b) For multi-hulled vessels—

i) For the main bilge suction pipe in the case of multi-hulled vessels having only a single main bilge line, the sum of the breadths of the hulls;

ii) for the main bilge suction pipe in the case of a multi-hulled vessels having a dedicated main bilge line in each hull, the breadth of the applicable hull; or

iii) for branch section lines, the breadth of the applicable hull.

D = depth of vessel, in metres

C = length of compartment, in metres.

5.8.6 Strainers

5.8.6.1 Vessels of 20 m in measured length and over

All bilge suctions shall be fitted with a mudbox, strum box or strainer that is accessible for cleaning. Each bilge suction in a machinery space shall be fitted with a mudbox and metallic tail pipe.

5.8.6.2 Strainer holes

Strainer holes shall not be greater than 10 mm in diameter, and the aggregate area of the holes shall not be less than twice the area of the suction pipe.

5.8.7 Bilge level alarms

On decked vessels, a bilge level alarm shall be fitted—

a) in the propulsion machinery space; and

b) in all other compartments that contain seawater pumping systems.

The alarm shall be clearly audible at a continuously manned control position with the machinery operating under full power conditions.

NOTE: Additional bilge alarms may be required on certain vessels, see Clauses 2.19.9.6 and 5.7.4.1.

5.8.7.1 Power supply

The power supply for the bilge level alarm shall be available at all times there is a person on board.

5.8.8 Collision bulkhead piping

Where a pipe pierces a collision bulkhead, it shall be fitted with a suitable valve or cock at the bulkhead. The control mechanism for the valve or cock shall incorporate a means to indicate clearly whether the valve or cock is open or closed.

5.8.8.1 Means of control

Unless otherwise provided for in Clause 5.8.8.2, the valve or cock shall be controllable from the bulkhead deck.

5.8.8.2 Location and accessibility of collision bulkhead valve

Where the valve or cock is fitted on the after side of the bulkhead and is readily accessible at all times, it need not be controllable from the bulkhead deck.

NOTE: See Clause 5.8.2.3.

5.8.9 Sounding arrangements

5.8.9.1 Means of sounding required

Sounding pipes or other means of readily determining the amount of liquid shall be provided for—

a) any tank or watertight compartment that is not part of a machinery space, including a cofferdam and a double bottom tank; and

b) any cofferdam or double bottom tank that is located in a machinery space.

5.8.9.2 Sounding pipes

Where a sounding pipe is fitted it shall comply with the following:

a) If located outside of a machinery space, extend to a readily accessible position on deck.

b) If located in a machinery space, extend either—

   i) to a readily accessible position on deck; or

   ii) to a lesser height provided the pipe is fitted with a cock (or ball valve) arranged for automatic closure when released. Cocks for such applications shall be of parallel plug type to provide ready movement. Handles shall be weighted or spring loaded and permanently secured.

c) Terminate in such a position that there is no risk of overflow spillage onto hot surfaces or electrical equipment.

d) Incorporate a means of closing to prevent the free entry of water.

e) Wherever possible be straight, but if curved to suit the shape of the vessel, the curvature shall be sufficient to permit the passage of a sounding rod or a sounding chain.

f) Be protected against mechanical damage and, where it passes through refrigerated space, shall be thermally insulated.

g) Be fitted with a striking plate under the lower end of a sounding pipe.

h) Be of thickness not less than that determined in accordance with Clause 5.7.3.2.2.

i) Be not less than 32 mm internal diameter.

CHAPTER 6 STEERING SYSTEMS

6.1 SCOPE

This Chapter specifies requirements for steering systems. It applies to vessels of less than 35 m in measured length.

NOTE: For vessels of 35 m or more in measured length, refer to Clause 1.2.1.

6.2 OBJECTIVE

The objective of this Chapter is to control the risks associated with the steering system or a failure of the steering system.

NOTES:

1. Specific hazards associated with the steering system include the following: poor steering system performance, inadequate feedback on steering orientation, contact with the propeller or hull, loss of watertight integrity.
2. Specific hazards that may lead to failure of the steering system include the following: rupture or yield, rudder (or nozzle) sole piece or components; fatigue failure of rudder stock, rudder (or nozzle) or components; seizure of rudder (or nozzle) bearings, failure of the steering actuator.
3. Consequences of these hazards include the following: inadequate responsiveness or loss of vessel control in critical situations causing collision or grounding, flooding of the vessel, inability to return to shelter.

REQUIRED OUTCOMES

6.3 DIRECTIONAL CONTROL

The steering system must be capable of reliably altering the vessel's heading at a rate appropriate for the navigational hazards that might be expected in normal and abnormal conditions. The steering system must also be capable of reliably holding or returning the vessel's head to a given course to counteract the effects of wind, current and waves.

6.4 STRENGTH

The rudder, steering nozzle or other directional control device must have sufficient strength to meet the demands of service in both ahead and astern operation, and in normal and emergency situations. Consideration must be given to peak, fatigue and shock loading.

6.5 CORROSION AND EROSION

The rudder, steering nozzle or other directional control device must be designed and constructed to avoid or reduce the effects of corrosion and erosion.

NOTE: Erosion is caused by operation adjacent to a propeller or other propulsive device.

DEEMED-TO-SATISFY SOLUTIONS

6.6 COMPLIANCE

For the purpose of this National Standard, the steering system shall be deemed to have satisfied the Required Outcomes in Clauses 6.3 to 6.5 if it complies with Clauses 6.7 to 6.11.

6.7 GENERAL STEERING DESIGN CRITERIA

6.7.1 Strength of steering gear

The steering gear shall be designed to withstand maximum helm at maximum ahead and astern speed. The rudderstock, rudder or steering nozzle and tiller arm or quadrant shall comply with Clauses 6.8, 6.9, 6.10 and 6.11 below.

6.7.2 Steering arrangement

The steering arrangement shall be such that the person at the helm has a clear view ahead while at the normal steering position.

NOTE: See also Part C Section 1: Arrangement, Accommodation and Personal Safety) of the NSCV.

6.7.3 Secondary means of steering

All vessels, except twin screw vessels, shall be fitted with two independent means of steering unless steering is normally achieved via a hand tiller, in which case a second means of steering need not be provided. The secondary or emergency means of steering shall be capable of being brought speedily into action.

6.7.4 Rudder movement

Rudder movement shall be no less than 35° to port to 35° to starboard.

NOTE: The formulas specified in Clauses 6.8, 6.9 and 6.11 are based on helm angles not exceeding 35º. Rudder movement in excess of 35° will require a change in the minimum diameter of the rudderstock and the scantlings of the rudder and tiller arm or quadrant.

6.7.5 Performance

In vessels of 12.5 m measured length and over, the steering gear shall be capable of putting the rudder over from 35° on one side to 30° on the other in 30 seconds when the vessel is at maximum ahead service speed with the rudder totally submerged. It shall be designed to prevent violent recoil of the steering wheel.

6.7.6 Helm movement direction

The trailing edge of a rudder blade of a vessel shall move in the same direction as the top spokes of the steering wheel. Where any vessel is not fitted with a conventional steering wheel, movement of the helm actuator to port or starboard shall cause the ship's head to move in the same direction.

6.7.7 Rudder position indicator

A rudder position indicator shall be fitted on all vessels of 15 m measured length and over which are fitted with power-operated steering gear. The rudder position indicator shall be in full view of the person at the helm while the person is at any steering position. This latter requirement need not apply to a person at the helm at the emergency steering position.

6.7.8 Steering component material

Components that transmit torque, tensile stresses or shock loads, including the tiller or quadrant, shall not be manufactured from ordinary grades of cast iron or other non-ductile material.

6.7.9 Hydraulic steering systems

Hydraulic steering systems shall comply with the following requirements:

a) Means shall be provided to facilitate a quick change over from the primary to the secondary steering.

b) A relief valve shall be installed in hydraulic systems that incorporate a power pump. The relief valve shall be set to prevent mechanical damage to the steering gear.

c) Hydraulic hose and piping shall comply with Clauses 7.9.4 and 7.9.5 and shall be located and arranged to minimise the possibility of mechanical, fire or other damage.

   NOTE: Mechanical damage includes chafing, crushing and holing.

6.7.10 Mechanical transmission or actuator shaft bearings

Steering transmission or actuator shafts shall be adequately supported in bearings spaced apart not more than 70 times the diameter of the shaft. Bearing spacing adjacent to sprockets or gears shall be such that no undue bending load can be applied to the shaft.

6.8 RUDDER STOCKS

6.8.1 Definitions

For the purposes of this Chapter, the following definitions apply:

Balanced rudder—
a rudder having blade area forward of the rudder stock or pintles (see Figure 14 and Figure 15).

Unbalanced rudder—
a rudder having no blade area forward of the rudder stock or pintles (see Figure 16).

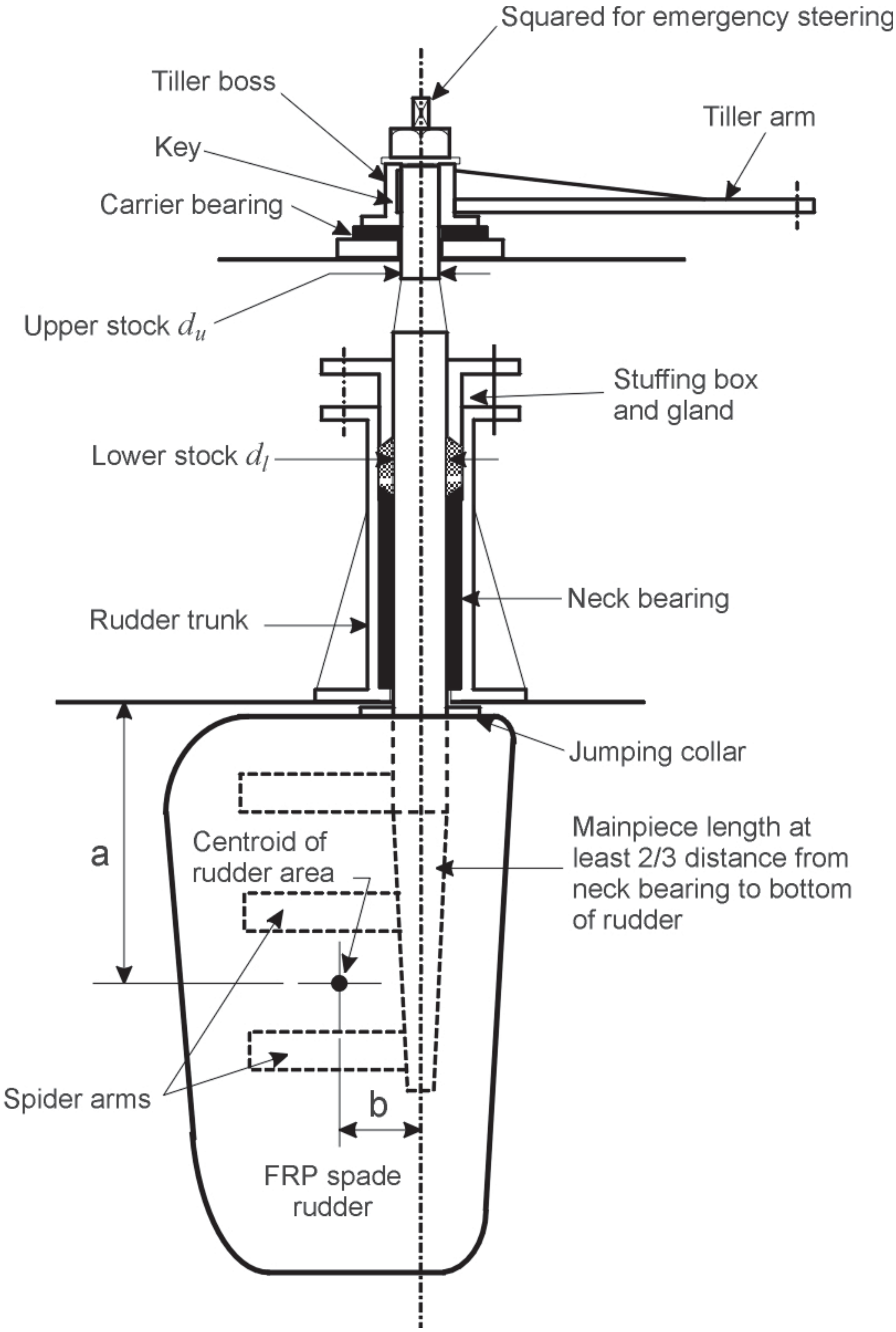

Figure 14 — Balanced spade rudder of FRP construction

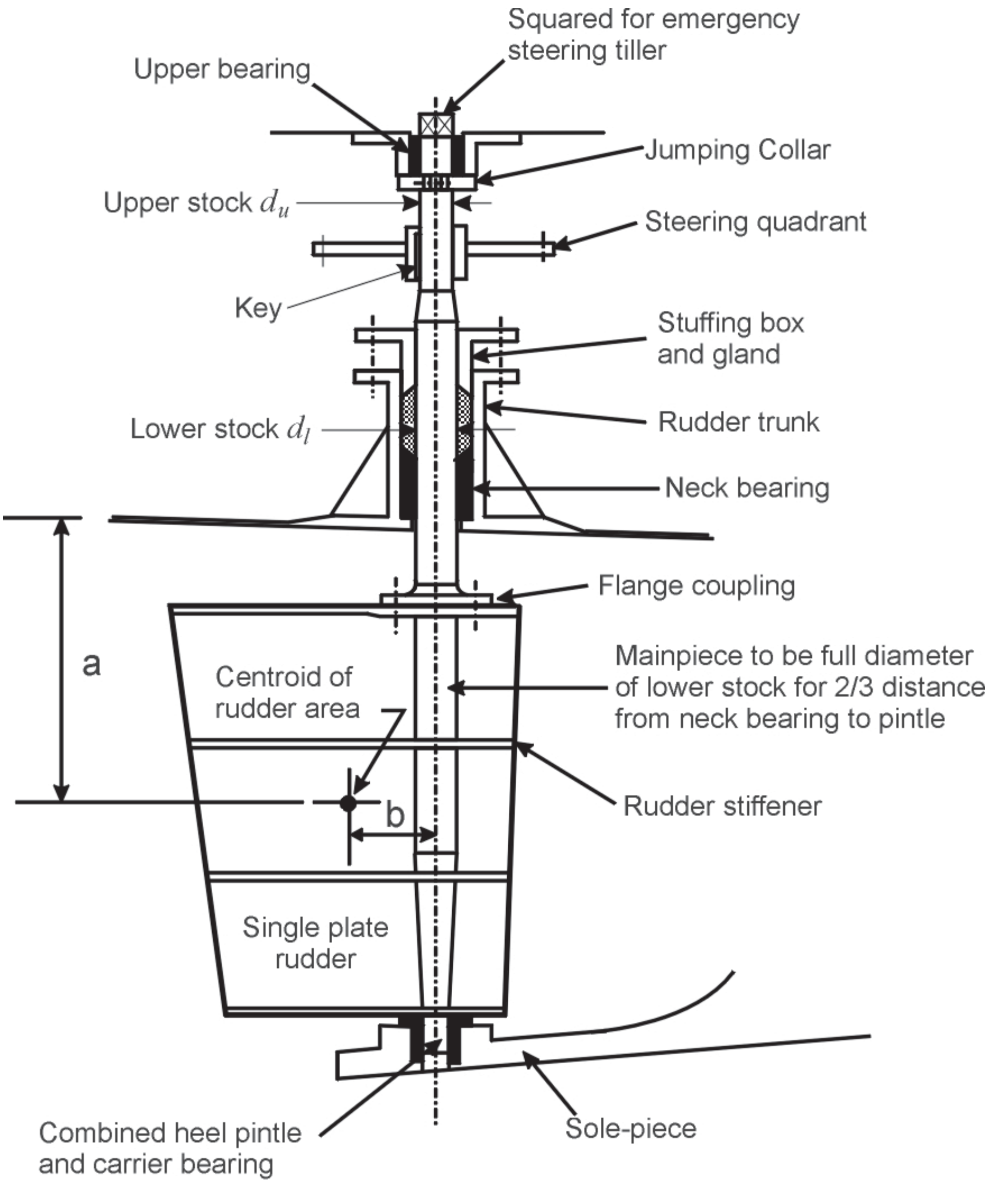

Figure 15 — Balanced rudder of single plate construction

6.8.2 Manufacture

Rudders shall be manufactured in accordance with one of the following methods, or by a means that can be demonstrated to be equivalent:

a) The rudder blade shall be fabricated or cast, and shall incorporate either an integral flange that is secured to a flanged rudder stock with fitted bolts or shall be secured by means of a taper, key and retaining nut.

b) The rudder blade shall be fabricated with an integral rudder stock.

NOTE: Special attention should be given to the attachment of the rudder stiffeners, pintles and rudder coupling to the main-piece of the rudder.

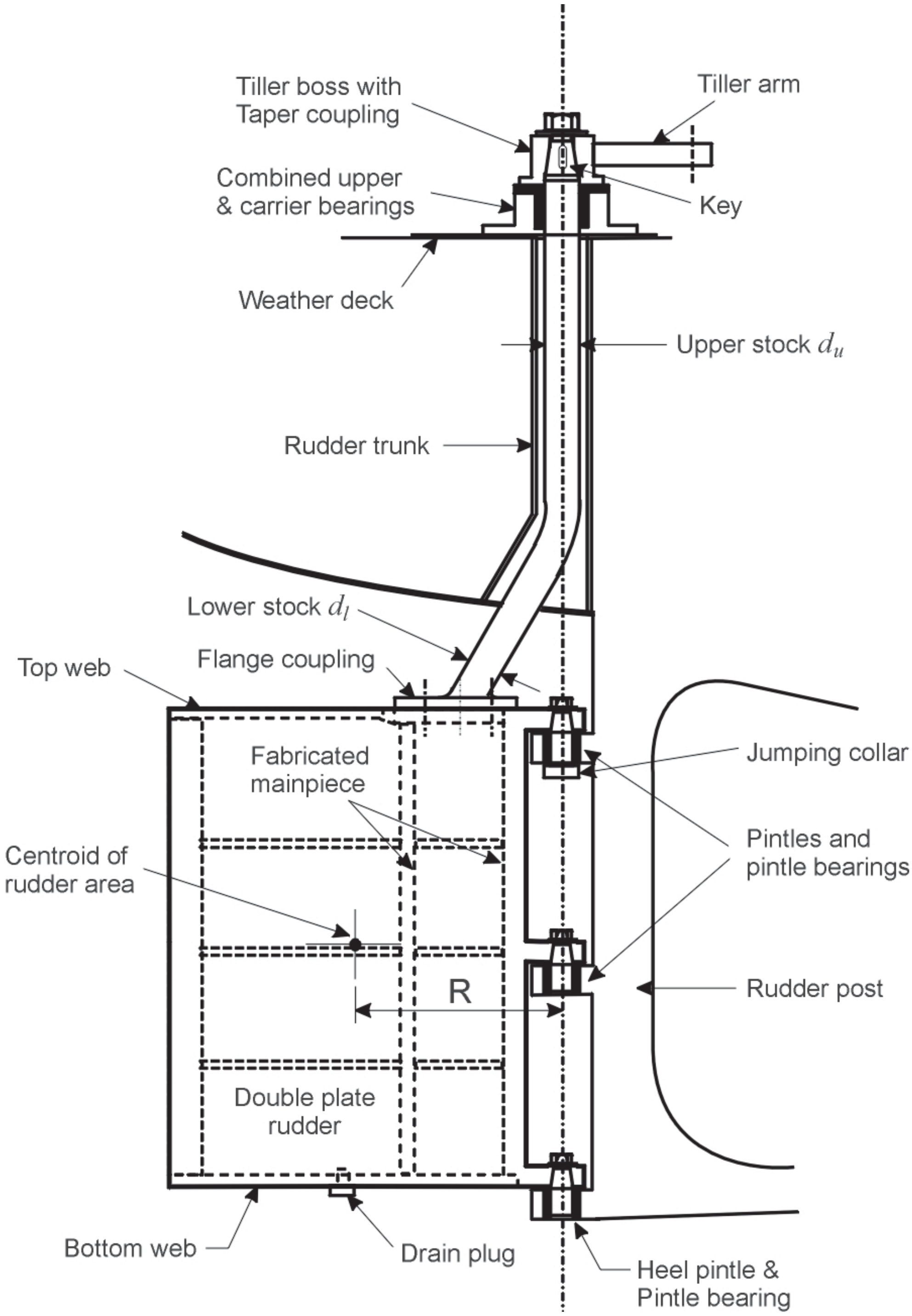

Figure 16 — Unbalanced rudder of double plate construction

6.8.3 Component materials

Unless otherwise permitted in this Chapter the following shall apply:

a) Rudder stocks, couplings, coupling bolts, pintles and similar parts subject to dynamic stress shall be manufactured from materials having minimum mechanical properties as specified for shaft materials in Clause 3.10.1. Other materials may be used where equivalence can be demonstrated.

b) Rudder plating and stiffeners shall be of material complying with the requirements specified for hull material in Part C Section 3: Construction of the NSCV.

c) Cast rudder blades shall be manufactured from ductile material.

NOTE: Most of the formulae for rudder components contained within this Chapter are based on “minimum required” rather than “as fitted” diameters in order to give minimum scantlings. Designing to the minimum required diameter may limit future flexibility in regard to rudder modification or alterations to the vessel which result in an increase in speed.

6.8.4 Rudder stock and main-piece—unbalanced rudders

6.8.4.1 Arrangement of bearings

For the purposes of this Clause, unbalanced rudders are assumed to have at least one pintle (at the heel) with a neck bearing, or additional pintles, or both a neck bearing and additional pintles.

6.8.4.2 Upper stock size

A rudder stock at the tiller or quadrant for an unbalanced rudder shall not be less than that obtained from the following formula:

$$d_u = f_C f_N C \sqrt[3]{\frac{410 R A V^2}{UTS_{stock}}}$$

where

d_u = minimum diameter of upper stock, in millimetres

R = distance from the centre line of stock to the centre of area of the rudder (see Figure 16), in metres

A = area of rudder, in square metres (m²)

V = speed of vessel in knots with—

a) a minimum of 8 in vessels less than 30 m in measured length; and

b) a minimum of 9 in vessels of 30 m in measured length and over.

UTS_{stock} = ultimate tensile strength of stock material, in megapascals (MPa)

C = the coefficient obtained from Table 6.

f_C = rudder cross-section coefficient—

a) 1 for normal cross-section rudders

b) 1.08 for hollow cross-section rudders; e.g. whale-tail

c) 1.19 for high lift rudders with active trailing edge

f_N = nozzle coefficient—

a) 1 for rudders behind an open propeller

b) 1.09 for rudders behind a propeller in a fixed nozzle.

Table 6 — Values of coefficient *C* for varying vessel speed *V*

V (knots)	8	9	10	11	12	13	14	15 and over
C (Measured length of vessel less than 30 m)	21.66	21.25	20.84	20.43	20.02	19.61	19.20	19.20
C (Measured length of vessel 30 m and over)	N/A	21.66	21.25	20.84	20.43	20.02	19.61	19.20

NOTE: Values of coefficient C for vessel speeds between those shown in the table may be obtained by applying the formulas $C = 24.94 - 0.41V$ for vessels of measured length less than 30 m (and speed up to 14 knots) and $C = 25.35 - 0.41V$ for vessels of measured length 30 m and over.

6.8.4.3 *Lower stock size*

The minimum required diameter of the lower stock d_l above the top pintle or in way of the neck bearing of an unbalanced rudder shall be the same as the minimum required diameter of the upper stock d_u.

6.8.4.4 *Mainpiece size*

The mainpiece of an unbalanced rudder may be gradually reduced from the minimum required diameter of the lower stock at the top of the rudder blade d_l (as calculated in Clause 0) to 0.75 d_l at the heel pintle.

6.8.5 Rudder stock and mainpiece — balanced rudders

6.8.5.1 *Upper stock size*

A rudder stock above the neck bearing for a balanced rudder shall not be less than that obtained from the following formula:

$$d_u = f_C f_N C \sqrt[3]{\frac{410\, b\, A\, V^2}{UTS_{stock}}}$$

where

d_u = minimum diameter of upper stock, in millimetres

b = horizontal distance, in metres, from the centre of the lower stock to the centre of area of total rudder area (see Figure 14 or Figure 15).

A = area of rudder, in square metres (m²)

V = speed of vessel in knots with—

a) a minimum of 8 knots in vessels less than 30 m in measured length; and

b) a minimum of 9 knots in vessels of 30 m in measured length and over.

UTS_{stock} = ultimate tensile strength of stock material, in megapascals (MPa)

C = the coefficient obtained from Table 6

f_C = rudder cross-section coefficient—

a) 1 for normal cross-section rudders

b) 1.08 for hollow cross-section rudders; e.g. whale-tail

c) 1.19 for high lift rudders with active trailing edge

f_N = nozzle coefficient—

a) 1 for rudders behind an open propeller

b) 1.09 for rudders behind a propeller in a fixed nozzle.

6.8.5.2 *Lower stock size*

The stock in way of and below the neck bearing for a balanced rudder shall have a diameter not less than that determined from the following formula:

$$d_l = f_C \, f_N \, C \sqrt[3]{\frac{410 \, R \, A \, V^2}{UTS_{stock}}}$$

where

d_l = minimum diameter of lower stock, in millimetres

R = $0.25\left(a+\sqrt{a^2+16b^2}\right)$ for rudders fitted with neck and heel pintle bearings; or

$a+\sqrt{a^2+b^2}$ for rudders not fitted with a heel pintle bearing.

where (from Figure 14 and Figure 15)

a = vertical distance, in metres, from the bottom of the neck bearing to the centre of area of total rudder area; and

b = horizontal distance, in metres, from the centre of the lower stock to the centre of area of total rudder area.

A = total area of rudder, in square metres (m^2)

V = speed of vessel in knots with—

a) a minimum of 8 in vessels less than 30 m in measured length; and

b) a minimum of 9 in vessels of 30 m in measured length and over.

UTS_{stock} = ultimate tensile strength of stock material, in megapascals (MPa)

C = the coefficient determined in accordance with either Item a) or b) as follows:

a) Where the speed of the vessel is not greater than $4\sqrt{LWL}$ (LWL being the measured length of the vessel, in metres, at the designed waterline), the value of C shall be obtained from Table 6.

b) Where the speed of the vessel is greater than $4\sqrt{LWL}$ (LWL being the length of the vessel in m at the designed waterline), the value of C shall be 16.

f_C = rudder cross-section coefficient—

a) 1 for normal cross-section rudders

b) 1.08 for hollow cross-section rudders; e.g. whale-tail

c) 1.19 for high lift rudders with active trailing edge

f_N = nozzle coefficient—

a) 1 for rudders behind an open propeller

b) 1.09 for rudders behind a propeller in a fixed nozzle.

6.8.5.3 *Mainpiece size (with heel pintle bearing)*

The mainpiece of a balanced rudder having neck and heel pintle bearings (see Figure 15) shall be the full diameter of the lower stock d_l for at least two-thirds of the distance from the neck bearing to the heel pintle bearing. The diameter may be gradually reduced below this point to $0.75d_l$ at the heel pintle.

6.8.5.4 *Stock and mainpiece size (no heel pintle bearing)*

The stock and mainpiece of a balanced spade rudder that has no heel pintle bearing (Figure 14) shall be the required diameter of the lower stock dl from the neck bearing to the underside of the top rudder arm if a single plate rudder, or to the top of the rudder if a built-up rudder. The diameter of the mainpiece may be gradually reduced below this point until it is 0.5dl. The length of mainpiece in way of the rudder shall not be less than two-thirds of the depth of the rudder at the centre line of the stock. The stock above the neck bearing may be gradually reduced from the required diameter of the lower stock dl to the required diameter of the upper stock du at a point just below the upper bearing.

6.8.6 Non-circular sections

The width, depth, section modulus and torsional modulus of a mainpiece or stock of non-circular section shall not be less than those required for a circular mainpiece or stock. When calculating the section modulus of the mainpiece, the effective width of plating that may be included on each side of a web forming the mainpiece shall not be greater than the thickness of the rudder at the centre line of the stock. Where the material of the mainpiece differs from that of the stock, the section modulus of the mainpiece shall not be less than that determined from the following formula:

$$Z_{mpiece} = \frac{\pi \, d_l^{\,3}}{32000}\left(\frac{UTS_{stock}}{UTS_{mpiece}}\right)$$

where

Z_{mpiece} = minimum section modulus of mainpiece at the top of the rudder, in cubic centimetres (cm^3)

d_l = required diameter of the mainpiece, in millimetres, as determined in Clauses 6.8.4.4, 6.8.5.3 or 6.8.5.4

UTS_{stock} = ultimate tensile strength of stock material, in megapascals (MPa)

UTS_{mpiece} = ultimate tensile strength of mainpiece material, in megapascals (MPa).

6.8.7 Rudder bearings, pintles, gland and stops

6.8.7.1 Rudder support

Rudder bearings shall be adequately supported, and their housings shall be rigidly attached to the vessel's structure.

The weight of a rudder shall be supported at a pintle bearing (normally the heel pintle) or a carrier bearing. The structure in way of the pintle or carrier bearing shall be strengthened for that purpose.

6.8.7.2 Sole-pieces

6.8.7.2.1 Ratio of width to depth

For the purposes of the formulas contained in Clauses 6.8.7.2.2 to 6.8.7.2.4, the width to depth ratio of a sole-piece shall not be greater than 2.3 to 1 nor less than 1.8 to 1.

6.8.7.2.2 Section modulus

The section modulus of the sole-piece about the vertical axis at a distance l_S from the centreline of the rudder stock shall not be less than that determined from the following formula:

$$Z_S = C_S A V^2 l_S f_C \left(\frac{410}{UTS_S} \right)$$

where

Z_S = required section modulus of the sole-piece about the vertical axis, in cubic centimetres (cm^3)

C_S = a coefficient varying with speed obtained from Table 7

A = total area of rudder, in square metres (m^2)

V = maximum speed of vessel, in knots

l_S = horizontal distance from the centreline of rudder stock to the particular section of the sole-piece, in millimetres

UTS_S = ultimate tensile strength of sole-piece material, in megapascals (MPa)

f_C = rudder cross-section coefficient—

a) for normal cross-section rudders

b) 1.08 for hollow cross-section rudders; e.g. whale-tail

c) 1.19 for high lift rudders with active trailing edge.

Table 7 — Values of coefficient C_S for varying vessel speed V

V (knots)	10	11	12	13	14	15	16 and over
C_S for vessels without an outer post	2.054	1.811	1.617	1.464	1.339	1.235	1.138
C_S for vessels with an outer post	1.707	1.540	1.394	1.283	1.179	1.096	1.026

NOTE: Values of coefficient C_S for vessel speeds between those shown in the table may be obtained by linear interpolation.

6.8.7.2.3 *Stiffness*

Where the sole-piece is a material other than carbon steel, the moment of inertia about the vertical axis at a distance l_S from the centreline of the rudder stock shall not be less than that determined from the following formula:

$$I_S = 1.1 Z_S^{1.333} \left(\frac{207}{E_S} \right)$$

where

I_S = required moment of inertia of the sole-piece about the vertical axis, in cm^4

Z_S = required section modulus of the sole-piece about the vertical axis as calculated in Clause 6.8.7.2.2, in cubic centimetres (cm^3)

E_S = modulus of elasticity of the sole-piece material, in gigapascals (GPa).

6.8.7.2.4 Area

Where the sole-piece is a material other than carbon steel, the cross-sectional area of the sole-piece at a distance l_S from the centreline of the rudder stock shall not be less than that determined from the following formula:

$$A_S = 2.5 Z_S^{0.667} \left[\frac{410}{UTS_S} \right]$$

where

A_S = required area of the sole-piece, in square centimetres (cm^2)

Z_S = required section modulus of the sole-piece about the vertical axis as calculated in Clause 6.8.7.2.2, in cubic centimetres (cm^3)

UTS_S = ultimate tensile strength of sole-piece material, in megapascals (MPa).

6.8.7.3 Rudder stock neck bearing

Neck bearings for rudders shall incorporate bushes and shall be fitted as shown in Figure 15. The bush shall have a length not less than that determined from the following formula:

$$l_n = k_n \, d_l$$

where

l_n = required length of neck bearing, in millimetres

k_n = 4 for spade rudders without an upper bearing, or 1.5 for all other balanced rudders

d_l = minimum required diameter of lower stock, in millimetres.

6.8.7.4 Spade rudder bearing pressure

High bearing loads are likely on the neck and upper bearings of a spade rudder (see Figure 14). Calculations shall be made to ensure that the pressure on the neck and upper bearings does not exceed that specified by the manufacturer of the bearings. Where allowable bearing pressure information is not available, then the maximum nominal bearing pressure shall not exceed 3.9 MPa.

NOTE: For the purposes of this calculation, a neck bearing of a rudder having no upper bearing as in Figure 14 may be modelled as two bearings (a neck bearing and an upper bearing) with a gap between the bearings of at least 1.0 times the required diameter of the lower stock d_l.

The nominal bearing pressure may be determined by first determining the rudder force from the following formula:

$$F_p = 196AV^2$$

where

F_p = rudder force, in newtons (N)

A = area of rudder, in square metres (m²)

V = speed of vessel, in knots

The nominal bearing pressure is then determined as follows—

$$P_B = \frac{F_p}{d\,l_B}$$

where

P_B = nominal bearing pressure, in megapascals (MPa)

F_p = rudder force from the above formula, in newtons (N)

d = actual diameter of rudder stock in way of the bearing, in millimetres

l_B = length of bearing, in millimetres.

6.8.7.5 *Rudder stock upper bearing*

Upper rudder stock bearings, where fitted, shall have a length not less than the required upper stock diameter d_u in way of the bearing. For spade rudders of the type shown in Figure 14 the upper bearing (not depicted in the figure) should have a length not less than that determined from the following formula:

$$l_u = \frac{h_n d_l l_n}{h_u d_{uf}}$$

where

l_u = length of upper bearing, in millimetres

d_{uf} = fitted diameter of upper stock in way of upper bearing, in millimetres

h_u = height of centre of upper bearing above centre of rudder area, in millimetres

l_n = required length of neck bearing, in millimetres

d_l = required diameter of lower stock in way of neck bearing, in millimetres

h_n = height of centre of neck bearing above centre of rudder area, in millimetres.

For the purposes of this calculation, the bottom of the upper bearing should be located no less than d_l from the top of the lower bearing.

6.8.7.6 Distance from tiller or quadrant boss to nearest bearing

The distance from the tiller or quadrant boss to the nearest upper or neck bearing; gland; or other support should not exceed 2.5 times the fitted diameter of the rudder stock in way of the boss.

6.8.7.7 Rudder pintle diameter

Where a single heel pintle (Figure 15), or multiple equidistant pintles (Figure 16) are fitted, the diameter of pintles shall not be less than that determined from the following formula:

$$d_{pi} = 0.75 \frac{d_l}{\sqrt{N - K_p}} \sqrt{\frac{UTS_{stock}}{UTS_{pintle}}}$$

where

d_{pi} = required diameter of heel or intermediate pintle, in millimetres

d_l = minimum required diameter of rudder lower stock, in millimetres

N = number of pintles supporting the rudder inclusive of the heel pintle

K_p = 0 for rudders having a neck bearing, or

1 for rudders with no neck bearing

NOTE: Rudders with only a single pintle at the heel are required to have a neck bearing.

UTS_{stock} = ultimate tensile strength of stock material, in megapascals (MPa)

UTS_{pintle} = ultimate tensile strength of pintle material, in megapascals (MPa).

6.8.7.8 Rudder pintle bearings

Pintle bearings, if fitted, shall incorporate bushes. The length of pintle bearings shall not be less than that determined from the following formula:

$$l_p = k_p \, d_{pi}$$

where

l_p = required length of pintle bearing, in millimetres

k_p = a factor of 0.93 for balanced rudders having a bottom pintle bearing, or 1 for other rudders

d_{pi} = required diameter of pintle calculated in accordance with Clause 6.8.7.7, in millimetres.

6.8.7.9 Rudder stops

Rudders shall incorporate stops at the “full over” position to prevent the rudder coming into contact with the propeller or hull. Vertical movement shall also be limited by stops or jumping collars.

6.8.7.10 Rudder trunk and gland

The rudder trunk shall be of a thickness sufficient to support any rudder stock bearings carried within the trunk. For materials subject to corrosion, the thickness shall incorporate a 25 per cent allowance for corrosion. The thickness of the rudder trunk shall not be less than that of the hull shell thickness to which it is attached.

NOTE: The thickness of the rudder trunk is typically 25 per cent greater than that of the hull shell thickness to allow for boring, support of bearings, welding and/or integration into the structure.

The rudder trunk enclosing the rudderstock and neck bearing should extend above the fully loaded waterline. A gland shall be fitted to seal the rudder trunk if the trunk terminates below the level of the deck.

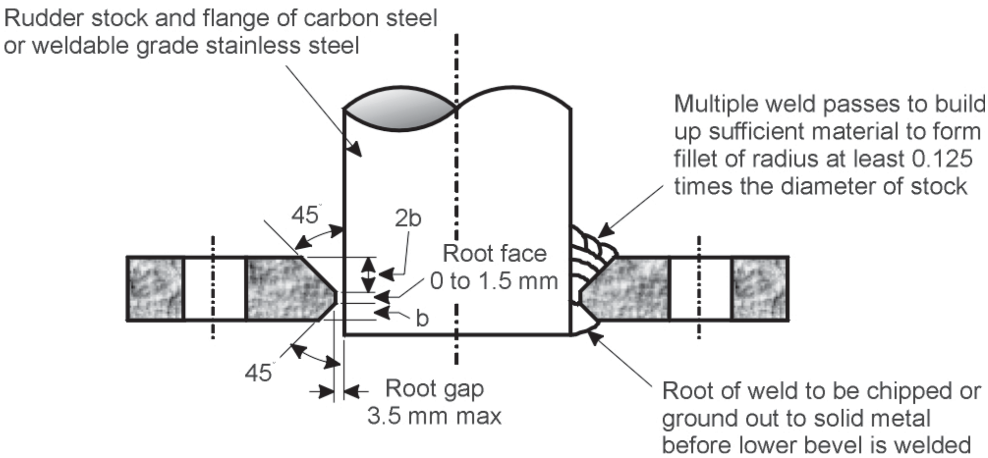

Figure 17 — Flange couplings of fabricated construction

6.8.8 Rudder couplings

6.8.8.1 Coupling types

Rudder couplings shall be one of the following types:

a) Flange couplings of fabricated construction, which have been stress relieved subsequent to welding (see Figure 17).

b) Flange couplings formed by upsetting the end of the stock, provided that there is no necking or narrowing of the stock.

c) Taper couplings, keyed and held in place by a nut. The taper coupling may be arranged to secure the boss of a flanged coupling or alternatively, to secure the stock directly into the mainpiece without the need of a flange coupling.

6.8.8.2 Flange coupling dimensions and bolting arrangements

The dimensions and bolting arrangements of rudder flange couplings shall be as follows:

a) The minimum thickness of a coupling flange shall be the greater of those calculated in accordance with the following formulae—

$$t_f = k\,d_l \sqrt{\frac{UTS_{stock}}{UTS_{coup}}} \quad \textbf{or} \quad t_f = d_b \sqrt{\frac{UTS_{bolt}}{UTS_{coup}}}$$

where

t_f = minimum flange thickness, in millimetres

k = 0.25 for a rudder with one or more pintles, or 0.32 for a spade rudder

d_l = required diameter of the rudder stock in way of the coupling, in millimetres

d_b = required diameter of the coupling bolts, in millimetres, calculated in accordance with Clause 6.8.8.2 (e)

UTS_{stock} = ultimate tensile strength of rudder stock material, in megapascals (MPa)

UTS_{coup} = ultimate tensile strength of coupling flange material, in megapascals (MPa)

UTS_{bolt} = ultimate tensile strength of coupling bolts of diameter calculated in accordance with Clause 6.8.8.2 (f) below, in millimetres.

b) The fillet radius at the base of the flange shall not be less than 0.125 times the actual diameter of the stock in way of the coupling.

c) The ligament thickness outside the coupling bolt holes shall not be less than 0.6 times the required diameter of the coupling bolt.

d) The pitch circle radius of bolts for couplings of the forged or welded flange type shall not be less than the required diameter of the rudder stock in way of the coupling, and for couplings keyed to the stock, shall be not less than 1.25 times the required diameter of the rudder stock.

e) Where a rudderstock is 150 millimetres or more in diameter in way of the coupling, at least 6 bolts shall be used in each coupling flange. Where the diameter is less than 150 mm, at least 4 bolts shall be used in each coupling flange.

f) The total area of bolts shall not be less than that determined from the following formula:

$$A = \frac{0.3\,d^3}{R} \sqrt{\frac{UTS_{stock}}{UTS_{bolt}}}$$

where

A	=	total bolt area at root of threads, in square millimetres (mm²)
d	=	required diameter of stock in way of coupling, in millimetres, calculated in accordance with Clause 6.8.4 or 6.8.5 as appropriate
R	=	pitch circle radius of bolts, in millimetres
UTS_{stock}	=	ultimate tensile strength of stock material, in megapascals (MPa)
UTS_{bolt}	=	ultimate tensile strength of bolt material, in megapascals (MPa).

Rudder coupling bolts shall be machine finished, neat fitting and the nuts shall be locked to prevent any possibility of backing off while in service. Rudder coupling bolts need not be neat fitting on small rudders not being spade rudders and having a lower stock diameter of less than 75 mm, provided a key of dimensions complying with Clause 3.11 is incorporated into the flange coupling.

6.8.8.3 Tapered couplings

The dimensions of tapers and taper retaining nuts for tapered couplings shall be in accordance with the requirements for shafting given in Clauses 3.10.11 and 3.12.4, except that a taper as steep as 1 in 8 may by used.

Keys for taper couplings shall comply with the relevant requirements of Clause 3.11 and shall be sized on the required upper stock diameter.

The boss thickness of flange couplings fitted on a taper shall not be less than 1.5 times the required thickness of the key, and the boss length shall not be less than 1.6 times the required diameter of the rudder stock in way of the coupling.

6.9 RUDDERS

6.9.1 Single plate rudders

Refer to Figure 15.

6.9.1.1 Plate thickness

The minimum plate thickness for single plate rudders shall be the greater of those calculated in accordance with the following two formulas:

$$t = [2.5 + (0.0015\, V\, h)]\sqrt{\frac{410}{UTS_{plate}}}$$

or

$$t = 10\sqrt{\frac{410}{UTS_{plate}}}$$

where

t = thickness of plating, in millimetres

V = maximum service speed, in knots, that the vessel is designed to maintain in a fully loaded condition

h = vertical distance between the centres of stiffeners, in millimetres

UTS_{plate} = ultimate tensile strength of plating material, in megapascals (MPa).

6.9.1.2 *Distance between stiffeners*

The distance between centres of single plate rudder stiffeners shall not exceed 1000 mm.

6.9.1.3 *Section modulus of stiffeners*

The section modulus of the stiffeners immediately forward and aft of the stock shall not be less than that determined from the following formula:

$$Z = 0.0005\, V^2\, l\, h \left(\frac{410}{UTS_{stiffr}} \right)$$

where

Z = section modulus of stiffeners, in cubic centimetres (cm^3)

V = maximum service speed, in knots, that the vessel is designed to maintain in a fully loaded condition

l = horizontal distance from the aft edge of the rudder to the centre of the rudder stock, in metres

h = distance between centres of stiffeners, in millimetres

UTS_{stiffr} = ultimate tensile strength of stiffener material, in megapascals (MPa).

6.9.1.4 *Tapering of stiffeners*

The width of the stiffeners may be tapered forward and aft of the maximum widths required to satisfy the above section modulus. The minimum stiffener section modulus at the leading and trailing edges of the rudder shall not be less than that determined from the following formula:

$$Z_t = 1.7 \left(\frac{410}{UTS_{stiffr}} \right) + 0.1Z$$

where

Z_t = section modulus of stiffeners at the leading and trailing edges of the rudder, in cubic centimetres (cm^3)

Z = section modulus of stiffeners immediately forward and aft of the stock, in cubic centimetres (cm^3) (see Clause 6.9.1.3)

UTS_{stiffr} = ultimate tensile strength of stiffener material, in megapascals (MPa).

6.9.1.5 Attachment

The blade of a single plate rudder shall be attached to the mainpiece by a full penetration continuous weld. Stiffeners shall be attached to the mainpiece and blade by a double continuous fillet weld.

6.9.2 Double plate rudders

Refer Figure 16.

6.9.2.1 Arrangement and testing

Double plate rudders shall have horizontal internal webs. They shall be watertight and tested to a head of water of 2.5 m or equivalent. A means for draining shall be incorporated in the rudder.

6.9.2.2 Plating thickness—equivalent carbon steel rudder upper stock diameter less than 75 mm

The thickness of carbon steel plating for a double plate rudder having a required equivalent carbon steel rudder upper stock less than 75 mm diameter shall be as specified in Table 8. Horizontal and vertical webs in double plate rudders not replacing the mainpiece shall have the same thickness as the side plates. Plates forming the top and bottom of the rudders shall not be less than the thickness given in Table 8 for webs spaced at 600 mm.

NOTE: The equivalent carbon steel rudder upper stock diameter is determined by the following formula:

$$d_{ue} = d_u \sqrt[3]{\frac{410}{UTS_{stock}}}$$

where

d_{ue} = equivalent carbon steel upper stock diameter, in millimetres

d_u = required upper stock diameter for the actual stock material, calculated in accordance with Clauses 6.8.4.2 or 6.8.5.1, in millimetres

UTS_{stock} = ultimate tensile strength of rudder stock material, in megapascals (MPa).

Table 8 — Carbon steel plate thickness for rudders—equivalent carbon steel rudder upper stock less than 75 mm diameter

Required equivalent carbon steel diameter of upper stock, in millimetres, calculated in accordance with Clause 6.8.4.2 or 6.8.5.1 as appropriate	Carbon steel plate thickness (mm)		
	Webs spaced 300 mm or less	Webs spaced 450 mm	Webs spaced 600 mm
less than 40	4.5	4.5	6.5
40 and over but less than 45	4.5	6.5	6.5
45 and over but less than 60	4.5	6.5	8.0
60 and over but less than 65	6.5	6.5	8.0
65 and over but less than 75	6.5	8.0	9.5

For plating material other than carbon steel, the required thickness of plating shall be determined by multiplying the tabular value by—

$$\sqrt{\frac{410}{UTS_{plate}}}$$

where

UTS_{plate} = ultimate tensile strength of the plating material, in megapascals (MPa).

6.9.2.3 *Plating thickness—equivalent carbon steel rudder upper stock diameter 75 mm and over*

Where the required equivalent carbon steel rudder upper stock diameter is 75 mm or over (see note to Clause 6.9.2.2), the thickness of the rudder side plating and webs shall not be less than that determined as follows:

The thickness of rudder side plating and webs t_p shall be determined from a reference thickness t_r adjusted for the variation between the actual spacing of web centres and a reference spacing of web centres S_p.

The reference thickness shall be determined from the following formula:

$$t_r = \left(6.5 + 0.117\, V \sqrt{A}\right)\sqrt{\frac{410}{UTS_{plate}}}$$

where

t_r = reference plate thickness, in millimetres

V = speed of vessel in knots with—

a) a minimum of 8 knots in vessels less than 30 m in measured length; and

b) a minimum of 9 knots in vessels of 30 m in measured length and over.

A = total area of rudder, in square metres (m²)

UTS_{plate} = ultimate tensile strength of plating material, in megapascals (MPa).

The thickness of the rudder side plating t_p shall be determined from the following formula:

$$t_p = t_r + 0.015\,(S_a - S_p)\sqrt{\frac{410}{UTS_{plate}}}$$

where

t_p = required minimum thickness of rudder side plating, in millimetres

t_r = reference plate thickness, in millimetres

UTS_{plate} = ultimate tensile strength of plating material, in megapascals (MPa)

S_a = actual spacing of web centres, in millimetres

S_p = reference spacing of web centres, in millimetres calculated in accordance with the following formula:

$$585 + 2.41\,V\sqrt{A}$$

where

V = speed of vessel in knots with—

a) a minimum of 8 knots in vessels less than 30 m in measured length; and

b) a minimum of 9 knots in vessels of 30 m in measured length and over.

A = total area of rudder, in square metres (m²).

The minimum thickness of plates forming the top and bottom of the rudder shall be the greater of—

a) the thickness of the rudder side plating t_p, calculated for the actual spacing of web centres; and

b) the reference thickness t_r.

6.9.2.4 *Attachment of stiffeners*

Horizontal and vertical webs in double plate rudders shall be attached to the main-piece by continuous double fillet welds and to the plating by fillet welds consisting of 75 mm lengths, spaced 150 mm between their centres. Where the interior of the rudder is inaccessible for welding, the stiffeners shall be fitted with flat bars and the plating connected to these flat bars by continuous or slot welds.

6.9.3 Fibre-reinforced plastic (FRP) rudders

Refer to Figure 14.

6.9.3.1 Construction

FRP rudders shall incorporate a substantial spider, formed by plate arms approximately half the rudder width in length and welded to the rudder mainpiece. The spider arms shall be perforated or otherwise arranged to facilitate a rigid connection between the mainpiece and the FRP blade. The mainpiece should be continuous through the rudder wherever possible, or alternative arrangements should be made to ensure continuity of strength and alignment. The blade shall be manufactured from reinforced epoxy or polyester resins. The rudder should be filled with a suitable material such as a resin/glass dough, timber or a micro-balloon mixture.

NOTE: The formulae given in Clause 6.9.2 for double-plate rudders are not applicable to FRP rudders constructed with a spider and solid core. Typically the skins of FRP rudders have a minimum mass of reinforcement of 3000 g/m^2. Lighter laminates down to 2300 g/m^2 may suffice on small sailing vessels or where advanced composite materials are used.

6.10 STEERING NOZZLES

Refer to Figure 18.

6.10.1 Testing

Steering nozzles shall be watertight and tested to a head of water of 2.5 m or equivalent. A means for draining shall be incorporated in the nozzle.

6.10.2 Shroud plating in way of propeller blade tips

The shroud plating in way of the propeller blade tips shall extend forward and aft of this position for a distance appropriate for the limits of rotation of the nozzle. Shroud plating may be carbon or stainless steel. The thickness of this shroud plating shall be determined from the following formulae:

a) If P x D is less than or equal to 6300—

$$t_s = (11 + 0.001\,P\,D)\sqrt{\frac{410}{UTS_s}}$$

b) If P x D is greater than 6300—

$$t_s = (14 + 0.00052\,P\,D)\sqrt{\frac{410}{UTS_s}}$$

where

t_s = thickness of shroud plating in way of propeller tips, in millimetres

P = power transmitted to the propeller, in kilowatts

D = propeller diameter, in metres

UTS_s = ultimate tensile strength (UTS) of the shroud plating in way of propeller tips, in megapascals (MPa).

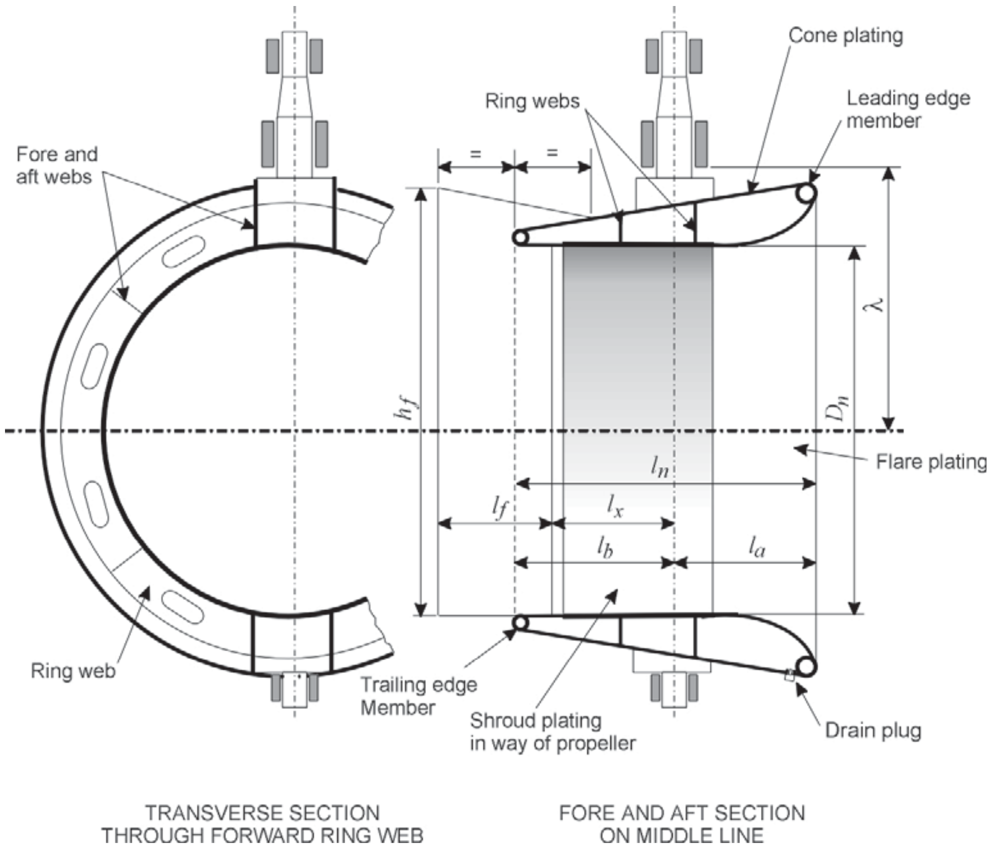

Figure 18 — Steering nozzle details and dimensions

6.10.3 Flare plating, cone plating and shroud plating clear of propeller tips

The thickness of flare plating, cone plating and shroud plating clear of propeller blade tips (see Figure 18), which shall not be less than:

$$8\sqrt{\frac{410}{UTS_p}}\ \text{mm},$$

shall be determined in accordance with the following formula:

$$t_p = \left(t_s - 7\sqrt{\frac{410}{UTS_s}}\right)\sqrt{\frac{UTS_s}{UTS_p}}$$

where

t_p = thickness of shroud plating clear of propeller tips, flare and cone plating, in millimetres

t_s = required thickness of shroud plating in way of the propeller tips, in millimetres

UTS_p = ultimate tensile strength of the shroud plating clear of propeller tips (assumed to be the same material as the web plating), in megapascals (MPa)

UTS_s = ultimate tensile strength of the shroud plating in way of propeller tips, in megapascals (MPa).

6.10.4 Fore and aft webs

Fore and aft webs, which shall not be less than the thickness of shroud plating clear of propeller tips, shall be fitted between the inner and outer skins of the nozzle. Fore and aft webs in way of the headbox and pintle support structure shall have their thickness increased in accordance with the following formula:

$$t_w = t_p + 4\sqrt{\frac{410}{UTS_p}}$$

where

t_w = thickness of webs in way of headbox and pintle support, in millimetres

t_p = thickness of shroud plating other than that in way of the propeller tips, in millimetres

UTS_p = ultimate tensile strength, in megapascals (MPa), of the shroud plating clear of propeller tips (assumed to be the same material as the web plating).

6.10.5 Ring webs

Ring webs, which shall not be less than the thickness of the shroud plating clear of the propeller blade tips, shall be fitted to maintain the transverse strength of the nozzle. A minimum of two such webs should be fitted.

The thickness of ring webs in way of the headbox and pintle support shall be increased in accordance with the formula given in Clause 6.10.4, and this increased thickness shall be maintained to the adjacent fore and aft web.

6.10.6 Leading and trailing edge members

The wall thickness of leading and trailing edge members shall not be less than the required thickness of shroud plating clear of propeller blade tips.

6.10.7 Stiffening

Local stiffening shall be fitted in way of the top and bottom supports, which shall in turn be integrated with the fore and aft webs and the ring webs. Continuity of bending strength shall be maintained in areas where stiffening is fitted.

6.10.8 Fins

Fabricated fins should be adequately reinforced. The plating thickness of double plate fins should not be less than that of the plating clear of propeller tips.

6.10.9 Nozzle stock, heel pintle, etc.

6.10.9.1 Scantlings

The diameter of the upper and lower nozzle stock shall be calculated in accordance with Clause 6.8.5 for balanced rudders, assuming the steering nozzle has the geometric properties given in Clauses 6.10.9.2 to 6.10.9.4 below (refer to Figure 18).

Scantlings for the heel pintle, keys, coupling bolts, etc., shall be determined from the required stock diameter as per the relevant clauses for rudders.

6.10.9.2 Equivalent area

The equivalent area of the nozzle and fin shall be determined from the following formula:

$$A = 2\,D_n\,l_n + 0.85\,h_f\,l_f$$

where

A = equivalent area of nozzle and fin, in square metres (m^2)

D_n = inner diameter of the nozzle, in metres

l_n = nozzle length, in metres

h_f = mean height of fin, in metres

l_f = length of fin, in metres.

NOTE: Refer to Figure 18 for details of dimensions

6.10.9.3 Equivalent horizontal lever arm

The equivalent horizontal lever arm b shall be calculated as the greater of the absolute values of the following two formulae:

$$b = \frac{\left(l_f\,h_f\,\left(l_x + 0.2\,l_f\right) - 1.5\,D_n\,l_n\,l_a\right)}{A};$$

or

$$b = \frac{\left(l_f\,h_f\left(l_x + l_f\right) + 1.5\,D_n\,l_n\,l_b\right)}{A}\left[\frac{0.45V + 2}{V + 2}\right]^2$$

where

b = equivalent horizontal distance from centre of lower stock to the centre of area of total rudder area, in metres

A = equivalent area of nozzle and fin, in square metres (m^2)

D_n = inner diameter of the nozzle, in metres

l_n = nozzle length, in metres

l_a = distance from nozzle leading edge to stock axis, in metres

l_b = distance from nozzle trailing edge to stock axis, in metres

l_x = distance between stock axis and fin, in metres

h_f = mean height of fin, in metres

l_f = length of fin, in metres

V = speed of vessel in knots with—

a) a minimum of 8 knots in vessels less than 30 m in measured length; and

b) a minimum of 9 knots in vessels of 30 m in measured length and over.

NOTE: Refer to Figure 18 for details of dimensions.

6.10.9.4 *Equivalent vertical lever arm*

The equivalent vertical lever arm a, in metres, shall be the vertical distance from the nozzle axis to the bottom of the nozzle stock neck bearing.

6.11 TILLER ARM OR QUADRANT

6.11.1 Section modulus of tiller arms or quadrant clear of boss

The section modulus of a tiller arm just clear of the boss, or quadrant just clear of the boss, shall not be less than that determined from the following formula:

$$Z = \frac{0.15\, d_u^3 (a-b)}{1000a}\left(\frac{UTS_{Stock}}{UTS_{Arm}}\right)$$

where

Z = required section modulus of quadrant or tiller about the vertical axis, in cubic centimetres (cm^3)

d_u = required diameter of the upper rudder stock, in millimetres, calculated in accordance with Clause 6.8.4.2 or 6.8.5.1 as appropriate

a = distance from the point of application of the steering force on the tiller or quadrant to the centre of the rudder stock, in millimetres

b = distance between the section of tiller or quadrant just clear of the boss and centre of the rudder stock, in millimetres

UTS_{Stock} = ultimate tensile strength of stock material, in megapascals (MPa)

UTS_{Arm} = ultimate tensile strength of tiller arm or quadrant material, in megapascals (MPa).

The section modulus of tiller arm or quadrant just clear of the boss about the horizontal axis shall not be less than one-third times the required value of Z determined above.

6.11.2 Section modulus at point of application of load

The section modulus at the point of application of the load shall not be less than one-third times the required value of Z calculated in Clause 6.11.1.

6.11.3 Thickness of tiller boss or quadrant boss

The thickness of the tiller boss or quadrant boss should not be less than 0.4 times the required upper rudder stock diameter. The depth of the boss shall not be less than the key length determined in accordance with Clause 6.11.4.

6.11.4 Securing of tiller or quadrant boss on the rudderstock

The tiller or quadrant boss shall be securely affixed to the rudderstock by means of a key or other equivalent means. Where a key is fitted, the size of the key shall be determined in accordance with Clause 3.11 using the required diameter of the upper stock d_u in place of the shaft diameter d.

NOTE: Methods similar to those applied to attaching shaft couplings to shafting may provide a suitable means for securing the tiller or quadrant boss to the rudder stock. See Clause 3.12.2.

CHAPTER 7 ANCILLARY SYSTEMS

7.1 SCOPE

This Chapter specifies requirements for compressed air, hydraulic and refrigeration systems. It applies to vessels of less than 35 m in measured length.

NOTE: For vessels of 35 m or more in measured length, refer to Clause 1.2.1.

7.2 OBJECTIVE

The objective of this Chapter is to control specific risks associated with the operation of certain ancillary systems or the failure of these systems.

NOTES:

1. Specific hazards associated with air compressors and their systems include the following: failure caused by overpressure in the compressor, air cooler casing or piping; hydraulic overpressure; corrosion; ingestion of inflammable vapours; overheating. Consequences of these hazards include the following: explosion; fire; loss of emergency systems; loss of control systems; inability to start propulsion machinery; personal injury or death.
2. Specific hazards associated with hydraulic power systems include the following: failure caused by hydraulic overpressure; discharge of flammable liquids; loss of hydraulic pressure. Consequences of these hazards include the following: fire; loss of emergency systems; loss of control systems; personal injury or death.
3. Specific hazards associated with refrigeration systems include the following: escape of refrigerant gas; overpressure; prolonged exposure to cold conditions. Potential consequences of these hazards include the following: environmental damage; asphyxiation; gas poisoning; fire; personal injury; hypothermia or death.

REQUIRED OUTCOMES

7.3 CONTAINMENT OF PRESSURE

Auxiliary systems must be designed and constructed to contain the system pressure and eliminate the risk of overpressure.

7.4 CONTROL THE RISK OF FIRE

Auxiliary systems must be designed and constructed to eliminate or control the risk of fire to acceptable levels.

7.5 RELIABILITY

Auxiliary systems must provide appropriate levels of reliability where operation of the auxiliary system is essential to the safety of the vessel.

7.6 MINIMISE TOXICITY AND POLLUTION

Auxiliary systems must be designed and constructed to eliminate or control to acceptable levels the risks to persons arising from the toxicity of gases used in an auxiliary system and the potential impact of these gases on the environment.

Maritime Safety Queensland, National Standard for Commercial Vessels Part C Design and Construction Section 5 Engineering Subsection 5A Machinery, 2008

7.7 PROTECTION FROM EXTREMES OF TEMPERATURE

Auxiliary systems must be designed and constructed to eliminate or control to acceptable levels the risks to persons being exposed to extremes of temperature associated with the operation of an auxiliary system.

EXAMPLE

Arrangements to eliminate or control the risk to a person being trapped within a refrigerated space.

DEEMED-TO-SATISFY SOLUTIONS

7.8 COMPRESSED AIR SYSTEMS

7.8.1 Application

Clause 7.8 applies to air compressors supplying compressed air for purposes other than breathing apparatus.

7.8.2 Compliance

For the purpose of this National Standard, a compressed air system shall be deemed to have satisfied the Required Outcomes in Clauses 7.3 and 7.4 if it complies with Clauses 7.8.3 to 7.8.9.

7.8.3 Relief valves—compressor

An air compressor shall be provided with one or more relief valves capable of discharging the maximum capacity of the compressor, and set so that when the compressor discharge valve is closed while the compressor is running normally, the maximum accumulation pressure will not exceed 10 per cent of the working pressure.

7.8.4 Relief valves—casing

The casing of an air cooler of an air compressor shall be fitted with a relief valve or a safety diaphragm to provide protection against an air tube bursting.

7.8.5 Drainage

An air compressor shall incorporate means for draining water and oil from the intermediate and final discharge stages.

7.8.6 Location of air intake

The air intake for a compressor shall be located to minimise the induction of exhaust gases, oil vapours or other potentially hazardous fumes.

7.8.7 Delivered air temperature

An air compressor shall be designed and installed so that the temperature of the air delivered from the after cooler does not exceed 93ºC.

7.8.8 Pressure monitoring

A pressure gauge shall be fitted between the after cooler and the compressor discharge.

7.8.9 Pressure piping

Pressure piping shall meet the requirements specified in AS 4041.

7.9 HYDRAULIC POWER SYSTEMS

7.9.1 Compliance

For the purpose of this National Standard, a hydraulic system shall be deemed to have satisfied the Required Outcomes in Clauses 7.3, 7.4 and 7.5 if it complies with Clauses 7.9.2 to 7.9.5.

7.9.2 Relief protection

Hydraulic pumps shall have pressure relief protection on the discharge side. Such pressure relief protection shall operate in a closed circuit.

7.9.3 Materials and hydraulic fluid

The materials of hydraulic pumps, motors and accessories shall be compatible with the hydraulic fluid. Hydraulic fluid shall be non-flammable or shall have a flashpoint of 157ºC or over.

7.9.4 Hydraulic hose and piping

The application and installation of, and the fittings for, hydraulic hose and piping shall comply with the manufacturer's instructions. Unless otherwise provided for in Clause 7.9.5, hydraulic hose shall comply with AS 3791, and hydraulic piping shall comply with AS 4041.

7.9.5 Use of nylon tubing in hand hydraulic systems

Nylon tubing may be used in hand hydraulic applications on vessels provided that—

a) it meets the requirements of AS 3791 or an equivalent national or international standard;

b) it is stabilised against degradation due to exposure to ultra-violet light;

c) it is only used where suitable for the application;

d) it has a pressure cycling resistance equivalent to that required for hoses complying with AS 3791; and

e) it does not pass through a space designated as a high risk or machinery space (see Part C Section 4: Fire Safety of the NSCV), or alternatively, the tubing is adequately shielded from the effects of fire within such a space.

7.10 REFRIGERATION

7.10.1 Compliance

For the purpose of this National Standard, a refrigeration system shall be deemed to have satisfied the Required Outcomes in Clauses 7.3 to 7.7 if it complies with Clauses 7.10.2 to 7.10.8.

7.10.2 System design, construction and testing

A refrigeration system shall be designed, constructed and tested in accordance with AS/NZS 1677.1 and AS/NZS 1677.2.

NOTE: AS/NZS 1677.1 classifies refrigerants on a risk basis (i.e. toxic/non-toxic, flammable/non-flammable) and contains some basic technical information on their physical properties. The most important criteria is the "practical limit" of the refrigerant which forms the basis of AS/NZS 1677.2, which covers safety requirements for fixed refrigeration systems.

7.10.3 Refrigerant gas

Gas used in a refrigeration system shall be selected in accordance with AS/NZS 1677.1.

NOTES:

1. For additional guidance, refer to the Refrigerant Selection Guide, published by the Australian Institute of Refrigeration Air Conditioning and Heating (Inc) dated June 1998.
2. The Australian Government is a signatory to the Montreal Protocol, which sets out a mandatory timetable for the phase-out of ozone-depleting substances and urges additional action to minimise damage to the ozone layer. The Refrigerant Selection Guide includes information on the Protocol and on alternatives to CFC refrigerants.

7.10.4 Restrictions pertaining to the use of ammonia

The following restrictions apply in refrigeration systems:

a) Ammonia shall not be used as a refrigerant on a Class I vessel.

b) An ammonia plant shall not be installed in a manned machinery space.

7.10.5 Alarm systems and exits

A refrigerated space that a person may be required to enter shall be provided with—

a) a manually activated alarm which is audible outside the space and which can only be activated and cancelled from within the space;

b) means inside the space for locating the exit door and alarm, should lights in the space be switched off or fail; and

c) means to manually open every door from both outside and inside the space.

7.10.6 Proximity to accommodation space

Boundaries between a refrigeration machinery space and sleeping accommodation shall be gastight. The refrigeration system shall be arranged so that refrigerant gas cannot migrate to an accommodation space. The refrigeration system shall not be used for air-conditioning purposes.

NOTE: Clause 7.10.6 does not apply to the piping associated with dedicated air conditioning installations that serve a particular accommodation space.

7.10.7 Ventilation

Spaces containing refrigeration machinery shall be provided with ventilation to the outside air, either by natural or mechanical means. The minimum air ventilation rates and openings shall be in accordance with AS/NZS 1677.2.

7.10.8 Respiratory breathing apparatus

The requirements for respiratory breathing apparatus shall be determined by the toxicity and flammability of the refrigerant used and the design of the refrigeration system. Respiratory breathing apparatus shall be located in a position unlikely to become inaccessible in case of leakage of gas.

NOTE: AS 1677.1 provides a classification system for the toxicity and flammability of gases.