RULES FOR CLASSIFICATION OF

Ships

PART 3 CHAPTER 3

NEWBUILDINGS
HULL AND EQUIPMENT – MAIN CLASS

Hull Equipment and Safety

JULY 2011

DET NORSKE VERITAS AS

FOREWORD

DET NORSKE VERITAS (DNV) is an autonomous and independent foundation with the objectives of safeguarding life, property and the environment, at sea and onshore. DNV undertakes classification, certification, and other verification and consultancy services relating to quality of ships, offshore units and installations, and onshore industries worldwide, and carries out research in relation to these functions.

The Rules lay down technical and procedural requirements related to obtaining and retaining a Class Certificate. It is used as a contractual document and includes both requirements and acceptance criteria.

Any comments may be sent by e-mail to *rules@dnv.com*
For subscription orders or information about subscription terms, please use distribution@dnv.com
Computer Typesetting (Adobe Frame Maker) by Det Norske Veritas

CHANGES

General

The present edition of the rules includes additions and amendments approved by the Executive Committee as of June 2011, and supersedes the January 2011 edition of the same chapter.

The rule changes come into force as indicated below.

Text affected by the main rule changes is highlighted in red colour in the electronic pdf version. However, where the changes involve a whole chapter, section or sub-section, only the title may be in red colour.

This chapter is valid until superseded by a revised chapter.

Main changes coming into force 1 July 2011

- **General**

— References to documentation type "Z030 – System arrangement plan" have been amended to read "Z030 – Arrangement plan".

- **Sec.5 Foundations for Deck Machinery, Towing Equipment and Lifting Appliances**

— B301: Rope breaking load statement removed.
— B500: material grade requirement for foundations of Winches, Windlasses and other Pulling Accessories is amended.

- **Sec.6 Openings and Closing Appliances**

— Items A, C102, C301, C703, C802, F101, F301, F302, G101, G102 and G305 have been amended.
— Renumbering for C703,C704, C705, E103, E104, E105, E106, E107 and F700.
— Items C707, E103, F701 and F702 have been added.

Main changes coming into force 1 January 2012

- **Sec.2 Sternframes, Rudders and Steering**

— In item G, the requirements to pull-up for conical pintle fitting have been modified.

- **Sec.3. Anchoring and Mooring Equipment**

— B104: Requirements to access to spurling pipes and list of recognized standards added in accordance with revised IACS UR L4 (Rev.3).

- **Sec.9 Stability**

— Introduced lower length limitation of 24 m for application of main class requirements to intact stability.
— Updated Table D1 "Stability design requirements for different ship types and class notations" to reflect all changes in the rules.
— Removed class requirements to damage stability for cargo ships of 80 m in length and above and for ships having a reduced freeboard type A or B.

Corrections and Clarifications

In addition to the above stated rule requirements, a number of corrections and clarifications have been made in the existing rule text.

CONTENTS

Sec. 1 General Requirements 9

A. Classification 9
A 100 Application 9

B. Definitions 9
B 100 Symbols 9

C. Documentation 9
C 100 General 9

Sec. 2 Sternframes, Rudders and Steering 10

A. General 10
A 100 Introduction 10
A 200 Definitions 10
A 300 Documentation requirements 12

B. Materials 12
B 100 Plates and sections 12
B 200 Forgings and castings 13
B 300 Bearing materials 13
B 400 Material certificates 13
B 500 Heat treatment 14

C. Arrangement and Details 14
C 100 Sternframes and rudders 14

D. Design Loads and Stress Analysis 14
D 100 Rudder force and rudder torque, general 14
D 200 Rudders with stepped contours 16
D 300 Stress analysis 17

E. Sternframes and Rudder Horns 18
E 100 General 18
E 200 Propeller posts 18
E 300 Sole pieces 19
E 400 Rudder horns 20

F. Rudders 23
F 100 General arrangement and details 23
F 200 Rudder plating 23
F 300 Rudder bending 24
F 400 Web plates 25
F 500 Single plate rudders 26

G. Rudder Stocks and Shafts 26
G 100 General 26
G 200 Rudder stock with couplings 26
G 300 Rudder shaft 32
G 400 Bearings and pintles 33

H. Propeller Nozzles 36
H 100 General 36
H 200 Plating 36
H 300 Nozzle ring stiffness 37
H 400 Welding 37
H 500 Supports 37

I. Propeller Shaft Brackets 37
I 100 General 37
I 200 Arrangement 38
I 300 Struts 38

J. Welding, Mounting and Testing 38
J 100 Welding 38
J 200 Rudders and rudder stock connections 39
J 300 Testing of stern frames and rudders 39
J 400 Mounting of rudder 39

Sec. 3 Anchoring and Mooring Equipment 40

A. General 40
A 100 Introduction 40
A 200 Documentation 40
A 300 Certification 40
A 400 Assumptions 40

B. Structural Arrangement for Anchoring Equipment 41
B 100 General 41

C. Equipment Specification 42
C 100 Equipment number 42
C 200 Equipment tables 44

D. Anchors 45
D 100 General 45
D 200 Materials 46
D 300 Anchor shackle 46
D 400 Manufacturing 46
D 500 Testing 46
D 600 Additional requirements for H.H.P. and S.H.H.P. anchors 48
D 700 Identification 48

E. Anchor Chain Cables 49
E 100 General requirements 49
E 200 Materials and manufacture 51
E 300 Heat treatment 51
E 400 Proof load testing 51
E 500 Breaking load testing 51
E 600 Mechanical testing 54
E 700 Inspection and dimensional tolerances 56
E 800 Identification 56
E 900 Certification 57

F. Windlass and Chain Stoppers 57
F 100 General design 57
F 200 Materials 58
F 300 Testing 58

G. Towlines and Mooring Lines 59
G 100 General 59
G 200 Materials 59
G 300 Testing of steel wire ropes 60
G 400 Testing of natural fibre ropes 61
G 500 Mooring Winches 61

Sec. 4 Masts and Rigging 62

A. General 62
A 100 Introduction 62
A 200 Assumptions 62
A 300 Definitions 62
A 400 Documentation 63

B. Materials and Welding 63
B 100 Materials 63

C. Arrangement and Support 63
C 100 Masts and posts 63
C 200 Standing rigging 63

D. Design and Scantlings 63
D 100 General 63
D 200 Unstayed masts and posts with derricks 64
D 300 Stayed masts or posts with derricks with a lifting capacity not exceeding 10 t 64
D 400 Stayed masts of posts with derricks with a lifting capacity of 10 t or more, but not exceeding 40 t 64
D 500 Stayed masts without derricks 65
D 600 Shrouds 65

Sec. 5 Foundations for Deck Machinery, Towing Equipment and Lifting Appliances 66

A. Crane and Lifting Appliances 66
A 100 Introduction 66

A 200 Documentation 66
A 300 Materials 67
A 400 Arrangement 67
A 500 Design loads 68
A 600 Allowable stresses 68
A 700 Testing 68

B. Foundations for Winches, Windlasses and other Pulling Accessories 69
B 100 Introduction 69
B 200 Documentation 69
B 300 Design loads and allowable stresses 69
B 400 Securing requirements for fore deck windlasses 69
B 500 Materials 71

C. Shipboard Fittings and Supporting Hull Structures Associated with Towing and Mooring on Conventional Vessels 72
C 100 Introduction 72
C 200 Documentation 72
C 300 General 73
C 400 Towing 73
C 500 Mooring 74
C 600 Materials 74

Sec. 6 Openings and Closing Appliances 75

A. General 75
A 100 Application 75
A 200 Definitions 75
A 300 Documentation requirements 76
A 400 On board documentation 77
A 500 Testing 77
A 600 Certificate requirements 77

B. Access Openings in Superstructures and Freeboard Deck 77
B 100 Doors 77
B 200 Sill heights 78
B 300 Access openings in freeboard and superstructure decks 79
B 400 Strength and securing of small hatches on the exposed fore deck 79

C. Side and Stern Doors 82
C 100 General. 82
C 200 Structural arrangement 82
C 300 Design loads 82
C 400 Plating 83
C 500 Stiffeners 83
C 600 Girders 84
C 700 Allowable stress 84
C 800 Closing arrangement, general 84
C 900 Closing arrangement, strength 85
C 1000 Closing arrangement, system for operation and indication/monitoring 85

D. Hatchway Coamings 87
D 100 General 87
D 200 Coaming heights 87
D 300 Scantlings 87

E. Hatch Covers 88
E 100 General 88
E 200 Design loads 88
E 300 Plating 91
E 400 Stiffeners 91
E 500 Girders 93
E 600 Stiffness of cover edges 93
E 700 Structural analysis 93
E 800 Buckling Control 94
E 900 Deflection limit and connections between hatch cover panels 94
E 1000 Corrosion addition and steel renewal 94

F. Hatchway Tightness Arrangement and Closing Devices 95
F 100 General 95
F 200 Design and tightness requirements 95
F 300 Securing devices in general 96
F 400 Securing arrangement for weathertight hatch covers 96

F 500 Securing arrangement for deep tank or cargo oil tank hatch covers 97
F 600 Securing arrangement for hatch covers carrying deck cargo 98
F 700 Securing arrangement for hatch covers in watertight decks 98
F 800 Drainage arrangement 98

G. Internal Doors and Hatches for Watertight Integrity 98
G 100 General 98
G 200 Operation 99
G 300 Strength 99

H. Ventilators 100
H 100 Coamings and closing arrangements 100
H 200 Thickness of coamings 100
H 300 Arrangement and support 100
H 400 Strength requirements for fore deck ventilators 101

I. Tank Access, Ullage and Ventilation Openings 102
I 100 General 102
I 200 Hatchways 102
I 300 Air Pipes 102
I 400 Strength requirements for fore deck air pipes 103

J. Machinery Space Openings 105
J 100 Openings 105

K. Scuppers, Inlets and Discharges 105
K 100 Inlets and discharges 105
K 200 Pipe thickness 107
K 300 Scuppers 107
K 400 Periodically unmanned machinery space 108
K 500 Garbage chutes 108
K 600 Spurling pipes and cable lockers 109

L. Side Scuttles, Windows and Skylights 109
L 100 Side Scuttles, Windows and Skylights 109
L 200 Glass dimensions, side scuttles and windows 110

M. Freeing Ports 111
M 100 Definitions 111
M 200 Freeing port area 111
M 300 Location and protection of openings 112
M 400 Multiple wells 112
M 500 Free flow area 112
M 600 Type «A», «B-100» and «B-60» ships 113

N. Special Requirements for Type A Ships 113
N 100 Machinery casings 113
N 200 Gangway and access 113
N 300 Hatchways 113
N 400 Freeing arrangements 113

O. Retractable Bottom Equipment 113
O 100 Introduction 113
O 200 Arrangement 114
O 300 Design loads and allowable stresses 114

P. Box Coolers 114
P 100 Introduction 114
P 200 Arrangement 114

Sec. 7 Corrosion Prevention 116

A. Corrosion prevention systems 116
A 100 General 116
A 200 Documentation requirements 116
A 300 Corrosion prevention of dedicated seawater ballast tanks 116
A 400 Coatings 116
A 500 Cathodic protection 116

Sec. 8 Protection of the Crew 118

A. Protection of the Crew 118
A 100 Guard rails 118
A 200 Gangways, walkways and passageways 119

Sec. 9 Stability 122

A. Application, Definitions and Document Requirements 122
A 100 Application........ 122
A 200 Terms 122
A 300 Documentation for approval 123

B. Surveys and Tests 123
B 100 General........ 123

C. General Requirements........ 123
C 100 Stability book 123
C 200 Fixed Ballast 124
C 300 Draught Marks 124
C 400 Loading Computer System 124

D. Intact Stability Criteria 124
D 100 General stability criteria........ 124
D 200 Weather criterion 125
D 300 Assumptions concerning intact stability criteria and calculations........ 128

E. Damage Stability........ 129
E 100 Damage stability 129

F. Determination of Lightweight Data 129
F 100 Application........ 129
F 200 Procedure 129
F 300 Lightweight survey 129

SECTION 1
GENERAL REQUIREMENTS

A. Classification

A 100 Application

101 The Rules in this chapter apply to steering arrangement and anchoring, mooring and load handling equipment.

102 Necessary strengthening of the hull structure due to loads imposed by the equipment and installations are given where appropriate.

B. Definitions

B 100 Symbols

101

L = Rule length in m [1)]
B = Rule breadth in m [1)]
D = Rule depth in m [1)]
T = Rule draught in m [1)]
Δ = Rule displacement in t [1)]
C_B = Rule block coefficient [1)]
V = maximum service speed in knots on draught T.

1) For details see Ch.1 Sec.1 B

C. Documentation

C 100 General

101 Plans and particulars to be submitted for approval or information are specified in the respective sections of this chapter.

SECTION 2
STERNFRAMES, RUDDERS AND STEERING

A. General

A 100 Introduction

101 Vessels shall be provided with means for steering (directional control) of adequate strength and suitable design. The means for steering shall be capable of steering the ship at maximum ahead service speed, which shall be demonstrated.

102 Steering may be achieved by means 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.

103 Requirements in this section are related to rudder and rudder design. For requirement to steering gear operating the rudder, reference is made to Pt.4 Ch.14 Sec.1.

If steering is achieved by means of waterjet or thrusters reference is made to Pt.4 Ch.5 Sec.2 and Sec.3 respectively. Other means of steering is subject to special consideration.

A 200 Definitions

201 *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. (IACS UR S10)

202 *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.

203 Some terms used for rudder, rudder stock and supporting structure are shown in Fig.1.

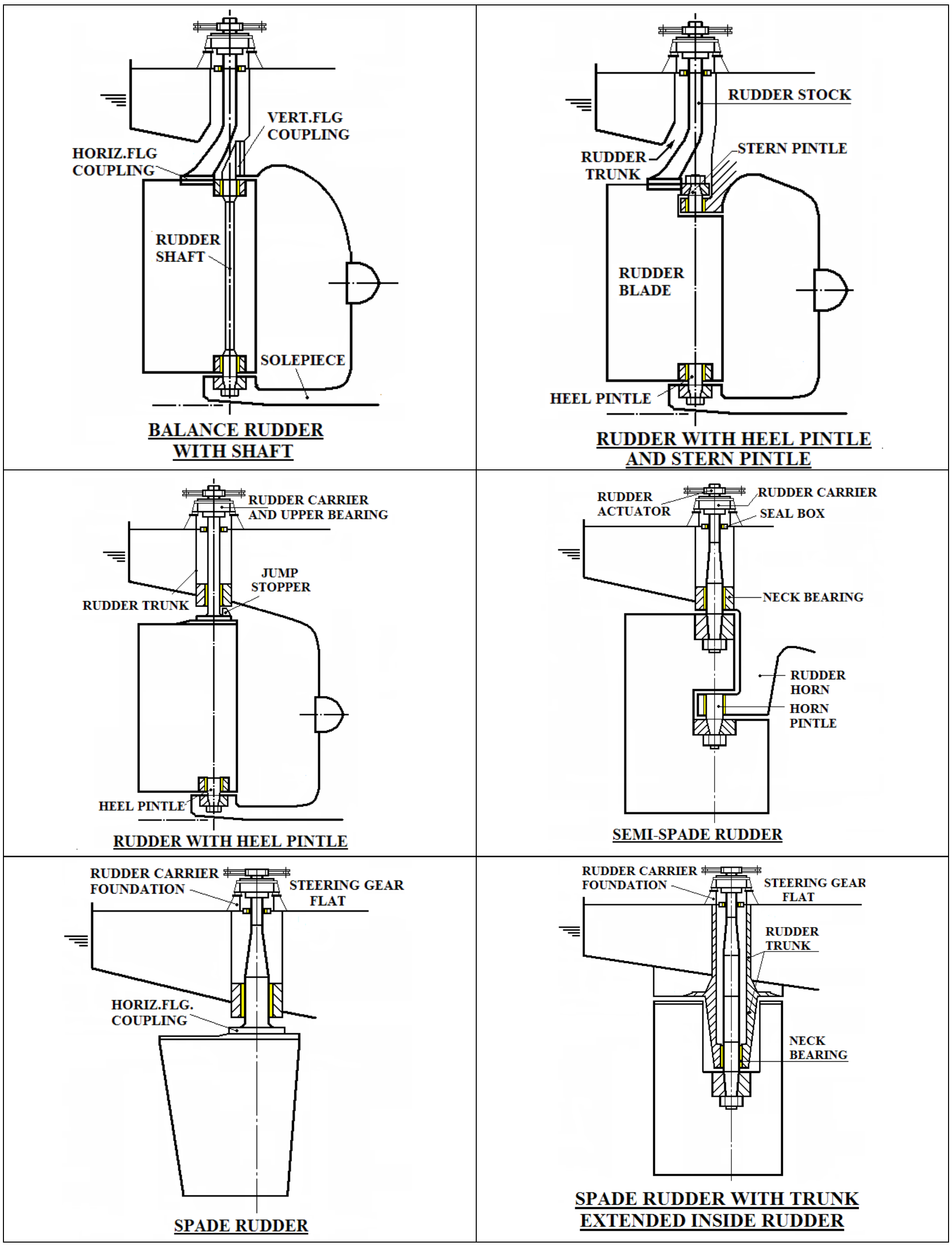


Fig. 1
Rudders

204 Symbols:

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

A 300 Documentation requirements

301 Documentation shall be submitted as required by Table A1.

Table A1 Documentation requirements

Object	*Documentation type*	*Additional description*	*For approval (AP) or For information (FI)*
Rudder arrangement	Z030 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
	Z250 Procedure	Mounting and dismounting or rudder (including flaps as a detached component), rudder stock and pintles.	FI
	Z250 Procedure	Measurement of bearing clearances.	FI
	Z180 Maintenance manual	Flap rudders: Hinges, link systems and criteria for allowable bearing clearances.	FI
	Z110 Data sheet	Non-conventional rudder designs: Torque characteristics (torque versus rudder angle in homogeneous water stream).	FI
	Z240 Calculation report*	Expected life time of bearings subjected to extraordinary wear rate due to dynamic positioning.	AP
Stern frame, sole pieces and rudder horns	H050 Structural drawing		AP
Rudder blades	H050 Structural drawing	Including details of bearings, shafts and pintles.	AP
Rudder stocks	H050 Structural drawing	Including details of connections, bolts and keys.	AP
Propeller nozzles	H050 Structural drawing		AP
Propeller shaft brackets	H050 Structural drawing		AP
Rudder and steering gear supporting structures	H050 Structural drawing	Including fastening arrangements (bolts, cocking and side stoppers).	AP

* Only for rudders included under DP-Control documentation, see Pt.6 Ch.7.

302 For general requirements to documentation, see Pt.0 Ch.3 Sec.1.

303 For a full definition of the documentation types, see Pt.0 Ch.3 Sec.2.

B. Materials

B 100 Plates and sections

101 Selection of material grades for plates and sections for sternframes, rudders, rudder horns and shaft brackets are in general not to be of lower grades as given in Table B1.

Table B1 Plate material grades

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

For rudder and rudder body plates subjected to stress concentrations (e.g. in way of lower support of semi-spade rudders or at upper part of spade rudders) Class IV as given in Pt.3 Ch.1 Sec.2 Table B1 shall be applied.

(IACS UR S6 Rev.4)

102 The material factor f_1 included in the various formulae for structures may be taken as:

f_1 = 1.0 for NV-NS steel

f_1 = 1.08 for NV-27 steel

f_1 = 1.28 for NV-32 steel

f_1 = 1.39 for NV-36 steel

f_1 = 1.47 for NV-40 steel

B 200 Forgings and castings

201 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.

Guidance note:

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

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

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

202 Nodular cast iron may be accepted in certain parts after special considerations. Materials with minimum specified tensile strength lower than 400 N/mm^2 or higher than 900 N/mm^2 will normally not be accepted in rudder stocks, shafts or pintles, keys and bolts.

203 The material factor f_1 for forgings (including rolled round bars) and castings may be taken as:

$$f_1 = \left(\frac{\sigma_f}{235}\right)^a$$

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 $\sigma_f > 235$
= 1.0 for $\sigma_f < 235$

204 Before significant reductions in rudder stock diameter due to the application of steels with yield stresses exceeding 235 N/mm^2 are granted, the Society 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, see G405.

B 300 Bearing materials

301 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 difference in hardness of bushing and liners shall not be less than 65 Brinell. 13% Chromium steel shall be avoided.

302 Synthetic bearing bushing materials shall be of an approved type. For this type of bushing, adequate supply of lubrication to the bearing for cooling/lubrication purposes shall be provided.

303 The maximum surface pressure pm for the various bearing combinations shall be taken as given in Table B2. Higher values than given in Table B2 may be taken in accordance with the maker's specification if they are verified by tests and recorded in respective type approval certificate.

(IACS UR S10)

Table B2 Bearing surface pressures

Bearing material	p_m *(kN/m^2)*
Lignum vitae	2 500
White metal, oil lubricated	4 500
Synthetic material with hardness between 60 and 70 Shore D 1)	5 500
Steel 2) and bronze and hot-pressed bronze-graphite materials	7 000

1) Indentation hardness test at 23°C and with 50% moisture, according to a recognized standard

2) Stainless and wear-resistant steel in an approved combination with stock liner

B 400 Material certificates

401 DNV material certificate (NV) will be required for:

— sternframe structural parts
— rudder structural parts
— rudder shaft or pintles
— rudder stock
— rudder carrier
— bolts for flanged couplings.

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

— bolts
— stoppers.

B 500 Heat treatment

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

C. Arrangement and Details

C 100 Sternframes and rudders

101 Relevant types of rudder arrangements are shown in Fig.1. Other combinations of couplings and bearings may be applied.

102 Suitable arrangement to prevent the rudder from lifting and accidental unshipping shall be provided. The arrangement shall effectively limit vertical movement of rudder in case of extreme (accidental) vertical load on rudder.

103 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.

104 If the rudder trunk is 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.

An additional seal of approved type is required when the rudder carrier is below the summer load waterline.

105 Vibration analysis.

Guidance note:

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 centre 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

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

106 Over-balanced 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. See Pt.4 Ch.14 Sec.1 B900.

Guidance note:

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.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

D. Design Loads and Stress Analysis

D 100 Rudder force and rudder torque, general

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

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

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 (see Fig.2):

Table D1 Rudder profile type - coefficient		
Profile type	*Ahead*	*Astern*
NACA - Göttingen	1.1	0.8
Hollow profile [1)]	1.35	0.9
Flatsided	1.1	0.9
Profile with «fish tail»	1.4	0.8
Rudder with flap	1.65	1.3
Nozzle rudder	1.9	1.5
1) 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.3

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 A201.

When the speed is less than 10 knots, V_{str} 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:

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

(IACS UR S10)

102 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 101 for ahead and astern conditions

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

B = mean breadth of rudder area, see Fig.3

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, $\alpha = 0.40$ 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 101.

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.

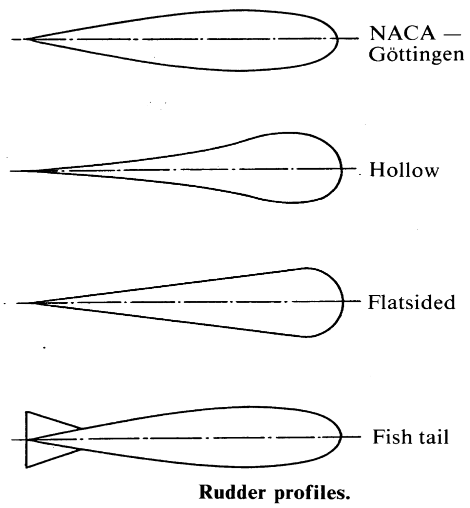


Fig. 2
Rudder profiles

D 200 Rudders with stepped contours

201 The total rudder force F_R shall be calculated according to 101, with height and area taken for the whole rudder.

202 The pressure distribution over the rudder area may be determined by dividing the rudder into relevant rectangular or trapezoidal areas, see e.g. Fig.4. The rule rudder torque may be determined by:

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

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

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.3
α = as given in 102
For parts of a rudder behind a fixed structure such as a rudder horn:

$$\alpha = 0.25 \text{ for ahead condition}$$
$$= 0.55 \text{ for astern condition}$$

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

A_{iF} = rudder part area forward of rudder stock centre line, see Fig.4

F_R and A as given in 101.

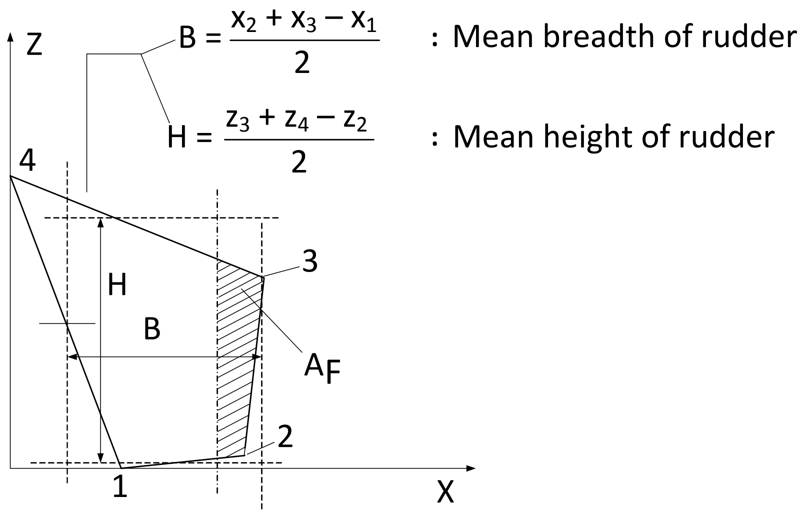


Fig. 3
Rudder dimensions

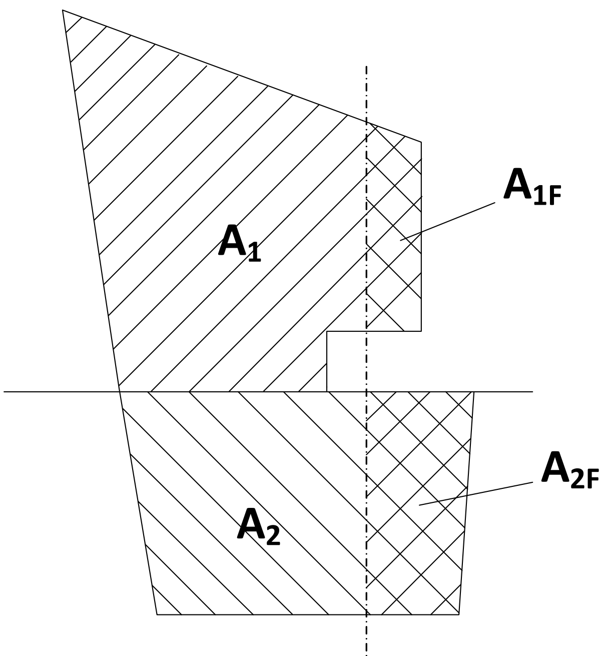


Fig. 4
Rudder area distribution

D 300 Stress analysis

301 The rudder force and resulting rudder torque as given in 100 and 200, 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.

Acceptable direct calculation methods are given in Classification Note No. 32.1 “Strength Analysis of Rudder Arrangements”. For rudder horns, see also E404.

302 Allowable stresses for the various strength members are given in subsections E to J.

For evaluation of angular deflections, see B204, G201 and G405.

E. Sternframes and Rudder Horns

E 100 General

101 Sternframes 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.

102 Cast steel sternframes and welded sternframes 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.

103 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 may be welded to a suitable steel bar at the after end of the propeller post.

104 Stresses determined by direct calculations as indicated in D300 are normally not to exceed the following values:

— Normal stress: $\sigma = 80\ f_1$ (N/mm^2)
— Shear stress: $\tau = 50\ f_1$ (N/mm^2)
— Equivalent stress: $\sigma_e = 120\ f_1$ (N/mm^2)

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

E 200 Propeller posts

201 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.

202 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.5 Alt. I.

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

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

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

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

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

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

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

l, b, t_1 and t_2 are as shown in Fig.5 Alt. II.

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

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

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.

E 300 Sole pieces

301 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.

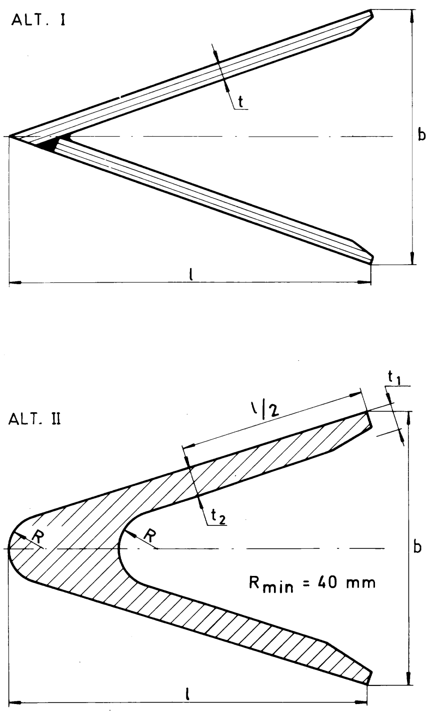


Fig. 5
Propeller posts

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

$$Z_1 = \frac{6.25 F_R l_s}{f_1} \quad (\text{cm}^3)$$

l_s = distance in m from the centre 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.

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

$\sigma = 120\ f_1$

304 The section modulus of the sole piece about a horizontal axis abaft the forward edge of the propeller post is in no place to be less than:

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

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

$$A_S = \frac{0.1F_R}{f_1} \quad (cm^2)$$

E 400 Rudder horns

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

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

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

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, see D202
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:

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

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, see Fig.6).

The formula for Z_W is based on the material in web plates and shell plate being of the same strength.

For a cast rudder horn any vertical extension of the side plating (see Fig.7) may be included in the section modulus.

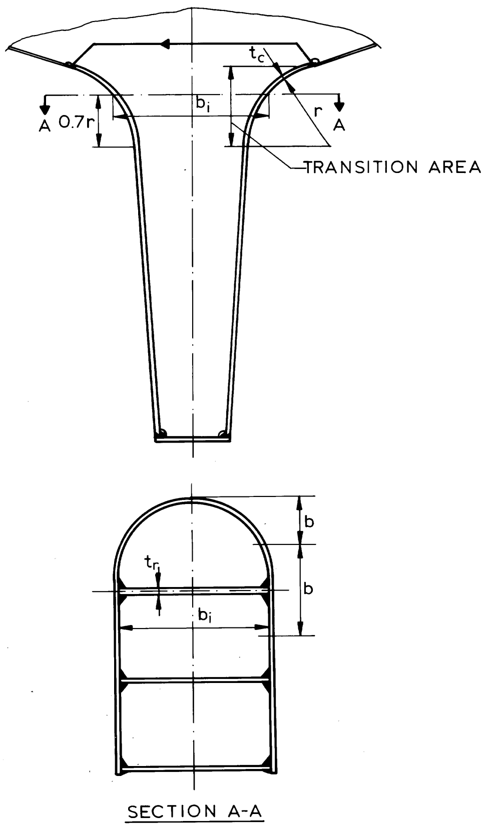


Fig. 6
Curved plate transition rudder horn/shell plating

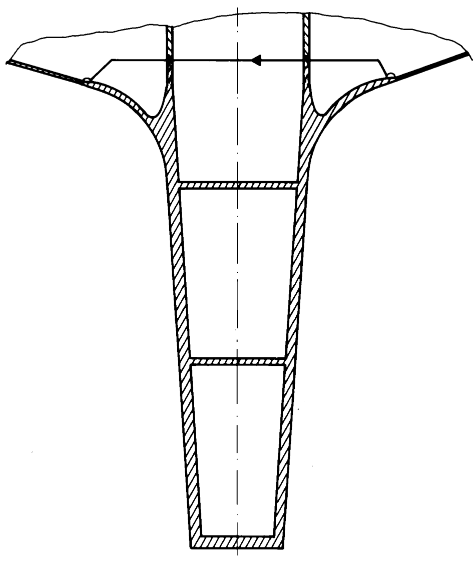


Fig. 7
Curved cast transition rudder horn/shell plating

402 The rudder horn thickness requirement is given by:

$$t = \frac{110 k F_R e_h}{f_1 A_S} \quad \text{(mm)}$$

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

e_h = horizontal projected distance in m from the centre 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:

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

s = spacing between transverse webs in mm
r = radius of curved transition in mm
Z_A = section modulus at section immediately below the transition zone
Z = section modulus requirement in same section, as given in 401.

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

$$A_W = C\frac{0.3F_R}{f_1} \quad (cm^2)$$

C = $\left(1 + \frac{(A + A_H)A_H}{A^2}\right)$ at upper end of horn
= 1.0 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:

$$t_r = 0.8\ t_c \quad \text{(mm)}$$

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:

$$t = 0.55\ f_1\ t_r \quad \text{(mm)}$$

404 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 104, may in the curved plate be increased to:

$$\sigma = 120\ f_1\ \text{N/mm}^2$$

$$\sigma_e = 180\ f_1\ \text{N/mm}^2$$

A fine-mesh finite element calculation will be considered as an acceptable method.

In the web plates the normal stresses should not exceed
$\sigma = 130\ f_1\ \text{N/mm}^2$.

405 For a curved transition between the horn side plating and the shell plating, the side plate thicknesses given in 401 to 404 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 (see Fig.8), or weld it to the shell plate in line with longitudinal girders. In the latter case the welds below and above the shell plate shall be full penetration welds, and the shell plate shall be specially checked for lamellar tearing. The transverse girders shall be connected to/supported by transverse floors.

Floor plating welded to rudder horn web plates shall have a thickness not less than 75% of the web plate thickness.

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

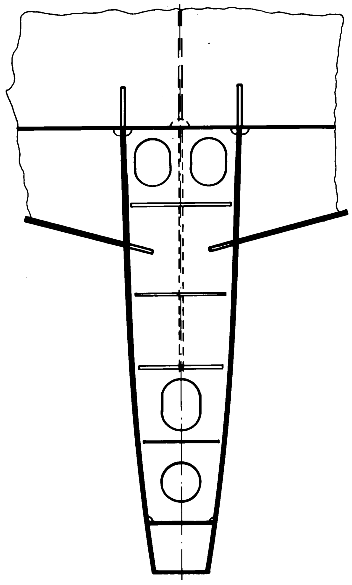


Fig. 8
Shell plating connected to longitudinal girders in line with rudder horn sides

F. Rudders

F 100 General arrangement and details

101 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, see 500.

102 All rudder bearings shall be accessible for measuring of wear without lifting or unshipping the rudder.

Guidance note:
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.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

103 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 are not to be 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.

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

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

104 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.

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

F 200 Rudder plating

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

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

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

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 Ch.1 Sec.7 C101 or Ch.2 Sec.6 C102.

F 300 Rudder bending

301 Bending moments in the rudder shall be determined by direct calculations as indicated in D300.

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

— For balanced rudders with heel support:

$$M_{max} = 0.125\ F_R\ H \quad \text{(kNm)}$$

— For semi-spade rudders at the horn pintle:

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

— For spade rudders:

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

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 A_1 to the section in question.

302 The nominal bending stress distribution in the rudder may normally be determined on the basis of 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.

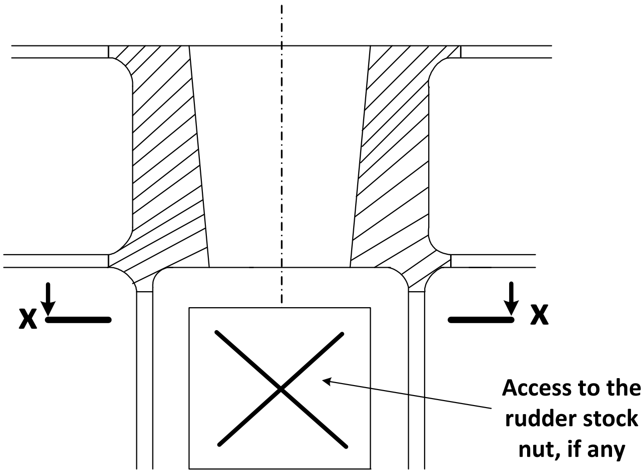
At the top of the rudder, the actual section modulus of the cross-section of the structure of the rudder blade which is connected with the solid part where the rudder stock is housed is to be calculated with respect to the symmetrical axis of the rudder.

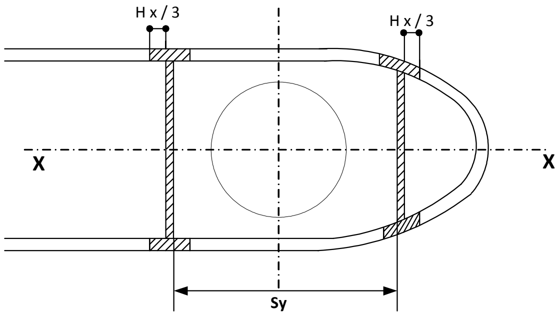
The breadth of the rudder plating to be considered for the calculation of this actual section modulus is to be not greater than that obtained from the following formula:

$$b = s_v + 2\frac{H_x}{m} \quad \text{[m]}$$

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.





Section x-x

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.

303 Nominal bending stresses calculated as given in 301 and 302 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.

F 400 Web plates

401 The thickness of vertical and horizontal webs shall not be less than 70% of the thickness requirement given in 200, in no case less than 8 mm.

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

$$A_W = \frac{P}{5f_1} \quad (\text{cm}^2)$$

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

with heel support

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

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:

$$\tau = 50\ f_1 \quad (N/mm^2)$$

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.

F 500 Single plate rudders

501 *Mainpiece diameter*

The mainpiece diameter is calculated according to G201. 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 D101 the factor k_1 may be taken equal to 1.0 in ahead condition.

502 *Blade thickness*

The blade thickness shall not be less than:

$$t_b = 1.5\ s\ V + 2.5\ (mm)$$

s = spacing of stiffening arms in metres, not to exceed 1 m
V = speed in knots, see D101.

503 *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:

$$Z_a = 0.5\ s\ C_1^2\ V^2\ (cm^3)$$

C_1 = horizontal distance from the aft edge of the rudder to the centre line of the rudder stock in metres.

For higher tensile steels the material factor according to B100 shall be used correspondingly.

G. Rudder Stocks and Shafts

G 100 General

101 Stresses determined by direct calculations as indicated in D300 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:

$$\sigma_e = \sqrt{\sigma^2 + 3\tau^2} \quad (N/mm^2)$$

σ = bending stress in N/mm²
τ = torsional stress in N/mm².

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

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

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

G 200 Rudder stock with couplings

201 The diameter requirement is given by:

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

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:

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

— for semi-spade rudder:

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

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, h_s 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:

$$\delta_{ub} = \frac{10^5 l\, h_{ub} M_B}{6 E I_a} \quad \text{(mm)}$$

I_a = 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
h_{ub}= centre distance of the rotor bearings in mm

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

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

or

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

h_A = vertical distance between force and bearing centre
F_{MTR} = according to Pt.4 Ch.14 Sec.1 B1121
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 (see Pt.4 Ch.14 Sec.1 B1108).

202 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 (see Fig.9):

	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 must enable escape of the oil from between the mating surfaces. 2) Tapering 1: ≥ 15 is recommended for higher tolerances for push-up length.		

— contact area minimum 70% evenly distributed (see J200 for control and testing)
— the connection shall be secured by a nut which is properly locked to the shaft.

203 Connection between rudder stock and steering gear to be according to Pt.4 Ch.14 Sec.1 B1200.

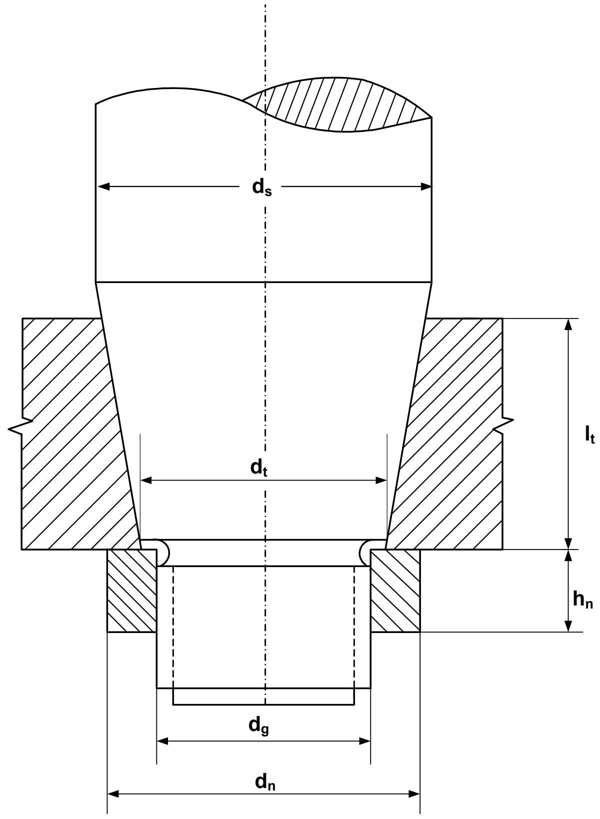


Fig. 9
Cone coupling

204 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) Pull-up length, minimum:

$$\delta_{min} = K\,(\Delta_{min} + 2\,(R_{Ai} + R_{Ae})\,10^{-3})\ (mm)$$

$\delta_{min} \geq 2$ mm for all keyless rudder - rudder stock connections.

b) Pull-up length, maximum:

$$\delta_{max} = K\,(\Delta_{max} + 2\,(R_{Ai} + R_{Ae})\,10^{-3})\ (mm)$$

δ = pull-up length (mm)
K = taper of the cone = $l_t/(d_s - d_t)$
Δ_{min} = calculated minimum shrinkage allowance
Δ_{max} = calculated maximum shrinkage allowance
R_{Ai} = surface roughness R_A of shaft (micron)
R_{Ae} = surface roughness R_A of hub (micron).

c) Shrinkage allowance Δ (mm):

$$\Delta = \frac{2dp}{E}\left(\frac{1}{1 - c_e^2}\right)$$

E = module of elasticity: $2.06 \cdot 10^5$ (N/mm²)
c_e = diameter ratio d/D at considered section
d = mean shaft diameter (mm)
p = surface pressure
D = outer diameter of the hub at considered section (mm).

Minimum shrinkage allowance (Δ_{min}) shall be calculated based on average diameters and the minimum required surface pressure (p_{min}).

Maximum shrinkage allowance (Δ_{max}) shall be calculated based on average diameters and maximum permissible surface pressure (p_{max}).

In case hub wall thickness have large variation the mean outer diameter of the hub will have to be specially considered.

d) The minimum surface pressure used for calculation of pull-up length (δ_{min}) shall be taken as the greater of:

$$p_{min} \geq p_r$$

or

$$p_{min} \geq 1.25 p_b$$

The maximum surface pressure used for calculation of pull-up length (δ_{max}) shall not exceed:

$$p_{max} \leq k\sigma_f \frac{1 - c_e^2}{\sqrt{3 + c_e^4}} - p_b \quad (\mathrm{N/mm^2})$$

k = 0.95 for steel forging and cast steel
= 0.90 for nodular cast iron
= 0.50 for keyed connections.

Variation due to different hub wall thickness shall be considered.

Pressure at the bigger end due to bending moment, M_b, may be taken as:

$$p_b = \frac{3.5 M_b}{d_m l^2} 10^6 \quad (\mathrm{N/mm^2})$$

which may be reduced to zero at a distance l_x = 0.5 d or 0.5 l (smaller applies) as follows:

$$p_{bx} = p_b\left(1 - \sqrt{\frac{l_x}{0.5 d_x}}\right) \quad (\mathrm{N/mm^2})$$

p_{bx} = pressure due to bending moment at position x
l_x = distance from top of cone, see Fig.9 (mm)
d_x = ditto shaft diameter at distance l_x (mm)
M_b = bending moment (kNm).

e) Average surface pressure (p_r) due to shrinkage for transmission of torque by means of friction shall be:

$$p_r \geq \frac{2 T_{fr} 10^6}{\pi d_m^2 l \mu} \quad (\mathrm{N/mm^2})$$

T_{fr} = required torque to be transmitted by means of friction in following coupling = 3 M_{TR}

d_m = mean diameter = 0.5 (d_s + d_t) (mm)
l = effective cone length, which may normally be taken as boss length l_t, see Fig.9, (mm)
μ = maximum 0.14 for oil injection fitting
= maximum 0.17 for dry fitting
M_{TR} = rule rudder torque (kNm), see D102 and D202.

f) Force, F for pull-up corresponding to a surface pressure, p may be estimated as follows:

$$F \geq \pi\, d_m l\, p\left(\frac{1}{2K} + \mu_{pu}\right)10^{-3} \qquad \textbf{(kN)}$$

μ_{pu} = average friction coefficient for pull-up. For oil injection usually in the range 0.01 to 0.03 For dry fitting usually in the range of 0.1 to 0.2, typically 0.15.

205 Tapered key-fitted (keyed) connections shall be designed to transmit rudder torque in all normal operating conditions by means of friction in order to avoid mutual movements between rudder stock and hub. The key shall be regarded as a securing device.

For calculation of required pull-up length (δ), see 204 a), b) and e) where p_r is given with T_{fr} = 1.5 M_{TR}.

Where it is not possible or practicable to obtain the required pull-up length (δ), special attention shall be given to fitting of the key in order to ensure 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-fitted connections shall in addition comply with the following:

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

$$r \geq 0.01\, d_s$$

b) The abutting surface area between the key and key-way in the rudder stock and hub respectively, shall not be less than:

$$A_{ab} \geq \frac{65 T_{key}}{d_m f_k} \quad (\text{cm}^2)$$

where the torque T_{key} is (kNm):
$T_{key} \geq 2\, M_{TR} - T_{fr}$
based on verification of pull-up force, and
$T_{key} \geq 2\, M_{TR} - 0.7\, T_{fr}$
based on verification of pull-up distance, but not less than:

$$T_{key} = M_{TR} \quad \text{(kNm).}$$

Yield strength used for calculation of f_k shall not exceed the lowest of:

$\sigma_{f,key}$
and

1.5 $\sigma_{f,\,hub}$ (for calculation of hub) or
1.5 $\sigma_{f,\,stock}$ (for calculation of stock).

A_{ab} = effective abutting area of the key-way in stock and hub respectively (cm^2)
f_k = material factor (see B204)
$\sigma_{f,hub}$ = yield strength of hub material (N/mm^2)
$\sigma_{f,key}$ = yield strength of key material (N/mm^2)
$\sigma_{f,stock}$ = yield strength of stock material (N/mm^2).

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 (see Fig.9):

— 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.

206 Where the rudder stock 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:

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

d_s = rule diameter as given in 201 for the rudder stock at coupling flange.

For rudder stocks with a slanted lower part, d_s 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 centre of the coupling bolt system

n = number of coupling bolts

e = mean distance in mm from the centre of bolts to the centre of the bolt system

f_{ms} = material factor (f_1) for rudder stock

f_{mb} = material factor (f_1) for bolts.

c) Nuts 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 centre of the bolts to the longitudinal centre 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:

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

at the root section, however, not less than 0.25d_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 centre of bolts to the longitudinal centre 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	0.8	0.6	0.45	0.35	0.25

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

$k_f = r_f/(a - 0.5d)$

r_f = radius of fillet, not to be taken less than $0.3\cdot(a - 0.5d)$.

Guidance note:

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

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

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

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

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

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

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

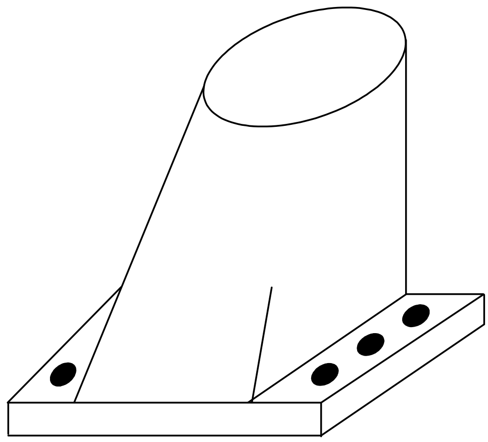


Fig. 10
Rudder stock / flange

207 The welded joint between the rudder stock and the flange shall be made in accordance with Fig.11 or equivalent.

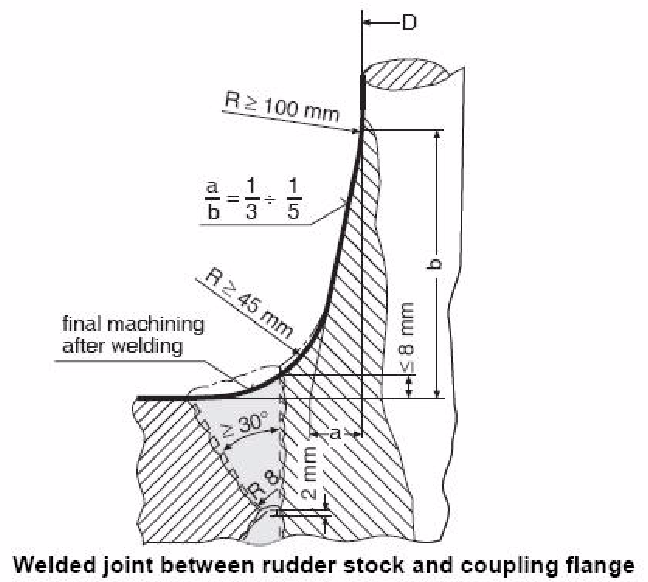


Fig. 11
Welded joint between rudder stock and coupling flange

G 300 Rudder shaft

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

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

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

l, a and b are given in Fig.12 in m.

The diameter d_f 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.

302 The taper, nut, etc. at lower end of rudder shafts, shall be taken as for rudder stock given in 202.

303 The scantlings of the vertical coupling at the upper end of the rudder shaft shall be as required for horizontal rudder couplings in 206, inserting the shaft d_l instead of the stock diameter d_s in the formula for bolt diameter.

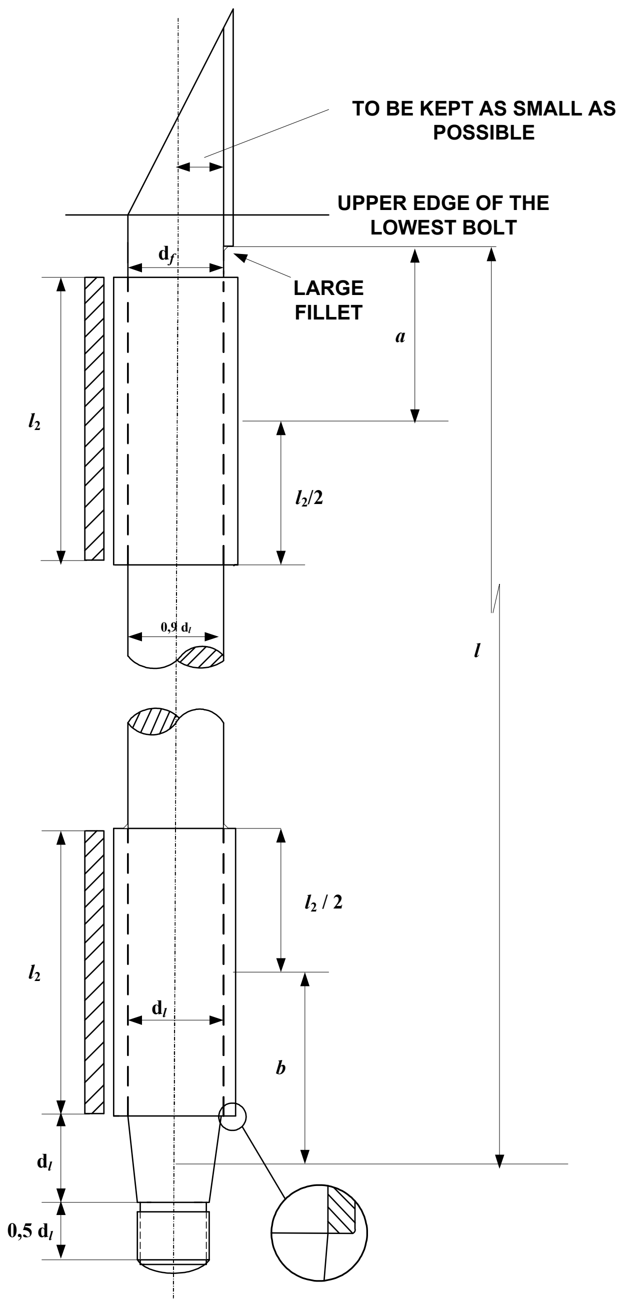


Fig. 12
Rudder shaft

G 400 Bearings and pintles

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

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

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.

402 The bearing surface area shall not be less than:

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

h_b and d_{sl} = as given in 401
P = calculated reaction force in kN at the bearing in question
p_m = maximum surface pressure as given in B303.

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 centre 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:

$$P = \frac{h_1 + h_2}{h_2} F_R \quad \text{(kN) at neck bearing}$$

$$P = \frac{h_1}{h_2} F_R \quad \text{(kN) at upper bearing}$$

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 D101.

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.

403 The diameter of pintles shall not be less than:

$$d_p = 10 \sqrt{\frac{P}{f_1}} \quad \text{(mm)}$$

P = as given in 402.

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

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

— 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 402.

The bushing shall be effectively secured to the bearing. The thickness of bearing material outside of the bushing shall not be less than:

For balanced rudder or semi-spade rudders:

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

For spade rudders:

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

Reduced thickness may be accepted based on direct analysis.

P = as given in 402.

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

$$0.001\ d_b + 1.0\ \ \text{(mm)}$$

d_b = inner diameter in mm of the bushing.

If non-metallic bearing material is applied, 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.

The clearance should be related to the calculated angular deflection over the bearing length e.g. neck bearing of spade rudder.

Due attention should, however, be given to the manufacturer's recommended clearance. For pressure lubricated bearings the clearance will be especially considered.

406 Pintles shall have a conical attachment to the gudgeons. The pintle fitting shall be as required for rudder stock in 204, inserting the pintle diameter d_p instead of the stock diameter d_s in the various formulae with the following exemptions:

— In the case of dry pintle fitting, p_{min} used for calculation of pull-up length (δ_{min}) shall be taken as the greater of p_r and p_b.
— Irrespective of pintle fitting calculation result, pull-up length (δ_{min}) shall be not less than 0.5 mm for dry fitting and 2.0 mm for oil injection fitting.

The conical pintle connection shall comply with the following:

	Dry fitting 1)	*Oil injection* 2)
Length/diameter ratio (l_t/d_p)	≥1.0	≥1.0
Hub/pintle diameter ratio (D/d_p)	≥1.5	≥1.5
Taper of cone	1:8 to 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 205.
2) The design must 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 (see J200 for control and testing).

The connection shall be secured by a nut which is properly locked to the pintle.

In the fitting calculations, bending moment, Mb and friction torque, T_{fr} shall be taken as given in the following:

$$Mb = P \cdot h_p \cdot 10^{-3} \text{ (kNm)}$$

$$T_{fr} = 1.5P \cdot d_b \cdot 10^{-4} \text{ (kNm)}$$

where

P is pintle force as given in 402 and h_p is bending moment arm (mm) taken as the distance from bigger end of cone to 1/3 of bearing height (see Fig. 13).

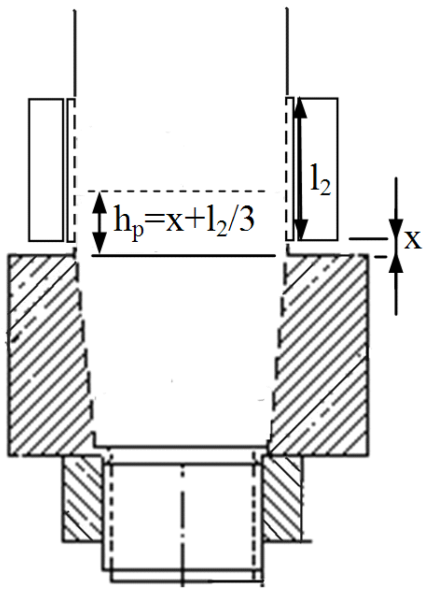


Fig. 13
Bending moment arm for pintle force

H. Propeller Nozzles

H 100 General

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

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

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

H 200 Plating

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

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

where:

N = 0.01 P_S D, 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 metres in the formula
k_a = aspect ratio correction as given in F201, 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.

202 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.

203 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.

Guidance note:
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%.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

H 300 Nozzle ring stiffness

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

$$I = 2.8\ k\ b\ D^3\ V^2 \quad (cm^4)$$

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

$$k = \frac{28b}{\sqrt{Dt_m}(n+1)}$$

t_m = mean thickness of nozzle inner and outer shell plating (mm), in propeller plane
b = length of nozzle, see Fig.14, in m
D = as given in 201
V = maximum service speed (knots)
n = number of ring webs.

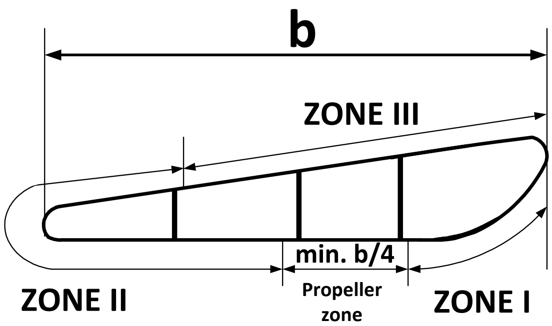


Fig. 14
Section through nozzle ring

302 If the ship is reinforced according to an ice class notation the parameter V for the requirement in 301 shall not be taken less than:

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

H 400 Welding

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

402 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.16 may be accepted.

H 500 Supports

501 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.

I. Propeller Shaft Brackets

I 100 General

101 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.

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

I 200 Arrangement

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

202 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 centre 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.

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

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

I 300 Struts

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

$$h = 0.4\ d \quad (mm)$$

$$A = 0.4\ d^2 \quad (mm^2)$$

$$W = 0.12\ d^3 \quad (mm^3)$$

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.15

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.

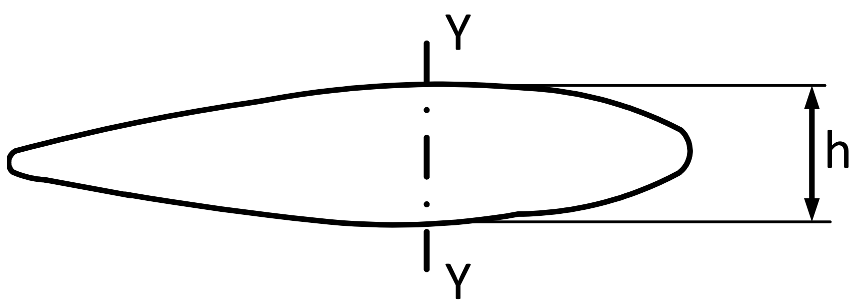


Fig. 15
Strut section

J. Welding, Mounting and Testing

J 100 Welding

101 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.

102 Two sided full penetration welding shall normally be arranged. Where back welding is impossible welding shall be performed against ceramic backing bar or equivalent.

103 Webs shall be connected to the side plates in accordance with Ch.1 Sec.11. Weld factor C to be used is 0.43

104 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. Continuous slot welds as shown in figure 15 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

J 200 Rudders and rudder stock connections

201 Contact area of conical connections shall be (minimum 70%) verified by means of paint test (e.g. toolmaker blue) in presence of the surveyor.

202 Test pull-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 non-symmetric design or other relevant reasons. Pull-up length during test pull-up shall not be less than final pull-up length.

J 300 Testing of stern frames and rudders

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

Guidance note:

Rudder and rudder horn is defined as critical area and at least 20% of the welded length is subject to non destructive testing (see Pt.2. Ch.3 Sec.7).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.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

J 400 Mounting of rudder

401 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.

402 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.

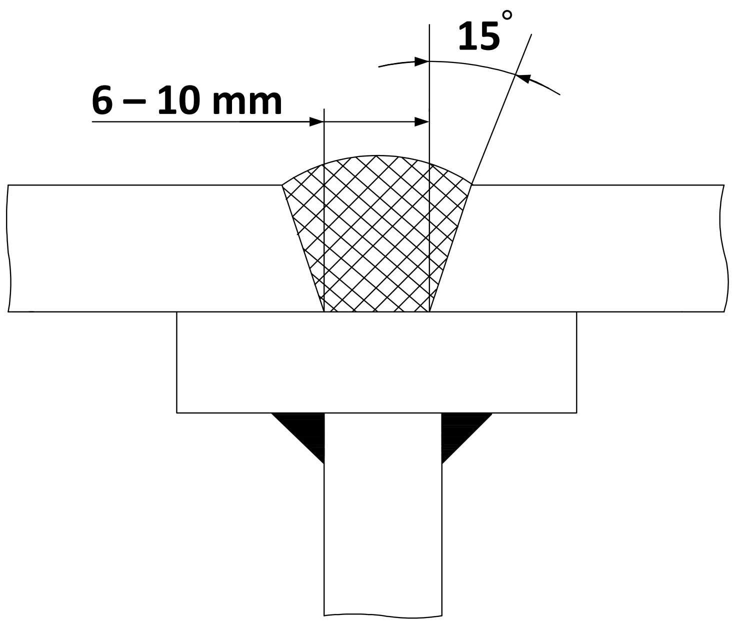


Fig. 16
Connection shell plate/ring web

SECTION 3
ANCHORING AND MOORING EQUIPMENT

A. General

A 100 Introduction

101 The requirements in this section apply to equipment and installation for anchoring and mooring.

102 Towlines and mooring lines are not subject to classification. Lengths and breaking strength are, however, given in the equipment tables as guidance. If voluntary certification of such equipment is requested, it shall be carried out in accordance with G.

A 200 Documentation

201 The following plans and particulars shall be submitted for approval:

— equipment number calculations
— equipment (list) including type of anchor, grade of anchor chain, type and breaking load of steel and fibre ropes
— anchor design if different from standard or previously approved anchor types. Material specification
— windlass design. Material specifications for cable lifters, shafts, couplings and brakes
— chain stopper design. Material specification.

202 The following plans and particulars shall be submitted for information:

— arrangement of deck equipment.

203 For barges the towline fastening arrangement and details, stating towing force shall be submitted for approval.

A 300 Certification

301 DNV product certificates will be required for the following items:

— anchor and anchor shackle
— anchor chain cable and accessories (shackles, swivels, etc.)
— windlass.

302 DNV material certificates will be required for the following items:

— anchor with anchor shackle
— anchor chain cable and accessories (shackles, swivels, etc.)
— windlass cable lifter
— winch drum and drum flanges
— shafts for cable lifter and/or drum
— pawl wheel, stopper and couplings
— brake components
— chain stopper.

303 Works material certificates from an approved manufacturer will normally be accepted for:

— gear shafts and wheels
— windlass/winch frame work
— steel wire ropes
— fibre ropes.

A 400 Assumptions

401 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 therefore 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.

Guidance note:

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, 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.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

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

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

B. Structural Arrangement for Anchoring Equipment

B 100 General

101 The anchors are normally to be housed in hawse pipes of suitable size and form 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. Upon release of the brake, the anchor is immediately to start falling by its own weight. At the upper and lower ends of hawse pipes, there shall be chafing lips. 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 laying at anchor. Alternatively, roller fairleads of suitable design may be fitted.

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

102 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.

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

104 The chain locker shall have adequate 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.

Guidance note:

Bulkheads separating adjacent chain lockers need not be watertight.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

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 (see footnote) or equivalent for watertight manhole covers. Butterfly nuts and/or hinged bolts are prohibited as the securing mechanism for the access cover.

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

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.

Guidance note 1:

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

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

Guidance note 2:

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

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

Guidance note 3:

Concerning 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”.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

(IACS UR L4 Rev. 3)

105 The windlass and chain stoppers shall be efficiently bedded to the deck. The deck plating in way of windlass and chainstopper shall be increased in thickness and supported by pillars carried down to rigid structures. See Sec.5 B.

C. Equipment Specification

C 100 Equipment number

101 The equipment number is given by the formula:

$$E\,N = \Delta^{2/3} + 2\,B\,H + 0.1\,A$$

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 centre line of each tier of houses having a breadth greater than B/4. For the lowest tier, h_i 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.

Guidance note:
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.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

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

Table C1 Equipment, general

Equipment number	*Equipment letter*	*Stockless bower anchors*		*Stud-link chain cables*				*Towline (guidance)*		*Mooring lines 1) (guidance)*		
		Number	*Mass per anchor*	*Total length*	*Diameter and steel grade*			*Steel or fibre ropes*		*Steel or fibre ropes*		
					NV K1	*NV K2*	*NV K3*	*Minimum length*	*Minimum breaking strength*	*Number*	*Length of each*	*Minimum breaking strength*
			kg	*m*	*mm*	*mm*	*mm*	*m*	*kN*		*m*	*kN*
30-49	a_0	2	120	192.5	12.5			170	88.5	2	80	32
50-69	a	2	180	220	14	12.5		180	98.0	3	80	34
70-89	b	2	240	220	16	14		180	98.0	3	100	37
90-109	c	2	300	247.5	17.5	16		180	98.0	3	110	39
110-129	d	2	360	247.5	19	17.5		180	98	3	110	44
130-149	e	2	420	275	20.5	17.5		180	98	3	120	49
150-174	f	2	480	275	22	19		180	98	3	120	54
175-204	g	2	570	302.5	24	20.5		180	112	3	120	59
205-239	h	2	660	302.5	26	22	20.5	180	129	4	120	64
240-279	i	2	780	330	28	24	22	180	150	4	120	69
280-319	j	2	900	357.5	30	26	24	180	174	4	140	74
320-359	k	2	1020	357.5	32	28	24	180	207	4	140	78
360-399	l	2	1140	385	34	30	26	180	224	4	140	88
400-449	m	2	1290	385	36	32	28	180	250	4	140	98
450-499	n	2	1440	412.5	38	34	30	180	277	4	140	108
500-549	o	2	1590	412.5	40	34	30	190	306	4	160	123
550-599	p	2	1740	440	42	36	32	190	338	4	160	132
600-659	q	2	1920	440	44	38	34	190	371	4	160	147
660-719	r	2	2100	440	46	40	36	190	406	4	160	157
720-779	s	2	2280	467.5	48	42	36	190	441	4	170	172
780-839	t	2	2460	467.5	50	44	38	190	480	4	170	186
840-909	u	2	2640	467.5	52	46	40	190	518	4	170	201
910-979	v	2	2850	495	54	48	42	190	559	4	170	216
980-1059	w	2	3060	495	56	50	44	200	603	4	180	230
1060-1139	x	2	3300	495	58	50	46	200	647	4	180	250
1140-1219	y	2	3540	522.5	60	52	46	200	691	4	180	270
1220-1299	z	2	3780	522.5	62	54	48	200	738	4	180	284
1300-1389	A	2	4050	522.5	64	56	50	200	786	4	180	309
1390-1479	B	2	4320	550	66	58	50	200	836	4	180	324
1480-1569	C	2	4590	550	68	60	52	220	888	5	190	324
1570-1669	D	2	4890	550	70	62	54	220	941	5	190	333
1670-1789	E	2	5250	577.5	73	64	56	220	1024	5	190	353
1790-1929	F	2	5610	577.5	76	66	58	220	1109	5	190	378
1930-2079	G	2	6000	577.5	78	68	60	220	1168	5	190	402
2080-2229	H	2	6450	605	81	70	62	240	1259	5	200	422
2230-2379	I	2	6900	605	84	73	64	240	1356	5	200	451
2380-2529	J	2	7350	605	87	76	66	240	1453	5	200	480
2530-2699	K	2	7800	632.5	90	78	68	260	1471	6	200	480
2700-2869	L	2	8300	632.5	92	81	70	260	1471	6	200	490
2870-3039	M	2	8700	632.5	95	84	73	260	1471	6	200	500
3040-3209	N	2	9300	660	97	84	76	280	1471	6	200	520
3210-3399	O	2	9900	660	100	87	78	280	1471	6	200	554
3400-3599	P	2	10500	660	102	90	78	280	1471	6	200	588
3600-3799	Q	2	11100	687.5	105	92	81	300	1471	6	200	618
3800-3999	R	2	11700	687.5	107	95	84	300	1471	6	200	647
4000-4199	S	2	12300	687.5	111	97	87	300	1471	7	200	647
4200-4399	T	2	12900	715	114	100	87	300	1471	7	200	657
4400-4599	U	2	13500	715	117	102	90	300	1471	7	200	667
4600-4799	V	2	14100	715	120	105	92	300	1471	7	200	677
4800-4999	W	2	14700	742.5	122	107	95	300	1471	7	200	686
5000-5199	X	2	15400	742.5	124	111	97	300	1471	8	200	686
5200-5499	Y	2	16100	742.5	127	111	97	300	1471	8	200	696
5500-5799	Z	2	16900	742.5	130	114	100	300	1471	8	200	706
5800-6099	A*	2	17800	742.5	132	117	102	300	1471	8	200	706
6100-6499	B*	2	18800	742.5	137	120	107	300	1471	9	200	716
6500-6899	C*	2	20000	770		124	111	300	1471	9	200	726
6900-7399	D*	2	21500	770		127	114	300	1471	10	200	726
7400-7899	E*	2	23000	770		132	117	300	1471	11	200	726

Table C1 Equipment, general (Continued)

Equipment number	*Equipment letter*	*Stockless bower anchors*		*Stud-link chain cables*				*Towline (guidance)*		*Mooring lines* [1] *(guidance)*		
		Number	*Mass per anchor*	*Total length*	*Diameter and steel grade*			*Steel or fibre ropes*		*Steel or fibre ropes*		
					NV K1	*NV K2*	*NV K3*	*Minimum length*	*Minimum breaking strength*	*Number*	*Length of each*	*Minimum breaking strength*
			kg	*m*	*mm*	*mm*	*mm*	*m*	*kN*		*m*	*kN*
7900-8399	F*	2	24500	770		137	122	300	1471	11	200	735
8400-8899	G*	2	26000	770		142	127	300	1471	12	200	735
8900-9399	H*	2	27500	770		147	132	300	1471	13	200	735
9400-9999	I*	2	29000	770		152	132	300	1471	14	200	735
10000-10699	J*	2	31000	770			137			15	200	735
10700-11499	K*	2	33000	770			142			16	200	735
11500-12399	L*	2	35500	770			147			17	200	735
12400-13399	M*	2	38500	770			152			18	200	735
13400-14599	N*	2	42000	770			157			19	200	735
14600-16000	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.

C 200 Equipment tables

201 The equipment is in general to be in accordance with the requirements given in Table C1.

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.

Guidance note:

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.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

202 For fishing vessels the equipment shall be in accordance with the requirements given in Table C2. When the equipment number is larger than 720, table C1 should be applied.

203 Unmanned barges are only to have equipment consisting of 2 mooring lines with length as required by Table C1.

204 For ships and manned barges with restricted service the equipment specified in Table C1 and C2 may be reduced in accordance with Table C3. No reductions are given for class notations **R0** and **R1**.

205 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 C1 and C2 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 **R4** in Table C3. 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 DNV”, e.g. **f(–)**.

Table C2 Equipment for fishing vessels and sealers

Equipment number	*Equipment letter*	*Stockless bower anchors*		*Stud-link chain cables*			*Towline (guidance)*		*Mooring lines (guidance)*		
			Mass per anchor	*Total length*	*Diameter and steel grade*		*Steel or fibre ropes*		*Steel or fibre ropes*		
		Number			*NV K1*	*NV K2*	*Minimum length*	*Minimum breaking strength*	*Number*	*Length of each*	*Minimum breaking strength*
			kg	*m*	*mm*	*mm*	*m*	*kN*		*m*	*kN*
30-39	a_0f_1	2	80	165	11				2	50	29
40-49	a_0f_2	2	100	192.5	11				2	60	29
50-59	af_1	2	120	192.5	12.5		180	98	3	80	34
60-69	af_2	2	140	192.	12.5		180	98	3	80	34
70-79	bf_1	2	160	220	14	12.5	180	98	3	100	37
80-89	bf_2	2	180	220	14	12.5	180	98	3	100	37
90-99	cf_1	2	210	220	16	14	180	98	3	110	39
100-109	cf_2	2	240	220	16	14	180	98	3	110	39
110-119	df_1	2	270	247.5	17.5	16	180	98	3	110	44
120-129	df_2	2	300	247.5	17.5	16	180	98	3	110	44
130-139	ef_1	2	340	275	19	17.5	180	98	3	120	49
140-149	ef_2	2	390	275	19	17.5	180	98	3	120	49
150-174	f	2	480	275	22	19	180	98	3	120	54
175-204	g	2	570	302.5	24	20.5	180	112	3	120	59
205-239	h	2	660	302.5	26	22	180	129	4	120	64
240-279	i	2	780	330	28	24	180	150	4	120	69
280-319	j	2	900	357.5	30	26	180	174	4	140	74
320-359	k	2	1020	357.5	32	28	180	207	4	140	78
360-399	l	2	1140	385	34	30	180	224	4	140	88
400-449	m	2	1290	385	36	32	180	250	4	140	98
450-499	n	2	1440	412.5	38	34	180	277	4	140	108
500-549	o	2	1590	412.5	40	34	190	306	4	160	123
550-599	p	2	1740	440	42	36	190	338	4	160	132
600-659	q	2	1920	440	44	38	190	371	4	160	147
660-720	r	2	2100	440	46	40	190	406	4	160	157

Table C3 Equipment reductions for service restriction notations. (See Table C1)

Class notation	*Stockless bower anchors*		*Stud-link chain cables*	
	Number	*Mass change per anchor*	*Length reduction*	*Diameter*
R2	2	- 10%	No red.	No red.
R3	2	- 20%	No red.	No red.
R4	2	- 30%	- 20%	- 10%
RE	2	- 40%	- 30%	- 20%
Alternatively:				
R3	1	+40%	- 40%	No red.
R4	1	No change	- 50%	No red.
RE	1	- 20%	- 60%	- 10%

D. Anchors

D 100 General

101 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.

102 The mass of ordinary stockless bower anchors shall not be less than given in C. 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 mass of the head shall not be less than 60% of the table value.

103 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.

104 For anchors approved as H.H.P. anchors, the mass shall not be less than 75% of the requirements given in C. In such cases the letter **r** will follow the equipment letter entered in the “Register of vessels classed with DNV”.

105 For anchors approved as S.H.H.P. anchors, the mass shall not be less than 50% of the requirements given in C. In such cases the letter **rs** will follow the equipment letter entered in the “Register of vessels classed with DNV”.

106 The use of S.H.H.P. anchors is limited to vessels with service restriction notation **R1** or stricter.

107 The S.H.H.P. anchor mass shall not exceed 1500 kg.

D 200 Materials

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

202 The materials shall comply with relevant specification given in Pt.2.

Plate material in welded anchors shall be of the grades as given in F200 Table F3.

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

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

D 300 Anchor shackle

301 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, see Table C1 or C2. For shackle material different from the steel grades NV K1, NV K2 and NV K3, linear interpolation between table values of d_c will normally be accepted.

302 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 301
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.

D 400 Manufacturing

401 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 is not to exceed 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, see Fig.1.

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

D 500 Testing

501 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, shall be subjected to proof testing in a machine specially approved for this purpose.

502 The proof test load shall be as given in Table D1, dependent 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.

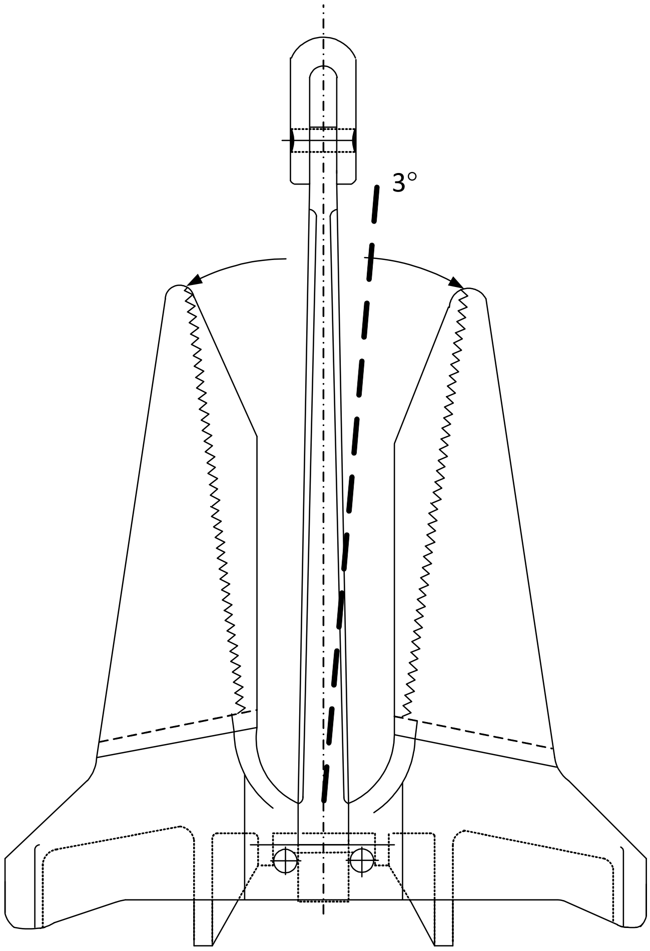


Fig. 1
Allowable lateral movement of shank

503 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.

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

For stocked anchors, each arm shall be tested individually.

505 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. For all types of anchors, high stress areas shall be checked my magnetic particle testing (MT) or penetrant testing (PT). The welds of fabricated anchors (if relevant) are in addition subject to MT.

506 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%).

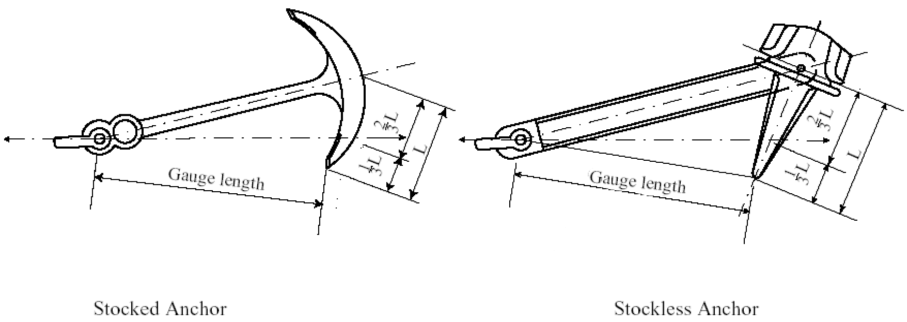


Fig. 2
Gauge length

D 600 Additional requirements for H.H.P. and S.H.H.P. anchors

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

602 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 Products No.3 "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 Products No.3: Containers, Cargo Handling, Lifting Appliances and Miscellaneous Equipment."

603 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. 608) shall form the basis for holding power.

604 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. 608) shall form the basis for holding power.

605 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.

606 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.

607 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.

608 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.

609 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.

D 700 Identification

701 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
— Det Norske Veritas' stamp
— Manufacturer's mark
— Additionally the unique cast identification shall be cast on the shank and the fluke.

Table D1 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

E. Anchor Chain Cables

E 100 General requirements

101 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.

102 The form and proportion of links and accessories together with examples of connections of links, shackles and swivels are shown in Fig.3. Other design solutions, e.g. short link chain cable or steel wire rope may be accepted after special consideration.

103 The diameter of stud link chain cable shall not be less than given in C.

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 ≤ 110, the diameter shall be at least 20% in excess of the table value for the chain grade used.

104 Chain grade NV K1 shall normally not be used in association with H.H.P. or S.H.H.P. anchors.

105 Chain grade NV K3 shall not be used for chain diameter less than 20.5 mm.

106 Ships equipped with chain cable grade NV K2 or NV K3 will have the letters **s** or **sh**, respectively, added to the equipment letter.

107 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.

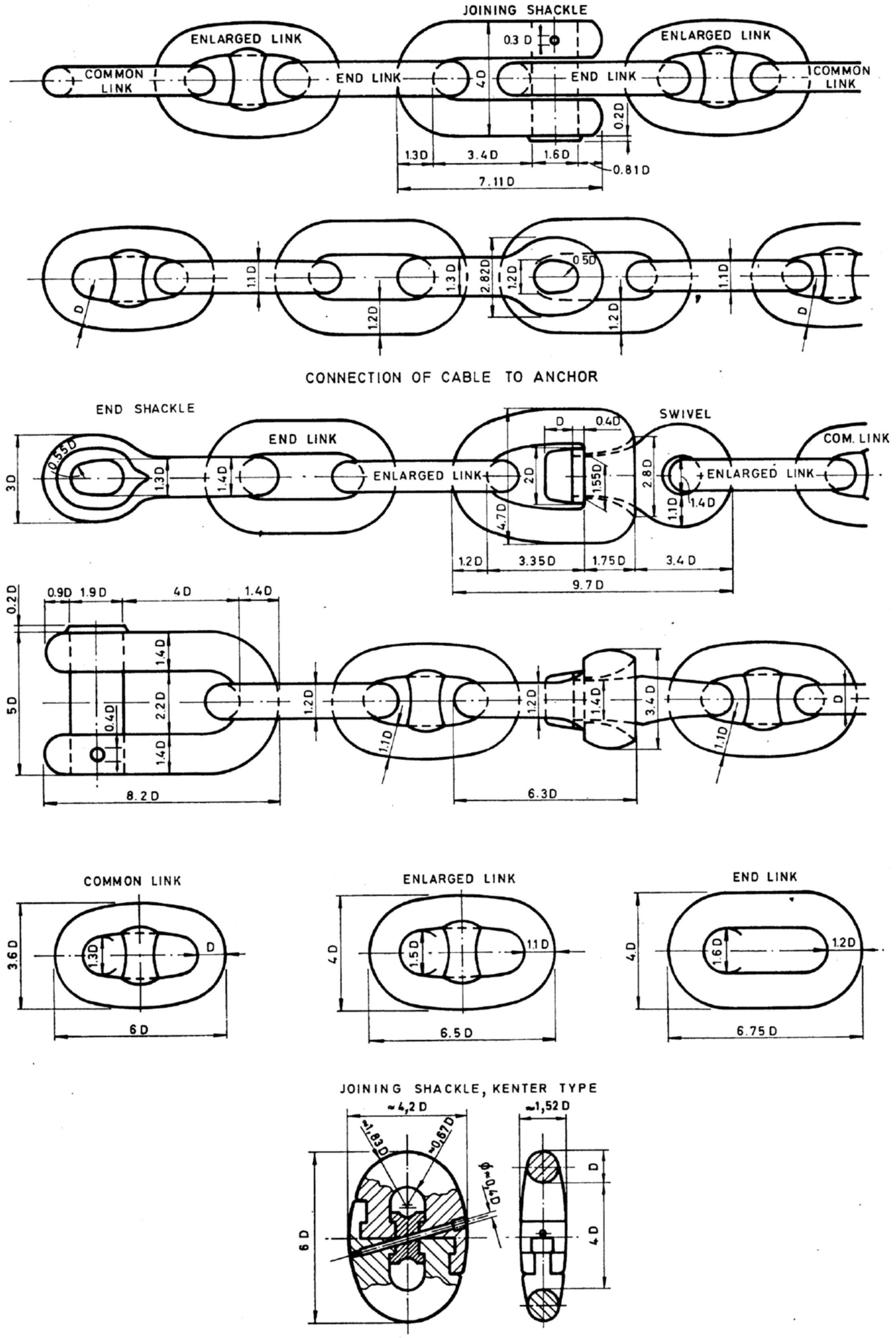


Fig. 3
Standard dimensions of stud link chain cable and examples of connections
D = dc = rule diameter of chain cables

E 200 Materials and manufacture

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

202 Stud link chain cables shall be manufactured by flash butt welding or, in the case of grade NV K2 and 3 chain cables, drop forging or casting. Pressure butt welding may also be approved for grade NV K1 and 2 short link chain cables provided that the nominal diameter of the chain cable does not exceed 26 mm.

203 Bar material for chain cables shall be in accordance with Pt.2 Ch.2 Sec.6. 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.

204 Where studs are welded into the links this shall be completed before the chain cable is heat treated. Stud welds 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.

205 Accessories such as shackles and swivels shall be made of forged or cast steel in accordance with the general requirements in Pt.2 Ch.2 Sec.5 or Sec.7, as appropriate. Tapered locking pins for detachable components shall be made of stainless or tinned steel with a lead stopper at the thick end.

E 300 Heat treatment

301 Chain cables and accessories shall be supplied in one of the conditions given in Table E1. Where alternative conditions are permitted, the manufacturer shall supply chain cables and accessories only in those conditions for which he has been approved.

302 When heat treating in batch furnaces, links shall be stretched out or otherwise suitably arranged to ensure uniform heating and cooling.

Table E1 Condition of supply for chain cables and accessories

Grade	*Chain cables*	*Accessories*
NV K1	As welded or Normalised	NA
NV K2	As welded or Normalised 1)	Normalised
NV K3	Normalised, Normalised and Tempered, Quenched and Tempered	Normalised, Normalised and Tempered, Quenched and Tempered

NA = Not Applicable

1) NV K2 chain cables made by forging or casting shall be supplied in the normalised condition.

E 400 Proof load testing

401 Each length of chain cable and all accessories shall be proof load tested in the condition of supply and shall withstand the proof load specified in Table E2 or Table E3 without fracture. Accessories shall be subjected to the proof load prescribed for the chain cable grade and size for which they are intended.

402 If one 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.

403 If an accessory fails, 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.

E 500 Breaking load testing

501 Samples of chain cables and accessories shall be breaking load tested in the condition of supply and shall withstand the breaking load specified in Tables E2 or E3. 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.

502 For chain cables, one sample consisting of at least three links shall be taken at the frequency given in 503. 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.

503 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.

504 For accessories, one sample item out of every test unit (batch) shall be taken. 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.

505 Except as provided in 506, accessories that have been breaking load tested shall be discarded and not used as part of an outfit.

506 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, or
— the accessory is specially approved and designed 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.

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

— 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, see 510, are proved, and
— the accessories are subjected to suitable non-destructive testing.

508 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.

509 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.

510 If an accessory fails, 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 E2 Proof and breaking loads for stud link chain cables and accessories							
Diameter of chain mm	*Grade NV K1*		*Grade NV K2*		*Grade NV K3*		*Guidance*
	Proof load kN	*Breaking load kN*	*Proof load kN*	*Breaking load kN*	*Proof load kN*	*Breaking load kN*	*Approximate mass per m 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 E3 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

E 600 Mechanical testing

601 Samples of chain cables and accessories shall be tensile and, where applicable, impact tested in the condition of supply, as given in Table E4, and shall meet the mechanical properties specified in Table E5. Testing of NV K1 chain cables and welded NV K2 chain cables supplied in normalised 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.

602 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:

- each sample is properly identified with the chain represented, and
- each sample is securely attached to and heat treated with the chain represented, and
- each sample is subjected to the appropriate proof load test prior to preparation of the mechanical test pieces.

603 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. Separately made samples shall be in accordance with the applicable requirements in Pt.2 Ch.2 Sec.5 or Sec.7.

604 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 Fig.4. In the case of welds, the notch shall be positioned at the centre of the weld.

605 The preparation of test pieces and the procedures used for testing shall comply with the applicable requirements in Pt.2 Ch.1 Sec.2.

606 If the results do not meet the specified requirements, the re-test procedures in Pt.2 Ch.1 Sec.2 may be adopted.

Table E4 Scope of mechanical tests for chain cables and accessories

Grade	*Method of manufacture*	*Condition of supply*	*Number of test pieces per sample*		
			Tensile test, base material	*Charpy V-notch impact test*	
				Base material	*Weld*
NV K1 Cable	Flash butt welded	As welded, Normalised	-	-	-
NV K2 Cable	Flash butt welded	As welded	1	3	3
		Normalised	-	-	-
	Forged or cast	Normalised	1	3	-
NV K3 Cable	Flash butt welded	Normalised, Normalised and tempered, Quenched and tempered	1	3	3
	Forged or cast		1	3	-
NV K2 Accessory	Forged or cast	Normalised	1	3	-
NV K3 Accessory	Forged or cast	Normalised, Normalised and tempered, Quenched and tempered	1	3	-

Table E5 Mechanical properties for chain cables and accessories

Grade	*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*
NV K2	295	490 - 690	22	-	0	27	27
NV K3	410	690 minimum	17	40	0	60	50

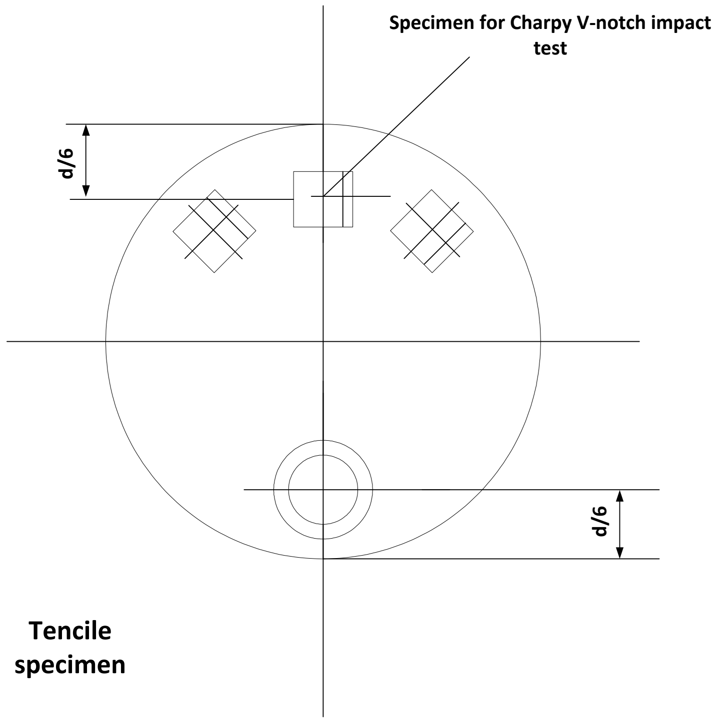


Fig. 4
Position of test pieces

E 700 Inspection and dimensional tolerances

701 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.

702 All links and accessories shall be visually inspected after proof load testing 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.

703 The 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.

704 Three 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 705 and 706, 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.

705 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 $40 < d_c \leq 84$ mm
— Minus 3 mm when $84 < d_c \leq 122$ mm
— Minus 4 mm when $d_c > 122$ 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.

706 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°.

707 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.

708 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.

E 800 Identification

801 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 certificate, as furnished by the surveyor,
— the Society's stamp.

802 Chain cables shall be marked at both ends of each length and as indicated in Fig.5.

803 Accessories that have been breaking load tested and are used as part of an outfit, as permitted in E506, shall be marked with the grade of chain for which they are intended.

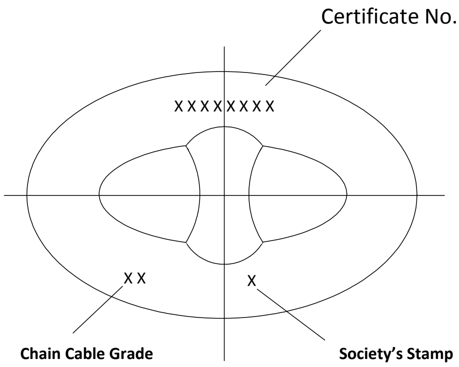


Fig. 5
Marking of chain cables

E 900 Certification

901 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.

F. Windlass and Chain Stoppers

F 100 General design

101 The anchors are normally to be 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.

102 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 release 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.

When the chain cable diameter is less than 26 mm, only one of the cable lifters need be fitted with release coupling and brake.

103 For each chain cable there is normally to be a chain stopper, arranged between windlass and hawse pipe. The chain cables shall reach the hawse pipes through the cable lifter only.

104 Electrically driven windlasses shall have a torque limiting device.

Electric motors shall comply with the requirements of Pt.4 Ch.8.

105 The windlass with prime mover shall be able to exert the pull specified by Table F1 directly on the cable lifter. For double windlasses the requirements apply to one side at a time.

Table F1 Lifting power			
Lifting force and speed	*Grade of chain*		
	K1	*K2*	*K3*
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 × normal lifting force		
d_c = diameter of chain in mm.			

Attention shall be paid to stress concentrations in keyways and other stress raisers and also to dynamic effects due to sudden starting or stopping of the prime mover or anchor chain.

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

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 E2, without any permanent deformation of the stressed parts and without brake slip.

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.

107 Calculations indicating compliance with the requirements in 105 and 106 may be dispensed with when complete shop test verification shall be carried out.

108 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.

Guidance note:

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

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

F 200 Materials

201 Cable lifter shafts and cable lifters with couplings shall be made from materials as stated in Table F2.

Table F2 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	

202 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 elongation not less than 18%. Plate material in welded parts shall be of grade as given in Table F3.

Table F3 Plate material grades

Thickness in mm	*Normal strength structural steel*	*High strength structural steel*
t ≤ 20	A	A
20 < t ≤ 25	B	A
25 < t ≤ 40	D	D
40 < t ≤ 150 *)	E	E

*) For plates above 40 mm joined with fillet-/partly penetration welds, grade D will normally be accepted.

F 300 Testing

301 Before assembly the following parts shall be pressure tested:

- housings with covers for hydraulic motors and pumps
- hydraulic pipes
- valves and fittings
- pressure vessels
- steam cylinders.

The tests shall be carried out in accordance with Pt.4 Ch.6 Sec.5 and Sec.7, and Pt.4 Ch.7. Test pressure for steam cylinders shall be 1.5 times the working steam pressure.

302 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.

303 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.

G. Towlines and Mooring Lines

G 100 General

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

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

103 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.

Fig.6 gives examples of rope constructions. Other rope constructions may be accepted by the Society upon special consideration.

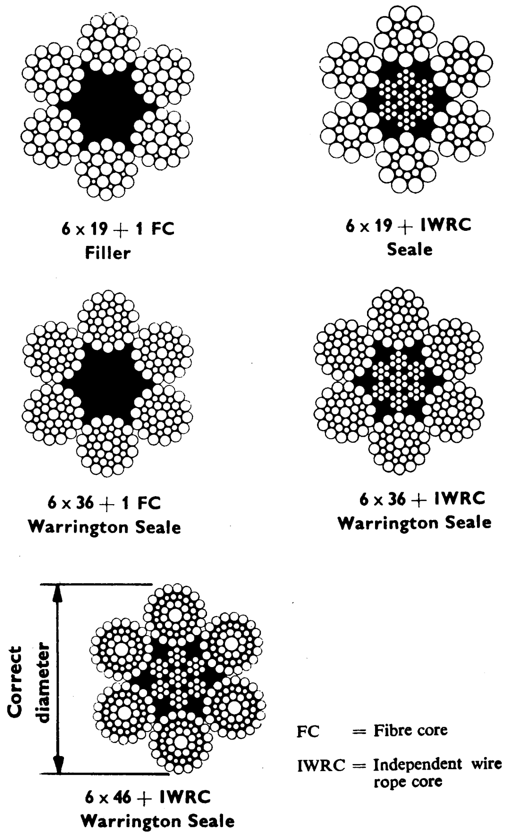


Fig. 6
Constructions of steel wire ropes

104 The diameter of a fibre rope shall not be less than 20 mm.

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

G 200 Materials

201 Towlines and mooring lines may be of steel, natural fibre or synthetic fibre construction.

202 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 galvanised or bright (uncoated). Galvanised wire shall comply with the specifications in ISO Standard 2232.

203 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 fibre core shall be manufactured from a synthetic fibre.

204 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 fibres in the rope.

G 300 Testing of steel wire ropes

301 Steel wire ropes shall be tested by pulling a portion of the rope to destruction. The test length which is dependent on the rope diameter, is given in Table G1. The breaking load of the ropes shall not be less than given in Table G2 for the dimension concerned.

Table G1 Test lengths

Rope diameter in mm	*Minimum test length in mm*
d ≤ 6	300
6 < d ≤ 20	600
d < 20	30 × d

Table G2 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/mm²		*1770 N/mm²*			
		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 × 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

302 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:

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

f = average breaking strength of one wire in kN
t = total number of wires
k = lay factor as given in Table G3.

Table G3 Lay factor k

Rope construction group	*Rope with FC*	*Rope with IWRD*
6 × 19	0.86	0.80
6 × 36	0.84	0.78

303 The following individual wire tests shall be performed:

— torsion test
— reverse bend test
— weight and uniformity of zink coating.

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

G 400 Testing of natural fibre ropes

401 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 G4.

Table G4 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

402 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.

G 500 Mooring Winches

501

Guidance note:

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.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

SECTION 4
MASTS AND RIGGING

A. General

A 100 Introduction

101 In this section the requirements to strength and support of masts, derrick posts and standing rigging are given.

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

A 200 Assumptions

201 The cargo handling systems are assumed only to be operated in harbours or in sheltered waters.

202 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 $7.5 \cdot 10^6$ N/mm^2.

A 300 Definitions

301 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 = athwartship distance in m from the mast to the deck attachment of shroud in question, see Fig.1

c = longitudinal distance in m from the mast to the deck attachment of shroud in question, see Fig.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, see Fig.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.

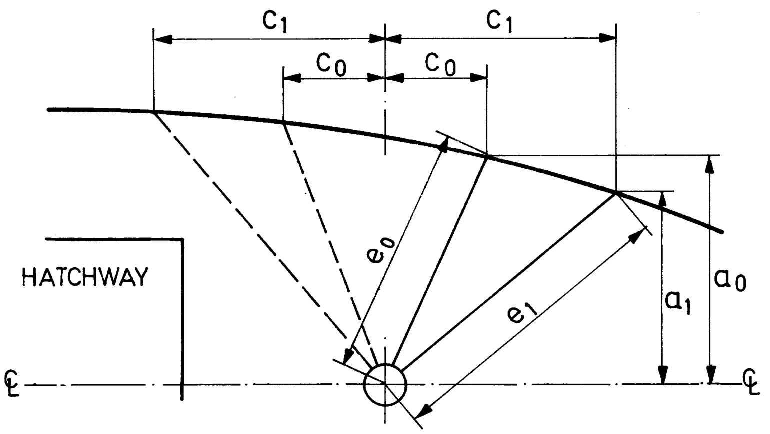


Fig. 1
Arrangement of shrouds.

A 400 Documentation

401 The following plans and information shall be submitted:

— Arrangement plan showing location of mast or derrick post, standing rigging and cargo handling gear. 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. Safe working load and working position for each provided derrick.
— Plan showing proposed scantlings of mast, derrick post and standing rigging.
— Plan showing supporting structures and strengthening of hull in way of mast, post and standing rigging fastenings.
— Specification of the steel wire ropes intended to be used for standing rigging, indicating rope construction, scantlings and minimum breaking strength.

B. Materials and Welding

B 100 Materials

101 Selection of material grades for plates and sections shall be based on material thickness. NV-steel grades as given in Table B1 will normally be accepted.

Table B1 Plate material grades

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

102 The tensile strength of wire ropes intended for shrouds and stays is normally to be minimum 1570 or 1770 N/mm^2 (see Table G2 of Sec.3) and should not exceed 2200 N/mm^2.

103 Material certificates for standing rigging shall be issued by the manufacturer, confirming that the delivered products are manufactured and tested according to the Rules (see Sec.3 G) or another approved specification.

C. Arrangement and Support

C 100 Masts and posts

101 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 sufficient size and adequately stiffened. A winch house of usual size and scantlings is not considered to meet the requirements.

C 200 Standing rigging

201 The mast or post shall have at least two shrouds on each side of the centre line of the ship. The attachment of shrouds to mast shall be carefully made so as to reduce torsional strains as far as possible.

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

D. Design and Scantlings

D 100 General

101 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. Minimum thickness is 7.5 mm.

102 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:

$$Z = 120\, r\, Q \quad (\text{cm}^3)$$

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

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

Σ P = total load in t which may be lifted by the derricks on one side of the centre line of the ship
n = 1, 2, 3 etc. for single, double and triple blocks etc., respectively.

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

D 200 Unstayed masts and posts with derricks

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

$$Z = 100\, \Sigma\, (P\, l_d) \quad (\text{cm}^3)$$

$$I = 240 \frac{l_m^2}{l_m - H} \sum (P l_d) \quad (\text{cm}^4)$$

Minimum thickness of plating t = 7.5 mm.

Masts with outriggers on unusual spread will be specially considered.

D 300 Stayed masts or posts with derricks with a lifting capacity not exceeding 10 t

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

$$d_0 = 140 \sum (P l_d)^{\frac{1}{3}} \quad (\text{mm})$$

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

$$t_0 = 0.014\, d_0 \text{ mm, minimum 7.5 mm}$$

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

$$I = 240 \frac{l_m^2}{l_m - H} \sum (P l_d) - 1500\, l_m^3 \sum \frac{f_c^2}{l_s^3} \alpha \quad (\text{cm}^4)$$

α = 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.

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

V = breaking strength of shrouds in N
q = tensile strength of shrouds in N/mm^2.

D 400 Stayed masts of posts with derricks with a lifting capacity of 10 t or more, but not exceeding 40 t

401 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:

$$\frac{d_0 t_0}{100} \geq 1.5 \sum P + 10 l_m^2 F$$

t_0 = plate thickness of mast in mm at diameter d_0
F = the greater of:

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

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

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

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

G = the smaller of

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

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

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

G = as defined in 403.

405 Where derricks are fitted both forward and aft of the mast, the section modulus is further not to be less than:

$$Z = \frac{80 l_m}{l_m - H} \sum P l_d - \frac{K l_m^3}{d_0} \sum \frac{f_a^2}{l_m^3} \quad (\text{cm}^3)$$

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

$\Sigma P_1 l_{d1}$ and $\Sigma P_2 l_{d2}$ refer to derricks on either side of a transverse plane through the mast.
$\Sigma P_1 l_{d1}$ shall be the smaller of these products.

D 500 Stayed masts without derricks

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

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

$$d_1 = 0.75 \, d_0 \quad (\text{mm})$$

d_0 and d_1 are the diameter at deck and hounds respectively.

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

502 The plate thickness shall not be less than:

$$t = 2.5 + 0.35\, l_{m1} \quad \text{(mm)}$$

D 600 Shrouds

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

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

Permanent centre line stays may be included in Σ e when relevant.

602 Shrouds for masts without derricks shall have circumference of steel wire rope not less than 63 mm.

SECTION 5
FOUNDATIONS FOR DECK MACHINERY, TOWING EQUIPMENT AND LIFTING APPLIANCES

A. Crane and Lifting Appliances

A 100 Introduction

101 In this sub-section the requirements for strength and support of crane pedestals, support of davits, A-frames and other lifting equipment are given. 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.

102 The crane including pedestal flange and bolts or the lifting gear itself is not subject to approval, unless class notation **CRANE, DSV** or **Crane Vessel** is requested.

Guidance note:
If ILO certification of lifting appliances is requested and DNV shall issue the certificate, approval of documentation will be required. See DNV Standard for Certification No. 2.22 “Lifting Appliances”.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

103 For the requirements in this section, the following definitions will apply:

— *Shipboard cranes* are lifting appliances onboard ships and similar units intended for use within harbours areas and when at sea within the cargo deck area.
— *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 discharging of offshore support vessels, barges, etc. or from the seabed.

104 Design of foundations and supporting structure for lifting appliances in general, e.g. cranes and A-frames, intended for large loads, having a complex arrangement and or comprised by irregular shaped plating, shall be supported by a strength analysis at an extent and content to be agreed before hand with the Society. Calculations shall follow principles outlined in Ch.1 Sec.12.

A 200 Documentation

201 The following plans shall be submitted:

For approval:

— pedestal/post with scantlings and grades of material
— support for stowage of crane and derrick booms during transit
— hull strengthening

for cranes on rails, also:

— support of rails with scantlings, material grades and details of fixation bolts and /or pads
— end buffers and respective supports
— arrangement and details of support for rack bar with scantlings, material grades and fixation bolts and/or pads
— parking position with locking arrangement and hull reinforcements.

For information:

— arrangement of crane showing main dimensions, limiting positions of its movable parts, location on board during operation and in parked position
— load data including the safe working load (SWL) and corresponding arm, e.g. as a load chart
— dynamic coefficient "ψ"
— crane self-weight and position of centre of gravity
— resulting loads acting on the hull supporting structure during operation in various lifting positions and in parked position

for "offshore cranes", also:

— significant wave height (H_S) for operation
— if available, dynamic load chart, i.e. chart showing crane capacity at each given H_S.

A 300 Materials

301 For pedestal/posts and supporting structures to be used in harbour only, selection of material grade for plates and sections shall be based on Table B1 of Sec.4.

302 When intended for offshore use, the selection of materials for crane pedestal and respective foundation shall be based on the DNV Standard for Certification No. 2.22 “Lifting Appliances”.

If not otherwise stated the design temperature T_D, for determination of the impact test temperature, shall be –20°C or lower.

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

— either Z-quality material (Pt.2 Ch.2 Sec.1 E) shall be used
— or an ultrasonic lamination test of plate before welding, shall be carried out in tension exposed areas (Pt.2 Ch.2 Sec.1 E).

Guidance note:

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

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

304 For welding procedures and details in general, see relevant requirements given in Pt.2 and Pt.3 Ch.1 and Ch.2.

A 400 Arrangement

401 Support of heavily loaded crane pedestals shall preferably be provided by at least 2 deck levels. The supporting structure shall have continuity and allow safe access for survey of its interior. Reference is made to Fig.1 and Fig.2.

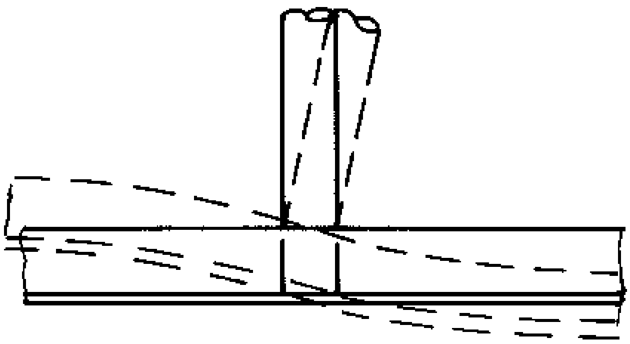


Fig. 1
Not recommended

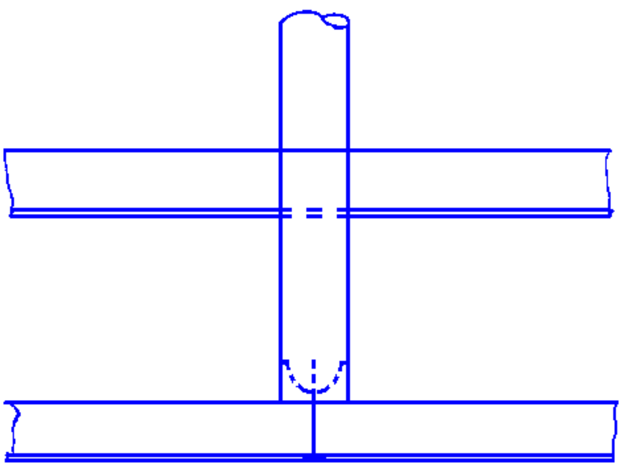


Fig. 2
Recommended support

A 500 Design loads

501 The structural strength of the supporting structure and pedestal shall be based on the safe working load (SWL) 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":

— 1.3.

For "offshore cranes":

— with the operator placed above the slewing ring:
  - ψ increased by 30%, min. 2.0

— with the operator placed below the slewing ring:
  - 1.5.

Lifting appliances fitted with shock absorbers may be specially considered.

502 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 Ch.1 Sec.4 B. Accelerations to be combined as indicated for deck equipment in Ch.1 Sec.4 C500.

Guidance note:

When the significant wave height H_S is known,

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

may be inserted in the formulae of Ch.1 Sec.4 B.

C_w = wave coefficient.

- Wind forces for the specified wind velocity, according to the DNV Standard for Certification No. 2.22 "Lifting Appliances".

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

503 When the transit condition is considered critical, the design loads shall normally be taken as given for idle deck equipment in Ch.1 Sec.4 C500.

For vessels with length less than 100 metres, see also Ch.2 Sec.3 B300.

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.

Guidance note:

For vessel with class notation **Supply Vessel**, the loads mentioned above shall be determined as given in Pt.5 Ch.7 Sec.2 E401.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

504 Supporting structure for survival craft and work boat davits shall be designed for a dynamic coefficient taken as 2.2.

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

A 600 Allowable stresses

601 Allowable stresses in crane pedestals and respective supporting structure 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.

A 700 Testing

701 Upon completion of crane foundation, load test shall be carried out in the presence of a DNV surveyor.

B. Foundations for Winches, Windlasses and other Pulling Accessories

B 100 Introduction

101 This sub-section gives requirements for foundations and respective supporting structures for deck machinery in general, like winches, windlasses, chain stoppers, and other similar items, including stern rollers and shark jaws for handling chains of offshore rigs fitted onboard offshore support vessels. Foundations and structures covered by C need not comply with this sub-section.

Guidance note:

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 DNV.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

B 200 Documentation

201 When the breaking load of the wire or chain is > 150 kN, or SWL > 30 kN, the following plans and information shall be submitted:

Documents for approval:

— foundations and respective supporting structure including scantlings, material data, details of connections and welding
— fixation of windlass (bolts, chocks and stoppers).

Documents for information:

— arrangement of the equipment showing main dimensions, design loads (SWL, brake rendering load and wire breaking load, if relevant) and foot print loads.

B 300 Design loads and allowable stresses

301 The strength of the foundations and supporting structures shall fulfil the strictest of the following requirements as found relevant:

a) 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, see A503.

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 Sec.3 F106.

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

B 400 Securing requirements for fore deck windlasses

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

— in ships of length 80 m or more
— 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 the lesser.

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

403 Where mooring winches are integral with the anchor windlass, they shall be considered as part of the windlass.

404 The following pressures and associated areas shall be applied (see Fig.3):

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:

$$f = 1 + B/H, \text{ but not greater than } 2.5$$

where:

B = width of windlass measured parallel to the shaft axis

H = overall height of windlass.

405 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, see Fig.3.

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

$$R_{xi} = P_x \, hx_i \, A_i / I_x$$

$$R_{yi} = P_y \, hy_i A_i / I_y$$

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* (cm^2)
I_x	=	$\Sigma A_i \; x_i^2$ for N bolt groups
I_y	=	$\Sigma A_i \; y_i^2$ for N bolt groups
R_{si}	=	static reaction at bolt group i, due to weight of windlass.

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

$$F_{xi} = (P_x - \alpha g M) / N$$

$$F_{yi} = (Py - \alpha g M) / N$$

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/sec^2)
N	=	number of bolt groups.

408 Axial tensile and compressive forces in 406 and lateral forces in 407 shall also be considered in the design of the supporting structure.

409 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)

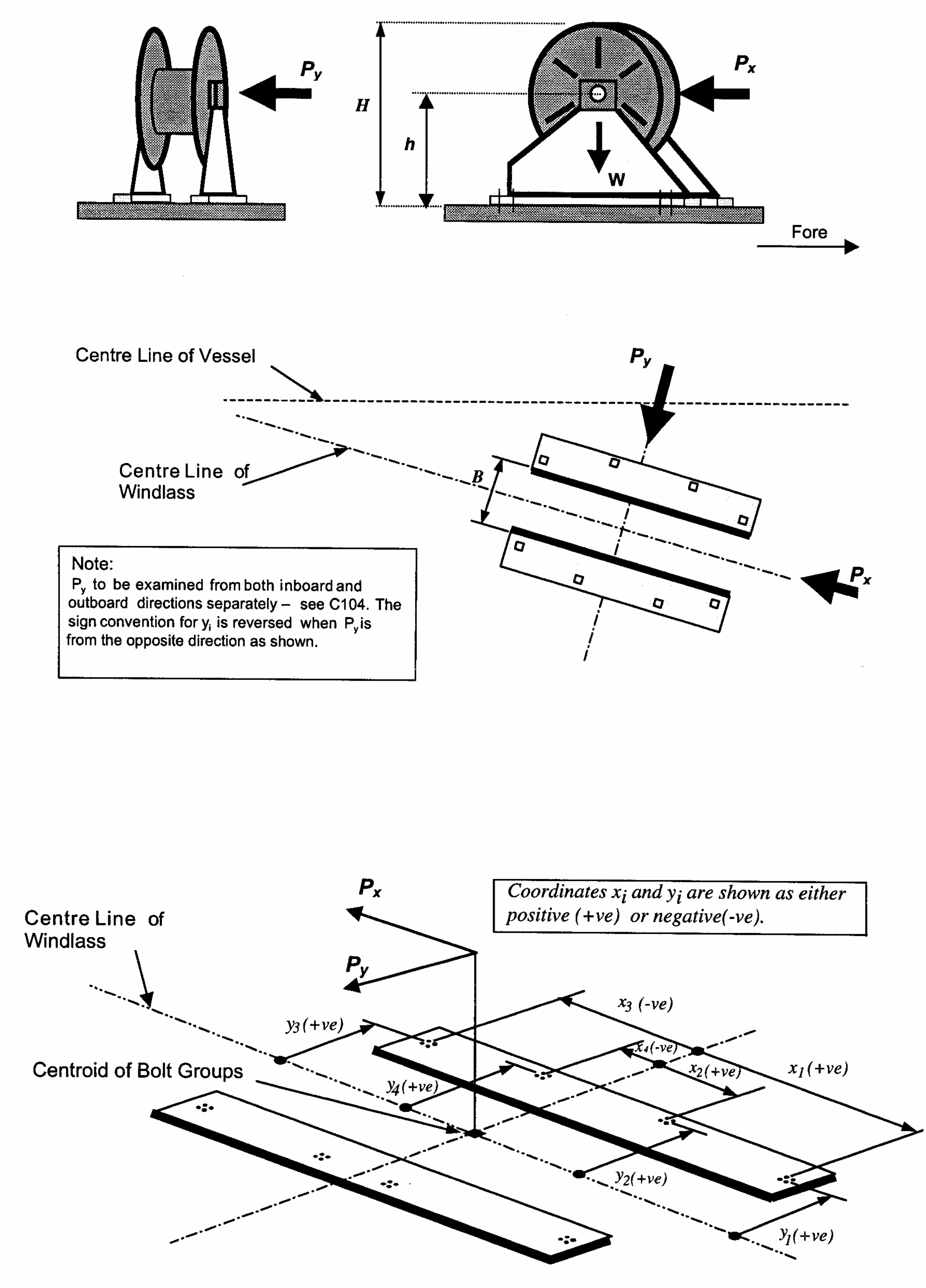


Fig. 3
Direction of forces and weight

B 500 Materials

501 Selection of material grades for plates and sections shall be based on material thickness. Steel grade given in Table B1 or equivalent will be accepted.

Table B1 Plate material grades		
Thickness (mm)	*Normal strength structural steel*	*High strength structural steel*
t ≤ 40	A	A
40 < t ≤ 150	B	A

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

C. Shipboard Fittings and Supporting Hull Structures Associated with Towing and Mooring on Conventional Vessels

C 100 Introduction

101 The requirements in this sub-section apply to the design and construction of shipboard fittings and respective supporting structures, used for normal towing (at bow, sides and stern) and mooring operations on conventional vessels.

102 For the purpose of applying this sub-section, the following definitions apply:

— conventional vessels means new displacement-type vessels of 500 GT and above, excluding high speed craft, special purpose vessels, and offshore units of all types.
— shipboard fittings means 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. Other components such as capstans, winches, etc. are not covered by the requirements in this sub-section. Any weld, bolt or equivalent device connecting the shipboard fitting to the supporting structure is part of the shipboard fitting and subject to the Industry standard applicable to this shipboard fitting.
— supporting hull structures mean that part of the ship structure on/in which the shipboard fitting is placed and which is directly subjected to the forces exerted on the shipboard fitting. The supporting hull structure of capstans, winches, etc. used for the normal towing and mooring operations mentioned above is also subject to the requirements in this sub-section.
— 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.

103 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.5 Ch.3 Sec.2 C500.

Shipboard fittings being part of emergency towing procedure, as required by SOLAS II-1/3-4 for passenger and cargo ships, shall comply with C500.

104 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 (e.g. Pt.5 Ch.7 Secs.2, 3 & 15).

C 200 Documentation

201 The following plans shall be submitted:

For approval:

— mooring fittings, towing devices (if provided) and respective supporting hull structures showing scantlings, connection details (bolts, welds or equivalent devices) and material grades.

For information:

— Towing, emergency towing and mooring arrangement plan providing information for each item regarding location on the ship, fitting type, dimensions, Safe Working Load (SWL), maximum breaking strength of the towing and mooring lines, purpose (mooring / harbour towing etc.), manner of applying the towing or mooring line including limiting fleet angles.
— Emergency towing procedure (SOLAS II-1/3-4).

For vessels with increased number of mooring lines to compensate for reduced breaking strength as outlined in footnote to Sec.3 Table C1, the "Towing and mooring arrangements plan" is also to show the number of mooring lines together with the breaking strength of each mooring line.

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

C 300 General

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

302 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.

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

— Ships covered by CSR for bulk carriers and CSR for double hull oil tankers: Total corrosion additions defined in these rules
— Other ships: 2.0 mm.

304 The selection of shipboard fittings shall be made by the shipyard normally in accordance with an Industry standard (e.g. ISO3913 Shipbuilding Welded Steel Bollards) accepted by the society.

305 When a shipboard fitting is not selected from an accepted Industry standard, the design is subject to approval. The design load used to assess its strength and its attachment to the ship shall be in accordance the relevant requirements in C400 and C500, for towing and mooring respectively.

306 Allowable stresses for fittings according to C305 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.

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

308 The method of using the towing lines and mooring lines shall be defined in the “Towing and mooring arrangement plan”.

309 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.

C 400 Towing

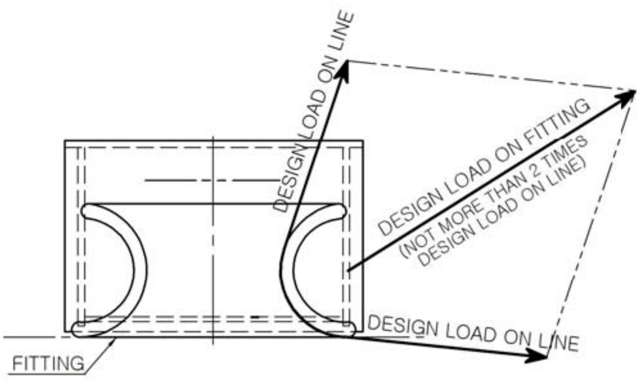
401 Unless greater safe working load (SWL) of shipboard fittings is specified, the minimum design load to be used is the following value of (1) or (2), whichever is applicable:

(1) for normal towing operations (e.g. in harbour / manoeuvring), 1.25 times the intended maximum towing load (e.g. static bollard pull) as indicated on the “Towing and mooring arrangement plan”.
(2) for other towing service, the nominal breaking strength of the towing line according to values given in Sec.3 Table C1, for the ship's corresponding equipment number.

For the selection of the towing lines, the projected area including maximum stacks of deck cargoes shall be considered in the calculation of the equipment number. The breaking loads of towing lines given as guidance in Sec.3 Table C1 is the design load to be applied to the shipboard fittings and supporting hull structure.

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

402 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, i.e. no more than one turn of one line (see figure below).



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

1) The SWL used for normal towing operations (e.g. harbour / manoeuvring) is not to exceed 80% of the design load per 401(1) and the SWL used for other towing operations is not to exceed the design load per 401(2). For fittings used for both normal and other towing operations, the greater of the design loads given in 401 shall be used.
2) The above requirements on SWL apply for a single post basis (no more than one turn of one cable).

C 500 Mooring

501 For the mooring shipboard fittings and respective supporting hull structures, the following will apply to definition of the design load:

1) Unless greater safe working load (SWL) of mooring fittings are specified by the applicant, 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 Sec.3 Table C1 as guidance for the ship's corresponding equipment number.
2) 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.
3) The design load shall be applied through the mooring line according to the arrangement shown on the “Towing and mooring arrangements plan”.
4) 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.
5) 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.
6) 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 Sec.3 Table C1 shall be used for determining the design load to be applied to the shipboard fittings and supporting hull structure.

502 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 C501.
2) The above requirements on SWL apply for a single post basis (no more than one turn of one cable).

(IACS UR A2)

C 600 Materials

601 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 Sec.4 Table B1.

SECTION 6
OPENINGS AND CLOSING APPLIANCES

A. General

A 100 Application

101 In this section the requirements for the arrangement of openings and closing appliances have been collected. The closing appliances are in general to have strength at least corresponding to the required strength of that part of the hull in which they are fitted.

102 This section applies to all ships above 24 m in length, with the following exceptions:

— pleasure yachts not engaged in trade
— fishing vessels, see Pt.5 Ch.6 Sec.6.

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

A 200 Definitions

201 Symbols:

L = rule length in m [1)]
B = rule breadth in m [1)]
C_B = rule block coefficient [1)]
t = plate thickness in mm. [1)]
Z = rule section modulus in cm^3 of stiffeners and simple girders
k_a = correction factor for aspect ratio of plate field
= $(1.1 - 0.25\ s/l)^2$
= 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 topflange of the member. For definition of span point, see Ch.1 Sec.3 C100. For curved stiffeners l may be taken as the cord length
S = girder span in m. For definition of span point, see Ch.1 Sec.3 C100
f_1 = material factor
= 1.0 for NV-NS steel [2)]
= 1.08 for NV-27 steel [2)]
= 1.28 for NV-32 steel [2)]
= 1.39 for NV-36 steel [2)]
= 1.47 for NV-40 steel [2)]
t_k = corrosion addition as specified in Ch.1 Sec.2
w_k = section modulus correction factor in tanks, see Ch.1 Sec.3 C1004
σ = nominal allowable bending stress in N/mm^2 due to lateral pressure
τ = nominal 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) See Ch.1 Sec.1 B.

2) For details see Ch.1 Sec.2 B and C.

202 Terms

Position

For the purpose of the Regulations, two positions of hatchways, doorways and ventilators are defined as follows:

Position 1 - Upon exposed freeboard and raised quarter decks, and upon exposed superstructure decks situated forward of a point located a quarter of the ship's length from the forward perpendicular.

Position 2 - Upon 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.

Upon 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 are required to be increased, because of such consideration as strength, location of shell or side scuttles or other reasons, then:

a) The height of doors sills, hatchway coamings, sills of machinery space openings, miscellaneous openings, ventilators and air pipes

b) the scantlings of hatch covers

c) freeing arrangements and means for protection of crew

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 weathertight 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 water will not penetrate into the vessel.

Watertight means capable of preventing the passage of water through the structure under a head of water 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 a substantial length or the entire 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, pa llets, 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*, see Ch.1 Sec.1 B200.

A 300 Documentation requirements

301 Documentation shall be submitted as required by Table A1.

Table A1 Documentation requirements

Object	*Documentation type*	*Additional description*	*For approval (AP) or For information (FI)*
External watertight integrity	B200 – Freeboard plan	Drawing including information about openings and closing appliances requested in Chapter II of the ICLL.	AP
Cargo hatches	C030 – Detailed drawing	Including covers and opening, closing, sealing, securing and locking devices.	AP
Shell doors and ramps (bow, side and stern as applicable)	C030 – Detailed drawing	Including securing devices.	AP
	I200 - Control and monitoring system documentation	Shell doors control and monitoring system.	AP
	I200 - Control and monitoring system documentation	Water leakage monitoring system.	AP
	Z160 – Operation manual		AP
	Z180 – Maintenance manual		AP
Service hatches	C030 – Detailed drawing		AP
Manholes	Z030 – Arrangement plan		FI
Scuppers	S010 – Piping diagram		AP

Table A1 Documentation requirements

Object	*Documentation type*	*Additional description*	*For approval (AP) or For information (FI)*
Internal watertight doors	Z030 – Arrangement plan	Including for each door: Size, design principle (sliding, hinged), pressure rating and fire rating. Including remote control positions.	AP
	I200 - Control and monitoring system documentation	Internal watertight doors control and monitoring system.	AP
Retractable bottom equipment	H050 – Structural drawing	Foundations including watertight boundaries.	AP
	H050 – Structural drawing	Supporting structures.	AP
	Z030 – Arrangement plan	Including resulting loads acting on the supporting structures, and details of sealings.	FI
Box coolers	H050 – Structural drawing	Foundations including watertight boundaries.	AP
	H050 – Structural drawing	Supporting structures.	AP
	Z030 – Arrangement plan	Including details of sealings.	FI

302 For general requirements to documentation, see Pt.0 Ch.3 Sec.1.

303 For a full definition of the documentation types, see Pt.0 Ch.3 Sec.2.

A 400 On board documentation

401 The operation and maintenance manuals for the shell doors shall be provided on board.

A 500 Testing

501 All weathertight/watertight doors and hatch covers shall be function tested.

502 For ships exclusively intended for the carriage of containers in the cargo holds, for which an exemption to the ICLL, Reg.16 (see E and F) has been granted by the Flag Administration, and which complies with the requirements given in Pt.5 Ch.2 Sec.6 K, the required testing for weathertightness given in Pt.2 Ch.3 Sec.8 may be dispensed with.

503 If non weathertight hatch covers are fitted in accordance with 402, this will be noted in the main letter of approval with the implication that hose testing for weathertightness in accordance with Pt.2 Ch.3 Sec.8 will not be carried out.

504 Doors and hatch covers which become immersed by an equilibrium or an intermediate water plane in a damaged condition are to be subjected to a hydrostatic pressure test. 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 unfavourable damage waterplane. The acceptance criteria for the test is no leakage.

For large doors, above 6 m^2, structural analysis may be accepted in lieu of pressure testing. Where such doors utilise gasket seals, a prototype pressure test of the gasket seal to confirm that the compression of the gasket material is capable of accommodating maximum deflection, revealed by the structural analysis, is to be carried out. After installation of such door or hatch, the initial gasket compression is to be documented.

A 600 Certificate requirements

601 Certificates shall be issued as required by Table A2.

Table A2 Certificate requirements

Object	*Certificate type*
Internal watertight doors control and monitoring system	DNV product certificate
Shell doors control and monitoring system	DNV product certificate

B. Access Openings in Superstructures and Freeboard Deck

B 100 Doors

101

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 unpierced bulkhead and weathertight when closed. The means for securing these doors weathertight 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) 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 millimetres above the deck.

(ICLL Reg.12)

102

a) Doors should generally open outwards to provide additional security against the impact of the sea. 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) They must be installed before the ship leaves port.
   ii) Sills shall be gasketed and fastened by closely spaced through bolts.
   iii) Whenever the sills are replaced after removal, the weathertightness of the sills and the related doors must be verified by hose testing. The dates of removal, replacing and hose testing shall be recorded in the ship's log book.

(IACS LL5)

103 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 in the freeboard deck
— companionways on freeboard deck and superstructure deck
— bulkheads of deckhouses on superstructure deck protecting openings in the superstructure deck
— companionways and bulkheads of deckhouse upon another deckhouse on freeboard deck protecting openings in the freeboard deck.

104 For weathertight doors the minimum required door blade thickness corresponding to lateral pressure shall be calculated by the following formula:

$$t = \frac{1.58 k_a s \sqrt{p}}{\sqrt{f_1}} \quad \text{(mm)}$$

The section modulus requirement for stiffeners is given by:

$$Z = \frac{0.8\, l^2 s\, p}{f_1} \quad (\text{cm}^3)$$

assuming simply supported ends.

105 The number of the cleats is to comply with ISO6042(1998). The cleats may be individual or centrally operated.

106 A hinged watertight door that opens inwards is acceptable in lieu of a weathertight door that opens outwards.

B 200 Sill heights

201 Openings as mentioned in 100 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:

— Companionways
— where access is not provided from the deck above: Openings in poop frontbulkhead, bulkheads at ends of midships 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.

202 In ships which have their freeboard assignment 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 according to the calculated damage 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 shall not be less than 230 mm.

Guidance note:

“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. Accordingly two weather tight doors in series are not required.”

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

203 Openings which are used only when the ship is in harbour (for handling of spare parts, etc.), may have a reduced sill height.

204 For vessels trading in domestic waters reduced sill height may be accepted in accordance with Pt.1 Ch.1 Sec.2 A 300.

B 300 Access openings in freeboard and superstructure decks

301 Manholes and flush scuttles in position 1 or 2 or within superstructures other than enclosed superstructures shall be closed by substantial covers capable of being made watertight. Unless secured by closely spaced bolts, the covers shall be permanently attached.

302 Openings in freeboard decks other than hatchways, machinery space openings, manholes and flush scuttles shall be protected by an enclosed superstructure, or by a deckhouse or companionway of equivalent strength and weathertightness. Any such 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 101.

303 In position 1 the height above the deck of sills to the doorways in companionways shall be at least 600 millimetres. In position 2 it shall be at least 380 millimetres.

(ICLL Reg.18)

304 Regarding the requirement to protect openings in superstructures (302) 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 raised quarterdeck shall be provided with an acceptable means of closing but need not be protected by an efficient deckhouse or companionway as defined in the regulation provided the height of the deckhouse is at least the height of a full superstructure.

(IACS LL46)

305 Only those doorways in deckhouses leading to or giving access to companionways leading below, need to be fitted with doors in accordance with 101.

Alternatively, if stairways within a deckhouse are enclosed within properly constructed companionways fitted with doors complying with 101, the external doors need not be weathertight.

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 L100. 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.

In the application of 301 and 302 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 101, interior deck openings shall be considered exposed, i.e. situated in the open deck.

(IACS LL8)

B 400 Strength and securing of small hatches on the exposed fore deck

401 For vessels with L > 80 m:

Small hatches (< 2.5 m^2) on the exposed deck over 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 403 to 414.

(IACS UR S 26)

402 Hatches designed for use as emergency escape shall comply with these requirements, except 414.

In 407, option (iii) shall be used (for emergency escapes).

403 For small rectangular steel hatch covers, the plate thickness, stiffener arrangement and scantlings shall be in accordance with Table B1, and Fig 1. Stiffeners, where fitted, shall be aligned with the metal-to-metal contact points, required in 409, see Fig.1. Primary stiffeners shall be continuous. All stiffeners shall be welded to the inner edge stiffener, see Fig.2.

Table B1 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
1330 × 1330	8	150 × 12; 2	100 × 10; 2

404 The upper edge of the hatchway coamings shall be suitably reinforced by a horizontal section, normally not more than 170 to 190 mm from the upper edge of the coamings.

405 For small hatch covers of circular or similar shape, the cover plate thickness and reinforcement shall be according to the requirements of E.

406 For small hatch covers constructed of materials other than steel, the required scantlings shall provide equivalent strength.

407 Small hatches located on exposed fore deck shall be fitted with primary securing devices such that their hatch covers can be secured in place and weather tight by means of a mechanism employing any one of the following methods:

i) butterfly nuts tightening onto forks (clamps)
ii) quick acting cleats, or
iii) central locking device.

For emergency escape hatches the central locking device shall be of a quick-acting type operable from both sides of the hatch cover. (IACS UR S26)

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

409 The hatch cover shall be fitted with a gasket of elastic material. This shall be designed to allow a metal to metal contact at a designed compression and to prevent over compression of the gasket by green sea forces that may cause the securing devices to be loosened or dislodged. The metal-to-metal contacts shall be arranged close to each securing device in accordance with Fig.1, and of sufficient capacity to withstand the bearing force.

410 The primary securing method shall be designed and manufactured such that the designed compression pressure is achieved by one person without the need of any tools.

411 For a primary securing method using butterfly nuts, the forks (clamps) shall be of robust 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 Fig.2.

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

413 On small hatches located between the main hatches, for example between Nos. 1 and 2, the hinges shall be placed on the fore edge or outboard edge, whichever is practicable for protection from green water in beam sea and bow quartering conditions.

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

(IACS UR S26)

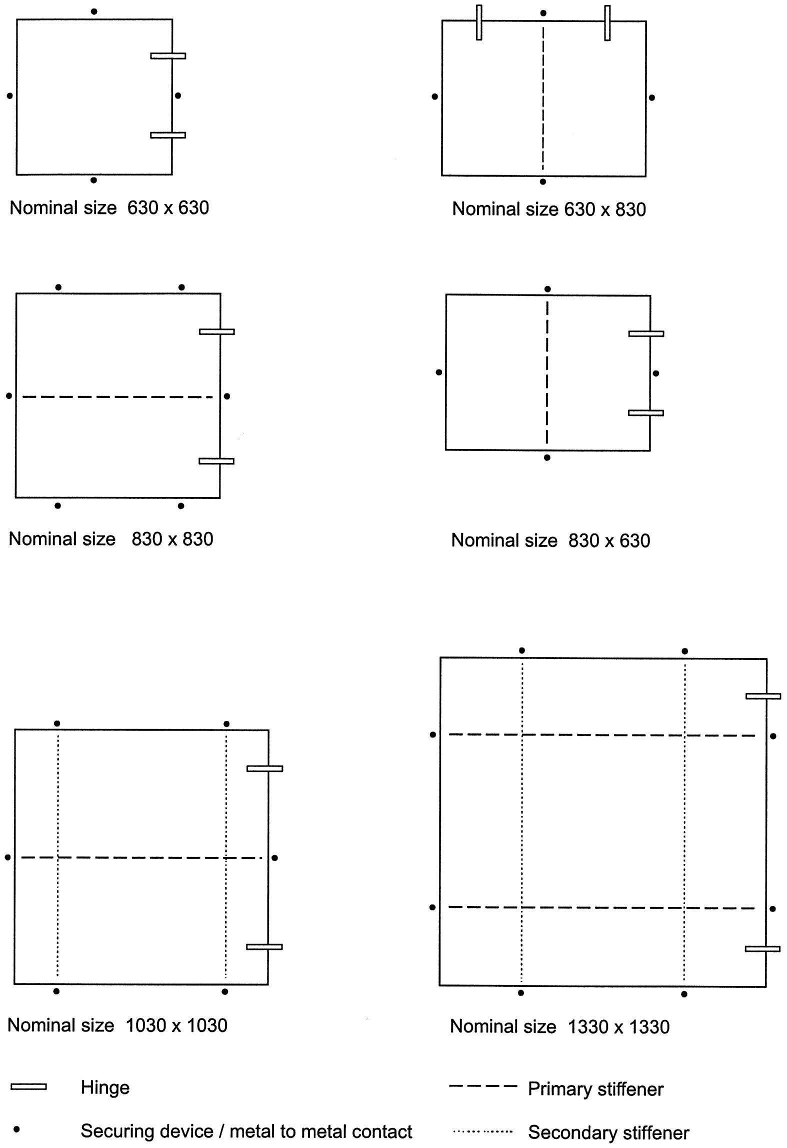


Fig. 1
Arrangement of stiffeners

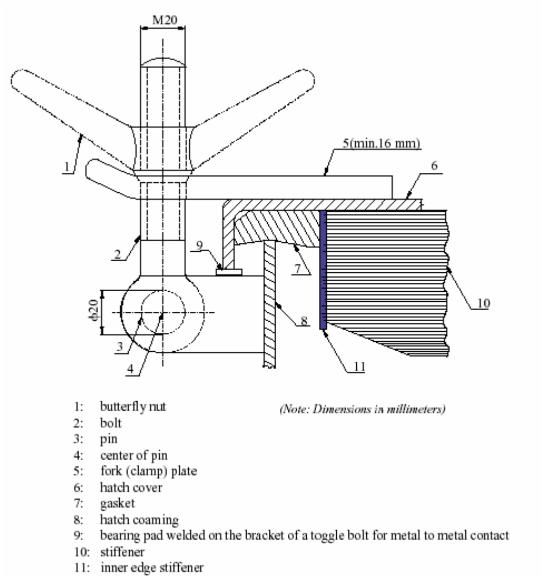


Fig. 2
Example of primary securing method

C. Side and Stern Doors

C 100 General.

101 These requirements cover 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 for bow doors, see Pt.5 Ch.2 Sec.3.

102 The side and stern doors shall be fitted as to ensure tightness and structural integrity commensurate 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.

All external openings leading to compartments assumed intact in the damage analysis, which are below the final damage waterline, are required to be watertight.

(2006/05 SOLAS Am/II-1/B-2/15-1)

103 The lower edge of any cargo or service door, if located below the freeboard deck, shall not be below a line drawn parallel to the freeboard deck at side, which at its lowest point is 230 mm above the upper edge of the uppermost load line. Special consideration shall be given to preventing the spread of any leakage water over the deck. A flatbar welded to the deck and provision of scuppers would be an acceptable arrangement.

104 Where the sill of any cargo or service door is below the line defined in C103, the arrangements will require to be specially considered to ascertain that the safety of the ship is in no way impaired. It is considered that the fitting of a second door of equivalent strength ad watertightness 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.

(IACS LL21)

105 Doors should preferably open outwards.

106 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.

C 200 Structural arrangement

201 Door openings in the shell shall have well rounded corners and adequate compensation shall be arranged with web frames at sides and stringers or equivalent above and below.

202 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/manoeuvring arms and hinges to the doors structures and to the ship structure.

203 $A \geq 12\ m^2$ Doors with light opening area shall be such that the sea pressure is transferred directly to the hull coamings.

204 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 203 is not feasible.

205 If a door is divided into separate sections, each section shall have full strength independent of the other sections.

206 Where doors also serve as vehicle ramps, 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.

C 300 Design loads

301 The design sea pressure is given by:

$$p = (p_{dp} - (4 + 0.2\ k_s)\ h_0)\ ^{1)}$$
$$\text{minimum } 6.25 + 0.025\ L\ (kN/m^2)$$

or

p = $10\ h_b$ [2)], whichever is the largest.

p_{dp}, k_s = as given in Ch.1 Sec.4 C201

h_0 = vertical distance in m from the load point to the waterline at draught T.

h_b = vertical distance in metres 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 Ch.1 Sec.4 B202. C_W should not be reduced.

302 The design force for securing bolts and other closing devices, supporting members and surrounding structure is given by:

$$F_1 = A\, p_e\, 10^3 + F_P \quad (N)$$

or

$$F_2 = F_0 + 10\, W + F_P \quad (N)$$

F_1 is applicable for ports opening inwards.

F_2 is applicable for ports opening outwards.

p_e = external design pressure p according to 301, minimum 25 kN/m^2
F_P = total packing force in N
F_0 = 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 rampway 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 = 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. The packing line pressure shall be specified.

C 400 Plating

401 The thickness requirement corresponding to lateral pressure is given by:

$$t = \frac{1.58 k_a\, s \sqrt{p}}{\sqrt{f_1}} \quad \text{(mm)}$$

p = as given in 300.

The thickness is in no case to be less than the minimum shell plate thickness.

402 Where doors also serve as vehicle ramps, the plating shall not be less than required for vehicle decks.

C 500 Stiffeners

501 The section modulus requirement is given by:

$$Z = \frac{0.8\, l^2\, s\, p}{f_1} \quad (\text{cm}^3)$$

assuming simply supported ends.

p = as given in 300.

502 The stiffener web plate at the ends shall have a net sectional area not less than:

$$A = 0.08\, l\, s\, p \quad (\text{cm}^2)$$

p = as given in 300.

503 Edge stiffeners of doors shall have a moment of inertia not less than:

$$I = 8\, p_l\, d^4 \quad (\text{cm}^4)$$

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, see 302.

504 For edge stiffeners supporting main door stiffeners between securing devices, the moment of inertia shall be increased corresponding to the extra force.

505 Where doors also serve as vehicle ramps, the stiffener scantlings shall not be less than required for vehicle decks.

C 600 Girders

601 The section modulus requirement for simple girders assuming simply supported ends is given by:

$$Z = \frac{1.05\, S^2\, b\, p}{f_1} \quad (\text{cm}^3)$$

S = girder span in m
b = loading breadth in m
p = design pressure according to 300.

602 The web area requirement (after deduction of cut-outs) at the girder ends is given by:

$$A = \frac{0.08\, S\, b\, p}{f_1} \quad (\text{cm}^2)$$

S, b and p as in 601.

603 The webs of girders and stringers shall be adequately stiffened, preferably in a direction perpendicular to the shell plating.

604 The girder system shall be given sufficient stiffness to ensure integrity of the boundary support of the door. Edge girders should be adequately stiffened against rotation and shall have a moment of inertia not less than:

$$I = 8\, p_l\, d^4 \quad (\text{cm}^4)$$

d = distance between closing devices in m
p_l = packing line pressure in N/mm, see 302.

For edge girders supporting main door girders between securing devices, the moment of inertia shall be increased in relation to the additional force.

C 700 Allowable stress

701 Girder systems with direct strength calculations

For large doors with a grillage girder system, a direct stress analysis as outlined in Ch.1 Sec.12 may be necessary. Design loads shall be as given in 300, and the allowable stresses are as follows:

Bending or normal stress:

σ = 120 f_1 N/mm^2

Shear stress:

τ = 80 f_1 N/mm^2

Equivalent stress:

$$\sigma_e = \sqrt{s^2 + 3t^2} = 150\, f_1 \;\; \text{N/mm}^2$$

The material factor f_1 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.

702 Damage condition

In general:

$\sigma = 220 f_1$ and $\tau = 120 f_1$

For cleats:

$\sigma = 165 f_1$ and $\tau = 110 f_1$

C 800 Closing arrangement, general

801 Closing devices shall be simple to operate and easily accessible. Where hinges are used as closing devices they should be well integrated into the door structure.

802 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.

803 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 A404.

804 Flat bar or similar fastening devices for packings shall have scantlings and welds determined with simple considerations to wear and tear.

805 Devices shall be arranged for the doors to be secured in open position.

806 Documented operating procedures for closing and securing of side shell, bow and stern doors shall be kept on board and posted at the appropriate places.

807 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)

C 900 Closing arrangement, strength

901 Side and stern doors shall be fitted with adequate means of closing and securing, commensurate with the strength of the surrounding structure.

902 The number of devices is generally to be the minimum practical whilst taking into account the requirement for redundant provision given in 806 and the available space for adequate support in the surrounding hull structure which may limit the size of each device.

903 Only supports having an effective stiffness in a given direction shall be included in a calculation of the load carrying capacity of the devices. The total external or internal force, as given in 302, 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. Design clearances shall be included in the Operating and Maintenance Manual as given in Pt.5 Ch.2 Sec.3 A301 c). Allowable normal, shear and equivalent stresses in closing and supporting elements are as given in 603.

904 The nominal tensile stress in way of threads of bolts shall not exceed 105 f_1 N/mm^2. The arrangement of securing and supporting devices shall be such that threaded bolts do not carry support forces.

905 For steel to steel bearings in closing and supporting devices, the nominal bearing pressure calculated by dividing the design force by 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.

906 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 603 may be increased by 20%.

907 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.

C 1000 Closing arrangement, system for operation and indication/monitoring

1001 Cleats and support devices shall be equipped with mechanical locking arrangement (self locking or separate arrangement) or to be of the gravity type.

1002 Where hydraulic operating systems are applied, cleats and support devices shall remain locked in closed position in case of failure in the hydraulic system.

1003 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.

1004 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.

1005 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 shall be inaccessible to unauthorised persons.

1006 The requirements given in 907 to 911 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 907 to 911 need not be applied.

1007 Separate indicator lights shall be provided on each operating panel to indicate that the doors are closed and that their cleats, support and locking devices as applicable are properly positioned.

Indication panels shall be provided with a lamp test function.

1008 Separate indicator lights and audible alarms shall be provided on the navigation bridge 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 "harbour/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.

1009 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) The electrical circuits used for indicating door position shall be normally closed when the door is completely closed and completely open. When more limit switches are provided for each door they may be connected in series.
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.

1010 The power supply for indicator and alarm systems shall be independent of the power supply for 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.

1011 For passenger ships, a water leakage detection system with audible alarm and 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.

For cargo ships, a water leakage detection system with audible alarm shall be arranged to provide an indication to the navigation bridge.

1012 For 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 unauthorised access by passengers thereto can be detected whilst the ship is underway.

D. Hatchway Coamings

D 100 General

101 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.

102 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.

103 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.

104 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.

105 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.

106 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.

D 200 Coaming heights

201 The minimum height of coamings for hatches with weathertight covers is normally not to be less than:

600 mm in position 1

450 mm in position 2

202 Manholes and small scuttles with coaming height less than given in 201, 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.

203 Coamings with heights less than given in 201 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:

$$I = \frac{7\, p\, b\, l^4}{n^2 E} 10^5 \qquad (\text{cm}^4)$$

p = design pressure for deck girder in kN/m^2 as given in E200
b = breadth in m of load area for deck girder
l = total length in m of hatch coaming between supports
n = number of cover elements along length l of coaming.

204 Coamings with increased height may be required on ships of «type B-100» and «B-60» if found necessary by the floatability calculation.

D 300 Scantlings

301 Hatchway coamings to holds also intended to carry water ballast or oil in bulk, shall satisfy the requirements for tank bulkheads given in Ch.1 Sec.9.

302 The scantlings of coamings acting as deck girders shall satisfy the requirements in Ch.1 Sec.8.

303 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.

304 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. Coaming brackets spaced not more than 3 m apart, shall be fitted. The brackets shall not end on unstiffened plating. The coamings shall be satisfactorily stiffened against buckling.

Guidance note:

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.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

305 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, see E200.

306 The strength of the stiffeners shall also comply with the requirements given in Ch.1 Sec.7 C. Maximum stiffener spacing shall not exceed 750 mm.

E. Hatch Covers

E 100 General

101 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.

102 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.

103 Steel hatch covers shall be fitted to openings in watertight decks inside dry cargo holds. Requirements for small access hatches, below 6 m^2, are given in Sec G.

104 Requirements for small cargo tank hatch covers used for access and ventilation only, are given in I.

105 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 aluminium alloys, see Ch.1 Sec.2 C.

106 Tank hatch covers of closed box type construction shall be provided with effective means for ventilation and gasfreeing.

107 Hatch covers shall be mechanically lockable in open position.

108 Upon completion of installation of hatch covers, a chalk test shall be carried out. For tightness testing, see A400.

Guidance note:

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.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

109 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.

110 Corrosion addition shall be included in addition to the minimum scantlings as given in 600 to 900.

For hatch covers of cargo holds on weather decks, when $p = p_1$, the required corrosion addition t_s is given in 1000.

In all other cases, the required corrosion addition t_k is given in Ch.1 Sec.2 D.

E 200 Design loads

201 All generally applicable lateral loads on hatch covers are given in Table E1, based upon the general loads given in Ch.1 Sec.4.

Table E1 Design loads		
Hatch cover at	*Load type*	*p (kN/m²)*
Weather decks 1)	Sea pressure	p_1 as given in Table E2 2) $p_2 = a(p_{dp} - (4 + 0.2k_s)h_0)^{3)}$ minimum 5.0
Weather decks 1)	Deck cargo	$p_3 = (g_0 + 0.5\ a_v)\ q$
Cargo 'tweendecks	Deck cargo	$p_4 = \rho_c\ (g_0 + 0.5\ a_v)\ H_C$
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	$p_7 = \rho g_0[0.67(h_s + \phi b) - 0.12\sqrt{H\phi b_t}] + p_V$ 4)
Deck as tank top towards ends of tanks with length > 0.15 L	Ballast or liquid cargo	$p_8 = \rho g_0[0.67(h_s + \theta l) - 0.12\sqrt{H\theta l_t}] + p_V$
Deck as tank top in tanks with unrestricted filling and with free breadth b_t < 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 Ch.1 Sec.4 B202. 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, see Ch.1 Sec.4 C305.
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 foremost position
= 0.8 for weather decks elsewhere
p_{dp}, k_s = as given in Ch.1 Sec.4 C201
h_0 = vertical distance in m from the waterline at draught T to the cover top
a_v = vertical acceleration as given in Ch.1 Sec.4 B600
q = deck cargo load in t/m², as specified.
ρ_c = dry cargo density in t/m³, if not otherwise specified to be taken as 0.7, see also Ch.1 Sec.4 C401
ρ = density of ballast, bunker or liquid cargo in t/m³, 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 'tweendeck 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 metres 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
$\Delta\ p_{dyn}$ = as given in Ch.1 Sec.4 C300
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 = height in m of tank

b = the largest athwartship 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_t = length in m of top of tank
ϕ = roll angle in radians as given in Ch.1 Sec.4 B400
θ = pitch angle in radians as given in Ch.1 Sec.4 B500.

Table E2 Sea pressure load p_1 for hatch covers on weather decks, required only for ships complying with ILLC

Position	p_1 (kN/m²)	
	$\frac{x_F}{L_F} \le 0.75$	$0.75 < \frac{x_F}{L_F} \le 1$
1	for 24 m ≤ L_F ≤ 100 m	
	$\frac{9.81}{76} \cdot (1.5 \cdot L_F + 116)$	on the freeboard deck $\frac{9.81}{76} \cdot \left[(4.28 \cdot L_F + 28) \cdot \frac{x_F}{L_F} - 1.71 \cdot L_F + 95\right]$
		upon exposed superstructure decks located at least one standard height of superstructure above the freeboard deck $\frac{9.81}{76} \cdot (1.5 \cdot L_F + 116)$
	for L_F > 100 m	
	$9.81 \cdot 3.5$	on freeboard deck for type B freeboard ships $9.81 \cdot \left[(0.0296 \cdot L_1 + 3.04) \cdot \frac{x_F}{L_F} - 0.0222 \cdot L_1 + 1.22\right]$
		on freeboard deck for ships with reduced freeboard $9.81 \cdot \left[(0.1452 \cdot L_1 - 8.52) \cdot \frac{x_F}{L_F} - 0.1089 \cdot L_1 + 9.89\right]$
		upon exposed superstructure decks located at least one standard height of superstructure above the freeboard deck $9.81 \cdot 3.5$
2	for 24 m ≤ L_F ≤ 100 m	
	$\frac{9.81}{76} \cdot (1.1 \cdot L_F + 87.6)$	
	for L_F > 100 m	
	$9.81 \cdot 2.6$	
other than 1 and 2	$9.81 \cdot 2.1$	

L_F = freeboard length, in m, as given in Ch.1 Sec.1 B101
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

202 Horizontal loads from cargo stored on hatch covers are given by:

— Total transverse force:

$$P_T = C\, a_t\, q\, l_h\, b_h \quad \text{(kN)}$$

— Total longitudinal force:

$$P_L = C\, a_l\, q\, l_h\, b_h \quad \text{(kN)}$$

a_t = transverse acceleration as given in Ch.1 Sec.4 B 700
a_l = longitudinal acceleration as given in Ch.1 Sec.4 B 800
q = deck cargo load in t/m², see Table E1
l_h = length of hatch in m

b_h = breadth of hatch in m
$q\, l_h\, b_h$ = 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.

203 In addition to the distributed design loads specified in 201, forces acting on hatch covers from heavy cargo units shall be taken into account as given in Ch.1 Sec.4 C500.

Deflections and loads due to movements and thermal effects are also to be considered, see F 203.

204 Hatch covers subjected to wheel loading shall satisfy the strength requirements given in Pt.5 Ch.2 Sec.4 C.

E 300 Plating

301 The thickness corresponding to lateral pressure is given by:

$$t = \frac{15.8 k_a s \sqrt{p}}{\sqrt{\sigma}} F_p + t_k' \text{ (mm)}$$

p = $p_1 - p_{10}$, whichever is relevant, as given in Table E1
F_p = 1.50 in general for hatch covers on weather decks, when $p = p_1$
= 2.375 σ_{top}/σ_f, for hatch covers on weather decks, when $p = p_1$ and $\sigma_{top}/\sigma_f \geq 0.64$ for the attached plate flange of primary supporting members
= 1.0 in all other cases
σ = 0.95 σ_f N/mm^2 for hatch covers on weather decks, when $p = p_1$
= 0.58 σ_f N/mm^2 for hatch covers on weather decks, when $p = p_2$ or p_3
= 0.67 σ_f N/mm^2 in all other cases
σ_{top} = normal stress of hatch cover top plating in N/mm^2
t_k' = t_s as given in 1000 in mm, for hatch covers of cargo holds on weather decks, when $p = p_1$
= t_k as given in Ch.1 Sec.2 D in mm, in all other cases
σ_f = minimum upper yield stress in N/mm^2. NV-NS-steel may be taken as having σ_f = 235 N/mm^2.

σ_f shall not be taken greater than 70% of the ultimate tensile strength.

302 The thickness of top plating shall not be less than:

t = 10 s + t_k' (mm), min. 6 + t_k' mm.
t_k' = t_s as given in 1000 in mm, for hatch covers of cargo holds on weather decks
= t_k as given in Ch.1 Sec.2 D in mm, in all other cases

303 The thickness of bottom plating of closed box construction shall not be less than:

t = 5 + t_k' mm
t_k' = t_s as given in 1000 in mm, for hatch covers of cargo holds on weather decks
= t_k as given in Ch.1 Sec.2 D in mm, in all other cases.

E 400 Stiffeners

401 The section modulus is given by:

$$Z = \frac{1000 l^2 s p w_k'}{m \sigma} \quad (\text{cm}^3)$$

p = $p_1 - p_{10}$, whichever is relevant, as given in Table E1
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
σ = 0.8 σ_f N/mm^2 for hatch covers on weather decks, when $p = p_1$
= 0.58 σ_f N/mm^2 for hatch covers on weather decks, when $p = p_2$ or p_3
= 0.67 σ_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 1000 in mm, for hatch covers of cargo holds on weather decks, when $p = p_1$;

t_k as given in Ch.1 Sec.2 D in mm, in all other cases.

Stiffeners subject to point loads from heavy cargo units (see 203) shall be specially considered.

402 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. Covers with gradually reduced Z and I towards the ends of the span shall be designed 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 Fig.3.

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 Fig.3.

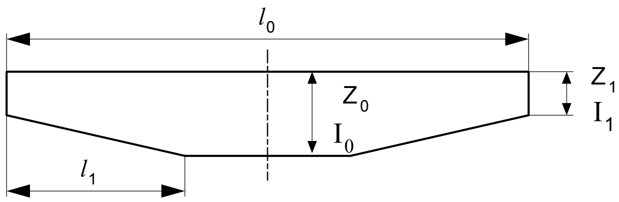


Fig. 3
Hatch cover with variable cross-section

403 The web area shall not be less than:

$$A = C_3\left(0.5 - \frac{x}{l}\right) lsp + 10ht_k' \quad (\text{cm}^2)$$

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 = web height in m
t_k' = t_s as given in 1000 in mm, for hatch covers of cargo holds on weather decks.
= t_k as given in Ch.1 Sec.2 D in mm, in all other cases.

(IACS LL20)

404 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, see also 600.

405 Connection area and welding of stiffeners shall be in accordance with Ch.1 Sec.11.

For covers above cargo- and ballast tanks, chain or staggered fillet welds on the tank side are not acceptable.

406 The web and flange thickness shall not be less than:

t = $5.0 + t_{k'}$ (mm)
t_k' = t_s as given in E1000 in mm, for hatch covers of cargo holds on weather decks.
= t_k as given in Ch.1 Sec.2 D in mm, in all other cases.

E 500 Girders

501 When calculating the actual Z for strength members supporting other stiffeners, the effective flange shall be determined in accordance with Ch.1 Sec.3 C400. When the hatch cover is of closed box girder construction, the flange may be taken as 100% effective.

502 The section modulus and moment of inertia shall not be less than according to the requirement given in 400, when s is replaced by b.

b = half the sum in m of stiffener span on either side of the girder.

503 The web area at ends shall not be less than:

$A = 0.5 C_3 \, lbp + 10 h t_k' \ (\text{cm}^2)$
C_3 = as defined in 403
b = as defined in 502
h = as defined in 403
t_k' = t_s as given in 1000 in mm, for hatch covers of cargo holds on weather decks
= t_k as given in Ch.1 Sec.2 D 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.

504 Double continuous fillet welds are normally to be used within areas with shear stress greater than 75 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.

505 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.

506 When structural analysis is carried out by finite element analysis in accordance with 700, requirements in 502 and 503 may be waived.

E 600 Stiffness of cover edges

601 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:

$$I = 6 \, p_l \, a^4 \quad (\text{cm}^4)$$

for cover edges connected to a rigid hatch coaming and

$$I = 12 \, p_l \, a^4 \quad (\text{cm}^4)$$

between cover edges of equal stiffness.

p_l = packing line pressure along edges in N/mm, minimum 5 N/mm
a = spacing in m of bolts or other securing devices.

602 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.

E 700 Structural analysis

701 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, see F203.

702 Load conditions shall be established in accordance with the loads given in 200. For calculations according to beam theory the following stresses will be accepted:

a) Bending stress:

σ = $0.8 \, \sigma_f$ 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_3
= $0.67 \, \sigma_f$ N/mm^2 in all other cases

b) Shear stress:

τ = $0.46 \, \sigma_f$ N/mm^2 for hatch covers on weather decks, when $p = p_1$
= $0.33 \, \sigma_f$ N/mm^2 for hatch covers on weather decks, when $p = p_2$ or p_3

= 0.37 σ_f N/mm^2 in all other cases.

σ_f as defined in 301

The sum of girder bending stress and local bending stress in stiffeners being part of the girder shall not exceed 0.8 σ_f N/mm^2.

E 800 Buckling Control

801 Buckling for hatch cover plating with primary supporting members parallel to the direction of stiffeners shall be in accordance with Ch.1 Sec.13 B, with ψ = 1.0.

Buckling for hatch cover plating with primary supporting members perpendicular to the direction of stiffeners shall be in accordance with Ch.1 Sec.13 B.

Buckling for stiffeners shall be in accordance with Ch.1 Sec.13 C.

The critical buckling stress shall be related to the actual compressive stresses as follows:

$$\sigma_c \geq \frac{\sigma_a}{\eta} \quad \text{(N/mm}^2\text{)}$$

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 Ch.1 Sec.13 B.

802 For flat bar stiffeners and buckling stiffeners, the ratio h/t_w shall not be greater than:

$$15\sqrt{\frac{1}{f_1}}$$

h = height of stiffener in mm

t_w = net thickness of stiffener in mm. Corrosion addition given in 109 shall be considered.

803 Buckling for web panels of hatch cover primary supporting members shall be in accordance with Ch.1 Sec.13 B300.

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:

$$\tau_c \geq \frac{\tau_a}{\eta} \quad \text{(N/mm}^2\text{)}$$

η = 0.8 for hatch covers on weather decks, when p = p_1
= 0.85 in all other cases

τ_a = actual calculated stress.

E 900 Deflection limit and connections between hatch cover panels

901 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.

E 1000 Corrosion addition and steel renewal

1001 The corrosion addition t_s for hatch covers of cargo holds on weather decks, when p = p_1, is given in Table E3.

Table E3 Corrosion additions t_s for hatch covers of cargo holds on weather decks, when $p = p_1$		
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 300 to 900.

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 in Pt.7 Ch.1 Sec.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.

F. Hatchway Tightness Arrangement and Closing Devices

F 100 General

101 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.

102 Closing of hatches by portable hatch beams, covers and tarpaulins will be specially considered.

103 Packing and drainage arrangements of hatch covers for cargoes which are not sensitive to moisture from small leakages may be specially considered.

F 200 Design and tightness requirements

201 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.

202 The sealing shall be obtained by a continuous gasket of relatively soft, elastic material compressed to achieve the necessary weathertightness. 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.

203 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 Ch.1 Sec.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.5 Ch.2 Sec.6.

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.

204 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.

205 There shall be a metallic contact between hatch cover and hull (earthing connection). If necessary, this shall be achieved by a special connection.

Guidance note:

1) As practical limits for the hatch opening horizontal deformations in ships with hatch openings less than given in Ch.1 Sec.5 A106 (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.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

F 300 Securing devices in general

301 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, see E600. Scantlings of securing devices are given in 400 to 700.

302 Securing means of other material than mild steel or other means than bolts shall be of strength equivalent to the requirements given in 400 to 700, 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.

303 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.

F 400 Securing arrangement for weathertight hatch covers

401 Ordinary packed hatch covers shall be secured to the coaming by a net bolt area for each bolt not less than:

$$A = \frac{1.4a}{f_{1e}} \quad (\text{cm}^2)$$

a = spacing of bolts in m

$$f_{1e} = \left(\frac{\sigma_f}{235}\right)^e$$

σ_f = minimum upper yield stress in N/mm^2, not to be taken greater than 70% of the ultimate tensile strength

e = 0.75 for $\sigma_f > 235$
= 1.0 for $\sigma_f < 235$.

402 Between cover and coaming and at cross-joints, a packing line pressure sufficient to obtain weathertightness shall be maintained by a bolt area as given in 401.

403 For packing line pressures exceeding 5 N/mm, the area shall be increased accordingly. The packing line pressure shall be specified.

404 The net bolt diameter shall not be less than 19 mm for hatchways exceeding 5 m^2 in area.

405 Closing appliances of covers to hatches on exposed decks (position 1 and 2) where reduced coaming heights are accepted (see D 200) 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 a_{max} = 2.5 metres.

F 500 Securing arrangement for deep tank or cargo oil tank hatch covers

501 In addition to the requirements given in 400, deep tank or cargo oil tank hatch covers have to fulfil the following requirements.

The net securing bolt area for each bolt shall not be less than:

$$A = \frac{0.08a}{f_{1e}}(0.5lp + p_l) \qquad (cm^2)$$

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 E1
p_l = packing line pressure in N/mm. For calculation purpose, however, the packing pressure shall not be taken less than 5 N/mm
f_{1e} = as given in 401.

502 Between cover elements the packing line pressure shall be maintained by a net bolt area for each bolt not less than:

$$A = \frac{3a}{f_{1e}} \qquad (cm^2)$$

a = spacing of bolts in m.

Corrections to be applied as given in 403 and 404.

503 Covers particularly calculated, as mentioned in E700, 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:

$$\sigma = 120 f_{1e} \quad N/mm^2$$

— shear stress:

$$\tau = 80 f_{1e} \quad N/mm^2$$

— equivalent stress:

$$\sigma_e = \sqrt{\sigma^2 + 3\tau^2} = 150 f_{1e} \quad N/mm^2$$

Guidance note:
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.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

F 600 Securing arrangement for hatch covers carrying deck cargo

601 In addition to the requirements given in 400 or 500, all hatch covers, especially those carrying deck cargo shall be effectively secured against horizontal shifting due to the horizontal forces given in E202, which may be reduced by 10% due to friction.

The maximum allowable stresses in stoppers are as given in 503.

602 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 centre-line, two-way stopper at outboard coaming may be required.

603 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 503.

604 Hatch coamings and supporting structure shall be adequately stiffened to accommodate the loading from hatch covers.

605 At cross-joints of multi-panel covers vertical guides (male/female) shall be fitted to prevent excessive relative vertical deflections between loaded/unloaded panels.

F 700 Securing arrangement for hatch covers in watertight decks

701 Allowable stresses for securing devices in hatch covers, submerged in damaged condition, are as follows:

normal stress: $\sigma = 165\ f_1$ N/mm2

shear stress: $\tau = 110\ f_1$ N/mm2

equivalent stress: $\sigma_e = (\sigma^2 + 3\,\tau^2)^{1/2} = 200 f_{1e}$ N/mm^2

Guidance note:
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.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

702 For hatches covers, opening contrary to pressure side, and which becomes immersed by an 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, see also 203. Test to be made according to A 4504.

F 800 Drainage arrangement

801 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.

802 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.

803 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.

804 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.

G. Internal Doors and Hatches for Watertight Integrity

G 100 General

101 General requirements for internal openings in connection with watertight integrity are given in Ch.1 Sec.3 A600. For pipe tunnel openings, see also Ch.1 Sec.6 A407. Requirements for watertight hatches above 6 m^2 is given in Sec. E and F.

102 Watertight doors or hatches may be of the following types:

— hinged doors or hatches, dividing cargo spaces, shall be of an approved type with mechanical securing

devices and may be fitted 'tween decks in approved 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. Indication open/closed shall be fitted on the bridge.
(IACS UI SC156, table 1).

— rolling doors, guided and supported by steel rollers, and with mechanical or hydraulic securing devices
— sliding doors, moving along and supported by track-way grooves and with mechanical locking due to taper and friction. A positive force shall be required to re-open the doors. These types of door may be only hand operated 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. (IACS UI SC156). Signboards and instructions shall be placed in way of the door advising how to act when the door is in the “door closed” mode. In passenger areas and areas of high ambient noise, audible alarms shall be supplemented by visual signals on both sides of the door.

G 200 Operation

201 All watertight doors and access hatches shall be operable from both sides of the bulkhead or deck.

202 Remotely controlled doors are also to be locally operable. Indicators shall be provided at the control position to indicate whether the doors are open or closed.

G 300 Strength

301 Watertight doors and hatches shall be designed with a strength equivalent to that of the structure in which they are positioned. They shall withstand the design pressure from both sides.

302 The thickness corresponding to lateral pressure is given by:

$$t = \frac{c k_a s \sqrt{p}}{\sqrt{f_1}} + t_k \quad \text{(mm)}$$

p = design pressure p, as given in Ch.1 Sec.9, Table B1
c = 1.58 for collision bulkhead
= 1.35 for all other bulkheads and decks.

The thickness is in no case to be less than the minimum bulkhead thickness.

303 The stiffener section modulus requirement is given by:

$$Z = \frac{c_1 l^2 s p w_k}{f_1} \quad (\text{cm}^3)$$

p = as given in 302
c_1 = 0.8 for collision bulkhead
= 0.6 for all other bulkheads and decks.

304 Edge stiffeners of doors shall have a moment of inertia not less than:

I = $8 p_e d^4$ (cm^4)
d = distance between closing devices in m, to be measured along door edge
p_e = packing line pressure along edges, not to be taken less than 5 N/mm
= pb, whichever is the greater
p = design pressure p_1 as given in Ch.1 Sec.9, Table B1
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 m.

The coaming of watertight doors (door frame) shall be designed with the necessary stiffness in order to avoid large deflections resulting in leakage in the damaged condition.

305 The structural analysis has to include the flexibility of the surrounding structure. Test to be made according to A404.

The door frames shall have no groove at the bottom in which dirt might lodge and prevent the door from closing properly.

306 Securing devices shall be designed for the load acting 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: $\sigma_e = \sqrt{\sigma^2 + 3\tau^2} = 200 f_{1e}\quad N/mm^2$

H. Ventilators

H 100 Coamings and closing arrangements

101

1) Ventilators in position 1 or 2 to spaces below freeboard deck or decks of enclosed superstructures shall have coamings of steel or other equivalent material, substantially constructed and efficiently connected to the deck. Where the coamings of any ventilators exceed 900 millimetres in height it shall be specially supported.
2) Ventilators passing through superstructures other than enclosed superstructures shall have substantially constructed coamings of steel or other equivalent material at the freeboard deck.
3) Ventilators in position 1 the coamings of which extend to more than 4.5 metres above the deck, and in position 2 the coamings of which extend to more than 2.3 metres above the deck, need not be fitted with closing arrangements unless specifically required by the Society.
4) Except as provided in (3) ventilator openings shall be provided with efficient weathertight closing appliances. In ships of not more than 100 metres 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 millimetres above the deck; in position 2 the coamings shall be of a height of at least 760 millimetres above the deck.
5) In exposed positions, the height of coamings may be required to be increased to the satisfaction of the Society.

(ICLL Reg.19)

102 Reduced coaming height may be accepted for vessels trading in domestic waters only, in accordance with Pt.1 Ch.1 Sec.2 A 300.

H 200 Thickness of coamings

201 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.

(IACS LL36)

H 300 Arrangement and support

301 Where required by 101, weathertight 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.

(IACS LL52)

302 The deck plating in way of deck openings for ventilator coamings shall be of sufficient thickness, and efficiently stiffened between ordinary beams or longitudinals. Coamings with heights exceeding 900 mm shall be additionally supported.

303 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.

304 Ventilators necessary to continuously supply the machinery space shall have coamings of sufficient height to comply with H101 (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 H101 (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 H101 and in combination with suitable means arranged to ensure uninterrupted and adequate supply of air to these spaces.

305 The height of ventilators may be required to be increased depending on where these flooding points are in relation to the damaged waterline in the stability calculation.

Guidance note:

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 101.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

H 400 Strength requirements for fore deck ventilators

401 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 402 to 408.

(IACS UR S 27)

402 The pressures p, in kN/m^2 acting on ventilator pipes and their closing devices to be calculated from:

$$p = 0.5 \rho V^2 C_d C_s C_p$$

where:

ρ = density of sea water (1.025 t/m^3)
V = velocity of water over the fore deck (13.5 m/sec)
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.

403 Forces acting in the horizontal direction on the pipe and its closing device may be calculated from 402 using the largest projected area of each component.

404 Bending moments and stresses in ventilator pipes shall be calculated at critical positions: at penetration pieces, at weld or flange connections, at toes of supporting brackets. Bending stresses in the net section shall 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.

405 For standard ventilators of 900 mm height closed by heads of not more than the tabulated projected area, pipe thicknesses and bracket heights are specified in Table H1. 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 H1, but need not extend over the joint flange for the head. Brackets toes at the deck shall be suitably supported.

406 For ventilators of height greater than 900 mm, brackets or alternative means of support shall be fitted according to the requirements in 302. Pipe thickness shall not be taken less than as required in 201.

407 All component parts and connections of the ventilator shall be capable of withstanding the loads defined in 402.

408 Rotating type mushroom ventilator heads are unsuitable for application in the areas defined in 401.

(IACS UR S27)

Table H1 900 mm ventilator pipe thickness and bracket standards

Nominal pipe diameter (mm)	*Minimum fitted gross thickness, LL36(c) (mm)*	*Maximum projected area of head (cm^2)*	*Height of brackets (mm)*
80A	6.3	–	460
100A	7.0	–	380
150A	8.5	–	300

Table H1 900 mm ventilator pipe thickness and bracket standards (Continued)			
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 401 to 407 shall be applied.			

I. Tank Access, Ullage and Ventilation Openings

I 100 General

101 The number of hatchways and other openings in the tank deck shall not be larger than necessary for reasonable access to and ventilation of each compartment.

102 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.

I 200 Hatchways

201 The thickness of the hatch coaming shall not be less than given in Ch.1 Sec.10 for a deckhouse in the same position.

202 The thickness of covers shall not be less than:

— 12.5 mm for cover area exceeding 0.5 m^2
— 10.0 mm for cover area less than 0.25 m^2.

For intermediate areas the thickness may be linearly varied.

203 Where the area of the hatchway exceeds 1.25 m^2, the covers shall be stiffened.

204 Covers shall be secured to the hatch coamings by fastenings spaced not more than 380 mm apart and not more than 250 mm from the corners. For circular covers the fastenings shall not be spaced more than 450 mm apart.

205 Other types of covers may be approved, provided their construction is considered satisfactory.

I 300 Air Pipes

301 Where air pipes to ballast and other tanks extend above the freeboard or superstructure decks, the exposed parts of the pipes shall be of substantial construction; the height from the deck to the point where water may have access below shall be at least 760 millimetres on the freeboard deck and 450 millimetres on the superstructure deck. Where these heights may interfere with the working of the ship, a lower height may be 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.

(ICLL Reg.20)

302 Air pipes shall be provided with automatic closing appliances.

(ICLL Reg. 20 (3))

303 Pressure- vacuum valves (PV valves) may be accepted on tankers.

Wooden plugs and trailing canvas hoses shall not be accepted in position 1 and position 2.

Guidance note:
The member Societies in formulating this interpretation realise that pressure-vacuum valves (PV valves) presently installed on tankers do not theoretically provide complete watertightness. 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.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

(IACS LL49)

304 The thickness of air pipe coamings in steel other than stainless 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. Coamings with heights exceeding 900 mm shall be additionally supported.

(IACS LL36)

305 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 ≤ 60	2.7
60 < d ≤ 120	3.0
120 < d ≤ 200	3.4
200 < d ≤ 250	3.7
250 < d ≤ 300	4.1
300 < d ≤ 350	4.5
350 < d ≤ 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.	

306 In cases where air pipes are led through the side of superstructures, the height of their openings to be at least 2.3 metres above the summer water line. Automatic vent heads of approved design shall be provided.

307 The height of air pipes may be required to be increased on ships of type "A", type "B-100" and type "B-60" where this is shown to be necessary by the floatability calculation.

308 The automatic closing appliances are to be permanently attached and of approved design. The closing appliances shall be so constructed that damage to the tanks by over pumping or occasionally possible vacuum by discharging is prevented.

309 All air pipes in cargo spaces shall be well protected.

310 For arrangement and size of air pipes, see also Pt.4 Ch.6 Sec.4 K.

I 400 Strength requirements for fore deck air pipes

401 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 402 to 407.

For tankers:

The requirements given in 402 to 407 are not applicable for cargo tank venting systems and the inert gas systems.

(IACS UR S 27)

402 The pressures p, in kN/m^2 acting on air pipes and their closing devices shall be calculated from:

$$p = 0.5 \rho V^2 C_d C_s C_p$$

where:

ρ = density of sea water (1.025 t/m^3)
V = velocity of water over the fore deck (13.5 m/sec)
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.

403 Forces acting in the horizontal direction on the pipe and its closing device may be calculated from 402 using the largest projected area of each component.

404 Bending moments and stresses in air pipes shall be calculated at critical positions: at penetration pieces, at weld or flange connections, at toes of supporting brackets. Bending stresses in the net section shall 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.

405 For standard air pipes of 760 mm height closed by heads of not more than the tabulated projected area, pipe thicknesses and bracket heights are specified in Table I1. 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 I1 but need not extend over the joint flange for the head. Bracket toes at the deck shall be suitably supported.

406 For other configurations, loads according to 402 shall be applied, and means of support determined in order to comply with the requirements of 404. Brackets, where fitted, shall be of suitable thickness and length according to their height. Pipe thickness shall not be taken less than as required in 304.

407 All component parts and connections of the air pipe shall be capable of withstanding the loads defined in 402.

(IACS UR S27)

Table I1 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 (see 405) 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, see Pt.4 Ch.6 Sec.4.

Note: For other air pipe heights, the relevant requirements of 401 to 407 shall be applied.

J. Machinery Space Openings

J 100 Openings

101 Machinery space openings in position 1 or 2 shall be properly framed and efficiently enclosed by steel casings of ample strength, and where the casings are not protected by other structures their strength shall be specially considered. Access openings in such casings shall be fitted with doors complying with the requirements of B101, the sills of which shall be at least 600 millimetres above the deck if in position 1, and at least 380 millimetres above the deck if in position 2. Other openings in such casings shall be fitted with equivalent covers, permanently attached in their proper positions.

102 Coamings of any machinery space ventilator in an exposed position shall be in accordance with H304

(ICLL Reg. 17)

103 Where 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 shall be provided.

(ICLL Reg. 17 (2))

104 Doorways in engine and boiler casings shall be arranged in positions which afford the greatest possible protection.

105 Fixed or opening skylights shall have a 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 position 1 or 2, shall be provided with permanently attached deadlights or storm covers.

(ICLL Reg. 23 (12))

For skylights in position 1 or 2 the coaming height shall not be less than given for hatchway coamings. For skylights in position 1, deadlights shall be fitted.

106 Side scuttles in engine casings shall be provided with fireproof glass.

K. Scuppers, Inlets and Discharges

K 100 Inlets and discharges

101

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 B101 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, see Pt.4 Ch.6 Sec.2.

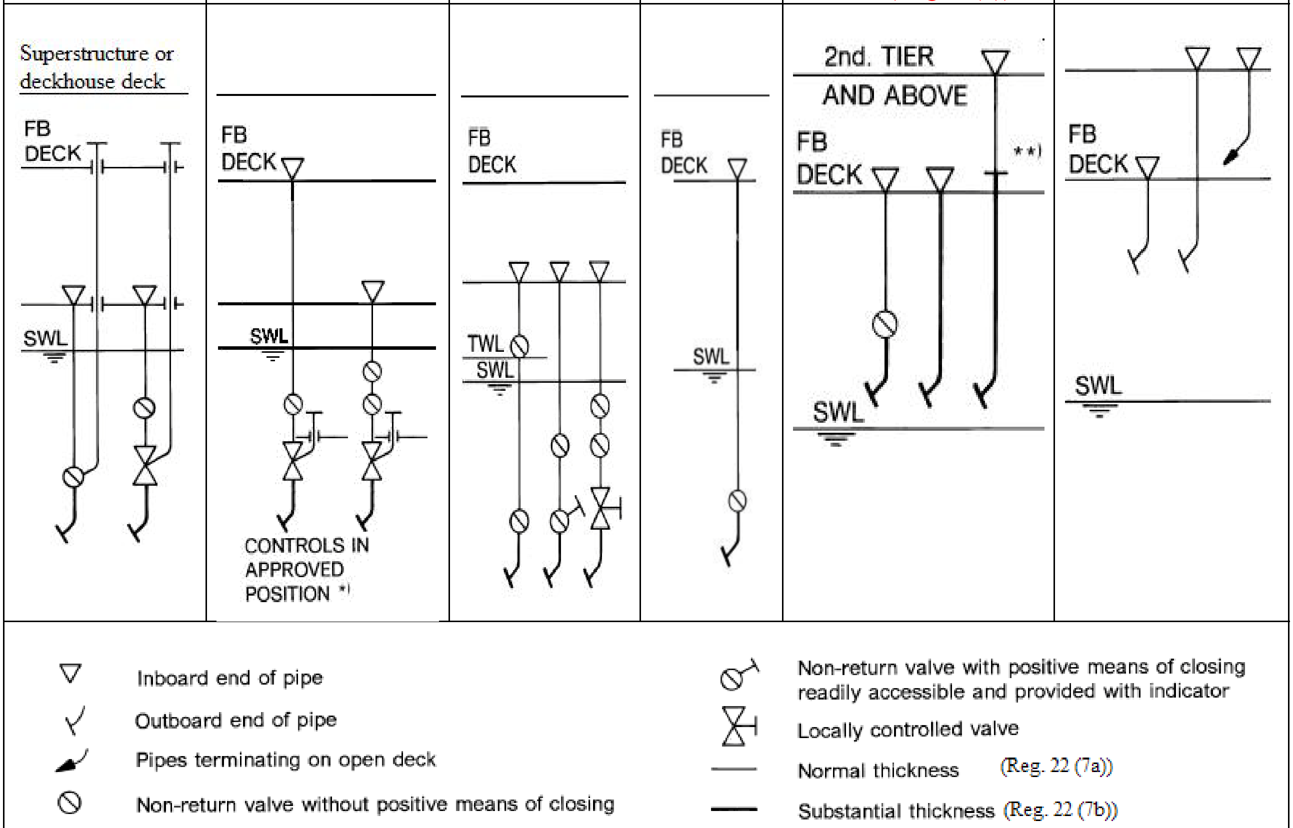
(ICLL Reg.22)

102 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.

(IACS LL22)

Table K1 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 regulations.

103 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.

104 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 101.

It is considered that the requirements of 101 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.

See Table K1 for the acceptable arrangement of scuppers, inlets, and discharges.

105 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 K1.

106 Discharges from spaces above the freeboard deck shall be of steel or material specially resistant to corrosion.

107 Adequate protection shall be provided to protect valves or pipes from being damaged by cargo, etc.

108 Plastic pipes may be used for sanitary discharges and scuppers as permitted by Pt.4 Ch.6 Sec.2 A700.

109 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.

110 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.

111 Scuppers and discharge pipes originating at any level and penetrating the shell either more than 450 millimetres below the freeboard deck or less than 600 millimetres above the summer load waterline shall be provided with a non-return valve at the shell. This valve, unless required by 101, may be omitted if the piping is of substantial thickness.

K 200 Pipe thickness

201 The wall thickness of steel piping between hull plating and closeable or non-return valve shall not be less than given in Table K2.

Table K2 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, see Pt.5 Ch.3 Sec.11 D602.

202 The wall thickness of steel piping inboard of the valve shall not be less than given in Table K3.

Table K3 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.

(IACS LL36)

K 300 Scuppers

301 A sufficient number of scuppers, arranged to provide effective drainage, shall be fitted on all decks.

302 Scuppers on weather portions of decks and scuppers leading from superstructures or deckhouses not fitted with doors complying with B101 shall be led overboard.

303 Scuppers 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.

304 Scuppers led through the deck or shell, shall comply with requirements to material and thickness as given for discharges.

305 Scupper pipes shall be well stayed to prevent any vibrations. However, sufficient possibility for expansion of the pipes to be provided when necessary.

306 Scuppers from spaces below the freeboard deck or spaces within closed superstructures, may be led to bilges. For drainage of cargo deck spaces, see Pt.4 Ch.6 Sec.4 D.

307 Scuppers leading overboard from spaces mentioned in 306, 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 201 and 202.

308 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.

309 Drainage from refrigerated cargo spaces shall comply with the requirements for class notation **Reefer**. Drain pipes from other compartments shall not be led to the bilges in refrigerated chambers.

310 Drainage from helicopter decks shall comply with the requirements for the class notation **HELDK-S**.

K 400 Periodically unmanned machinery space

401 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)

402 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 tanktop floor.

Guidance note:
Various Flag Administrations have worked out their own interpretations of this regulation.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

K 500 Garbage chutes

501 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.

502 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.

503 The controls for the gate valves and/or hinged covers shall be clearly marked: “Keep closed when not in use”.

504 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".

(ICLL Reg. 22-1)

K 600 Spurling pipes and cable lockers

601 Spurling pipes and cable lockers shall be watertight up to the deck exposed to weather.

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

603 Spurling pipes through which anchor cables are led shall be provided with permanently attached closing appliances to minimize water ingress.

(ICLL Reg. 22-2)

L. Side Scuttles, Windows and Skylights

L 100 Side Scuttles, Windows and Skylights

101

1) 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.

   Guidance note:

   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.

   ---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

2) 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.
3) 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.
4) Side scuttles to the following spaces shall be fitted with hinged inside deadlights:

   a) spaces below freeboard deck
   b) 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.

   Deadlights shall be capable of being closed and secured watertight if fitted below the freeboard deck and weathertight if fitted above.
5) Side scuttles shall not be fitted in such 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 the summer load line (or timber summer load line if assigned).
6) 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.
7) 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.
8) 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.
9) 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.
10) Cabin 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.
11) 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) 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.

Guidance note:

Deviation for the fitting of deadlights may be accepted for vessels trading in domestic waters only, in accordance with Pt.1 Ch.1 Sec.2 A 300.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

(IACS LL62, ICLL Reg. 23)

L 200 Glass dimensions, side scuttles and windows

201 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.

202 The glass thickness can be calculated from the following formulae:

$$\text{side scuttles:} \quad t = \frac{N}{362}\sqrt{p}$$

$$\text{windows:} \quad t = \frac{b}{200}\sqrt{\beta p}$$

1) The design load shall be in accordance with the rules as given in Ch.1 Sec.10 C100.
   For 2nd tier and below the design load for side scuttles and windows is in addition to be in accordance with ISO/DIS 5779 and 5780.
2) "The minimum design load for windows in sides and aft ends of deckhouses located 1.7 C_w (m) or more above S.W.L., may be reduced to 2.5 kN/m^2.
   L should not be taken less than 100 m.
   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 1.0 m^2 or more.

N = 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 Fig.2
p = design load in kN/m^2
t = glass thickness in mm
C_w = wave coefficient as given in Ch.1 Sec.4 B200.

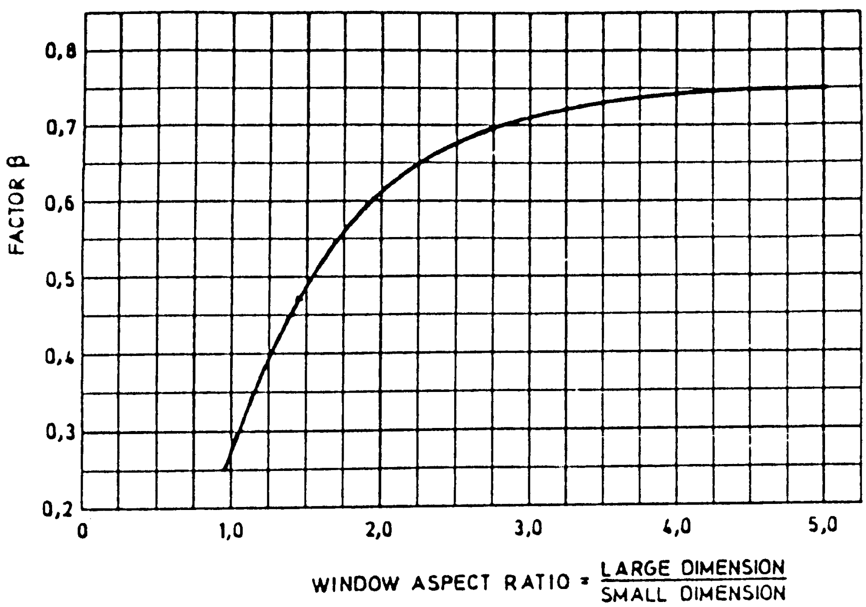


Fig. 4
Diagram for factor β for windows

203 Laminated toughened safety glass may also be used for windows, but the total required thickness will need to be increased in accordance with the following formula:

$$t = \sqrt{t_1^2 + t_2^2 + \ldots t_n^2}$$

where

n = number of laminates
t_1 to t_n = thickness of each glass in the laminate
t = equivalent thickness of laminated toughened safety glass.

M. Freeing Ports

M 100 Definitions

101 Where bulwarks on the weather portions of freeboard or superstructure decks form wells, ample provision shall be made for rapidly freeing the decks of water and for draining them.

M 200 Freeing port area

201 Except as provided in 202 and 203, the minimum freeing port area (A) on each side of the ship for each well on the freeboard deck shall 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 super- structure decks shall be one-half of the area given by the formula.

Where the length of bulwark (*l*) in the well is 20 metres or less:

$$A = 0.7 + 0.035\, l \text{ (square metres)},$$

where *l* exceeds 20 metres:

$$A = 0.07\, l \text{ (square metres)}.$$

l need in no case be taken as greater than 0.7 L.

If the bulwark is more than 1.2 metres in average height the required area shall be increased by 0.004 square metres per metre of length of well for each 0.1 metre difference in height. If the bulwark is less than 0.9 metre in average height, the required area may be decreased by 0.004 square metres per metre of length of well for each 0.1 metre difference in height.

202 In ships with no sheer the area calculated according to 201 shall be increased by 50 per cent. Where the sheer is less than the standard the percentage shall be obtained by linear interpolation.

203 Where a ship fitted with a trunk which does not comply 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 of the freeing port openings shall be calculated from the following table:

Breadth of hatchway or trunk in relation to the breadth of ship	*Area of freeing ports in relation to the total area 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.

204 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:

$$A_w = (0.07 l_w + A_c)(S_c)\left(\frac{0.5 h_s}{h_w}\right)$$

The freeing port area, A_S for the open superstructure:

l_t is more than 20 m:

$$A_s = (0.07 l_t)(S_c)\left(\frac{b_o}{l_t}\left(1 - \left(\frac{l_w}{l_t}\right)^2\right)\left(\frac{0.5 h_s}{h_w}\right)\right)$$

l_t is 20 meters or less:

$$A_s = (0.7 + 0.035 l_t)(S_c)\left(\frac{b_o}{l_t}\left(1 - \left(\frac{l_w}{l_t}\right)^2\right)\left(\frac{0.5 h_s}{h_w}\right)\right)$$

l_W = the length of the open deck enclosed by bulwarks in metres

l_s = the length of the common space within the open superstructure, in metres
l_t = $l_w + l_s$
S_c = sheer correction factor, max 1.5 as defined in 202
b_o = breadth of openings in the end bulkhead of the superstructure, in metres
h_w = distance of the well deck above the freeboard deck, in metres
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.

205 Gutter bars greater than 300 mm in height fitted around the weather decks of tankers are to 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 cannot occur while at sea.

Guidance note:

Reduced freeing port area may be accepted for vessels trading in domestic waters only, in accordance with Pt.1 Ch.1 Sec.2 A 300.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

M 300 Location and protection of openings

301 The lower edges of the freeing ports shall be as near the deck as practicable. Two-thirds of the freeing port area required shall be provided in the half of the well nearest the lowest point of the sheer curve.

302 All such openings in the bulwarks shall be protected by rails or bars spaced approximately 230 millimetres apart. If shutters are fitted to freeing ports, ample clearance shall be provided to prevent jamming. Hinges shall have pins or bearings of non-corrodible material. If shutters are fitted with securing appliances, these appliances shall be of approved construction.

(ICLL Reg.24)

M 400 Multiple wells

401 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 not then be allowed 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 superstructure deck it is considered that the freeing port area should be spread along the length of the well.

(IACS LL13)

M 500 Free flow area

501 The effectiveness of the freeing area in bulwarks required by 201 and 202 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 203.

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 the freeing area calculated from 203 as if the hatchway coamings were continuous, then the minimum freeing port area calculated from 201 and 202 should be deemed sufficient.

(ii) If the free flow area is equal to, or less than the area calculated from 201 and 202 minimum freeing area in the bulwarks should be determined from 203.

(iii) If the free flow area is smaller than calculated from 203 but greater than calculated from 201 and 202, the minimum freeing area in the bulwark should be determined from the following formula:

$$F = F_1 + F_2 - f_p \quad (m^2)$$

F_1 = the minimum freeing area calculated from 201 and 202,
F_2 = the minimum freeing area calculated from 203,
f_p = the total net area of passages and gaps between hatch ends and superstructures or deckhouses up to the actual height of bulwark.

(IACS LL44)

M 600 Type «A», «B-100» and «B-60» ships

601 Requirements for freeing arrangements for Type «A» ships are given in N100.

602 Type B-100 ships with bulwarks shall 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 shall be freeing port area in the lower part of the bulwarks equal to at least 25% of the total area of the bulwarks.

N. Special Requirements for Type A Ships

N 100 Machinery casings

101 Machinery casings on Type A ships shall be protected by an enclosed poop or bridge of at least standard height, or by a deckhouse of equal height and equivalent 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 B101 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.

N 200 Gangway and access

201 An efficiently constructed fore and aft permanent gangway of sufficient strength shall 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 shall be provided to carry out the purpose of the gangway, such as passages below deck. Elsewhere, and on Type A ships without a midship bridge, arrangements to the satisfaction of the Society shall be provided to safeguard the crew in reaching all parts used in the necessary work of the ship, see Sec.8.

202 Safe and satisfactory access from the gangway level shall be available between separate crew accommodations and also between crew accommodations and the machinery space.

N 300 Hatchways

301 Exposed hatchways on the freeboard and forecastle decks or on the tops of expansion trunks on Type A ships shall be provided with efficient watertight covers of steel or other equivalent material.

N 400 Freeing arrangements

401 Type A ships with bulwarks shall 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. The upper edge of the sheer strake shall be kept as low as practicable.

402 Where superstructures are connected by trunks, open rails shall be fitted for the whole length of the exposed parts of the freeboard deck.

(ICLL Reg.26)

O. Retractable Bottom Equipment

O 100 Introduction

101 The requirements below are valid for 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.

O 200 Arrangement

201 Equipment that is to be lowered through the bottom of the ship shall be fitted in a separate watertight compartment of limited volume to reduce the effect of flooding.

Alternatively 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 being flooded
— an unacceptable loss of stability
— damage to equipment vital for safe operation of the ship.

202 The compartment where the bottom equipment is located shall have a bilge system and an audible high water level alarm being set off in the engine control room.

203 Door leading into the compartment shall be watertight. A watertight sliding door is normally to be fitted. A hinged door is however normally 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.

O 300 Design loads and allowable stresses

301 The strength of the supporting structure for retractable thrusters shall be based on resulting loads acting during operation of the thrusters in various positions and in stowed position.

302 The supporting structure for retractable hydro acoustic equipment shall be able to resist maximum bending moment from the shaft, to which the equipment is mounted. Maximum bending moment from the shaft shall 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.

303 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.

P. Box Coolers

P 100 Introduction

101 The requirements below are valid for ships fitted with box coolers. The box coolers are normally installed between the tank top and the shell plating of the ship.

P 200 Arrangement

201 If the box cooler can be dismounted inwards, into the ship hull, and the box cooler is not fitted in a separate watertight compartment, an independent securing device for the box cooler is to be arranged, in addition to the bolt arrangement.

202 The box cooler shall be bolted to a separate mounting flange. The thickness of the flange shall be at least 1.25 times the depth of the bolt hole in the flange.

Guidance note:
The bolt grade is normally not to be higher than 8.8.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

203 The mounting flange shall be welded to the hull with double continuous fillet weld with minimum throat thickness of 10 mm.

204 Gaskets shall be of a quality suitable for sea water exposure.

205 The dimension of the bolts shall be minimum M16.

206 Longitudinal strength shall be specially considered in way of cut outs for box coolers.

Detail design of cut outs for box coolers shall be specially considered in order to reduce stress concentrations. For corners of the cut-outs the radius shall not be less than:

$$r = 0.1\ b\ (m)$$

b = breadth of opening (m).

207 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).

208 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 1 000 mm.

209 The thickness of the plate to which the box coolers are fitted shall not be less than:

$$t = 10 + \sqrt{l} \text{ (mm)}$$

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.

210 The thickness of the dividing plates between the box coolers shall not be less than:

$$t = 20 \, s \text{ (mm)}$$

s = stiffener spacing (m).

211 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 Ch.1 Sec.6 C501/Ch.2 Sec.5 C401.

SECTION 7
CORROSION PREVENTION

A. Corrosion prevention systems

A 100 General

101 All steel surfaces including ballast tanks, excluding other tanks and holds, shall be protected against corrosion by coating of suitable composition.

A 200 Documentation requirements

201 Documentation shall be submitted as required by Table A1.

202 For a full definition of the documentation types, see Pt.0 Ch.3.

Table A1 Documentation requirements

Object	*Documentation type*	*Additional description*	*For approval (AP) or For information (FI)*
Fastening of sacrificial anodes in liquid cargo tanks	C030 – Detailed drawing	Tanks for cargo with flash point below 60°C, and adjacent tanks.	AP
Fastening of sacrificial anodes in ballast tanks	C030 – Detailed drawing		AP
Sacrificial anodes in ballast tanks	M050 – Cathodic protection specification, calculation and drawings		FI
	Z030 – Arrangement plan		AP

A 300 Corrosion prevention of dedicated seawater ballast tanks

301 All dedicated seawater ballast tanks shall have an efficient corrosion prevention system, as required by SOLAS Reg. II-1/3-2.

Guidance note:

The attending surveyor of the Society will not verify the application of the coatings but will review the reports of the coating inspectors to verify that the specified shipyard coating procedures have been followed.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

A 400 Coatings

401 Shop primers applied over areas which will subsequently be welded, shall be approved by the Society.

402 The use of aluminium coating is generally not accepted in tanks for liquid cargo with flash point below 60°C, in adjacent ballast tanks, in cofferdams, in pump rooms or on deck above the mentioned spaces, nor in any other area where cargo gas may accumulate. Coating containing aluminium may, however, be accepted in places as mentioned above, provided it has been shown by tests that the coating will not increase the incendiary sparking hazard.

Guidance note:

Coating containing aluminium in gas hazardous areas limited to Al maximum 10% by weight in the dry film is acceptable.
Areas containing "liquid cargo with flash point below 60°C" are considered as "gas-dangerous" areas.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

A 500 Cathodic protection

501 All anodes shall be attached to the structure in such a way that they will remain securely fastened both initially and during service. Fillet welds shall 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 other positive locking devices 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 NV A or equivalent.

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

503 In tanks, permanent anodes made of, or alloyed with, magnesium are not accepted. Impressed current systems shall not be used in tanks due to development of chlorine and hydrogen that can result in an explosion hazard. Aluminium anodes are accepted in general. However, with regard to tanks for liquid cargo with flash point below 60°C and in adjacent ballast tanks, aluminium anodes shall be so located that a kinetic energy of not more than 275 J is developed in event of their loosening and becoming detached.

Guidance note:

Aluminium anodes in gas-dangerous 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 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.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

SECTION 8
PROTECTION OF THE CREW

A. Protection of the Crew

A 100 Guard rails

101 Guard rails or bulwarks shall be fitted around all exposed decks. The height of the bulwarks or guard rails shall be at least 1 metre from the deck, provided that, where this height would interfere with the normal operation of the ship, a lesser height may be approved if the Administration is satisfied that adequate protection is provided.

(ICLL Reg.25.2)

102 Guard rails fitted on superstructure and freeboard decks shall have at least 3 courses. The openings below the lowest course of the guard rails shall not exceed 230 millimetres. The other courses shall be not more than 380 millimetres apart.

In the case of ships with rounded gunwales the guard rail supports shall be placed on the flat of the deck. In other locations, guard rails with at least two coursed shall be fitted. In the case of ships with rounded gunwales the guard rail supports shall be placed on the flat of the deck.

(ICLL Reg.25.3)

103

a) Fixed, removable or hinged stanchions shall be fitted about 1.5 m apart.

b) At least every third stanchion shall be supported by a bracket or stay.
In lieu of at least every third stanchion supported by stay, alternatively (Ref Fig. 1):

   1) at least every third stanchion shall be of increased breadth: $kb_S = 2.9b_S$
   2) at least every second stanchion shall be of increased breadth: $kb_S = 2.4b_S$
   3) every stanchion shall be of increased breadth: $kb_S = 1.9b_S$.

   where b_S is the breadth of normal stanchion according to the design standard.

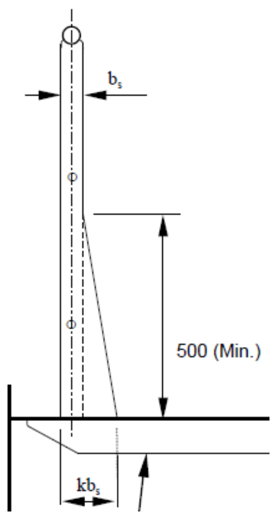


Fig. 1
Support of stanchions

   Stanchions with increased breadth are to be aligned with member below deck, minimum 100 × 12 mm flat bar welded to deck by double continuous filled weld, unless the thickness of the deck plating exceeds 20 mm.

c) Wire ropes may only be accepted in lieu of guard rails in special circumstances and then only in limited lengths.

d) Lengths of chain may only be accepted in lieu of guard rails if they are fitted between two fixed stanchions and/or bulwarks.

e) Wires shall be made taut by means of turnbuckles.
f) Removable or hinged stanchions shall be capable of being locked in the upright position.

(IACS LL47 to ICLL Reg. 25.2 and 25.3)

104 Protection for the crew in the form of guard rails or life lines shall be provided above the deck cargo if there is no convenient passage on or below the deck of the ship.

(ICLL Reg.25.5)

105 Scantlings of stanchions and courses shall comply with ISO 5480 (1979), or equivalent standards.

A 200 Gangways, walkways and passageways

201 Satisfactory means (in the form of guard rails, life lines, gangways or under deck passages etc.) shall be provided for the protection of the crew in getting to and from their quarters, the machinery space and all other parts used in the necessary work of the ship.

(ICLL Reg.25.4)

202 Acceptable arrangements referred to in Table E1 are defined as follows:

a) A well lit and ventilated under-deck passageway (clear opening 0.8 m wide, 2.0 m high) as close as practicable to the freeboard deck, connecting and providing access to the locations in question.
b) A permanent and efficiently constructed gangway fitted at or above the level of the superstructure deck on or as near as practicable to the centre line of the ship, providing a continuous platform at least 0.6 m in width and a non-slip surface, with guard rails extending on each side throughout its length. Guardrails shall be at least 1 m high with courses as required in 102, and supported by stanchions spaced not more than 1.5 m; a foot-stop shall be provided.
c) A permanent walkway at least 0.6 m in width fitted at freeboard deck level consisting of two rows of guard rails with stanchions spaced not more than 3 m. The number of courses of rails and their spacing shall be as required by 102. On Type B ships, hatchway coamings not less than 0.6 m in height may be regarded as forming one side of the walkway, provided that between the hatchways two rows of guardrails are fitted.
d) A 10 mm minimum diameter wire rope lifeline supported by stanchions about 10 m apart,
   or
   A single handrail or wire rope attached to hatch coamings, continued and adequately supported between hatchways.
e) A permanent and efficiently constructed gangway fitted at or above the level of the superstructure deck on or as near as practicable to the centre line of the ship:

   — located so as not to hinder easy access across the working areas of the deck;
   — providing a continuous platform at least 1.0 m in width (0.6 m will be accepted for tankers less than 100 m in length);
   — constructed of fire resistant and non-slip material;
   — fitted with guard rails extending on each side throughout its length; guard rails should be at least 1.0 m high with courses as required by 102 and supported by stanchions spaced not more than 1.5 m.
   — provided with a foot stop on each side;
   — having openings, with ladders where appropriate, to and from the deck. Openings should not be more than 40 m apart;
   — having shelters of substantial construction set in way of the gangway at intervals not exceeding 45 m if the length of the exposed deck to be traversed exceeds 70 m. Every such shelter should be capable of accommodating at least one person and be so constructed as to afford weather protection on the forward, port and starboard sides.

f) A permanent and efficiently constructed walkway fitted at freeboard deck level on or as near as practicable to the centre line of the ship having the same specifications as those for a permanent gangway listed in (e) except for foot-stops. On Type B ships (certified for the carriage of liquids in bulk), with a combined height of hatch coaming and fitted hatch cover of together not less than 1m in height the hatchway coamings may be regarded as forming one side of the walkway, provided that between the hatchways two rows of guard rails are fitted.
   Alternative transverse locations for (c), (d) and (f) above, where appropriate:

(1) At or near centre line of ship; or fitted on hatchways at or near centre line of ship.
(2) Fitted on each side of the ship.
(3) Fitted on one side of the ship, provision being made for fitting on either side.
(4) Fitted on one side only.
(5) Fitted on each side of the hatchways as near to the centre line as practicable.

Additional requirements:

1. In all cases where wire ropes are fitted, adequate devices shall be provided to ensure their tautness.
2. Wire ropes may only be accepted in lieu of guardrails in special circumstances and then only in limited lengths.
3. Lengths of chain may only be accepted in lieu of guardrails if fitted between two fixed stanchions.
4. Where stanchions are fitted, every 3rd stanchion shall be supported by a bracket or stay.
5. Removable or hinged stanchions shall be capable of being locked in the upright position.
6. A means of passage over obstructions, if any, such as pipes or other fittings of a permanent nature, shall be provided.
7. Generally, the width of the gangway or deck-level walkway should not exceed 1.5 m.

(ICLL Reg.25-1 and 27(8)) and SOLAS Ch. II-1/3-3.)

Table E1 Protection of the crew

Type of ship	*Locations of access in Ship*	*Assigned Summer Freeboard*	*Acceptable arrangements according to type of freeboard assigned*			
			Type A	*Type B-100*	*Type B-60*	*Type B and B+*
All ships other than Oil Tankers* Chemical Tankers* and Gas Carriers*	1.1 Access to midship quarters 1.1.1 Between poop and bridge, or 1.1.2 Between poop and deckhouse containing living accommodation or navigating equipment, or both.	≤ 3 000 mm	a b e	a b e	a b c(1) e f(1)	a b c(1) c(2) c(4) d(1) d(2) d(3) e f(1) f(2) f(4)
		> 3 000 mm	a b e	a b e	a b c(1) c(2) e f(1) f(2)	
	1.2 Access to ends 1.2.1 Between poop and bow (if there is no bridge) 1.2.2 Between bridge and bow, or 1.2.3 Between a deckhouse containing living accommodation or navigating equipment, or both, and bow, or 1.2.4 In the case of a flush deck vessel, between crew accommodation and the forward and after ends of ship.***	≤ 3 000 mm	a b c(1) e f(1)	a b c(1) c(2) e f(1) f(2)	a b c(1) c(2) e f(1) f(2)	
		> 3 000 mm	a b c(1) c(2) d(1) d(2) e f(1) f(2)	a b c(1) d(1) e f(1)	a b c(1) c(2) c(4) d(1) d(2) d(3) e f(1) f(2) f(4)	
Oil Tankers* Chemical Tankers* and Gas Carriers*	2.1 Access to bow 2.1.1 Between poop and bow, or 2.1.2 Between a deckhouse containing living accommodation or navigating equipment, or both, and bow, or 2.1.3 In the case of a flush deck vessel, between crew accommodation and the forward end of ship.	≤ (A_f+H_s)**	a e f(1) f(5)			
		> (A_f+H_s)**	a e f(1) f(2)			
	2.2 Access to after end In the case of a flush deck vessel, between crew accommodation and the after end of ship.***	as required in 1.2.4 for other types of ships				

* Oil Tankers, Chemical Tankers and Gas Carriers as defined in SOLAS Ch. II-1/2.12, VII/8.2 and VII/11.2, respectively.

** A_f: the minimum summer freeboard calculated as type A ship regardless of the type of freeboard actually assigned. H_s: the standard height of superstructure as defined in ICLL Regulation 33

*** Access to after end of ships is not applicable when crew accommodation is located aft.

Acceptable arrangements referred to in this table are given in 200.

Guidance note:

Deviations from some or all of these requirements or alternative arrangements for such cases as ships with very high gangways (i.e. certain Gas Carriers) may be allowed subject to agreement case by case with the relevant flag Administration.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

SECTION 9 STABILITY

A. Application, Definitions and Document Requirements

A 100 Application

101 All vessels with a length L_F of 24 m and above shall comply with the stability requirements of this section, as applicable for the main class.

102 The requirements in this section are in compliance with IMO 2008 Intact Stability Code (IMO Res. MSC.267(85)) and cover IACS UR L2.

103 For vessels with service restrictions as described in Pt.1 Ch.2 Sec.1 B400, modified stability requirements may be considered if consistent with the applicable service restriction.

104 Vessels with a length L_F of 24 m and above and with additional class notations shall comply with additional stability requirements as given in the appropriate rule chapters.

105 Ships with loading computer systems intended for stability control shall comply with Pt.6 Ch.9 Sec.1 A200.

106 The stability for vessels for which lifting operations are the main or one of the main functions shall also be in compliance with the criteria given in Pt.5 Ch.7 Sec.17.

The crane criteria shall be applied when the maximum heeling arm created by the crane and its load exceeds 0.10 m at any operational displacement.

A 200 Terms

201 *External watertight integrity*

The capability of the hull structure and its external closing appliances to prevent downflooding to volumes assumed buoyant. The external watertight integrity includes position and type of closing appliances, alarms, indicators, remote controls and signboards fitted to such appliances.

202 *Weathertight*

Weathertight means that in any sea conditions water will not penetrate into the ship.

203 *Watertight*

Capable of preventing ingress of water during static submersion under a head of water for which the surrounding structure is designed.

A watertight closing appliance is also considered weathertight.

204 *Downflooding*

Ingress of water through external openings to buoyancy volumes.

205 *Downflooding angle related to intact stability*

The minimum heel angle where an external opening without weathertight closing appliance is submerged.

206 *Lightweight*

Lightweight is the displacement of a ship in tonnes without cargo, fuel, lubricating oil, ballast water, fresh water and feed water in tanks, consumable stores, and passengers and crew and their effects.

The lightweight definition stated in the Stability Manual indicates which items are included or not included in the lightweight.

Guidance note:
The approved lightweight data are the data which are approved for the purpose of stability approval and control but not necessarily for determination of the deadweight.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

207 *Maximum allowable vertical centre of gravity*

The maximum vertical centre of gravity of the vessel, corrected for free surface effect, which complies with the stipulated stability requirements for the draught in question.

208 *Preliminary stability documentation*

The stability documentation which is based on estimated lightweight data.

209 *Final stability documentation*

The stability documentation which is based on approved lightweight data obtained from an inclining test or lightweight survey.

A 300 Documentation for approval

301 The following documentation shall be submitted for approval:

- preliminary stability booklet
- inclining test procedure
- inclining test report
- final stability booklet.

302 All stability documentation submitted for approval shall have a unique identification, i.e.:

- name and identity no. of ship
- date of issue
- revision number and date, if applicable
- name of originator
- table of contents (reports only)
- consecutive page numbering (reports only).

303 For each vessel built by the same yard from the same plans, it is sufficient to submit:

- lightweight survey procedure (inclining test procedure for passenger vessels)
- lightweight survey report (or inclining test report for passenger vessels)
- final stability booklet.

304 If the assignment of class shall be based on the approval of the Flag Administration according to Pt.1 Ch.1 Sec.1 B500, a copy of the final stability documentation stamped by the Flag Administration and the approval letter issued by the Flag Administration shall be submitted to the Society.

305 The following documentation shall be submitted for information:

- general arrangement
- body plan, lines plan or offset table
- external watertight integrity plan or freeboard plan.

Guidance note:
Details of the documentation are given in Classification Note No. 20.1 «Stability Documentation».

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

B. Surveys and Tests

B 100 General

101 The following surveys and tests shall be carried out:

- external watertight integrity survey with respect to unprotected and protected openings together with their closing appliances, alarms, indicators and signboards, normally covered by the load line initial survey
- checking of draught marks
- remote draught measurement and tank gauging systems
- inclining test or lightweight survey.

C. General Requirements

C 100 Stability book

101 An approved stability booklet shall be provided onboard. The stability booklet shall include information as is necessary to enable the master by a rapid and simple process to obtain accurate guidance as to the stability of the ship under varying conditions of service.

Guidance note:
The format and content of the stability book is further described in Classification Note No. 20.1 and IACS UI LL45.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

102 Stability data and associated plans shall include a translation into English, if English is not used as official language.

C 200 Fixed Ballast

201 If used, fixed ballast shall be installed in a manner that prevents shifting of position.

C 300 Draught Marks

301 The ship shall have scale of draught marks at the bow and stern on both port and starboard side.

Guidance note:

The draught marks should reflect the extreme draught at the location where they are fitted. The stability manual should contain guidance on, from draught mark readings, how to utilise the stability information contained therein. Norwegian Standard NS6301 may be referenced for further guidelines on the size and location of draught marks.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

C 400 Loading Computer System

401 Loading computers for stability calculation shall be considered as supplementary to the approved stability booklet.

402 Loading computers for stability control shall comply with Pt.6 Ch.9.

D. Intact Stability Criteria

D 100 General stability criteria

101 The following criteria are given for all ships:

- The area under the righting lever curve (GZ curve) shall not be less than 0.055 metre-radians up to θ = 30° angle of heel and not less than 0.09 metre-radians up to θ = 40° or the angle of flooding θ_f if this angle is less than 40°. Additionally, the area under the righting lever curve between the angles of heel of 30° and 40° or between 30° and θ_f, if this angle is less than 40°, shall not be less than 0.03 metre-radians.
- The righting lever (GZ) shall be at least 0.20 m at an angle of heel equal to or greater than 30°.
- The maximum righting lever should occur at an angle of heel preferably exceeding 30° but not less than 25°.
- The initial metacentric height, GM_0 shall not be less than 0.15 m.

Guidance note:

For ships carrying timber deck cargoes and provided that:

- the cargo extends longitudinally between superstructures end, or where there is no limiting superstructure at the after end, the timber deck cargo shall extend at least to the after end of the aftermost hatchway
- the cargo extends transversely for the full beam of the ship after due allowance for a rounded gunwale not exceeding 4% of the breadth of the ship
- supporting uprights are secured and remain securely fixed at large angles of heel

the following criteria may be used instead of the criteria in 101:

- the area under the righting lever curve (GZ curve) should not be less than 0.08 metre-radians up to θ = 40° angle of heel or the angle of flooding θ_f if this angle is less than 40°
- the maximum value of the righting lever (GZ) should be at least 0.25 m
- at all times during the voyage, the metacentric height GM_0 should be positive after correction for the free surface effects of liquid in tanks and, where appropriate, the absorption of water by the deck cargo and/or ice accretion on the exposed surfaces. Additionally, in the departure condition, the metacentric height GM_0 should not be less than 0.10 m.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

102 The following equivalent criteria are recommended where a vessel's characteristics render compliance with 101 impracticable (based on IMO 2008 IS Code Part B Ch.2.4.5):

- The area under the curve of righting levers (GZ curve) should not be less than 0.070 metre-radians up to an angle of 15° when the maximum righting lever (GZ) occurs at 15° and 0.055 metre-radians up to an angle of 30° when the maximum righting lever (GZ) occurs at 30° or above. Where the maximum righting lever (GZ) occurs at angles of between 15° and 30°, the corresponding area under the righting lever curve should be:

$$0.055 + 0.001\,(30° - \theta_{max})\ \text{metre-radians}$$

  where θ_{max} is the angle of heel in degrees at which the righting lever curve reaches its maximum.
- The area under the righting lever curve (GZ curve) between the angles of heel of 30° and 40°, or between 30° and θ_f this angle is less than 40°, should be not less than 0.03 metre-radians.
- The righting lever (GZ) should be at least 0.20 m at an angle of heel equal to or greater than 30°.
- The maximum righting lever (GZ) should occur at an angle of heel not less than 15°.

— The initial transverse metacentric height (GM_0) should not be less than 0.15 m.

103 When anti-rolling devices are installed in a ship, the applicable intact stability criteria shall be satisfied when the devices are in operation.

104 For certain ship types additional or alternative intact and damage stability criteria have been specified. These vessels (or class notations) are given in Table D1.

Table D1 Stability design requirements for different ship types and class notations

Class notation / Ship type	*Intact*	*Damage*	*Class Requirement*	*IMO Reference*
1A1	X		D101	IMO 2008 IS Code Part A Ch. 2.2
1A1, offshore/harbour service vessels	X		D102	IMO 2008 IS Code Part B Ch. 2.4.5
1A1, wind	X		D201	IMO 2008 IS Code Part A Ch. 2.3
1A1, timber	X		D101	IMO 2008 IS Code Part A Ch. 3.3
Tanker for Oil	X		Pt.5 Ch.3 Sec.3 A	MARPOL 73/78 Reg. 27
Offshore service vessel	X		Pt.5 Ch.7 Sec.2 D	IMO Res. MSC.235(82) Ch.2
SF	X	X	Pt.5 Ch.7 Sec.5 A102 Pt.5 Ch.7 Sec.5 B	IMO Res. MSC.235(82) Ch.3
Tug	X		Pt.5 Ch.7 Sec.12 E	No IMO requirements
Fire Fighter I (or **II** or **III**)	X		Pt.5 Ch.7 Sec.7 I	No IMO requirements
CRANE	X		Pt.6 Ch.1 Sec.3 E	No IMO requirements
Crane Vessel	X X	 X	Pt.5 Ch.7 Sec.17 D200 Pt.5 Ch.7 Sec.17 D100	No IMO requirements
DSV-SURFACE, -SAT) (diving support vessel)	X	X	Pt.5 Ch.16 DNV-OSS-305 DNV-OS-E402	IMO Res. MSC.235(82)
DEICE (de-icing/anti icing vessels)	X	X	Pt.6 Ch.1 Sec.4 B	
Offshore vessels				
Well Stimulation Vessel	X	X	Pt.5 Ch.7 Sec.9 H	IMO Res. MSC.235(82)
Escort (n, V)	X		Pt.5 Ch.7 Sec.13 D	No IMO requirements
Standby Vessel	X	X	Pt.5 Ch.7 Sec.6 E	No IMO requirements
Other vessels				
Passenger Ship	X		Pt.5 Ch.2 Sec.2 F300	IMO 2008 IS Code Part A Ch.3.1
Car Ferry, **Train Ferry** or **Car and Train Ferry**	X		Pt.5 Ch.2 Sec.3 F101	IMO 2008 IS Code Part A Ch.3.1
Fishing Vessel or **Stern Trawler**	X		Pt.5 Ch.6 Sec.1 F	To cover IMO 2008 IS Code Part B Ch.2.1 Torremolinos International Conference Ch.III modified by the Torremolinos Protocol of 1993
Icebreaker/POLAR	X	 X	Pt.5 Ch.1 Sec.4 L300 Pt.5 Ch.1 Sec.4 L400	No IMO requirements No IMO requirements
Barge for Deck Cargo	X		Pt.5 Ch.7 Sec.14 I	IMO 2008 IS Code Part B Ch.2.2
SPS (<240 persons) **SPS** (240 persons or more) All **SPS** ships	X X 	 X	Pt.3 Ch.3 Sec.9 D100 Pt.5 Ch.2 Sec.2 F300 Pt.5 Ch.7 Sec.11 B200	IMO 2008 IS Code IMO 2008 IS Code IMO Res. MSC.266(84)

D 200 Weather criterion

201 For all ships with a length L_F of 24 m and above, the criteria listed below shall be complied with (based on IMO 2008 IS Code Part A Ch.2.3):

1 The ability of a ship to withstand the combined effects of beam wind and rolling should be demonstrated for each standard condition of loading, with reference to the Fig.1 as follows:

1.1 - the ship is subjected to a steady wind pressure acting perpendicular to the ship's centreline which results in a steady wind heeling lever (l_{w_1})

1.2 - from the resultant angle of equilibrium (θ_0), the ship is assumed to roll owing to wave action to an angle of roll (θ_1) to windward. Attention should be paid to the effect of steady wind so that excessive resultant angles of heel are avoided.

The angle of heel under action of steady wind (θ_0) should be limited to a certain angle to the satisfaction of the Society. As a guide, 16° or 80% of the angle of deck edge immersion, whichever is less, is suggested.

1.3 - the ship is then subjected to a gust wind pressure which results in a gust wind heeling lever (l_{w_2})
1.4 - under these circumstances, area "b" should be equal to or greater than area "a";
1.5 - free surface effects should be accounted for in the standard conditions of loading as set out in D301.

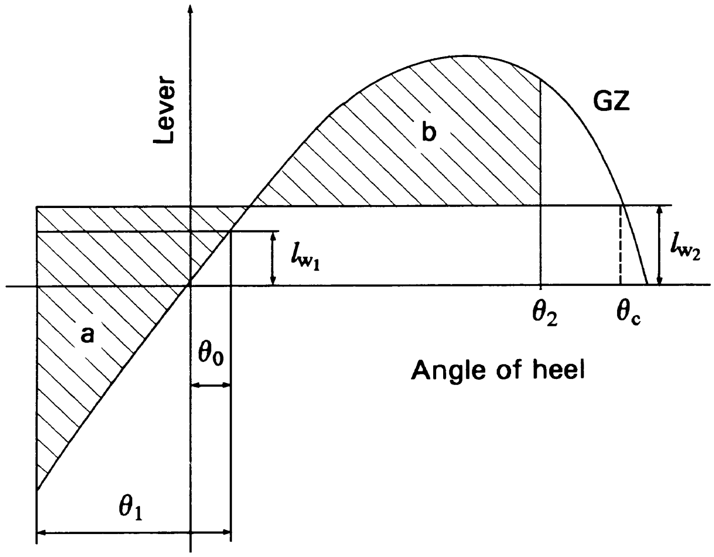


Fig. 1
Severe wind and rolling

The angles in Fig.1 are defined as follows:

θ_0 = angle of heel under action of steady wind (see 1.2 and 3)
θ_1 = angle of roll to windward due to wave action
θ_2 = angle of downflooding (θ_f) or 50° or θ_c whichever is less, where:
θ_f = angle of heel at which openings in the hull, superstructures or deckhouses which cannot be closed weathertight immerse. In applying this criterion, small openings through which progressive flooding cannot take place need not be considered as open.
θ_c = angle of second intercept between wind heeling lever (l_{w_2}) and GZ curves.

2 The wind heeling levers (l_{w_1}) and (l_{w_2}) referred to in 1.1 and 1.3 are constant values at all angles of inclination and should be calculated as follows:

$$l_{w_1} = \frac{PAZ}{1000\ g\ disp} \quad (m) \text{ and}$$

$$l_{w_2} = 1.5 l_{w_1} \quad (m)$$

P = 504 N/m^2 (wind speed = 29 m/s). The value of P, used for ships in restricted service and/or for ships with very large windage areas (due to coherence length for wind speed), may be reduced subject to the approval of the Society
A = projected lateral area of the portion of the ship and deck cargo above the waterline (m^2)
Z = vertical distance from the centre of A to the centre of the underwater lateral area or approximately to a point at one half the draught (m)
disp = displacement (t)
g = 9.81 m/s^2

The angle of roll θ_1 [1)] referred to in 1.2 should be calculated as follows:

$$\theta_1 = 109 k X_1 X_2 \sqrt{rs} \quad \text{(degrees)}$$

1) The angle of roll for ships with anti-rolling devices should be determined without taking into account the operation of these devices.

X_1 = factor as shown in Table D2
X_2 = factor as shown in Table D3
k = 1.0 for round-bilged ship having no bilge or bar keels
= 0.7 for a ship having sharp bilges
= as shown in Table D4 for a ship having bilge keels, a bar keel or both

r = 0.73 ± 0.6 OG/d, with:
OG = distance between the centre of gravity and the waterline (m) (+ if centre of gravity is above the waterline, - if it is below)
d = mean moulded draught of the ship (m)
s = factor as shown in Table D5.

Table D2 Values of factor X_1

B/d	X_1
≤ 2.4	1.0
2.5	0.98
2.6	0.96
2.7	0.95
2.8	0.93
2.9	0.91
3.0	0.90
3.1	0.88
3.2	0.86
3.3	0.84
3.4	0.82
≥ 3.5	0.80

Table D3 Values of factor X_2

C_b	X_2
≤ 0.45	0.75
0.50	0.82
0.55	0.89
0.60	0.95
0.65	0.97
≥ 0.70	1.0

Table D4 Values of factor k

$\frac{A_k 100}{LB}$	*k*
0	1.05
1.0	0.98
1.5	0.95
2.0	0.88
2.5	0.79
3.0	0.74
3.5	0.72
≥ 4.0	0.70

Table D5 Values of factor s

T	*s*
< 6	0.100
7	0.098
8	0.093
12	0.065
14	0.053
16	0.044
18	0.038
≥ 20	0.035

(Intermediate values in Tables D2 to D5 should be obtained by linear interpolation).

Rolling period

$$T = \frac{2CB}{\sqrt{GM}} \quad \text{(seconds)}$$

C = 0.373 + 0.023 (B/d) - 0.043 (L/100)

The symbols in Tables D2 to D5 and the formula for the rolling period are defined as follows:

L = waterline length of the ship (m)
B = moulded breadth of the ship (m)
d = mean moulded draught of the ship (m)

C_b = block coefficient
Ak = total overall area of bilge keels, or area of the lateral projection of the bar keel, or sum of these areas (m^2)
GM = metacentric height corrected for free surface effect (m).

202 Other calculation methods of equivalent safety level may be accepted as an alternative to the above.

Guidance note:
For some ships, the formulas may over-estimate the roll angle. As an alternative, the roll angle can be determined by model tests or direct calculations carried out for sea-states corresponding to the recommended wind speed.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

D 300 Assumptions concerning intact stability criteria and calculations

301 For all loading conditions the initial metacentric height and the stability curves shall be corrected for the effect of free surface of liquid in tanks.

Guidance note:
The free surface should be taken into account as described in the IACS UI LL61.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

302 Compliance with the stability criteria shall be checked for the main loading conditions intended by the owner in respect of the vessel's operation.

303 If the owner does not supply sufficiently detailed information regarding such loading conditions, calculations shall be made for the standard loading conditions in 304 and 305.

304 The following standard loading conditions apply to cargo ships:

- ship in the fully loaded departure condition, with cargo homogeneously distributed throughout all cargo spaces and with full stores and fuel
- ship in the fully loaded arrival condition, with cargo homogeneously distributed throughout all cargo spaces and with 10% stores and fuel remaining
- ship in ballast in departure condition, without cargo but with full stores and fuel
- ship in ballast in arrival condition, without cargo and with 10% stores and fuel remaining.

305 The following additional loading conditions apply to cargo ships intended to carry deck cargoes:

- ship in the fully loaded departure condition with cargo homogeneously distributed in the holds and with cargo specified in extension and weight on deck, with full stores and fuel
- ship in the fully loaded arrival condition with cargo homogeneously distributed in the holds and with cargo specified in extension and weight on deck, with 10% stores and fuel.

306 In the fully loaded departure conditions in 304 and 305 the ship shall be assumed loaded to the summer load waterline, or if intended to carry timber deck cargo, to the summer timber load line. The water ballast tanks should normally be assumed empty.

307 In all cases, the cargo in holds is assumed fully homogeneous unless this is inconsistent with the practical service of the ship.

308 Where timber deck cargoes are carried, the amount of cargo and ballast shall correspond to the worst service condition in which all the stability criteria in D100 are met. In the arrival condition it shall be assumed that the weight of the deck cargo has increased by 10% due to water absorption.

309 In all cases, when deck cargo is carried, a realistic stowage weight shall be assumed and stated, including the height of the cargo.

Guidance note:
For ships carrying timber deck cargoes conditions should be shown indicating the maximum permissible amount of deck cargo having regard to the lightest stowage rate likely to be met in service.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

310 Only those parts of the ship that are adequately protected by weathertight closing are accepted included as buoyant in the stability calculations.

Guidance note:
Reference is made to IMO Intact Code IMO 2008 IS Code Part B Ch.3.5 and the IACS UI LL62.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

311 The Society may allow account to be taken in stability calculations of the buoyancy of the deck cargo assuming that such cargo has a permeability of 0.25.

E. Damage Stability

E 100 Damage stability

101 Vessels with additional class notations shall comply with the additional damage stability requirements as given in the appropriate rule chapters.

102 When DNV is authorised to carry out stability approval on behalf of the Flag Administration,compliance with the damage stability provisions required for issuance of the relevant international certificates shall be demonstrated.

F. Determination of Lightweight Data

F 100 Application

101 Every passenger ship and cargo ship with length more than 24 metres shall be inclined upon its completion and the lightweight displacement and centre of gravity determined.

102 The inclining test required in 101 may be waived if basic stability data are available from the inclination test of a sister ship and it is shown that reliable stability information for the exempted ship can be obtained from such basic data.

Guidance note 1:

Dispensation according to 102 is not considered applicable to passenger ships and other ships where the lightweight is more than 75% of the total displacement.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

Guidance note 2:

The criteria for dispensation according to 102 are given in SOLAS Reg. II-1/5.2

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

F 200 Procedure

201 The inclining test shall be carried out in accordance with an approved test procedure or "*Yard's checklist for planning and execution of lightweight survey and inclining test*" given in Classification Note 20.1 - Appendix A. The inclining test shall be carried out in the presence of the Society's representative.

Guidance note:

Guidelines for conducting inclining test or lightweight survey are given in IACS Rec. No. 31.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---

202 The inclining test report shall be signed by the person responsible for the test and by the Society's representative.

203 The approved lightweight and centre of gravity shall be used in the final stability booklet.

F 300 Lightweight survey

301 A lightweight survey shall be carried out if an inclining test has been dispensed with according to 102.