing devices corresponding to the reaction forces found by the calculation. The maximum tension in way of threads of bolts shall not exceed $125 f_{1e} N/mm^2$ **.** The maximum stresses in closing devices of other types than bolts are:

- Normal stress: $\sigma = 120 f_{1e} N/mm^2$
- Shear stress: $\tau = 80 f_{1e} N/mm^2$
- Equivalent stress:

$$\sigma_e = \sqrt{\sigma^2 + 3\tau^2} = 150 f_{1e}\ N/mm^2.$$

Remarks *In order to satisfy the tightness requirements the following design recommendations are given:*

1) *The horizontal distance between the gaskets and the securing devices should be as small as possible.*
2) *Securing devices should be arranged as close to the panel corners as possible.*
3) *Securing devices with a vertical clearance (passive cleating) should be avoided, i.e. active cleating with a certain pre- tension should be used.*

6.6. Securing arrangement for hatch covers carrying deck cargo

6.6.1 In addition to the requirements given in [5.4] or [5.5], all hatch covers, especially that carrying deck cargo shall be effectively secured against horizontal shifting due to the horizontal forces given in Sect ,[5.2.2] which may be reduced by 10% due to friction. The maximum allowable stresses in stoppers are as given in Sect [5.5.3].

6.6.2 To prevent damage to hatch covers and ship structure, the location of stoppers shall be compatible with the relative movements between hatch covers and ship structure. The number of stoppers shall be as small as possible, preferably only one stopper at each end of each cover element. In case of twin hatches supported by a narrow box girder at center-line, two-way stopper at outboard coaming may be required.

6.6.3 Towards the ends of the ship vertical acceleration forces may exceed the gravity force. The resulting lifting forces must be considered when dimensioning the securing devices. Also lifting forces from cargo secured on the hatch cover during rolling shall be taken into account. The allowable stresses in bolts and other types of securing devices are as given in Sect [5.5.3].

6.6.4 Hatch coamings and supporting structure shall be adequately stiffened to accommodate the loading from hatch covers.

6.6.5 At cross-joints of multi-panel covers vertical guides (male/female) shall be fitted to prevent excessive relative vertical deflections between loaded/unloaded panels

6.7. Securing arrangement for hatch covers in watertight decks

6.7.1 Allowable stresses for securing devices in hatch covers, submerged in damaged condition, are as follows:

Normal stress: $\sigma = 165 f_1 N/mm^2$

Shear stress: $\tau = 110 f_1 N/mm^2$

Equivalent stress: $\sigma_e = \sqrt{\sigma^2 + 3\tau^2} = 200 f_{1e} N/mm^2$

Remark: *The number of securing devices is generally to be the minimum practical whilst taking into account the deflection of the hatch coaming and the available space for adequate support in the surrounding hull structure, which may limit the size of each device.*

6.7.2 For hatches covers, opening contrary to pressure side, and which becomes immersed by equilibrium or intermediate water plane in damaged condition, the deflections of the hatch coaming have to be documented to not affect the watertight capacity. The structural analysis has to include the flexibility of the surrounding structure, Refer also [5.2.3]. Test to be made according to Ch 6 Sec 1, .[1.5]

6.8. Drainage arrangement

6.8.1 On weather deck hatch covers drainage shall be arranged inside the line of gasket by means of a gutter bar or vertical extension of the hatch side and end coaming.

6.8.2 Drain openings shall be arranged at the ends of drain channels and shall be provided with effective means for preventing ingress of water from outside, such as non-return valves or equivalent.

6.8.3 Cross-joints of multi-panel covers shall be arranged with drainage of water from the space above the gasket and a drainage channel below the gasket.

6.8.4 If a continuous outer steel contact between cover and ship structure is arranged, drainage from the space between the steel contact and the gasket is also to be provided for.

SECTION 7 INTERNAL DOORS AND HATCHES FOR WATERTIGHT INTEGRITY

Contents

7.1. General

7.1.1 General requirements for internal openings in connection with watertight integrity are given in Pt 3 Ch 3. For pipe tunnel openings, Refer also Pt 3 Ch 6. A requirement for watertight hatches greater than 6 m^2 is given in Sec 5.

7.1.2 Watertight doors or hatches may be of the following types:

- Hatches or hinged doors, dividing cargo spaces, should be of an approved type with mechanical securing devices and may be fitted tween decks in respective positions. Such doors shall not be used where remote control is required. Hinged doors for passage shall be of quick acting or single acting type. Indications for open or closed shall be fitted on the bridge.

  (Ref. IACS UI SC156, table 1)

- rolling doors supported by steel rollers having mechanical or hydraulic securing devices
- Sliding doors moving along and supported by track-way grooves with mechanical locking due to taper and friction. A force which is positive shall be required to re-open the doors. These are operated only by hand or both power and hand operated. Sliding doors shall have an indication (i.e., a red light) placed locally on both sides showing that the door is in the remote control mode. Signboards and instructions shall be placed in way of the door and instructions can be made how to act when the door is in the "door closed" mode. Passenger areas and areas which are of noise producing, audible alarms shall be provided by visual signals on both sides of the door.

7.2 Operation

7.2.1 All watertight doors and access hatches shall be operable from both sides of the bulkhead or deck.

7.2.2 Remotely controlled doors are also to be locally operable. Indicators will be provided at the position control to indicate whether the doors are closed or open.

7.3 Strength

7.3.1 Watertight doors and hatches should be designed with strength equal to that of the structure in which they are positioned. They shall withstand the design pressure from both sides.

7.3.2 The thickness corresponding to lateral pressure is given by:

$$t = ck_a s\sqrt{p\,k} + t_c \ (mm)$$

p = design pressure as given in Pt 3 Ch 9

c = 1.58 for collision bulkhead

= 1.35 for all other bulkheads and decks.

The thickness should not be less than the minimum bulkhead thickness.

7.3.3 The stiffener section modulus requirement is given by:

$$Z = c_1 l^2 s\, p\, w_k k \ (cm^3)$$

p = as given in Sect [6.3.2]

c_1 = 0.8 For collision bulkhead

= 0.6 for all other bulkheads and decks.

7.3.4 Edge stiffeners of doors should have a moment of inertia not less than:

$$I = 8p_e d^4 (cm^4)$$

d = distance between closing devices in m, to be measured along the edge of the door.

p_e = Packing line pressure along edges, not to be taken less than 5 N/mm

$= p_b$, whichever is the greater

p = design pressure p_1 as given in Pt 3 Ch 9

b = load breadth, normally taken as h/3 or w/2, whichever is the less.

h and w are height and width of door in meters. The coaming of watertight doors (door frame) should be designed with the necessary stiffeners in order to avoid large deflections results in leakage in the damaged condition.

7.3.5 The structural analysis has to include the flexibility of the surrounding structure. Test to be made according to Ch 6 Sect [1.5.4]. Door frame should not have groove at bottom in which dirt might struck and prevent it from closing properly.

7.3.6 Securing devices shall be designed for the acting load also on the opposite side of where they are positioned. Allowable stresses in securing devices are as follows:

Normal stress: $\sigma = 165 f_1 N/mm^2$

Shear stress: $\tau = 110 f_1 N/mm^2$

Equivalent stress: $\sigma_e = \sqrt{\sigma^2 + 3\tau^2} = 200 f_1 N/mm^2$

SECTION 8 VENTILATORS

Contents

8.1. Coamings and closing arrangements

8.1.1 1) Ventilators in position 1 or 2 to spaces below freeboard deck or decks of enclosed superstructures should have coamings of steel or any equal material, substantially constructed and efficiently connected to the deck. When the coamings of any ventilators exceed 900 mm in height it shall be specially supported.

2) Superstructures having ventilators pass through other than enclosed superstructures should have substantially constructed coamings of steel or any other equivalent material at the freeboard deck.

3) Ventilators in position 1 the coamings of which extend to more than 4.5 meters above the deck, and in position 2 the coamings of which extend to more than 2.3 meters above the deck need not be fitted with closing arrangements unless specifically required by the Society.

4) Except as provided in (3) openings of ventilator should be provided with efficient weather tight closing appliances. In ships of length less than 100 meters in length the closing appliances shall be permanently attached; where not so provided in other ships, they shall be conveniently stowed near the ventilators to which they shall be fitted. Ventilators in position 1 shall have coamings of a height of at least 900 mm above the deck; in position 2 the coamings shall be of a height of at least 760 mm above the deck.

5) In exposed positions, the height of coamings may be required to be increased to the satisfaction of the Society. Reduced coaming height may be accepted for vessels trading in domestic waters only, on special consideration.

8.2. Thickness of coamings

8.2.1 The thickness of ventilator coamings shall not be less than given in the following table:

Location	External diameter in mm	Wall thickness in mm
Position 1 and 2	≤ 80	6.0
	≥ 165	8.5
Above Position 2	≤ 155	4.5
	≥ 230	6.0

For intermediate external diameter the wall thickness is obtained by linear interpolation.

8.3. Arrangement and support

8.3.1 Where required by ~~,~~Sect [8.1.1] weather tight closing appliances for all ventilators in positions 1 and 2 shall be of steel or other equivalent materials. Wood plugs and canvas covers are not acceptable in these positions

8.3.2 The deck plating in way of deck openings for ventilator coamings shall be of sufficient thickness, and efficiently stiffened between ordinary beams or longitudinal. Coamings with heights exceeding 900 mm shall be additionally supported.

8.3.3 Where ventilators are proposed to be led overboard in an enclosed superstructure deck house or shipside the closing arrangement shall be submitted for approval. If such ventilators are lead overboard more than 4.5 m above the freeboard deck, closing appliances may be omitted, provided that satisfactory baffles and drainage arrangements are provided.

8.3.4 Ventilators necessary to continuously supply the machinery space shall have coamings of sufficient height to comply with sect [8.1.1](3}, without having to fit weather tight closing appliances. Ventilators necessary to continuously supply the emergency generator room, if it is considered buoyant in the stability calculation, or protecting openings leading below shall have coamings of sufficient height to comply with [8.1.1](3), without having to fit weather tight closing appliances. Alternatively, depending on vessel's size and arrangement, lesser coaming heights may be accepted if weathertight closing appliances are provided, in accordance with Sect[8.1.1]. and in combination with suitable means arranged to ensure uninterrupted and adequate supply of air to these spaces.

8.3.5 The height of ventilators may be required to be increased depending on where these flooding points are in relation to the damaged stability calculation.

Remark: *The term suitable means is meant e.g. that direct and sufficient supply of air is provided through open skylights, hatches or doors at a higher level than the heights required by .[8.1.1]*

8.4. Strength requirements for fore deck ventilators

8.4.1 For vessels with L > 80 m:

The ventilators located on the exposed deck over the forward 0.25 L, where the height of the exposed deck in way of the item is less than 0.1 L or 22 m above the summer load waterline, whichever is the lesser, shall comply with the requirements given in [8.4.2] to [8.4.8]

(IACS UR S 27)

8.4.2 The pressures p, in kN/m² acting on ventilator pipes and their closing devices to be calculated from: $p = 0.5\rho\, {V_w}^2 C_D C_S C_P$

Where:

$\rho =$ density of sea water (1.025 t/m³)

V_w = velocity of water over the fore deck = 13.5 m/sec for $d \leq 0.5\, d_1$

$= 13.5\sqrt{2\left(1-\frac{d}{d_1}\right)}$ m/sec for $0.5\, d_1 < d < d_1$

d = distance from summer load line to exposed deck

d_1 = 0.1 L or 22m whichever is the lesser

$C_D =$ shape coefficient:

0.5 for pipes, 1.3 for ventilator heads in general,

0.8 for an air pipe or ventilator head of cylindrical form with its axis in the vertical direction

$C_S =$ Slamming coefficient (3.2)

$C_P =$ Protection coefficient:

0.7 For pipes and ventilator heads located immediately behind a breakwater or forecastle,

1.0 Elsewhere and immediately behind a bulwark.

8.4.3 Forces acting in the horizontal direction on the pipe and its closing device may be calculated from [8.4.2] using the largest projected area of each component.

8.4.4 Bending moments and stresses in ventilator pipes should be calculated at critical positions: at penetration pieces, at flange or weld connections, at toes of supporting brackets. Bending stresses in the net section should not exceed 0.8 σ_y, where σ_y is the specified minimum yield stress or 0.2% proof stress of the steel at room temperature. Irrespective of corrosion protection, a corrosion addition to the net section of 2.0 mm is then to be applied.

8.4.5 For ventilators which are of standard 900 mm height closed by heads of not more than the tabulated projected area, pipe thicknesses and bracket heights are specified in Table 6.7.1 Where brackets are required, three or more radial brackets shall be fitted. Brackets shall be of gross thickness 8 mm or more, of minimum length 100 mm, and height according to Table 6.7.1 but need not extend over the joint flange for the head. Brackets toes at the deck shall be suitably supported.

8.4.6 For ventilators of height greater than 900 mm, brackets or alternative means of support shall be fitted according to the requirements in [8.3.2]Pipe thickness shall not be taken less than as required in .[8.2.1]

8.4.7 All component parts and connections of the ventilator shall be capable of withstanding the loads defined in [8.4.2]

8.4.8 Rotating type mushroom ventilator heads are unsuitable for application in the areas defined in . [8.4.1]

(IACS UR S27)

Table 6.7.1. 900 mm ventilator pipe thickness and bracket standards

Nominal pipe diameter (mm)	Minimum fitted gross thickness, LL36(c) (mm)	Maximum projected area of head (cm2)	Height of brackets (mm)
80A	6.3	-	460
100A	7.0	-	380
150A	8.5	-	300
200A	8.5	550	-
250A	8.5	880	-
300A	8.5	1200	-
350A	8.5	2000	-
400A	8.5	2700	-
450A	8.5	3300	-
500A	8.5	4000	-

Note: *For other ventilator heights, the relevant requirements of 7.4.1 to 7.4.7 shall be applied.*

SECTION 9 TANK ACCESS, ULLAGE AND VENTILATION OPENINGS

Contents

9.1. General

9.1.1 The number of hatchways and other openings in the tank deck should not be larger than necessary for reasonable access to and ventilation of each compartment.

9.1.2 Hatchways, openings for ventilation, ullage plugs or sighting ports, etc. shall not be placed in enclosed compartments where there is a danger of accumulation of gases. Ullage plugs or sighting ports should be fitted as high above the deck as practicable, for instance in the cover of access hatches. Access hatches to holds or other openings, for example for tank cleaning devices, shall be of substantial construction, and may be arranged in the main hatch covers.

9.2. Hatchways

9.2.1 The hatch coaming thickness should not be less than given in Pt 3 Ch 10 for a deckhouse in the same position.

9.2.2 The thickness of covers should not be less than:

- 12.5 mm for cover area exceeding 0.5 m^2
- 10mm for cover area less than 0.25 m^2.

For intermediate areas the thickness may be linearly varied.

9.2.3 When the area of the hatchway tends to exceed 1.25$m^{2,}$ the covers shall be stiffened.

9.2.4 Covers should be secured to the hatch coamings by fastening spaced not greater than 380 mm apart and not greater than 250 mm from the corners. For circular covers the fastenings should not be spaced more than 450 mm apart.

9.2.5 Other types of covers may be approved, provided their construction is considered satisfactory.

9.3. Air Pipes

9.3.1 When air pipes to ballast and other tanks extend above the freeboard or superstructure decks, the exposed parts of the pipes shall be of considerable construction; the height from the deck to the point where water may have access below should be at least 760 mm on the freeboard deck and 450 mm on the superstructure deck. Where these heights may interfere with the working of the ship, a lower height may be taken approved, provided the Society is satisfied that the closing arrangements and other circumstances justify a lower height. Satisfactory means permanently attached, shall be provided for closing the openings of the air pipes. (Ref.ICLL Reg.20)

9.3.2 Air pipes shall be provided with automatic closing appliances.

(Ref.ICLL Reg.20 (3))

9.3.3 Pressure- vacuum valves (PV valves) may be accepted on tankers. Wooden plugs and trailing canvas hoses should not be accepted in position 1 and position 2.

Note: The members Societies in formulating this interpretation realize that pressure-vacuum valves (PV valves) presently installed on tankers do not theoretically provide complete water tightness. In view, however, of experience of this type of valve and the position in which they are normally fitted it was considered they could be accepted.

(Ref. IACS UI LL 49)

9.3.4 The thickness of air pipe coamings in steel other than stainless should not be less than given in the following table:

Location	External diameter in mm	Wall thickness in mm
Position 1 and 2	≤ 80	6.0
	≥ 165	8.5
Above Position 2	≤ 155	4.5
	≥ 230	6.0

For intermediate external diameter the wall thickness is obtained by linear interpolation. Coamings with heights exceeding 900 mm shall be additionally supported.

(IACS UI LL 36)

9.3.5 Above the deck the thickness of air pipe coamings made of stainless steel shall not be less than given in the following table:

External diameter in mm	Wall thickness in mm
$d \leq 60$	2.7
$60 < d \leq 120$	3.0
$120 < d \leq 200$	3.4
$200 < d \leq 250$	3.7
$250 < d \leq 300$	4.1
$300 < d \leq 350$	4.5
$350 < d \leq 500$	4.7
$d > 500$	5.5
Note: *The external diameters and thickness have been selected from ANSI B36*.19M Schedule 10S.For pipes covered by other standards, thickness slightly less may be accepted.	

9.3.6 In cases where air pipes are led through the side of superstructures, the height of their openings to be at least 2.3 m above the summer water line. Automatic vent heads of approved design shall be provided.

9.3.7 The height of air pipes may be required to increase on ships of type "A", type "B-100" and type "B- 60" where it is shown to be necessary by the calculation of floatability.

9.3.8 The automatic closing appliances are to be permanently attached and of detailed design. The closing appliances should be so constructed that damage to the tanks by over pumping or occasionally possible vacuum by discharging is prevented.

9.3.9 All air pipes in cargo spaces shall be well protected.

9.3.10 For arrangement and size of air pipes.Refer Pt. 5A Ch.9 Sec. 5.

9.4. Strength requirements for fore deck air pipes

9.4.1 For vessels with L > 80 m:

The air pipes located on the exposed deck over the forward 0.25 L, where the height of the exposed deck in way of the item is less than 0.1 L or 22 m above the summer load waterline, whichever is the lesser, shall comply with the requirements given in [8.4.2] to [8.4.7].

For tankers:

The requirements given in [8.4.2] to [8.4.7] are not applicable for cargo tank venting systems and the inert gas systems.

9.4.2 The pressures p, in kN/m^2 acting on air pipes and their closing devices shall be calculated from:

$$p = 0.5\rho\, V^2 C_D C_S C_P$$

$\rho =$ density of sea water (1.025 t/m^3)

V= velocity of water over the fore deck = 13.5 m/sec for $d \le 0.5\ d_1$

$= 13.5\sqrt{2\left(1-\frac{d}{d_1}\right)}$ m/sec for $0.5\ d_1 < d < d_1$

d = distance from summer load line to exposed deck

d_1 = 0.1 L or 22m whichever is the lesser

$C_D =$ shape coefficient:

0.5 for pipes, 1.3 for ventilator heads in general,

0.8 for an air pipe or ventilator head of cylindrical form with its axis in the vertical direction

$C_S =$ slamming coefficient (3.2)

$C_P =$protection coefficient:

0.7 for pipes and ventilator heads located immediately behind a breakwater or forecastle,

1.0 elsewhere and immediately behind a bulwark

9.4.3 Forces acting in the horizontal direction on the pipe and its closing device may be calculated from 8.4.2 using the largest projected area of each component.

9.4.4 Bending moments and internal stresses in air pipes should be calculated at critical positions: at penetration pieces, at flange or weld connections, at toes of supporting brackets. Stresses which are bending in the net section should not exceed $0.8\sigma_y$, where σ_y is the specified minimum yield stress or 0.2% proof stress of the steel at room temperature. Irrespective of corrosion protection, a corrosion addition to the net section of 2.0 mm is then to be applied.

9.4.5 For air pipes standard of 760 mm height closed by heads of not greater than the tabulated projected area, pipe thicknesses and bracket heights are specified in Table 6.8.1. Where brackets are required, three or more radial brackets shall be fitted. Brackets which should be of gross thickness 8 mm or more, of minimum length 100 mm, and height according to Table 6.8.1. but need not extend over the joint flange for the head. Bracket toes at the deck should be suitably supported.

9.4.6 For other configurations, loads according to [8.4.2] should be applied, and means of support determined in order to comply with the requirements of [8.4.4]. Brackets, where fitted, should be of suitable thickness and length according to their height. Pipe thickness should not be taken less than as required in [8.3.4].

9.4.7 All component parts and connections of the air pipe should be capable of withstanding the loads defined in [8.4.2]. (IACS UR S 27)

Table 6.8.1: 760 mm air pipe thickness and bracket standards

Nominal pipe diameter (mm)	Minimum fitted gross thickness, LL36(c) (mm)	Maximum projected area of head (cm^2)	Height 1) of brackets (mm)
40A 3)	6.0	_	520
50A 3)	6.0	_	520
65A	6.0	--	480
80A	6.3	--	460
100A	7.0	--	380
125A	7.8	--	300
150A	8.5	---	300
175A	8.5	--	300
200A	8.5 2)	1900	300 2)
250A	8.5 2)	2500	300 2)
300A	8.5 2)	3200	300 2)
350A	8.5 2)	3800	300 2)
400A	8.5 2)	4500	300 2)

1) Brackets Refer [8.4.5] need not extend over the joint flange for the head.

2) Brackets are required where the as fitted (gross) thickness is less than 10.5 mm, or where the tabulated projected area is exceeded.

3) For minimum permitted internal diameter, Rfer Pt. 5A Ch.9 Sec. 5.

***Note:** For other air pipe heights, the relevant requirements of [8.4.1] to [8.4.7] shall be applied.*

SECTION 10 MACHINERY SPACE OPENINGS

Contents

10.1. Openings

10.1.1 Machinery openings space in positions 1 or 2 should be properly framed and efficiently enclosed by steel casings of greater strength capability, and where the casings are not protected by other structures their strength should be specially considered. Access openings in such casings should be fitted with doors complying with the requirements of Ch 6 Sec 2, [2.1.1], the sills of which should have at least 600 mm above the deck level in position 1, and have at least 380 mm above the deck if in position 2. Openings in casings should be fitted with equivalent covers, permanently attached in their proper positions.

10.1.2 Coamings of any machinery space ventilator in an exposed position should be in accordance with Ch 6 Sec 8 [8.3.4]

10.1.3 When casings are not protected by other structures, double doors should be required for ships assigned free-boards less than those based on Table B in the ICLL. An inner sill of 230 mm in conjunction with the outer sill of 600 mm should be provided.

10.1.4 Engine Doorways and boiler casings should be arranged in positions which afford the greatest possible protection.

10.1.5 Fixed or opening skylights should have a glass thickness appropriate to their size and position as required for side scuttles and windows. Skylight glasses in any position should be protected from mechanical damage and, where fitted in position 1 or 2, should be provided with permanently attached deadlights or storm covers.

For skylights in position 1 or 2 the coaming height should not be less than given for hatchway coamings. For skylights in position 1, deadlights should be fitted.

10.1.6 Side scuttles in engine casing should be provided with fireproof glass.

SECTION 11 SCUPPERS, INLETS AND DISCHARGES

Contents

11.1. Inlets and discharges

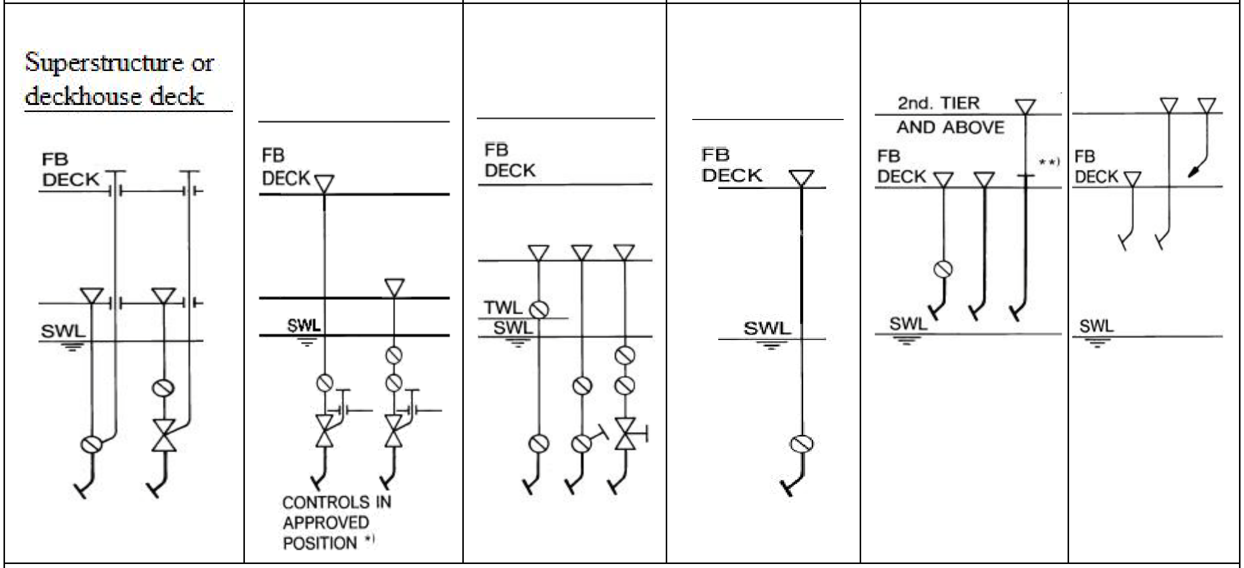
11.1.1 Discharges led through the shell either from spaces below the freeboard deck or from within superstructures and deckhouses on the freeboard deck fitted with doors complying with the requirements of Ch 6 Sec 2,[2.1.1] shall be fitted with efficient and accessible means for preventing water from passing inboard. Normally each separate discharge shall have one automatic non-return valve with a positive means of closing it from a position above the freeboard deck. Where, however, the vertical distance from the summer load waterline to the inboard end of the discharge pipe exceeds 0.01 L, the discharge may have two automatic non-return valves without positive means of closing, provided that the inboard valve is always accessible for examination under service conditions; where that vertical distance exceeds 0.02 L a single automatic non return valve without positive means of closing may be accepted subject to the approval of the Society. The means for operating the positive action valve shall be readily accessible and provided with an indicator showing whether the valve is open or closed.

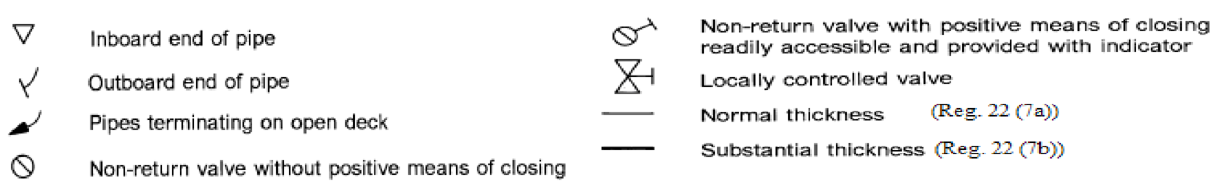
All shell fittings, and the valves required by this Rule shall be of steel, bronze or other approved ductile material. Valves of ordinary cast iron or similar material are not acceptable. All pipes to which this Rule refers shall be of steel or other equivalent material to the satisfaction of the Society, Refer Pt 2, Ch 2 Sec 17 and Sec 18

11.1.2 It is considered that the position of the inboard end of discharges should be related to the timber summer load waterline when timber freeboard is assigned.

Table 6.11.1: Acceptable arrangements of discharges with inboard ends

Discharges coming from below the freeboard deck or enclosed spaces above the freeboard deck***)				Discharges coming from other spaces	
General requirements (Reg.22 (1))	Discharges through machinery space	Alternatives where inboard end is		Outboard end > 450 mm below FB DECK or < 600 mm above SWL (Reg.22(4))	Otherwise Reg.22(5)
		> 0.01 × L above SWL	> 0.02 × L above SWL		





*) *The control shall be so sited as to allow adequate time for operation in case of influx of water to the space having regard to the time which could be taken to reach and operate such controls*
**) *Substantial pipe thickness from the shell and up to the freeboard deck and in cases further up in closed superstructure to a height at least 600 mm above the summer water line*
***) *The table takes into account both the requirements of ICLL Reg. 22 & SOLAS Ch.II-1 Reg. 15*
****) *References: ICLL regulation*

11.1.3 For vessels subject to SOLAS requirements each discharge led through the shell plating from spaces below the freeboard deck is to be provided with either one automatic non-return valve with positive means of closing it from above the freeboard deck or two automatic non-return valves, where the inboard valve must always be accessible under service conditions. Where a valve with positive means of closing is fitted. The operating position above the freeboard deck shall always be readily accessible and means shall be provided for Indicating whether the valve is open or closed.

11.1.4 It is considered that an acceptable equivalent to one automatic non-return valve with a positive means of closing from a position above the freeboard deck would be one automatic non-return valve and one sluice valve controlled from above the freeboard deck. Where two automatic non-return valves are required, the inboard valve must always be accessible under service conditions, i.e., the inboard valve should be above the level of the tropical load water line. If this is not practicable, then, provided a locally controlled sluice valve is interposed between the two automatic non-return valves, the inboard valve need not to be fitted above the SWL. Where sanitary discharges and scuppers lead overboard through the shell in way of machinery spaces, the fitting to shell of a locally operated positive closing valve, together with a non-return valve inboard, is considered to provide protection equivalent to the requirements of Sect 11.1.1] It is considered that the requirements of Sect [11.1.1] for non-return valves are applicable only to those discharges which remain open during the normal operation of a vessel. For discharges which must necessarily be closed at sea, such as gravity drains from topside ballast tanks, a single screw down valve operated from the deck is considered to provide efficient protection. The inboard end of a gravity discharge which leads overboard from an enclosed superstructure or space shall be located above the water line formed by a 5 degree heel, to port or starboard, at a draught corresponding to the assigned summer freeboard. It is considered that the position of the inboard end of discharges should be related to the timber summer load waterline when timber freeboard is assigned. Refer . Table 6.11.1 For the acceptable arrangement of scuppers, inlets, and discharges.

~~11.1.5~~ Discharges with inboard opening located lower than the ship's uppermost load line may be accepted when a loop of the pipe is arranged between the inboard opening and the outlet in hull. The top of the loop shall be regarded as the position of the inboard opening, and the pipeline shall be provided with valves according to Table 6.11.1

11.1.6 Discharges from spaces above the freeboard deck shall be of steel or material especially resistant to corrosion.

11.1.7 Adequate protection shall be provided to protect valves or pipes from being damaged by cargo, etc.

11.1.8 Plastic pipes may be used for sanitary discharges and scuppers as permitted.

11.1.9 The portion of discharge line from the shell to the first valve as well as shell fittings and valves shall be of steel, bronze or other approved ductile material.

11.1.10 In manned machinery spaces main and auxiliary sea inlets and discharges in connection with the operation of machinery may be controlled locally. The controls shall be readily accessible and shall be provided with indicators showing whether the valves are open or closed.

11.1.11 Scuppers and discharge pipes originating at any level and penetrating the shell either more than 450 millimeters below the freeboard deck or less than 600 millimeters above the summer load waterline shall be provided with a non-return valve at the shell. This valve, unless required by [11.1.1] May be omitted if the piping is of substantial thickness.

11.2. Pipe thickness

11.2.1 The wall thickness of steel piping between hull plating and closeable or non-return valve shall not be less than given in Table 6.11.2 below

Table 6.11.2: Wall thickness of steel piping

External diameter in mm	Wall thickness in mm
≤ 80	7.0
=180	10.0
≥ 220	12.5

For intermediate external diameter the wall thickness is obtained by linear interpolation.

For wall thickness of distance piece for discharge coming from an inert gas scrubber, Refer Pt 7B

11.2.2 The wall thickness of steel piping inboard of the valve shall not be less than given in Table 6.11.3

Table 6.11.3: Wall thickness of steel piping

External diameter in mm	Wall thickness in mm
≤ 155	4.5
≥ 230	6.0

For intermediate external diameter the wall thickness is obtained by linear interpolation.

11.3. Scuppers

11.3.1 A sufficient number of scuppers, arranged to provide effective drainage, shall be fitted on all decks.

11.3.2 Scuppers on weather portions of decks and scuppers leading from superstructures or deckhouses not fitted with doors complying with Sect [2.1.1] shall be led overboard.

11.3.3 led through the shell from enclosed superstructures used for the carriage of cargo shall be permitted only where the edge of the freeboard deck is not immersed when the ship heels 5 degrees either way. In other cases the drainage shall be led inboard in accordance with the requirements of the International Convention for the Safety of Life at Sea in force.

11.3.4 Scuppers led through the deck or shell, shall comply with requirements to material and thickness as given for discharges.

11.3.5 Scupper pipes shall be well stayed to prevent any vibrations. However, sufficient possibility for expansion of the pipes to be provided when necessary.

11.3.6 Scuppers from spaces below the freeboard deck or spaces within closed superstructures, may be led to bilges.

11.3.7 Scuppers leading overboard from spaces mentioned in [11.3.6], shall comply with the requirements given for discharges. Scuppers from exposed superstructure deck, led through the ship's sides and not having closeable valves, shall have wall thickness as required in .[11.2.1] and 11.2.2]

11.3.8 Gravity discharges from top wing tanks may be arranged. The drop valves shall be of substantial construction and of ductile material, and they shall be closeable from an always accessible position. It shall be possible to blank- flange the discharge or to lock the valves in closed position when the tanks are used for carrying cargo. The thickness of the pipe or box leading from the tank through the shell shall comply with the requirements given for discharges.

11.3.9 Drainage from refrigerated cargo spaces shall comply with the requirements for class notation **RM**. Drain pipes from other compartments shall not be led to the bilges in refrigerated chambers.

11.3.10 Drainage from helicopter decks shall comply with the requirements for the class notation **HELDK-S**.

11.4. Periodically unmanned machinery space

11.4.1 The location of the controls of any valve serving a sea inlet, a discharge below the waterline or a bilge injection system shall be so sited as to allow adequate time for operation in case of influx of water to the space, having regard to the time likely to be required in order to reach and operate such controls. If the level to which the space could become flooded with the ship in the fully loaded condition so requires, arrangements shall be made to operate the controls from a position above such level. (SOLAS Ch. II-1/48.3)

11.4.2 If it can be documented by calculation of filling time that the water level is not above the tank top floor after 10 minutes from the initiation of the uppermost bilge level alarm, it will be accepted that the valves are operated from the tank top floor.

Remark: *Various Flag Administrations have worked out their own interpretations of this regulation.*

11.5. Garbage chutes

11.5.1 Two gate valves controlled from the working deck of the chute instead of the non-return valve with a positive means of closing from a position above the freeboard deck which comply with the following requirements are acceptable:

a) The lower gate valve shall be controlled from a position above the freeboard deck. An interlock system between the two valves shall be arranged;

b) The inboard end shall be located above the waterline formed by an 8.5° heel to port or starboard at a draft corresponding to the assigned summer freeboard, but not less than 1.000 mm above the summer waterline. Where the inboard end exceeds 0.01L above the summer waterline, valve control from the freeboard deck is not required, provided the inboard gate valve is always accessible under service conditions; and

c) Alternatively, the upper and lower gate valves may be replaced by a hinged weathertight cover at the inboard end of the chute together with a discharge flap. The cover and flap shall be arranged with an interlock so that the discharge flap cannot be operated until the hopper cover is closed.

11.5.2 The entire chute, including the cover, shall be constructed of material of substantial thickness. This implies that the entire chute is to be of at least equivalent strength as the hull it is penetrating.

11.5.3 The controls for the gate valves and/or hinged covers shall be clearly marked: "Keep closed when not in use".

11.5.4 Where the inboard end of the chute is below the freeboard deck of a passenger ship or the equilibrium waterlines of a cargo ship to which damage stability requirements apply, then:

a) the inboard end hinged cover/valve shall be watertight;

b) The valve shall be a screw-down non-return valve fitted in an easily accessible position above the deepest load line; and

c) The screw-down non-return valve shall be controlled from a position above the bulkhead deck and provided with open/closed indicators. The valve control shall be clearly marked: "Keep closed when not in use"

11.6. Spurling pipes and cable lockers

11.6.1 Spurling pipes and cable lockers shall be watertight up to the deck exposed to weather.

11.6.2 Where means of access are provided, they shall be closed by a substantial cover and secured by closely spaced bolts.

11.6.3 Spurling pipes through which anchor cables are led shall be provided with permanently attached closing appliances to minimize water ingress. (ICLL Reg. 22-2)

SECTION 12 SIDE SCUTTLES, WINDOWS AND SKYLIGHTS

Contents

12.1. Application and General requirements

12.1.1 The requirements in this section apply to side scuttles, windows and skylights located on the shell, external bulkheads of “superstructures and deckhouses” and weather decks of ship structures.

12.1.2 The section gives requirements for the arrangement and strength of the glass and frame structure of items in 101 together with methods of securing the glass to the frames.

12.1.3 Side scuttles and windows together with their glasses, deadlights and storm covers, if fitted, shall be of an approved design and substantial construction. Non-metallic frames are not acceptable.

Remark: *Deadlights are fitted to the inside of windows and side scuttles while 'storm covers' are fitted to the outside of windows, where accessible, and may be hinged or portable.*

12.1.4 Side scuttles and windows made and tested according to ISO 1751 (1993) for side scuttles and ISO 3903 (1993) for windows, with glass according to ISO21005 (2004) and glass tested and marked according to ISO 614 (1989) will normally be accepted. The same applies to national standards equivalent to the ISO-standards.

12.1.5 Window designs which:

a) are not covered by a recognized standard or a type approval certificate, or

b) have dimensions greater than the largest standard dimensions in ISO 3903 will be subject to testing as described in Sect [12.8.1]

12.1.6 The glass panes of windows and side scuttles shall be made either by single pane toughened safety glass or laminated toughened safety glass. Toughened safety glass shall be made according to ISO 21005.

12.1.7 Laminated toughened safety glass shall be bonded over its entire mating surfaces by an adhesive

12.2. Definitions

12.2.1 Side scuttles are defined as being round or oval openings with an area not exceeding 0.16 m^2. Round or oval openings having areas exceeding 0.16 m^2 shall be treated as windows.

12.2.2 Windows are defined as being rectangular openings generally, having a radius at each corner relative to the window size and round or oval, openings with an area exceeding 0.16 m^2.

12.2.3 The 1st tier is normally that tier which is situated directly above the freeboard deck. However, where there is an excess in freeboard, the tier directly over the weather deck can be defined as an upper tier. It is recommended that “excess in freeboard” be that which exceeds the minimum tabular freeboard by more than one Standard tier height of the superstructure.

12.3. Document requirements

Documentation requirements			
Object	*Documentation type*	*Additional description*	*Info*
Windows	Windows	Glass type and thickness, mounting frame design, window arrangement plan	AP

12.4. Arrangement and positioning

12.4.1 Side scuttles to the following spaces should be fitted with hinged inside deadlights:

a) The spaces below freeboard deck.

b) The spaces within the first tier of enclosed superstructures.

c) First tier deckhouses on the freeboard deck protecting openings leading below or considered buoyant in stability calculations.

12.4.2 Deadlights should be capable of being closed and secured watertight if fitted below the freeboard deck and to be weather tight when fitted above freeboard deck

12.4.3 Side scuttles shall not be fitted in a position that their sills are below a line drawn parallel to the freeboard deck at side and having its lowest point 2.5 percent of the breadth B, or 500 mm, whichever is the greatest distance above or greater than the summer load line (or timber summer load line if assigned).

12.4.4 If required damage calculations indicate that side scuttles would become immersed in any intermediate stage of flooding or the final equilibrium waterlines they shall be of the non-opening type.

12.4.5 Windows shall not be fitted in the following locations:

a) below the freeboard deck

b) In the first-tier end bulkheads or sides of enclosed superstructures

c) In first tier deckhouses that are considered buoyant in the stability calculations.

12.4.6 Side scuttles and windows at the side shell in the second tier shall be provided with hinged inside deadlights capable of being closed and secured weathertight if the superstructure protects direct access to an opening leading below or is considered buoyant in the stability calculations.

12.4.7 Side scuttles and windows in side bulkheads set inboard from the side shell in the second tier, which protecting direct access below to spaces listed in paragraph (4), shall be provided with either hinged inside deadlights or, where they are accessible, permanently attached external storm covers which are capable of being closed and secured weathertight.

12.4.8 bulkheads and doors in the second tier and above separating side scuttles and windows from a direct access leading below or the second tier considered buoyant in the stability calculations, may be accepted in place of deadlights or storm covers fitted to the side scuttles and windows.

12.4.9 Deckhouses situated on a raised quarter deck or on the deck of a superstructure of less than standard height, may be regarded as being in the second tier as far as the requirements for deadlights are concerned, provided the height of the raised quarter deck or superstructure is equal to or greater than the standard quarter deck height.

12.4.10 Fixed or opening skylights shall have glass thickness appropriate to their size and position as required for side scuttles and windows. Skylight glasses in any position shall be protected from mechanical damage and where fitted in positions 1 or 2, shall be provided with permanently attached deadlights or storm covers.

Remark: *Deviation for the fitting of deadlights may be accepted for vessels trading in domestic waters only*

12.5. Design loads

12.5.1 The design pressure p on side scuttles and windows should be calculated as per Pt.3 Ch 10 or Pt 3 Ch 7 Sec 5.1 when located in a position where bow impact is applicable.

12.5.2 For windows and side scuttles located on the 2nd tier and below, the minimum design pressure shall be taken as described in ISO 5779 and ISO 5780 respectively.

12.5.3 Windows and side scuttles, as per 104, subjected to larger design pressure than given in ISO 5779 and ISO 5789 respectively, need to be tested according to requirements given in L800.

12.5.4 For windows in sides and aft ends of deck houses located 1.7 C_W (m) or more above SWL the design load need not be taken larger than 2.5 kN/m^2. When calculating Cw, L shall not be taken less than 100 m.

Cw = wave coefficient as given in Pt 3, Ch 4, Sec 2.2

12.5.5 When windows are allowed on exposed front bulkheads on the weather deck, the design pressure of exposed front bulkhead on 1st tier shall be used for the calculation of the required **glass thickness.**

12.6.1 **Glass thickness**

The required glass thickness of single pane windows and side scuttles can be calculated from the following formulae:

Side scuttles: $t = \frac{N_s}{362}\sqrt{p}$

Windows: $t = \frac{b}{200}\sqrt{\beta p}$

N_s = nominal diameter/light opening of side scuttle in mm

b = the minor dimension of the window in mm

β = factor obtained from the graph in Figure . **6.11.1**

p = design load in $k\ N/m^2$

t = glass thickness in mm

The thickness of windows shall not be less than:

- 8 mm for windows with area less than 1.0 m^2
- 10 mm for windows of 1.0m^2 or more.
- For windows with design load as per Sect [12.5.4], minimum thickness is 6.0 mm for windows with area less than 1.0 m^2 and 8.0 mm for windows of 1.0 m^2 or more.

12.6.2 For laminated safety glass, the total required thickness will need to be increased in accordance with the following formula:

$$t_e = \sqrt{t_1^2 + t_2^2 + \cdots + t_n^2 \geq t}$$

where;

n = number of laminates

t_1 to t_n = Thickness of each glass in the laminate

t_e = equivalent thickness of laminated toughened safety glass.

The minimum thickness however for any glass pane layer shall not be less than 4 mm.

12.6.3 The thickness of the glass panes may be reduced from that calculated by Sect [12.6.1] or [12.6.2], provided that testing, as per,[Sect [12.8] is done. The requirements to minimum thicknesses in 601 or 602 shall be followed in any case.

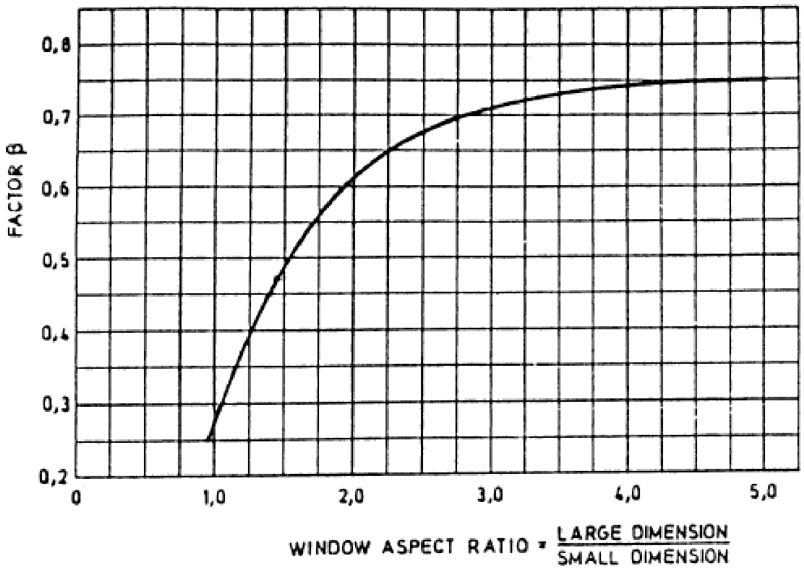


Figure 6.11.1: Diagram for factor β for windows

12.7. Mounting frame design

12.7.1 Metallic frames may be bolted or welded to the ship structure. The distance of the screws used for fastening the metal frames to the ship structure should be not more than 100 mm.

12.7.2 The stress levels in all load carrying members of the frame shall not exceed 60% of the yield strength of the material, under the design pressure. Thickness of metal frames should not be less than 5 mm.

12.7.3 The overlap between the glass pane and the mounting frame shall be at least b/75 (mm) and not to be less than 10 mm.

12.7.4 Glass panes can be fastened to the mounting frames by mechanical means or by adhesive bonding.

12.7.5 When adhesive bonding is used to secure the glass panes to the retaining frame the following rules should be followed:

1) The arrangement of the adhesive bond shall be such to prevent tension forces in the adhesive.
2) The weight of the glass pane shall be supported at the lower edge by stiffening arrangement. For inclined windows, additional supporting is necessary at the top or sides also.
3) The adhesive used shall be suitable for marine use and type approved.
4) Adhesive bonding in windows on fire rated A or B boundaries, shall have low flame spread properties as per IMO FTP code.
5) The adhesive bonding shall be protected from UV-light exposure, water and high and low temperatures. A sealing compound is normally to be used for this reason.
6) Mechanical fastening is to be provided to keep glass panes in place, in case of adhesive bonding failure.

7) The width of the adhesive bond shall not be less than:

$$d = \frac{b \cdot p}{2000 \cdot \sigma_t}$$

d = width of adhesive bond (mm)
b = the length of the smaller side of the light opening of a rectangular window (mm)
p = design load
σ_t = allowable tensile stress for the adhesive (MPa), taken as the stress at 12.5% strain.

8) The thickness of the adhesive shall not be smaller than:

$$t_{sdh} = 1.5 \cdot l \cdot 10^{-3}$$

t_{adh} = thickness of adhesive (mm)

l = length of the longer side of the light opening of a rectangular window (mm)

t_{adh} shall not be smaller than 6 mm and need not be larger than d/2.

12.8. Testing requirements

12.8.1 Where testing is required by the rules for window designs, the window manufacturer shall verify the strength as described in [12.8.2], [12.8.3] A test report shall be provided describing the following:

- description of test setup, including drawing of window and attachment to frame,
- test parameters, including load applied, temperature, duration of load application
- results.

Remark: *One test can be used to cover a range of window sizes, e.g. if the largest window size is selected for testing among windows subjected to similar load.*

12.8.2

1) During testing the glass pane shall be fixed to the window frame with an arrangement similar to that onboard the vessel.

2) The test pressure shall be uniform and at least four times that of the design load p as given in.Sect [12.5]
3) Load shall be applied for at least 10 minutes.
4) Test will be considered successful if
- no visible damage to the glass and the retaining frame occurs
- no leakage occurs.

12.8.3 In case of laminated windows, the ambient test temperature should not be below 25°C.

12.8.4 A hose test as per acceptable standards shall be performed after installation to verify the weathertight performance of the window.

SECTION 13 FREEING PORTS

Contents

13.1. Definitions

13.1.1 Where bulwarks on the weather portions of freeboard or superstructure decks form wells, ample provision should be made for rapidly freeing the water on decks for draining purpose.

13.2. Freeing port area

13.2.1 Except as provided in ,[13.2.2]and [13.2.3] the minimum freeing port area (A) on each side of the ship for each well on the freeboard deck should be that given by the following formula in cases where the sheer in way of the well is standard or greater than standard. The minimum area for each well on deck of superstructure should be one-half of the area given by the formula. Where the length of bulwark(l) in the well is 20 meters or less:

$\mathrm{A} = 0.7 + 0.035\ \mathrm{l}\ (\text{square meters}).$

where l exceeds 20 meters:

$\mathrm{A} = 0.07\ \mathrm{l}\ (\text{square meters}).$

l need in no case be taken as greater than 0.7 L.

If the bulwark is more than 1.2 meters in average height the area required must be increased by 0.004 square meters per meter of length of well for each 0.1 meter difference in height. If the bulwark is less than 0.9 meter in average height, the area required may be decreased by 0.004 square meters per meter of length of well for each 0.1 meter difference in height.

13.2.2 In ships with no sheer the area calculated according to [13.2.1] should be increased by percentage of 50. When the sheer is less than the standard the percentage should be obtained by interpolation technique of linear method.

13.2.3 Where a ship fitted with a trunk which not consider with the requirements of ICLL Regulations 36 (1)(e) or where continuous or substantially continuous hatchway side coaming are fitted between detached superstructures the minimum area or area which is to be there of the freeing port openings should be calculated from the following table:

Molded Breadth of hatchway or trunk in relation to the breadth of ship	Area of freeing ports in relation to the total are of the bulwarks
40% or less	20%
75% or more	10%

The area of freeing ports at intermediate breadths shall be obtained by linear interpolation.

13.2.4 In ships having superstructures which are open at either or both ends to wells formed by bulwarks on the open deck, adequate provision for freeing the open spaces are to be provided as follows:

The freeing port area, A_w for the open well:

$$A_w = (0.07\ l_w + A_c)(S_c)\left(\frac{0.5h_s}{h_w}\right)$$

The freeing port area, A_s for the open superstructure: $\mathrm{l_t}$ is more than 20 m:

$$A_w = (0.07\ l_t)(S_c)\left(\frac{b_0}{l_t}\left(1-\frac{l_w^2}{l_t^2}\right)\right)\left(\frac{0.5h_s}{h_w}\right)$$

$\mathrm{l_t}$ is 20 meters or less:

$$A_w = (0.7 + 0.035\, l_t)(S_c)\left(\frac{b_0}{l_t}\left(1 - \frac{l_w^2}{l_t^2}\right)\right)\left(\frac{0.5h_s}{h_w}\right)$$

l_t = The length of the open deck enclosed by bulwarks in meters

l_{css} = The length of the common space within the open superstructure, in meters

$l_t = l_w + l_s$

S_C = sheer correction factor, max 1.5 as defined in [13.2.2]

b_o = Breadth of openings in the end bulkhead of the superstructure, in meters

h_w = Distance of the well deck above the freeboard deck, in meters

h_s = One standard superstructure height

h_b = Height of bulwark (not to be taken as greater than h_s)

A_C = Bulwark height correction factor taken as;

= 0 for bulwarks between 0.9 and 1.2 m in height

= $0.04 l_w (h_b - 1.2) m^2$ for bulwarks of height greater than 1.2 m.

= $0.04 l_w (h_b - 0.9) m^2$ for bulwarks of height less than 0.9 m

13.2.5 Gutter bars which are more than 300 mm in height fitted all around the weather decks of tankers should be treated as bulwarks and freeing ports arranged as required by this section. Closures for use during loading and discharge operations are to be arranged in such a way that jamming should not occur while at sea.

Remark: *Reduced freeing port area may be accepted for vessels trading in domestic waters only subject to approval of the Society.*

13.3. Location and protection of openings

13.3.1 The lower edges of the freeing ports should be as near the deck as practicable. Two-thirds of the freeing port area required should be provided in the half of the well nearest the lowest point of the sheer curve.

13.3.2 All freeing ports are supported with bars and rails spacing given approximate of 230mm apart. If shutters are fitted to freeing ports, ample clearance should be provided to prevent jamming. Hinges should have pins or bearings of non-corrosion material. If shutters are fitted with securing appliances, these appliances should be of approved construction.

13.4. Multiple wells

13.4.1 On a flush deck ship with a substantial deckhouse amidships it is considered that the deckhouse provides sufficient break to form two wells and that each could be given the required freeing port area based upon the length of the well. It would be unallowed to base the area upon 0.7 L.

In defining a substantial deckhouse it is suggested that the breadth of the deckhouse should be at least 80% of the beam of the vessel, and that the passageways along the side of the ship should not exceed 1.5 m in width.

Where a screen bulkhead is fitted completely across the vessel, at the forward end of a midship deckhouse, this would effectively divide the exposed deck into wells and no limitation on the breadth of the deckhouse is considered necessary in this case.

It is considered that wells on raised quarterdecks should be treated as previously, i.e. as being on freeboard decks. With zero or little sheer on the exposed freeboard deck or an exposed super structure deck it is considered that the freeing port area should be spread along the length of the well.

13.5. Free flow area

13.5.1 The effectiveness of the freeing area in bulwarks required by [13.2.1] and [13.2.2] depends on free flow across the deck of a ship. Where there is no free flow due to the presence of a continuous trunk or hatchway coaming, the freeing area in bulwarks is calculated in accordance with [13.2.3].

The free flow area on deck is the net area of gaps between hatchways, and between hatchways and superstructures and deckhouses up to the actual height of the bulwark.
The freeing port area in bulwarks should be assessed in relation to the net flow area as follows:

(i) If the free flow area is not less than freeing as if hatch way coamings were continuous, then the minimum freeing port area calculated from [13.2.1] and [13.2.2]. should be deemed sufficient.

(ii) If the free flow area is equal to, or less than the area calculated from [13.2.1] and [13.2.2] minimum freeing area in the bulwarks should be determined from [13.2.3]

(iii) If the free flow area is smaller than calculated from [13.2.3] but greater than calculated from [13.2.1] and [13.2.2], the minimum freeing area in the bulwark should be determined from the following formula:

$$F = F_1 + F_2 - f_p (m^2)$$

F_1 = the minimum freeing area calculated from [13.2.1 and 13.2.2],

F_2 = the minimum freeing area calculated from [13.2.3],

f_p = the total net area of passages and gaps between hatch ends and superstructures or deckhouses up to the actual height of bulwark.

13.6. Type A, B-100 and B-60 ships

13.6.1 Requirements for freeing arrangements for Type A ships are given in [13.1].

13.6.2 Type B-100 ships with bulwarks should have open rails fitted for at least half the length of the exposed parts of the weather deck or a freeing port area, in the lower part of the bulwarks, of 33% of the total area of the bulwarks. For Type B-60 ships there should be freeing port area in the lower part of the bulwarks equal to at least 25% of the total area of the bulwarks.

SECTION 14 SPECIAL REQUIREMENTS FOR TYPE A SHIPS

Contents

14.1. Machinery casings

14.1.1 For Type A ships Machinery casings shall be protected by an enclosed poop or bridge of at least standard height, or by a deckhouse of equal height and equal strength provided that machinery casings may be exposed if there are no openings giving direct access from the freeboard deck to the machinery space. A door complying with the requirements of Ch 6 Sec 2, [2.1.1]. may, however, be permitted in the machinery casing, provided that it leads to a space or passageway which is as strongly constructed as the casing and is separated from the stairway to the engine room by a second weather tight door of steel or other equivalent material.

14.2. Gangway and access

14.2.1 An efficiently constructed forward and after permanent gangway of sufficient strength should be fitted on Type A ships at the level of the superstructure deck between the poop and the midship bridge or deckhouse where fitted, or equivalent means of access should be provided to carry out the importance of the gangway, such as passages below deck. Elsewhere, and on Type A ships not having a midship bridge, arrangements to the satisfaction of the Society should be provided to safe the crew and passengers in reaching all parts used in the necessary work of the ship,

14.2.2 Safe and satisfactory access from the level of the gangway should be available between separately for accommodation of the crew and also between crew accommodations and the machinery space.

14.3. Hatchways

14.3.1 Hatchways exposed on the freeboard and forecastle decks or on the tops of expansion trunks on Type A ships should be provided with efficient watertight covers of steel or other equal material.

14.4. Freeing arrangements

14.4.1 A ship with bulwarks should have rails open fitted for a minimum half the length of the exposed parts of the weather deck or a freeing port area, in the lower part of the bulwarks, of 33% of the total area of the bulwarks. The upper edge of the sheer strake should be kept as low as practicable.

14.4.2 When superstructures are connected by trunks, open rails should be fitted for the entire length of the exposed parts of the freeboard deck.

SECTION 15 RETRACTABLE BOTTOM EQUIPMENT

Contents

15.1. Introduction

15.1.1 The requirements are valid for below ships fitted with bottom equipment (e.g. hydro acoustic equipment, retractable thrusters, etc.) that is lowered through the bottom of the ship below the lower turn of the bilge.

15.2. Arrangement

15.2.1 Equipment which is to be lowered from the bottom of the ship should be fitted in a separate watertight compartment of limited volume to reduce the effect of flooding. Floatability and Stability calculations showing that, with the ship fully loaded to summer draught on even keel, flooding of the compartment in which the bottom equipment is fitted will not result in:

- any other compartments flooded
- an unacceptable loss of stability
- damage to equipment vital for safe operation of the ship.

15.2.2 The compartment where the bottom equipment is located should have a bilge system audible high-water level alarm being set off in the engine control room.

15.2.3 Door leading into the compartment should be watertight. A watertight sliding door is normally to be fitted. A hinged door is however accepted if opening into the compartment where the bottom equipment is located. A signboard stipulating that the door is not to be left open shall be fitted.

15.3. Design loads and allowable stresses

15.3.1 The strength of the structure supporting for retractable thrusters should be based on resulting loads acting during operation of the thrusters in various positions and in stowed position.

15.3.2 The supporting structure for retractable hydro acoustic equipment should be able to resist maximum bending moment from the shaft, to which the equipment is mounted. Maximum bending moment from the shaft should be taken as the moment causing local yield stress in the shaft. Arrangements other than based on retractable shaft will be specially considered, based on loads specified by the designer.

15.3.3 For the above load conditions the allowable stresses are the following:

Normal stresses: $160 f_1 N/mm^2$

Shear stresses: $90 f_1 N/mm^2$.

SECTION 16 BOX COOLERS

Contents

16.1. Introduction

16.1.1 The requirements below are valid for ships fitted with box coolers. They are normally installed between shell plating and tank top of the ship.

16.2. Arrangement

16.2.1 As far as practicable, the box coolers should be fitted in a separate watertight compartment. If not, the requirements in item [16.2.2] to 16.2.6] have to be complied with When the box coolers can be dismounted inwards, into the ship hull, an independent securing device for the box coolers is to be arranged, in addition to the bolt arrangement.

16.2.2 The box cooler should be bolted to a separate mounting flange. The thickness of the flange should be at least 1.25 times the depth of the bolt hole in the flange.

Remark: *The bolt grade is normally not to be higher than 8.8.*

16.2.3 The flange which is mounted should be welded to the hull with double continuous fillet weld with minimum throat thickness of 10 mm.

16.2.4 Gaskets should be of a quality suitable for sea water exposure.

16.2.5 The dimension of the bolts should be minimum M16.

16.2.6 Longitudinal strength should be specially considered in way of cut outs for box coolers. Detail design of cut outs for box coolers should be specially considered in order to reduce stress concentrations.

For corners of the cut-outs the radius should not be less than:

r = 0.1 b (m)

b = the greatest dimension of the of opening (m).

The radius need not be taken greater than 200mm

16.2.7 An insert plate shall be fitted in way of cut outs in shell plating. The thickness of the insert plate shall not be less than

$$t = 1.25\, t_s\ (mm)$$

t_s = Thickness of shell plate (mm).

16.2.8 The breadth of the remaining plate strip between adjacent cut outs is not to be less than 100 mm, and the length of the opening is not to be greater than 1000 mm.

16.2.9 The thickness of the plate to which the box coolers are fitted shall not be less than

$$t = 10 + \sqrt{l}\ (\,mm)$$

l= distance from free edge of plate in mm, to the nearest floor or support.

This thickness shall extend 100 mm beyond nearest floor or support.

16.2.10 The thickness of the dividing plates between the box coolers shall not be less than:

t = 20 s (mm)

s = stiffener spacing (m).

16.2.11 The thickness of floors in way of the cut outs for box coolers shall be calculated according to requirements for sea chest boundaries, as given in Pt 3, Ch 6, Sec 3.5

CHAPTER 7 CORROSION PREVENTION

CONTENTS

SECTION 1 CORROSION PREVENTION SYSTEMS

Contents

1.1 General

1.1.1 All surfaces of including ballast tanks, excluding other holds and tanks should be protected against corrosion by coating of suitable composition.

1.2 Documentation requirements for corrosion protection

1.2.1 Documentation should be submitted as required by Table 7.1.1

Table 7.1.1: Documentation requirements

Object	*Documentation type*	*Additional description*	*For approval (AP) or For information (FI)*
Fastening of sacrificial anodes in liquid cargo tanks	Detailed drawing	Tanks for cargo with flash point below 60°C, and adjacent tanks	AP
Fastening of sacrificial anodes in ballast tanks	Detailed drawing		AP
Sacrificial anodes in ballast Tanks	Cathodic protection specification, calculation and drawing		FI
	Arrangement plan		AP

1.3 Corrosion prevention of dedicated seawater ballast tanks

1.3.1 All sea water ballast tanks should have an efficient corrosion prevention system, as required by SOLAS Reg. II-1/3-2.

Remark: *The attending surveyor of the Society will not verify the application of the coatings but will go through review the reports of the coating inspectors to verify that the specified shipyard coating procedures have been followed.*

1.4 Coatings

1.4.1 Shop primers application over areas which will subsequently be welded, should be approved by the Society.

1.4.2 The use of aluminum coatings containing greater than 10% aluminum by weight in the dry film is prohibited in cargo tanks, cargo tank deck area, pump rooms, cofferdams or any other area where cargo vapor may accumulate.

1.4.3 Aluminized pipes may be permitted in ballast tanks, in inerted cargo tanks and, provided the pipes are protected from accidental impact, in hazardous areas on open deck.

1.5 Cathodic protection

1.5.1 All anodes should be attached to the structure shall be securely fastened both initially and during service. Fillet welds should be continuous and have adequate cross section. Attachment by clamps fixed by setscrews will normally not be accepted. Attachments by properly secured through-bolts or locking devices which are positive may however be accepted. Anode steel cores bent and directly welded to the steel structure shall be of a material complying with the requirements for grade A or equivalent.

1.5.2 Tanks which have anodes installed should be having sufficient holes for the circulation of air to prevent gas from collecting in pockets.

1.5.3 In tanks, anodes which are permanent made of alloys with, magnesium are not accepted. Impressed current systems should not be used in tanks due to development of chlorine and hydrogen that can result in an explosion hazard. Aluminum anodes are accepted in general. However, with regard to tanks for liquid cargo with flash point below 60°C and in adjacent ballast tanks, aluminum anodes shall be so located that a kinetic energy should not greater than 275 J is developed in event of their loosening and becoming detached.

Remark: *Aluminum anodes in dangerous gas-areas will be accepted when attached to tank bottoms, on stringer decks and up to a certain height above the tank bottom or stringer deck. The height which is above the tank bottom or stringer deck will be dependent upon anode weight, whose maximum acceptable height in m is 28 divided by the weight of the anode in kg. The attachment shall be arranged so that the anodes cannot eventually become detached and fall through holes or scallops in stringer decks*.