RULES AND REGULATIONS FOR THE CLASSIFICATION OF SPECIAL SERVICE CRAFT

PIPING SYSTEMS AND PRESSURE PLANT

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PART 15

Lloyd's Register

■ *Section 1* Application

1.1 General

1.1.1 The requirements of this Chapter apply to the design and construction of piping systems including pipe fittings forming part of such systems.

■ *Section 2* Details to be submitted

2.1 Plans and information

2.1.1 At least three copies of the following plans and information are to be submitted.

2.1.2 Venting, sounding and drainage arrangements for all watertight compartments.

2.1.3 The following diagrammatic plans including details of the material and pipe dimensions/thickness:

- Bilge and ballast system including the capacities of the pumps on bilge service.
- Lubricating oil systems.
- Flammable liquids used for power transmission, control and heating systems.
- Cooling water systems for main and auxiliary services.
  Compressed air systems for main and auxiliary services.
  Steam systems with a design pressure above 7 bar.

2.1.4 Arrangement of oil fuel storage tanks with a capacity of over 0,5 m^3 where these do not form part of the structure of the craft.

2.1.5 Where it is intended to use plastic pipes for Class I, Class II and any Class III systems for which there are requirements in these Rules, details of the following:

(a) Properties of the materials.
(b) Operating conditions.
(c) Intended service and location.
(d) Pipes, fittings and joints.

2.1.6 Design details of the following components:

(a) Flexible hoses.
(b) Sounding devices.
(c) Resiliently seated valves.
(d) Expansion joints.
(e) Components of an unusual or novel nature.

2.1.7 The requirements for plans and information for the fire-fighting systems are given in Pt 17, Ch 1,1.2.3.

■ *Section 3* Class of pipes

3.1 General

3.1.1 Pipework systems are divided into three classes depending on the internal fluid and design temperature and pressure of the system.

3.1.2 Material test requirements for the different classes of pipe are detailed in the *Rules for the Manufacture, Testing and Certification of Materials* (hereinafter referred to as the Rules for Materials).

3.1.3 Acceptable jointing methods for the different classes of pipe are given in the appropriate Section of this Chapter. Material certificate requirements are given in Section 11.

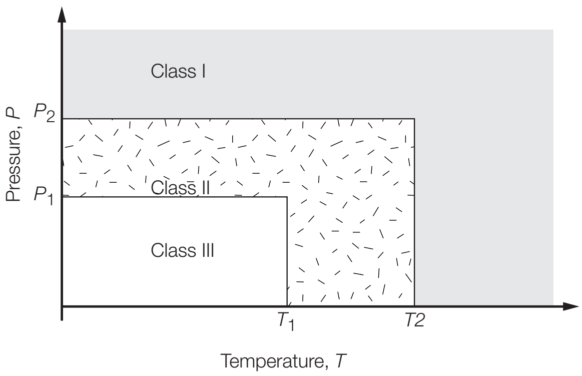
3.1.4 The maximum design pressure and temperature for Class II and III systems is given in Table 1.3.1. To illustrate, *see* Fig. 1.3.1.

3.1.5 Class I pipes are to be used where either the maximum design pressure or design temperature exceeds that applicable to Class II pipes.

Table 1.3.1 Maximum pressure and temperature conditions for Class II and III piping systems

Piping system	Class II		Class III	
	p	*T*	*p*	*T*
	bar	°C	bar	°C
Steam	16,0	300	7,0	170
Flammable liquids (*see* Note)	16,0	150	7,0	60
Other media	40,0	300	16,0	200

NOTE
Flammable liquids include: oil fuel, thermal oil and lubricating oil.



NOTE
T_1 and P_1 correspond to the maximum temperatures and pressures for a Class III piping system and T_2 and P_2 to those for a Class II piping system depending on the service.

Fig. 1.3.1 Classes of piping system

3.1.6 Class III pipes may also be used for open ended piping, e.g. overflows, vents, boiler waste steam pipes, open-ended drains, sounding pipes, etc.

■ *Section 4* Design symbols and definitions

4.1 Design symbols

4.1.1 The symbols used in this Chapter are defined as follows:

a = percentage negative manufacturing tolerance on thickness
c = corrosion allowance, in mm
d = inside diameter of pipe, in mm, *see* 4.1.3
e = weld efficiency factor, *see* 4.1.4
p = design pressure, in bar, *see* 4.2
p_t = hydraulic test pressure, in bar
t = the minimum thickness of a straight pipe, in mm, including corrosion allowance and negative tolerance, where applicable
t_b = the minimum thickness of a straight pipe to be used for a pipe bend, in mm, including bending allowance, corrosion allowance and negative tolerance, where applicable
D = outside diameter of pipe, in mm, *see* 4.1.2
R = radius of curvature of a pipe bend at the centre line of the pipe, in mm
T = design temperature, in °C, *see* 4.3.1
σ = maximum permissible design stress, in N/mm^2

4.1.2 The outside diameter, D, is subject to manufacturing tolerances, but these are not to be used in the evaluation of formulae.

4.1.3 The inside diameter, d, is not to be confused with nominal pipe size, which is an accepted designation associated with outside diameters of standard rolling sizes.

4.1.4 The weld efficiency factor, e, is to be taken as 1 for seamless and electric resistance or induction welded steel pipes.

4.2 Design pressure

4.2.1 The design pressure, p, is the maximum permissible working pressure and is to be not less than the highest set pressure of the safety valve or relief valve. In systems which have no safety valve or relief valve, the design pressure is to to be taken as 1,1 times the maximum working pressure.

4.2.2 The design pressure of piping on the discharge from pumps is to be taken as the pump pressure at full rated speed against a shut valve. Where a safety valve or other protective device is fitted to restrict the pressure to a lower value than the shut valve load, the design pressure is to be the highest set pressure of the device.

4.2.3 For design pressure of steering system components and piping, *see* Part 14.

4.3 Design temperature

4.3.1 The design temperature is to be taken as the maximum temperature of the internal fluid, but in no case is it to be less than 50°C.

■ *Section 5* Carbon and low alloy steels

5.1 General

5.1.1 The minimum thickness of steel pipes is to be determined by the formulae given in 5.1.2 and 5.1.3 except that in no case is it to be less than that shown in Table 1.5.1.

Table 1.5.1 Minimum thickness for steel pipes

External diameter *D* mm	Minimum pipe thickness mm
10,2–12	1,6
13,5–19	1,8
20–44,5	2,0
48,3–63,5	2,3
70–82,5	2,6
88,9–108	2,9
114,3–127	3,2
133–139,7	3,6
152,4–168,3	4,0
177,8 and over	4,5

NOTES
1. The thickness of air, overflow and sounding pipes for structural tanks is to be not less than 4,5 mm.
2. The thickness of bilge, ballast and general sea water pipes is to be not less than 4,0 mm.
3. The thickness of bilge, air, overflow and sounding pipes through ballast and oil fuel tanks, ballast lines through oil fuel tanks and oil fuel lines through ballast tanks is to be not less than 6,3 mm.
4. For air, bilge, ballast, oil fuel, overflow, sounding, and venting pipes as mentioned in Notes 1 to 3, where the pipes are efficiently protected against corrosion the thickness may be reduced by not more than 1 mm.
5. For air and sounding pipes the minimum thickness applies to the part of the pipe outside the tank but not exposed to weather. The section of pipe exposed to weather may be required to be suitably increased in thickness in accordance with statutory and loadline requirements as applicable.

5.1.2 The minimum thickness, *t*, of straight steel pressure pipes is to be determined by the following formula:

$$t = \left(\frac{pD}{20\sigma e + p} + c \right) \frac{100}{100 - a} \text{ mm}$$

where
symbols are as defined in 4.1.1
c is obtained from Table 1.5.2, *see also* 5.1.4
σ may be obtained directly from Table 1.5.3 or from the formula given in 5.1.6.

Table 1.5.2 Values of corrosion allowance (*c*) for steel pipes

Piping service	*c*, in mm
Saturated steam systems	0,8
Compressed air systems	1,0
Hydraulic oil systems	0,3
Lubricating oil systems	0,3
Fuel oil systems	1,0
Refrigerating plants	0,3
Fresh water systems	0,8
Sea-water systems in general	3,0

5.1.3 The minimum thickness, t_b, of a straight steel pipe to be used for a pipe bend is to be determined by the following formula, except where it can be demonstrated that the use of a thickness less than t_b would not reduce the thickness below *t* at any point after bending:

$$t_b = \left[\left(\frac{pD}{20\sigma e + p} \right) \left(1 + \frac{D}{2{,}5R} \right) + c \right] \frac{100}{100 - a} \text{ mm}$$

where
symbols are as defined in 4.1.1
c and σ are obtained as in 5.1.2
in general, *R* is to be not less than 3*D*.

5.1.4 For pipes passing through tanks, where the thickness has been calculated in accordance with 5.1.2 or 5.1.3, an additional corrosion allowance is to be added to take account of external corrosion; the addition will depend on the external medium and the value is to be in accordance with Table 1.5.2.

5.1.5 Where the pipes are efficiently protected against corrosion, the corrosion allowance, *c*, may be reduced by not more than 50 per cent.

Table 1.5.3 Carbon and carbon-manganese steel pipes

Specified minimum tensile strength, N/mm^2	Maximum permissible design stress, N/mm^2												
	Maximum design temperature, °C												
	50	100	150	200	250	300	350	400	410	420	430	440	450
320	107	105	99	92	78	62	57	55	55	54	54	54	49
360	120	117	110	103	91	76	69	68	68	68	64	56	49
410	136	131	124	117	106	93	86	84	79	71	64	56	49
460	151	146	139	132	122	111	101	99	98	85	73	62	53
490	160	156	148	141	131	121	111	109	98	85	73	62	53

5.1.6 The maximum permissible design stress, σ, is to be taken as the lowest of the following values:

$$\sigma = \frac{E_t}{1,6}$$

$$\sigma = \frac{R_{20}}{2,7}$$

$$\sigma = \frac{S_R}{1,6}$$

where

E_t = specified minimum lower yield or 0,2 per cent proof stress at the design temperature

R_{20} = specified minimum tensile strength at ambient temperature

S_R = average stress to produce rupture in 100 000 hours at the design temperature

Values of E_t, R_{20} and S_R may be obtained from Chapter 6 of the Rules for Materials. Intermediate values may be obtained by interpolation.

5.1.7 Steel stub pipes between the shell plating and the sea valve are to be of short rigid construction, adequately supported and of substantial thickness.

5.2 Steel pipe joints

5.2.1 Joints in steel pipelines may be made by:

- Screwed on or welded on bolted flanges.
- Butt welds between pipes or between pipes and valve chests.
- Socket welded joints (up to 60,3 mm outside diameter).
- Threaded sleeve joints (parallel thread), *see also* 5.5.
- Special types of approved joints that have been shown to be suitable for the design conditions, *see also* 5.4.

5.2.2 Where pipes are joined by welding a suitable number of flanged joints are to be provided at suitable positions to facilitate installation and removal for maintenance.

5.2.3 Where welded pipes are protected against corrosion then the corrosion protection is to be applied after welding or the corrosion protection is to be made good in way of the weld damaged area.

5.2.4 Where it is not possible to make good the corrosion protection of the weld damaged area, then the pipe is to be considered to have no corrosion protection.

5.2.5 Where backing rings are used for welding pipes, then the effect of the flow obstruction of the backing ring and erosion/crevice corrosion of the backing ring is to be taken into account.

5.3 Welded-on flanges, butt welded joints and fabricated branch pieces

5.3.1 The dimensions and material of flanges and bolting, and the pressure-temperature rating of bolted flanges in pressure pipelines, in accordance with National or other established standards will be accepted.

5.3.2 The types of welded-on flanges are to be suitable for the pressure, temperature and service for which the pipes are intended.

5.3.3 Typical examples of welded-on flange attachments are shown in Fig. 1.5.1, and limiting design conditions for flange types (a) to (f) are shown in Table 1.5.4.

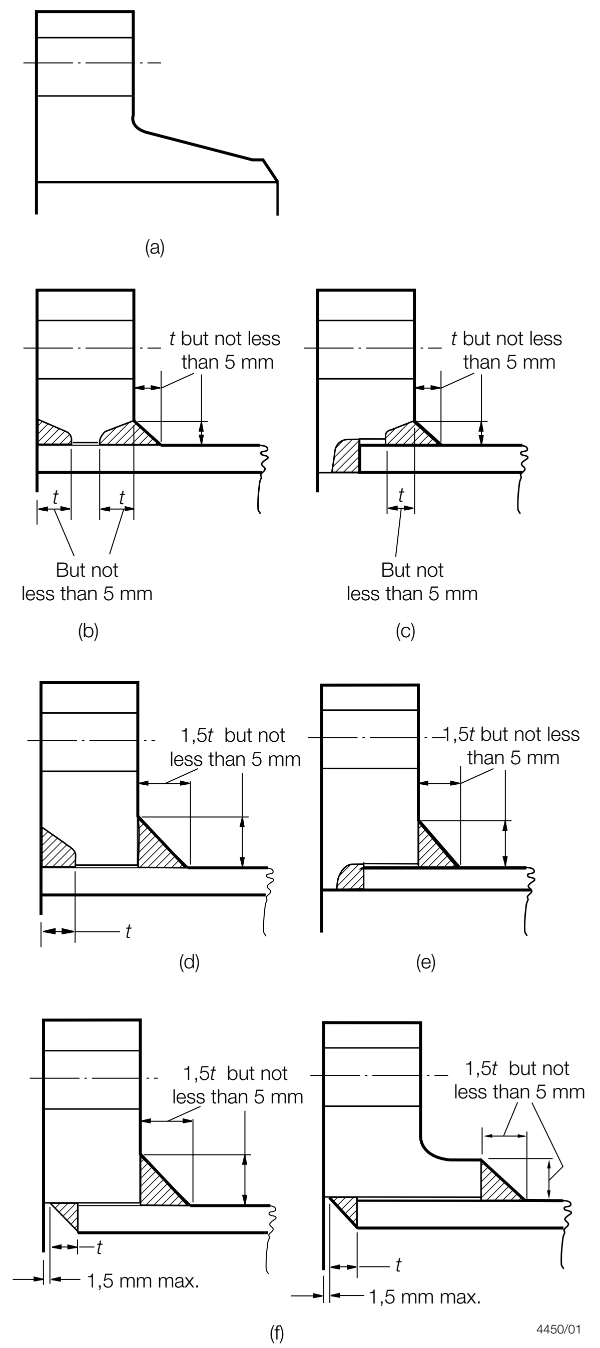


Fig. 1.5.1
Typical examples of welded flange connections

Table 1.5.4 Limiting design conditions for flange types

Flange type	Maximum pressure	Maximum temperature	Maximum pipe o.d.	Minimum pipe bore
		°C	mm	mm
(a)	Pressure-temperature ratings to be in accordance with a recognized standard	No restriction	No restriction	No restriction
(b)		No restriction	168,3 for alloy steels*	No restriction
(c)		No restriction	168,3 for alloy steels*	75
(d)		425	No restriction	No restriction
(e)		425	No restriction	75
(f)		425	No restriction	No restriction

* No restriction for carbon steels

5.3.4 Welded-on flanges are not to be a tight fit on the pipes. The maximum clearance between the bore of the flange and the outside diameter of the pipe is to be 3 mm at any point, and the sum of the clearances diametrically opposite is not to exceed 5 mm.

5.3.5 Where butt welds are employed in the attachment of flange type (a), in pipe-to-pipe joints or in the construction of branch pieces, the adjacent pieces are to be matched at the bores. This may be effected by drifting, roller expanding or machining, provided that the pipe wall is not reduced below the designed thickness. If the parts to be joined differ in wall thickness, the thicker wall is to be gradually tapered to the thickness of the thinner at the butt joint. The welding necks of valve chests are to be sufficiently long to ensure that the valves are not distorted as the result of welding and subsequent heat treatment of the joints.

5.3.6 Where backing rings are used with flange type (a) they are to fit closely to the bore of the pipe and should be removed after welding. The rings are to be made of the same material as the pipes or of mild steel having a sulphur content not greater than 0,05 per cent.

5.3.7 Branches may be attached to pressure pipes by means of welding provided that the pipe is reinforced at the branch by a compensating plate or collar or other approved means, or alternatively that the thickness of pipe and branch are increased to maintain the strength of the pipe. These requirements also apply to fabricated branch pieces.

5.4 Screwed fittings

5.4.1 Screwed fittings including compression fittings may be used in piping systems not exceeding 41 mm outside diameter. Where the fittings are not in accordance with an acceptable standard then Lloyd's Register (hereinafter referred to as 'LR') may require the fittings to be subjected to special tests to demonstrate their suitability.

5.5 Threaded sleeve joints (parallel thread)

5.5.1 Threaded sleeve joints in accordance with National or other established standards may be used within the limits given in Table 1.5.5. They are not to be used in piping systems conveying flammable liquids.

Table 1.5.5 Limiting design conditions for threaded sleeve joints

Nominal bore	Maximum pressure	Maximum temperature
mm	bar (kgf/cm^2)	°C
≤ 25	12,0 (12,2)	260
> 25 ≤ 40	10,0 (10,2)	260
> 40 ≤ 80	8,5 (8,7)	260
> 80 ≤ 100	7,0 (7,1)	260

5.6 Socket weld joints

5.6.1 Socket weld joints may be used with carbon steel pipes not exceeding 60,3 mm outside diameter. Socket weld fittings are to be of forged steel and the material is to be compatible with the associated piping. Such joints are not to be used where fatigue, severe erosion or crevice corrosion is expected to occur. *See also* Ch 4,7.3.9.

5.6.2 The thickness of the socket weld fittings is to meet the requirements of 5.1.3 but is to be not less than 1,25 times the nominal thickness of the pipe or tube. The diametrical clearance between the outside diameter of the pipe and the bore of the fitting is not to exceed 0,8 mm, and a gap of approximately 1,5 mm is to be provided between the end of the pipe and the bottom of the socket.

5.6.3 The leg lengths of the fillet weld connecting the pipe to the socket weld fitting are to be such that the throat dimension of the weld is not less than the nominal thickness of the pipe or tube.

5.7 Welded sleeve joints

5.7.1 Welded sleeve joints may be used in Class III systems only, subject to the restrictions and general dimensional requirements given in 5.6 for socket weld joints.

5.7.2 The pipe ends are to be located in the centre of the sleeve with a 1,5 to 2,0 mm gap.

5.8 Other mechanical couplings

5.8.1 Pipe unions, compression couplings, or slip-on joints, as shown in Fig. 1.5.2, may be used if type approved for the service conditions and the intended application. The type approval is to be based on the results of testing of the actual joints. The acceptable use for each service is indicated in Table 1.5.6 and dependence upon the Class of piping, with limiting pipe dimensions, is indicated in Table 1.5.7.

5.8.2 Where the application of mechanical joints results in a reduction in pipe wall thickness due to the use of bite type rings or other structural elements, this is to be taken into account in determining the minimum wall thickness of the pipe to withstand the design pressure.

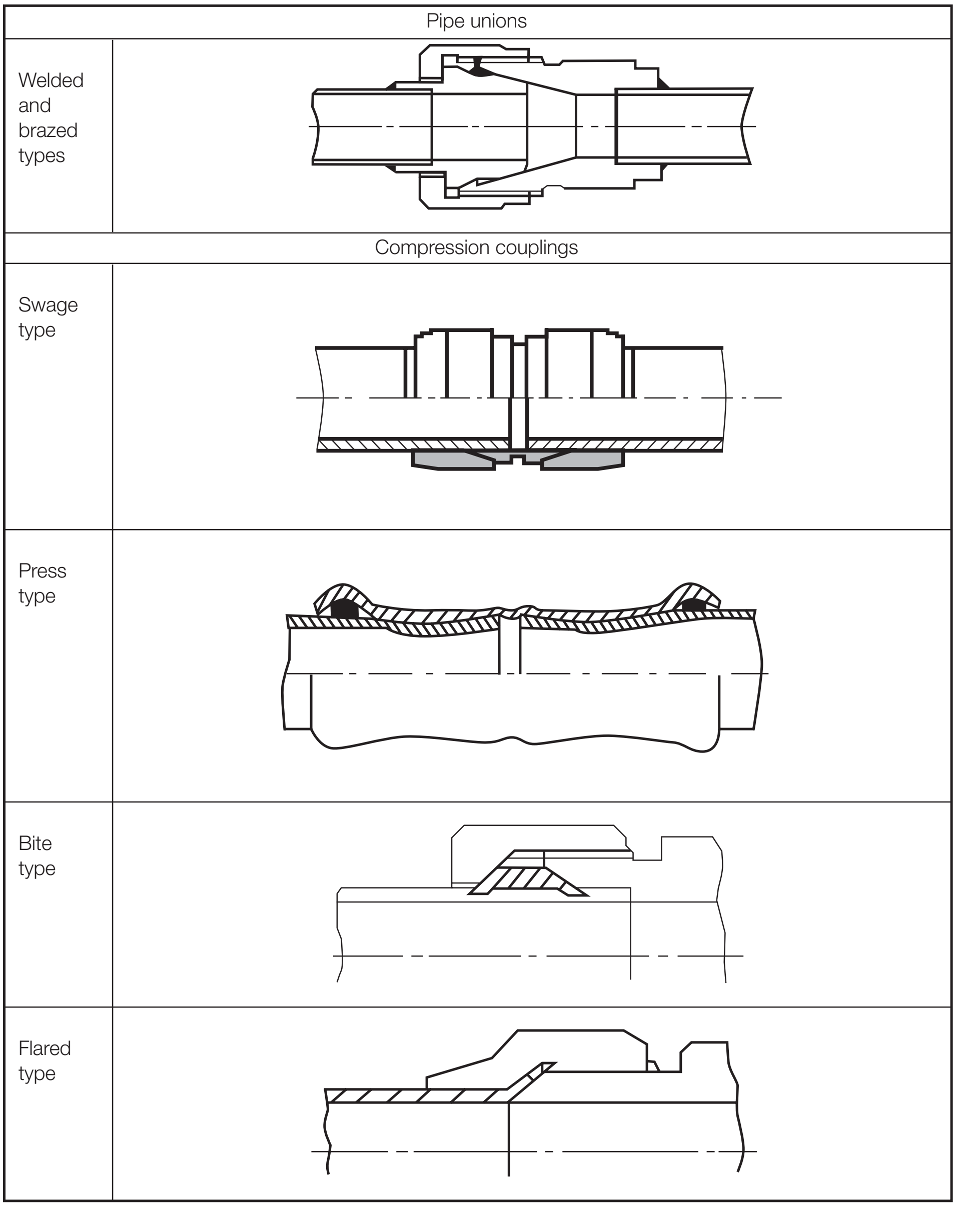


Fig. 1.5.2 Examples of mechanical joints (*see continuation*)

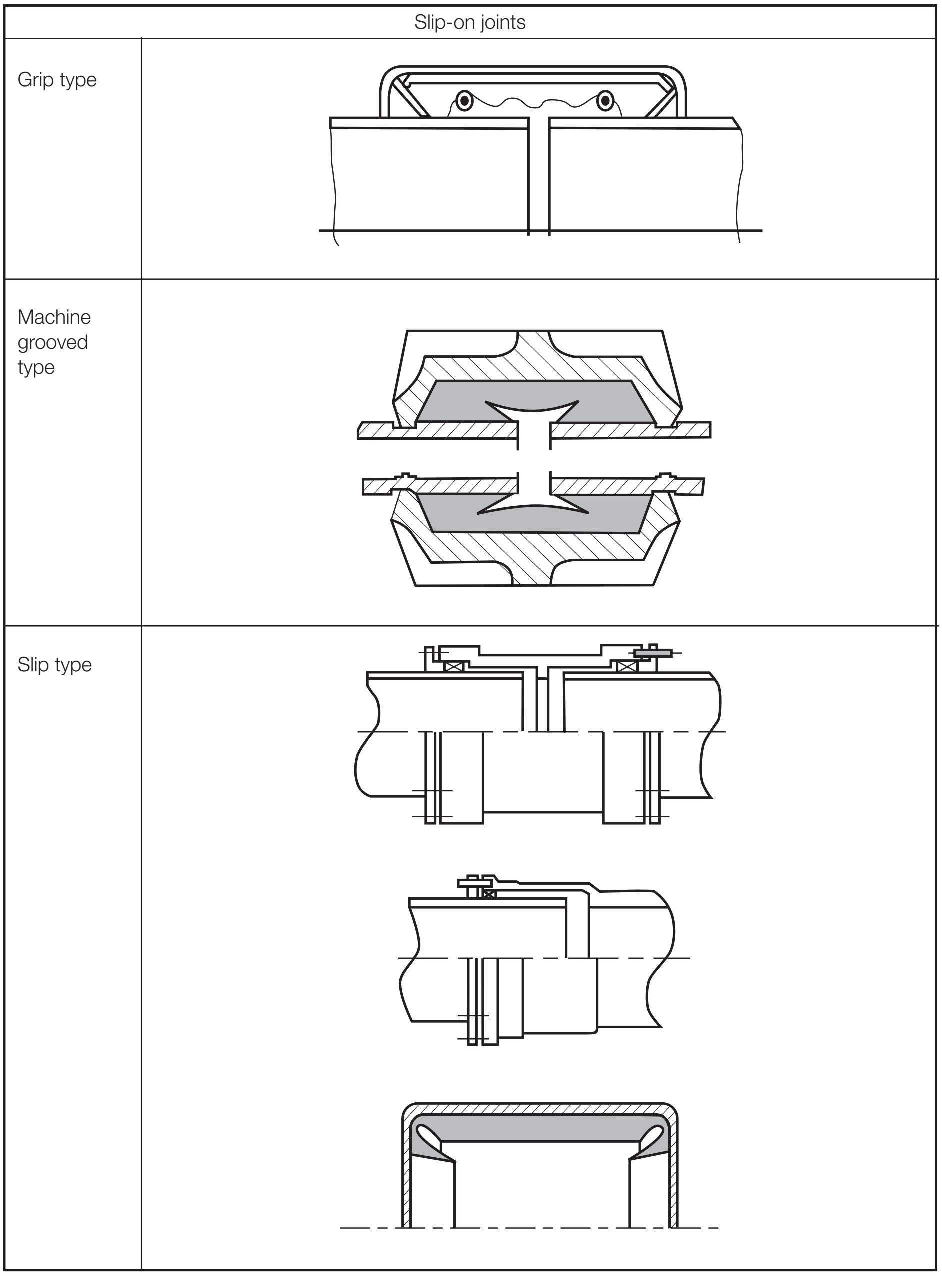


Fig. 1.5.2 Examples of mechanical joints (*conclusion*)

5.8.3 Construction of mechanical joints is to prevent the possibility of tightness failure affected by pressure pulsation, piping vibration, temperature variation and other similar adverse effects occurring during operation on board.

5.8.4 Materials of mechanical joints are to be compatible with the piping material and internal and external media.

5.8.5 Mechanical joints for pressure pipes are to be tested to a burst pressure of 4 times the design pressure. For design pressures above 200 bar the required burst pressure will be specially considered.

5.8.6 In general, mechanical joints are to be of fire-resistant type where required by Table 1.5.6.

5.8.7 Mechanical joints, which in the event of damage could cause fire or flooding, are not to be used in piping sections directly connected to the sea openings or tanks containing flammable fluids.

5.8.8 Mechanical joints are to be designed to withstand internal and external pressure as applicable and where used in suction lines are to be capable of operating under vacuum.

5.8.9 Generally, slip-on joints are not to be used in pipelines in cargo holds, tanks, and other spaces which are not easily accessible. Application of these joints inside tanks may only be accepted where the medium conveyed is the same as that in the tanks.

Table 1.5.6 Application of mechanical joints

Systems	Kind of connections		
	Pipe unions	Compression couplings (6)	Slip-on joints
Flammable fluids (Flash point <60°)			
Cargo oil lines	+	+	+5
Crude oil washing lines	+	+	+5
Vent lines	+	+	+3
Inert gas			
Water seal effluent lines	+	+	+
Scrubber effluent lines	+	+	+
Main lines	+	+	+2,5
Distribution lines	+	+	+5
Flammable fluids (Flash point > 60°)			
Cargo oil lines	+	+	+5
Fuel oil lines	+	+	+2,3
Lubricating oil lines	+	+	+2,3
Hydraulic oil	+	+	+2,3
Thermal oil	+	+	+2,3
Sea-water			
Bilge lines	+	+	+1
Fire main and water spray	+	+	+3
Foam system	+	+	+3
Sprinkler system	+	+	+3
Ballast system	+	+	+1
Cooling water system	+	+	+1
Tank cleaning services	+	+	+
Non-essential systems	+	+	+
Fresh water			
Cooling water system	+	+	+1
Condensate return	+	+	+1
Non-essential system	+	+	+
Sanitary/Drains/Scuppers			
Deck drains (internal)	+	+	+4
Sanitary drains	+	+	+
Scuppers and discharge (overboard)	+	+	—
Sounding/vent			
Water tanks/Dry spaces	+	+	+
Oil tanks (f.p.> 60°C)	+	+	+2,3
Miscellaneous			
Starting/Control air (1)	+	+	—
Service air (non-essential)	+	+	+
Brine	+	+	+
CO_2 system	+	+	—
Steam	+	+	—

KEY
+ Application is allowed
— Application is not allowed

NOTES
1. Inside machinery spaces of Category A – only approved fire resistant types.
2. Not inside machinery spaces of Category A or accommodation spaces. May be accepted in other machinery spaces provided the joints are located in easily visible and accessible positions.
3. Approved fire resistant types.
4. Above freeboard deck only.
5. In pump rooms and open decks – only approved fire resistant types.
6. If compression couplings include any components which are sensitive to heat, they are to be of approved fire resistant type as required for slip-on joints.

Table 1.5.7 Application of mechanical joints depending on class of piping

Types of joints	Classes of piping systems		
	Class I	Class II	Class III
Pipe unions			
Welded and brazed type	+(OD ≤ 60,3 mm)	+(OD ≤ 60,3 mm)	+
Compression couplings			
Swage type	–	–	+
Bite type	+(OD ≤ 60,3 mm)	+(OD ≤ 60,3 mm)	+
Flared type	+(OD ≤ 60,3 mm)	+(OD ≤ 60,3 mm)	+
Press type	–	–	+
Slip-on joints			
Machine grooved type	+	+	+
Grip type	–	+	+
Slip type	–	+	+

KEY
+ Application is allowed
– Application is not allowed

5.8.10 Unrestrained slip-on joints are only to be used in cases where compensation of lateral pipe deformation is necessary. Usage of these joints as the main means of pipe connection is not permitted.

■ *Section 6* Copper and copper alloys

6.1 General

6.1.1 Copper and copper alloy pipes are acceptable for a wide range of services, including bilge pipework and where non heat-sensitive material is required.

6.1.2 The maximum permissible service temperature of copper and copper alloy pipes, valves and fittings is not to exceed 200°C for copper and aluminium brass, and 300°C for copper-nickel. Cast bronze valves and fittings complying with the requirements of Chapter 9 of the Rules for Materials may be accepted up to 260°C.

6.1.3 The minimum thickness, t, of straight copper and copper alloy pipes is to be determined by the following formula but is not to be less than that shown in Table 1.6.1:

$$t = \left(\frac{pD}{20\sigma + p} + c\right)\frac{100}{100 - a} \text{ mm}$$

where

symbols are as defined in 4.1.1

c = 0,8 mm for copper, aluminium brass, and copper-nickel alloys where the nickel content is less than 10 per cent

= 0,5 mm for copper-nickel alloys where the nickel content is 10 per cent or greater

= 0 where the media are non-corrosive relative to the pipe material

σ may be obtained from Table 1.6.2.

Intermediate values may be obtained by linear interpolation.

Table 1.6.1 Minimum thickness for copper and copper alloy pipes

Standard pipe sizes (outside diameter)			Minimum overriding nominal thickness	
			Copper	Copper alloy
8	to	10	1,0	0,8
12	to	20	1,2	1,0
25	to	44,5	1,5	1,2
50	to	76,1	2,0	1,5
88,9	to	108	2,5	2,0
133	to	159	3,0	2,5
193,7	to	267	3,5	3,0
273	to	457,2	4,0	3,5
508	and	over	4,5	4,0

6.1.4 The minimum thickness t_b, of a straight seamless copper or copper alloy pipe to be used for a pipe bend is to be determined by the formula below, except where it can be demonstrated that the use of a thickness less than t_b would not reduce the thickness below t at any point after bending:

$$t_b = \left[\left(\frac{pD}{20\sigma + p}\right)\left(1 + \frac{D}{2{,}5R}\right) + c\right]\frac{100}{100 - a} \text{ mm}$$

where

symbols are as defined in 4.1.1

c and σ are obtained as in 6.1.3

in general, R is to be not less than $3D$.

6.1.5 Pipes are to be seamless, and branches are to be provided by cast or stamped fittings, pipe pressing or other approved fabrications.

Table 1.6.2 Copper and copper alloy pipes

Pipe material	Condition of supply	Specified minimum tensile strength, N/mm^2	Permissible stress, N/mm^2										
			Maximum design temperature, °C										
			50	75	100	125	150	175	200	225	250	275	300
Copper	Annealed	220	41,2	41,2	40,2	40,2	34,3	27,5	18,6	—	—	—	—
Aluminium brass	Annealed	320	78,5	78,5	78,5	78,5	78,5	51,0	24,5	—	—	—	—
90/19 Copper-nickel iron	Annealed	270	68,6	68,6	67,7	65,7	63,7	61,8	58,8	55,9	52,0	48,1	44,1
70/30 Copper-nickel	Annealed	360	81,4	79,4	77,5	75,5	73,5	71,6	69,6	67,7	65,7	63,7	61,8

6.1.6 Brazing and welding materials are to be suitable for the operating temperature and for the medium being carried.

6.1.7 Where silver brazing is used, strength is to be obtained by means of the bond in a capillary space over the whole area of the mating surfaces. A fillet braze at the back of the flange or at the face is undesirable. The alloy used for silver brazing is to contain not less than 49 per cent silver.

6.1.8 The use of copper-zinc brazing alloy is not permitted.

6.2 Heat treatment

6.2.1 Pipes which have been hardened by cold bending are to be suitably heat treated on completion of manufacture and prior to being tested by hydraulic pressure. Copper pipes are to be annealed and copper alloy pipes are to be either annealed or stress relief heat treated.

■ *Section 7* Cast iron

7.1 General

7.1.1 Grey cast iron valves and fittings will, in general, be accepted in Class III piping systems except as stated in 7.1.5. Grey cast iron valves and fittings may be accepted in the Class II steam systems referred to in Table 1.3.1 but the design pressure or temperature is not to exceed 13 bar or 220°C, respectively.

7.1.2 Spheroidal or nodular graphite iron castings for valves and fittings in Class II and Class III piping systems are to be made in a grade having a specified minimum elongation not less than 12 per cent on a gauge length of $5{,}65\sqrt{S_o}$, where S_o is the actual cross-sectional area of the test piece.

7.1.3 Proposals for the use of this material in Class I piping systems will be specially considered, but in no case is the material to be used in systems where the design temperature exceeds 350°C.

7.1.4 Where the elongation is less than the minimum required by 7.1.2, the material is, in general, to be subject to the same limitations as grey cast iron.

7.1.5 Grey cast iron is not to be used for the following:

- Valves and fittings for boiler blow-down systems and other piping systems subject to shock or vibration.
- Shell valves and fittings, *see* Ch 2,3.1.
- Valves fitted on the collision bulkhead.

■ *Section 8* Plastics

8.1 General

8.1.1 Proposals to use plastics pipes will be considered in relation to the properties of the materials, the operating conditions and the intended service and location. Special consideration will be given to any proposed service for plastics pipes not mentioned in these Rules.

8.1.2 Attention is also to be given to *Guidelines for the Application of Plastics Pipes on Ships* contained in IMO Resolution A.753(18).

8.1.3 Plastics pipes and fittings will, in general, be accepted in Class III piping systems.

8.1.4 Plastics pipes are not acceptable for oil fuel, lubricating oil or other flammable liquid systems in machinery spaces, cargo holds and other spaces of high fire risk.

8.1.5 For Class I, Class II and any Class III piping systems for which there are Rule requirements, the pipes are to be of a type which has been approved by LR.

8.1.6 For domestic and similar services where there are no Rule requirements, the pipes need not be of a type which has been approved by LR. However, the fire safety aspects as referenced in 8.4, are to be taken into account.

8.1.7 The use of plastics pipes may be restricted by statutory requirements of the National Authority of the country in which the craft is to be registered.

8.2 Design and performance criteria

8.2.1 Pipes and fittings are to be of robust construction and are to comply with a national or other established standard, consistent with the intended use. Particulars of pipes, fittings and joints are to be submitted for consideration.

8.2.2 The design and performance criteria of all piping systems, independent of service or location, are to meet the requirements of 8.3.

8.2.3 Depending on the service and location, the fire safety aspects such as fire endurance, and fire protection coatings, are to meet the requirements of 8.4.

8.2.4 Plastics piping is to be electrically conductive when:

(a) Carrying fluids capable of generating electrostatic charges.

(b) Passing through dangerous zones and spaces, regardless of the fluid being conveyed.

Suitable precautions against the build up of electrostatic charges are to be provided in accordance with the requirements of 8.5, *see also* Pt 16, Ch 2,1.12.

8.3 Design strength

8.3.1 The strength of pipes is to be determined by hydrostatic pressure tests to failure on representative sizes of pipe. The strength of fittings is to be not less than the strength of the pipes.

8.3.2 In service, the pipe is not to be subjected to a pressure greater than the nominal internal pressure pN_i.

8.3.3 The nominal internal pressure, pN_i, of the pipe is to be determined by the lesser of the following:

$$pN_i \leq \frac{P_{st}}{4}$$

$$pN_i \leq \frac{P_{lt}}{2,5}$$

where

p_{st} = short term hydrostatic test failure pressure, in bar

p_{lt} = long term hydrostatic test failure pressure (100 000 hours), in bar.

Due to the length of time stipulated for the long term test, testing may be carried out over a reduced period of time and the results extrapolated using a suitable standard such as ASTM D2837 and ASTM D1598.

8.3.4 The nominal external pressure, pN_e of the pipe, defined as the maximum total of internal vacuum and external static pressure head to which the pipe may be subjected, is to be determined by the following:

$$pN_e \leq \frac{P_{col}}{3}$$

where

p_{col} = pipe collapse pressure in bar

The pipe collapse pressure is to be not less than 3 bar.

8.3.5 Piping is to meet the design requirements of 8.3.2 and 8.3.4 over the range of service temperature it will experience.

8.3.6 High temperature limits and pressure reductions relative to nominal pressures are to be in accordance with a recognised standard, but in each case the maximum working temperature is to be at least 20°C lower than the minimum temperature of deflection under load of the resin or plastics material without reinforcement. The minimum temperature of deflection under load is not to be less than 80°C, *see also* Ch 14,4 of the Rules for Materials.

8.3.7 Where it is proposed to use plastics piping in low temperature services, design strength testing is to be made at a temperature 10°C lower than the minimum working temperature.

8.3.8 For guidance, typical temperature and pressure limits are indicated in Tables 1.8.1 and 1.8.2. The Tables are related to water service only.

8.3.9 The selection of plastics materials for piping is to take account of other factors such as impact resistance, ageing, fatigue, erosion resistance, fluid absorption and material compatibility such that the design strength of the piping is not reduced below that required by these Rules.

8.3.10 Design strength values may be verified experimentally or by a combination of testing and calculation methods.

8.4 Fire performance criteria

8.4.1 Where plastics pipes are used in systems essential for the safe operation of the craft, or for containing combustible fluids or sea-water where leakage or failure could result in fire or in the flooding of watertight compartments, the pipes and fittings are to be of a type which have been fire endurance tested, *see also* 8.2.3.

8.4.2 Where a fire protective coating of pipes and fittings is necessary for achieving the fire endurance standards required, the coating is to be resistant to products likely to come into contact with the piping and be suitable for the intended application.

8.5 Electrical conductivity

8.5.1 Where a piping system is required to be electrically conductive for the control of static electricity, the resistance per unit length of the pipe, bends, elbows, fabricated branch pieces, etc., is not to exceed 0,1 MΩ/m, *see also* 8.2.4.

Table 1.8.1 Typical temperature and pressure limits for thermoplastic pipes

Material	Nominal pressure, bar	Maximum permissible working pressure, bar						
		–20°C to 0°C	30°C	40°C	50°C	60°C	70°C	80°C
PVC	10		7,5	6				
	16		12	9	6			
ABS	10	7,5	7,5	7	6			
	16	12	12	10,5	9	7,5	6	
HDPE	10	7,5	6					
	16	12	9,5	6				

Abbreviations:

PVC Polyvinyl chloride
ABS Acrylonitrile – butadiene – styrene
HDPE High density polyethylene

Table 1.8.2 Typical temperature and pressure limits for glass fibre reinforced epoxy (GRE) and glass fibre reinforced polyester (GRP) pipes

Min. temperature of deflection under load of resin	Nominal pressure, bar	Maximum permissible working pressure, bar							
		–50°C to 30°C	40°C	50°C	60°C	70°C	80°C	90°C	95°C
80°C	10	10	9	7,5	6				
	16	16	14	12	9,5				
	25	16	16	16	15				
100°C	10	10	10	9,5	8,5	7	6		
	16	16	16	15	13,5	11	9,5		
	25	16	16	16	16	16	15		
135°C	10	10	10	10	10	9,5	8,5	7	6
	16	16	16	16	16	15	13,5	11	9,5
	25	16	16	16	16	16	16	16	15

8.6 Installation and construction

8.6.1 All pipes are to be adequately but freely supported. Suitable provision is to be made for expansion and contraction to take place without unduly straining the pipes.

8.6.2 Pipes may be joined by mechanical couplings or by bonding methods such as welding, laminating, adhesive bonding or other approved means.

8.6.3 Sufficient mechanical joints are to be provided to enable the pipes to be readily removed.

8.6.4 The required fire endurance level of the pipe is to be maintained in way of pipe supports, joints and fittings, including those between plastics and metallic pipes.

8.6.5 Where piping systems are arranged to pass through watertight bulkheads or decks, provision is to be made for maintaining the integrity of the bulkhead or deck by means of metallic bulkhead pieces. The bulkhead pieces are to be protected against corrosion and so constructed to be of a strength equivalent to the intact bulkhead; attention is drawn to 8.6.1. Details of the arrangements are to be submitted for approval.

8.6.6 Where a piping system is required to be electrically conductive, for the control of static electricity, continuity is to be maintained across the joints and fittings, and the system is to be earthed, *see also* Pt 16, Ch 2,1.12.

8.7 Testing

8.7.1 The hydraulic testing of pipes and fittings is to be in accordance with Section 14.

8.7.2 Where a piping system is required to be electrically conductive, tests are to be carried out to verify that the resistance to earth from any point in the system does not exceed 1 MΩ.

■ *Section 9* Stainless steel

9.1 General

9.1.1 Stainless steels may be used for a wide range of services and are particularly suitable for use at elevated temperatures. For guidance on the use of austenitic steels in sea water systems, *see* 16.3.4.

9.1.2 The minimum thickness of stainless steel pipes is to be determined from the formula given in 5.1.2 or 5.1.3 using a corrosion allowance of 0,8 mm. Values of the 0,2 per cent proof stress and tensile strength of the material for use in the formula in 5.1.6 may be obtained from Table 6.5.2 in Chapter 6 of the Rules for Materials.

9.1.3 Where stainless steel is used in lubricating oil and hydraulic oil systems, the corrosion allowance may be reduced to 0,3 mm.

9.1.4 In no case is the thickness of stainless steel pipes to be less than that shown in Table 1.9.1.

Table 1.9.1 Minimum thickness for stainless steel pipes

Standard pipe sizes (outside diameter)			Minimum nominal thickness
mm		mm	mm
8,0	to	10,0	0,8
12,0	to	20,0	1,0
25,0	to	44,5	1,2
50,0	to	76,1	1,5
88,9	to	108,0	2,0
133,0	to	159,0	2,5
193,7	to	267,0	3,0
273,0	to	457,2	3,5

9.1.5 Joints in stainless steel pipework may be made by any of the techniques described in 5.2 to 5.7.

9.1.6 Where pipework is butt welded, this should preferably be accomplished without the use of backing rings, in order to eliminate the possibility of crevice corrosion between the backing ring and pipe.

■ *Section 10* Aluminium alloy

10.1 General

10.1.1 The use of aluminium alloy material in Class III piping systems will be considered in relation to the fluid being conveyed and operating conditions of temperature and pressure.

10.1.2 In general, aluminium alloy may be used for air and sounding pipes for water tanks and dry spaces providing it can be shown that pipe failure will not cause a loss of integrity across watertight divisions. In craft of aluminium construction, aluminium alloy may also be used for air and sounding pipes for oil fuel, lubricating oil and other flammable liquid tanks provided the pipes are suitably protected against the effects of fire.

10.1.3 Aluminium alloy pipes are not to be used in machinery spaces or cargo holds for conveying oil fuel, lubricating oil or other flammable liquids, or for bilge suction pipework within machinery spaces.

10.1.4 Aluminium alloy pipes are not acceptable for fire extinguishing pipes unless they are suitably protected against the effect of heat. The use of aluminium alloy with appropriate insulation will be considered when it has been demonstrated that the arrangements provide equivalent structural and integrity properties compared to steel. In open and exposed locations, where the insulation material is likely to suffer from mechanical damage, suitable protection is to be provided.

10.1.5 The minimum thickness of aluminium alloy pipes is to be not less than that shown in Table 1.10.1.

Table 1.10.1 Minimum thickness of aluminium pipes

Nominal pipe size (mm)	Minimum wall thickness (mm)
10	1,7
15	2,1
20	2,1
25	2,8
40	2,8
50	2,8
80	3,0
100	3,0
150	3,4
200	3,8
250 and over	4,2

10.1.6 Design requirements for aluminium pressure pipes for design pressures greater than 7 bar will be specially considered.

10.1.7 Attention is drawn to the susceptibility of aluminium to corrosion in the region of welded connections.

■ *Section 11* Material certificates

11.1 Metallic materials

11.1.1 Materials for Class I and II piping systems and components as defined in Table 1.3.1, also for shell valves and fittings and fittings on the collision bulkhead are to be manufactured and tested in accordance with the Rules for Materials.

11.1.2 Ferrous castings and forgings for Class I and II piping systems are to be produced at a works approved by LR.

11.1.3 Materials for Class III piping systems are to be manufactured and tested in accordance with the requirements of acceptable National Standards.

11.1.4 The Manufacturer's materials test certificate will be accepted for all classes of piping and components in lieu of an LR materials certificate where the maximum design conditions are less than shown in Table 1.11.1.

Table 1.11.1 Maximum conditions for pipes, valves and fittings for which Manufacturer's materials test certificate is acceptable

Material	Working temperature °C	*DN* = Nominal Diameter, mm P_W = Working Pressure, bar
Carbon and low alloy steel. Stainless steel. Spheroidal or nodular cast iron.	< 300	*DN* < 50 or P_W x *DN* < 2500
Copper alloy	< 200	*DN* < 50 or P_W x *DN* < 1500

11.2 Non-metallic materials

11.2.1 Pipes and fittings intended for applications in Class I, Class II and Class III systems for which there are Rule requirements are to be manufactured in accordance with Chapter 14 of the Rules for Materials.

■ *Section 12*
Requirements for valves

12.1 General

12.1.1 The design, construction and operational capability of valves are to be in accordance with an acceptable National or International Standard appropriate for the piping system. Where valves are not in accordance with an acceptable Standard, details are to be submitted for consideration.

12.1.2 Valves are to be made of steel, cast iron, copper alloy, or other approved material suitable for the intended purpose.

12.1.3 Valves having isolation or sealing components sensitive to heat are not to be used in spaces where leakage or failure caused by fire could result in fire spread, flooding or the loss of an essential service.

12.1.4 Where valves are required to be capable of being closed remotely in the event of fire, the valves, including their control gear, are to be of steel construction or of an acceptable fire tested design.

12.1.5 Valves are to be arranged for clockwise closing and are to be provided with indicators showing whether they are open or shut unless this is readily obvious.

12.1.6 Valves are to be so constructed as to prevent the possibility of valve covers or glands being slackened back or loosened when the valves are operated.

12.1.7 Valves and cocks are to be fitted with legible nameplates, and, unless otherwise specifically mentioned in the Rules, the valves and cocks are to be fitted in places where they are at all times readily accessible.

12.1.8 Valves are to be used within their specified pressure and temperature rating for all normal operating conditions, and are to be suitable for the intended purpose.

12.1.9 Valves intended for submerged installation are to be suitable for both internal and external media. Spindle sealing is to prevent ingress of external media at the maximum external pressure head expected in service.

12.1.10 Additional requirements for shell valves are given in Ch 2,3.

12.2 Valves with remote control

12.2.1 All valves which are provided with remote control are to be arranged for local manual operation, independent of the remote operating mechanism.

12.2.2 In the case of valves which are required by the Rules to be provided with remote control, opening and/or closing of the valves by local manual means is not to render the remote control system inoperable.

12.3 Resiliently seated valves

12.3.1 Valves, having isolation or sealing components sensitive to heat, are not to be used in spaces where leakage or failure caused by fire could result in fire spread, flooding or loss of an essential service.

12.3.2 Where the valves are of the diaphragm type, they are not acceptable as shut off valves at the shell plating.

12.3.3 Resiliently seated valves are not to be used in main or auxiliary machinery spaces as branch or direct bilge suction valves or as pump suction valves from the main bilge line (except where the valve is located in the immediate vicinity of the pump and in series with a metal seated non-return valve. The non-return valve is to be fitted on the bilge main side of the resiliently seated valve). Where they are used in other locations and within auxiliary machinery spaces having little or no fire risk they should be of an approved fire safe type and used in conjunction with a metal seated non-return valve.

12.3.4 Resiliently seated valves are not acceptable for use in fire water mains unless they have been satisfactorily fire tested.

Section 13
Requirements for flexible hoses

13.1 General

13.1.1 A flexible hose assembly is a short length of metallic or non-metallic hose normally with prefabricated end fittings ready for installation.

13.1.2 For the purpose of approval for the applications in 13.2, details of the materials and construction of the hoses, and the method of attaching the end fittings together with evidence of satisfactory prototype testing, are to be submitted for consideration.

13.1.3 The use of hose clamps and similar types of end attachments are not be used for flexible hoses in piping systems for steam, flammable media, starting air systems or for sea water systems where failure may result in flooding. In other piping systems, the use of hose clamps may be accepted where the working pressure is less than 5 bar and provided that there are two clamps at each end connection.

13.1.4 Flexible hoses are to be limited to a length necessary to provide for relative movement between fixed and flexibly mounted items of machinery/equipment or systems.

13.1.5 Flexible hoses are not to be used to compensate for misalignment between sections of piping.

13.1.6 Flexible hose assemblies are not to be installed where they may be subjected to torsional deformation (twisting) under normal operating conditions.

13.1.7 The number of flexible hoses in piping systems mentioned in this Section is to be kept to a minimum and to be limited for the purpose stated in 13.2.1.

13.1.8 Where flexible hoses are intended for conveying flammable fluids in piping systems that are in close proximity to hot surfaces, electrical installation or other sources of ignition, the risk of ignition due to failure of the hose assembly and subsequent release of fluids is to be mitigated as far as practicable by the use of screens or other suitable protection.

13.1.9 Flexible hoses are to be installed in clearly visible and readily accessible locations.

13.1.10 The installation of flexible hose assemblies is to be in accordance with the manufacturer's instructions and use limitations with particular attention to the following:
(a) Orientation.
(b) End connection support (where necessary).
(c) Avoidance of hose contact that could cause rubbing and abrasion.
(d) Minimum bend radii.

13.1.11 Flexible hoses are to be permanently marked by the manufacturer with the following details:
(a) Hose manufacturer's name or trademark.
(b) Date of manufacture (month/year).
(c) Designation type reference.
(d) Nominal diameter.
(e) Pressure rating.
(f) Temperature rating.
Where a flexible hose assembly is made up of items from different manufacturers, the components are to be clearly identified and traceable to evidence of prototype testing.

13.2 Applications for rubber hoses

13.2.1 Short joining lengths of flexible hoses complying with the requirements of this Section may be used, where necessary, to accommodate relative movement between various items of machinery connected to permanent piping systems. The requirements of this Section may also be applied to temporarily-connected flexible hoses or hoses of portable equipment.

13.2.2 Rubber or plastics hoses, with integral cotton or similar braid reinforcement, may be used in fresh and sea-water cooling systems. In the case of sea-water systems, where failure of the hoses could give rise to the danger of flooding, the hoses are to be suitably enclosed.

13.2.3 Rubber or plastics hoses, with single or double closely woven integral wire braid or other suitable material reinforcement, or convoluted metal pipes with wire braid protection, may be used in bilge, ballast, compressed air, fresh water, sea-water, oil fuel, lubricating oil, Class III steam, hydraulic and thermal oil systems. Where rubber or plastics hoses are used for oil fuel supply to burners, the hoses are to have external wire braid protection in addition to the integral wire braid. Flexible hoses for use in steam systems are to be of metallic construction.

13.2.4 Flexible hoses are not to be used in high pressure fuel oil injection systems.

13.2.5 The requirements in this Section for flexible hose assemblies are not applicable to hoses intended to be used in fixed fire extinguishing systems.

13.3 Design requirements

13.3.1 Flexible hose assemblies are to be designed and constructed in accordance with recognised National or International Standards acceptable to LR.

13.3.2 Flexible hoses are to be complete with approved end fittings in accordance with manufacturer's specification. End connections which do not have flanges are to comply with 5.8 as applicable and each type of hose/fitting combination is to be subject to prototype testing to the same standard as that required by the hose with particular reference to pressure and impulse tests.

13.3.3 Flexible hose assemblies intended for installation in piping systems where pressure pulses and/or high levels of vibration are expected to occur in service, are to be designed for the maximum expected impulse peak pressure and forces due to vibration. The tests required by 13.4 are to take into consideration the maximum anticipated in-service pressures, vibration frequencies and forces due to installation.

13.3.4 Flexible hose assemblies constructed of non-metallic materials intended for installation in piping systems for flammable media, and sea-water systems where failure may result in flooding, are to be of fire-resistant type. Fire resistance is to be demonstrated by testing to ISO 15540 and ISO 15541.

13.3.5 Flexible hose assemblies are to be suitable for the intended location and application, taking into consideration ambient conditions, compatibility with fluids under working pressure and temperature conditions consistent with the manufacturer's instructions and any other applicable requirements in the Rules.

13.4 Testing

13.4.1 Acceptance of flexible hose assemblies is subject to satisfactory prototype testing. Prototype test programmes for flexible hose assemblies are to be submitted by the manufacturer and are to be sufficiently detailed to demonstrate performance in accordance with the specified standards.

13.4.2 For a particular hose type complete with end fittings, the tests, as applicable, are to be carried out on different nominal diameters for pressure, burst, impulse and fire resistance in accordance with the requirements of the relevant standard. The following standards are to be used as applicable:

- ISO 6802 – Rubber and plastics hoses and hose assemblies – Hydraulic pressure impulse test without flexing.
- ISO 6803 – Rubber and plastics hoses and hose assemblies – Hydraulic pressure impulse test with flexing.
- ISO 15540 – Ships and marine technology – Fire resistance of hose assemblies – Test methods.
- ISO 15541 – Ships and marine technology – Fire resistance of hose assemblies – Requirements for test bench.
- ISO 10380 – Pipework – Corrugated metal hoses and hose assemblies.

Other standards may be accepted where agreed by LR.

13.4.3 All flexible hose assemblies are to be satisfactorily prototype burst tested to an international standard (*see* Note) to demonstrate they are able to withstand a pressure of not less than four times the design pressure without indication of failure or leakage.

NOTE:
The International Standards, e.g. EN or SAE for burst testing of non-metallic hoses, require the pressure to be increased until burst without any holding period at 4 x Maximum Working Pressure.

Section 14
Hydraulic tests on pipes and fittings

14.1 Hydraulic tests before installation on board

14.1.1 All Class I and II pipes and their associated fittings are to be tested by hydraulic pressure. Further, all steam, feed, compressed air and oil fuel pipes, together with their fittings, are to be similarly tested where the design pressure is greater than 7 bar. The test is to be carried out after completion of manufacture and before installation on board and, where applicable, before insulating and coating.

14.1.2 The test pressure is to be 1,5 times the design pressure, as defined in 4.2.

14.1.3 Shell valves and valves on the collision bulkhead are to be tested by hydraulic pressure to 1,5 times the nominal pressure rating of the valve at ambient temperature.

14.2 Testing after assembly on board

14.2.1 Oil fuel piping is to be tested by hydraulic pressure, after installation on board, to 1,5 times the design pressure but in no case to less than 3,5 bar.

14.2.2 Where pipes specified in 14.1.1 are butt welded together during assembly on board, they are to be tested by hydraulic pressure in accordance with the requirements of 14.2.1 after welding. The pipe lengths may be insulated, except in way of the joints made during installation and before the hydraulic test is carried out.

14.2.3 The hydraulic test required by 14.2.2 may be omitted provided non–destructive tests by ultrasonic or radiographic methods are carried out on the entire circumference of all butt welds with satisfactory results.

14.2.4 Where ultrasonic tests have been carried out, the manufacturer is to provide the Surveyor with a signed statement confirming that ultrasonic examination has been carried out by an approved operator and that there were no indications of defects which could be expected to have prejudicial effect on the service performance of the piping.

CROSS-REFERENCE

See also Ch 2,2.4 for testing after installation.

■ *Section 15*
Requirements for small craft which are not required to comply with the HSC Code

15.1 General

15.1.1 The requirements of Sections 1 to 13 apply, except where modified by this Section.

15.2 Details to be submitted

15.2.1 Details of oil fuel storage tanks over 0,25 m^3, where these do not form part of the structure of the craft, are to be submitted.

15.2.2 Design details of the components listed in 2.1.6 are not required.

15.3 Materials

15.3.1 Materials for which no provision is made in this Chapter may be accepted provided that they comply with an acceptable National or International Standard and are satisfactorily tested as may be considered necessary. Manufacturer's material test certificates are not required unless the material is of unusual or special specification.

15.3.2 Shell valves and cocks, inlet chests, distance pieces and other sea connections are to be of approved ductile material. Due attention is to be paid to the compatibility of the material with that of the shell. Ordinary grey cast iron is not acceptable.

15.4 Aluminium alloy

15.4.1 Proposals for the use of aluminium alloy pipes in bilge systems in machinery spaces will be considered, provided that a single failure in any section of the pipe does not render the whole system inoperable.

15.4.2 Aluminium alloy pipes may be used for fire-fighting systems outside machinery spaces in locations of low fire risk.

15.5 Plastics pipes

15.5.1 IMO Resolution A.753(18) *Guidelines for the Application of Plastics Pipes on Ships* does not apply.

15.5.2 The requirements of 8.1.5 do not apply but where plastics pipes are used for bilge and cooling water services they are to be of a type which has been approved by LR. However, fire endurance testing is not required.

15.5.3 Where plastics pipes are used in bilge systems in machinery spaces, a single failure in any section of the pipe is not to render the whole system inoperable.

15.6 Copper and copper alloys

15.6.1 Where copper and copper alloy pipes are in accordance with an acceptable National Standard/ Specification which is applicable to the intended service or media, Table 1.6.1 need not be applied.

■ *Section 16*
Guidance notes on metal pipes for water services

16.1 General

16.1.1 These guidance notes, except where it is specifically stated, apply to sea-water piping systems.

16.1.2 In addition to the selection of suitable materials, careful attention should be given to the design details of the piping system and the workmanship in fabrication, construction and installation of the pipework in order to obtain maximum life in service.

16.2 Materials

16.2.1 Materials used in sea water piping systems include:
- Galvanized steel.
- Stainless and duplex steel, *see also* 16.3.4.
- Steel pipes lined with rubber, plastics or stoved coatings.
- Copper.
- 90/10 copper-nickel-iron.
- 70/30 copper-nickel.
- Aluminium alloy.
- Aluminium brass.
- Bronze.
- Approved plastics.

16.2.2 Selection of materials should be based on:
- The ability to resist general and localised corrosion, such as pitting, impingement attack and cavitation throughout all the flow velocities likely to be encountered;
- Compatibility with the other materials in the system, such as valve bodies and casings, in order to minimize bimetallic corrosion;
- The ability to resist selective corrosion, e.g. dezincification of brass, dealuminification of aluminium brass and graphitization of cast iron;
- The ability to resist stress corrosion and corrosion fatigue, and;
- The amenability to fabrication by normal practices.

16.3 Steel pipes

16.3.1 Steel pipes should be protected against corrosion and protective coatings should be applied on completion of all fabrication, i.e. bending, forming and welding of the steel pipes.

16.3.2 Welds should be free from lack of fusion and crevices. The surfaces should be dressed to remove slag and spatter and this should be done before coating. The coating should be continuous around the ends of the pipes and on the faces of flanges.

16.3.3 Galvanizing the bores and flanges of steel pipes as protection against corrosion is common practice, and is recommended as the minimum protection for pipes in sea-water systems, including those for bilge and ballast service.

16.3.4 Austenitic stainless steel pipes are not recommended for salt water services in polluted waters or where stagnant conditions exist. Steel of specification 316L or better may give satisfactory service in water circulating systems for clean sea water.

16.3.5 Rubber lined pipes are effective against corrosion and suitable for higher water velocities. The rubber lining should be free from defects, e.g. discontinuities, pinholes, etc., and it is essential that the bonding of the rubber to the bore of the pipe and flange face is sound. Rubber linings should be applied by firms specializing in this form of protection.

16.3.6 The foregoing comments on rubber lined pipes also apply to pipes lined with plastics.

16.3.7 Stove coating of pipes as protection against corrosion should only be used where the pipes will be efficiently protected against mechanical damage.

16.4 Copper and copper alloy pipes

16.4.1 Copper pipes are particularly susceptible to perforation by corrosion/erosion and should only be used for low water velocities and where there is no excessive local turbulence.

16.4.2 Aluminium brass and copper-nickel-iron alloy pipes give good service in reasonably clean sea-water. For service with polluted river or harbour waters, copper-nickel-iron alloy pipes with at least 10 per cent nickel are preferable. Alpha-brasses, i.e. those containing 70 per cent or more copper, must be inhibited effectively against dezincification by suitable additions to the composition. Alpha beta-brasses, i.e. those containing less than 70 per cent copper, should not be used for pipes and fittings.

16.4.3 New copper alloy pipes should not be exposed initially to polluted water. Clean sea-water should be used at first to allow the metals to develop protective films. If this is not available the system should be filled with inhibited town mains water.

16.5 Flanges

16.5.1 Where pipes are exposed to sea-water on both external and internal surfaces, flanges should be made, preferably, of the same material. Where sea-water is confined to the bores of pipes, flanges may be of the same material or of less noble metal than that of the pipe.

16.5.2 Fixed or loose type flanges may be used. The fixed flanges should be attached to the pipes by fillet welds or by capillary silver brazing. Where welding is used, the fillet weld at the back should be a strength weld and that in the face, a seal weld.

16.5.3 Inert gas shielded arc welding is the preferred process but metal arc welding may be used on copper-nickel-iron alloy pipes.

16.5.4 Mild steel flanges may be attached by argon arc welding to copper-nickel-iron pipes and give satisfactory service, provided that no part of the steel is exposed to the sea-water.

16.5.5 Where silver brazing is used, strength should be obtained by means of the bond in a capillary space over the whole area of the mating surfaces. A fillet braze at the back of the flange or at the face is undesirable. The alloy used for silver brazing should contain not less than 49 per cent silver.

16.5.6 The use of a copper-zinc brazing alloy is not permitted.

16.6 Water velocity

16.6.1 Water velocities should be carefully assessed at the design stage and the materials of pipes, valves, etc., selected to suit the conditions.

16.6.2 The water velocity in copper pipes should not exceed 1 m/s.

16.6.3 The water velocity in the pipes of the materials below should normally be not less than about 1 m/s in order to avoid fouling and subsequent pitting, but should not be greater than the following:

Galvanized steel	3,0 m/s
Aluminium brass	3,0 m/s
90/10 copper-nickel-iron	3,5 m/s
70/30 copper-nickel	5,0 m/s.

16.7 Fabrication and installation

16.7.1 Attention should be given to ensuring streamlined flow and reducing entrained air in the system to a minimum. Abrupt changes in the direction of flow, protrusions in the bores of pipes and other restrictions of flow should be avoided. Branches in continuous flow lines should be set at a shallow angle to the main pipe, and the junction should be smooth.

16.7.2 Pipe bores should be smooth and clean.

16.7.3 Jointing should be flush with the bore surfaces of pipes and misalignment of adjacent flange faces should be reduced to a minimum.

16.7.4 Pipe bends should be of as large a radius as possible, and the bore surfaces should be smooth and free from puckering at these positions. Any carbonaceous films or deposits formed on the bore surfaces during the bending processes should be carefully removed. Organic substances are not recommended for the filling of pipes for bending purposes.

16.7.5 The position of supports should be given special consideration in order to minimize vibration and ensure that excessive bending moments are not imposed on the pipes.

16.7.6 Systems should not be left idle for long periods, especially where the water is polluted.

16.7.7 Strainers should be provided at the inlet to sea-water systems.

16.8 Metal pipes for fresh water services

16.8.1 Mild steel or copper pipes are normally satisfactory for service in fresh water applications. Hot fresh water, however, may promote corrosion in mild steel pipes unless the hardness and pH of the water are controlled.

16.8.2 Water with a slight salt content should not be left stagnant for long periods in mild steel pipes. Low salinity and the limited supply of oxygen in such conditions promote the formation of black iron oxide, and this may give rise to severe pitting. Where stagnant conditions are unavoidable, steel pipes should be galvanized, or pipes of suitable non-ferrous material used.

16.8.3 Copper alloy pipes should be treated to remove any carbonaceous films or deposits before the tubes are put into service.

16.8.4 Brass fittings and flanges in contact with water should be made of an alpha-brass effectively inhibited against dezincification by suitable additions to the composition.

16.8.5 Aluminium brass has been widely used as material for heat exchanger and condenser tubes, but its use in ‘once through’ systems is not recommended since, under certain conditions, it is prone to pitting and cracking.

■ *Section 1* General

1.1 Application

1.1.1 The requirements of Sections 1 to 11 of this Chapter apply to all craft which are required to satisfy the relevant design and construction regulations of the HSC Code.

1.1.2 Special requirements for multi-hull craft are given in Section 12.

1.1.3 Additional requirements for Passenger (B) Craft are given in Section 13.

1.1.4 Requirements for craft of less than 24 m not required to comply with the HSC Code are given in Section 14.

1.1.5 Requirements for craft of 24 m or more not required to comply with the HSC Code are given in Section 15.

1.1.6 Additional requirements for yachts that are 500 gt or more are given in Section 16.

1.1.7 The requirements for air cushion vehicles are given in Section 17.

1.1.8 In addition to the requirements of this Chapter, attention should be given to any relevant statutory requirements of the National Authority of the country in which the craft is to be registered.

1.1.9 Consideration will be given to special cases or to arrangements which are equivalent to those required by these Rules.

1.2 Details to be submitted

1.2.1 The plans and information detailed in Chapter 1 are to be submitted before commencement of work.

1.3 Watertight and non-watertight decks

1.3.1 For the purpose of this Section, a non-watertight deck covered by a weathertight structure may be taken as equivalent to a watertight deck. For definitions of the terms watertight and weathertight, *see* Pt 3, Ch 1.

■ *Section 2* Construction and installation

2.1 Installation

2.1.1 All pipes for essential services are to be secured in position to prevent chafing or lateral movement.

2.1.2 Long or heavy lengths of pipe are to be supported by bearers so that no undue load is carried by pipe connections or pumps and fittings to which they are attached.

2.2 Provision for expansion

2.2.1 Suitable provision for expansion is to be made, where necessary, in each range of pipes.

2.2.2 Where expansion pieces are fitted, arrangements are to be provided to protect against over extension and compression. The adjoining pipes are to be suitably aligned, supported, guided and anchored. Where necessary, expansion pieces of the bellows type are to be protected against mechanical damage.

2.3 Miscellaneous requirements

2.3.1 All pipes situated in cargo spaces, chain lockers or other positions where they are liable to mechanical damage are to be efficiently protected.

2.3.2 So far as practicable, pipelines, including exhaust pipes from engines, are not to be routed in the vicinity of switchboards or other electrical appliances in positions where the drip or escape of fluids, gas or steam from joints or fittings could cause damage to the electrical installation. Where it is not practicable to comply with these requirements, drip trays or shields are to be provided as found necessary.

2.4 Testing after installation

2.4.1 After installation on board, all steam, hydraulic, compressed air and other piping systems covered by Ch 1,2.1.3 together with associated fittings which are under internal pressure, are to be subjected to a running test at the intended maximum working pressure.

■ *Section 3* Shell valves and fittings (other than those on scuppers and sanitary discharges)

3.1 Construction

3.1.1 All sea inlet and overboard discharge pipes are to be fitted with valves or cocks secured direct to the shell or to fabricated water boxes attached to the shell.

3.1.2 Distance pieces of short rigid construction and made of approved material may be fitted between the valve and shell. The thickness of such pipes is to be equivalent to shell thickness.

3.1.3 The arrangements are to be such that the section of pipe immediately inboard of the shell valve may be removed without affecting the watertight integrity of the hull.

3.1.4 The valves are to be in accordance with the general requirements for valves given in Ch 1,12.

3.1.5 Shell valves are to be manufactured from non-heat sensitive materials and tested in accordance with the appropriate requirements of the *Rules for the Manufacture, Testing and Certification of Materials* (hereinafter referred to as the Rules for Materials). Special consideration will be given to the use of other materials on craft of aluminium or composite construction. Where the valves are manufactured from spheroidal or nodular graphite cast iron they are to be produced at a works approved by Lloyd's Register (hereinafter referred to as 'LR'). Grey cast iron is not acceptable.

3.1.6 Shell valves are to be fitted in accessible positions and are to be capable of being operated from positions which are readily accessible in case of influx of water to the compartment.

3.1.7 Valve hand wheels and cock handles are to be suitably retained on the spindles. Means are to be provided to indicate whether the valve or cock is open or closed.

3.1.8 The scantlings of valves and valve stools fitted with steam or compressed air clearing connections are to be suitable for the maximum pressure to which the valves and stools may be subjected.

3.1.9 Shell valves are to be hydraulically tested before installation in accordance with Ch 1,14.

■ *Section 4* Bilge pumping and drainage systems

4.1 General

4.1.1 Arrangements are to be made for draining all watertight compartments other than those intended for permanent storage of fluids. Where drainage is not considered necessary, drainage arrangements may be omitted provided the safety of the craft is not impaired.

4.1.2 Pumping arrangements are to be provided having suctions and means of drainage so arranged that any water within any watertight compartment of the craft or any watertight section of any compartment, can be pumped out through at least one suction under all possible conditions of list and trim in the maximum assumed damage condition.

4.1.3 The bilge pumping system is to be designed to prevent water flowing from one watertight compartment to another.

4.1.4 The necessary valves for controlling the bilge suctions are to be capable of being operated from above the watertight deck.

4.1.5 Where a bilge main is not fitted and a compartment is served by a fixed submersible pump in accordance with Section 10, then an additional emergency means of pumping out the compartment is to be provided, *see* Section 6.

4.1.6 Small compartments may be drained by individual hand pump suctions.

4.1.7 The intactness of watertight bulkheads is not to be impaired by the fitting of scuppers discharging to machinery spaces or tunnels from adjacent compartments situated below the highest watertight deck.

4.1.8 Any unattended space for which bilge pumping arrangements are required is to be provided with a bilge level alarm.

4.1.9 Where it is intended to carry flammable or toxic liquids in enclosed spaces, the bilge system shall be designed to prevent pumping of such liquids through piping and pumps in machinery or other spaces where a source of ignition may exist.

■ *Section 5* Bilge drainage of machinery spaces with a propulsion prime mover

5.1 General

5.1.1 The bilge drainage arrangements are to comply with Section 4, except that the arrangements are to be such that any water which may enter this compartment can be pumped out through at least two bilge suctions under all possible conditions of list and trim in the maximum assumed damage condition.

5.1.2 Where a bilge main is fitted, one of the suctions referred to in 5.1.1 is to be a branch bilge suction i.e. a suction connected to the bilge main. The second bilge suction is to be a direct bilge suction as detailed in 8.6.

5.1.3 Where a bilge main is not fitted, the branch bilge suction referred to in 5.1.2 may be replaced by a suction from a submersible bilge pump. The second bilge suction is to be either a second submersible bilge pump or a direct bilge suction as detailed in 8.6.

5.1.4 The emergency bilge drainage arrangements detailed in Section 6 are to be provided where either 5.1.2 or 5.1.3 applies.

5.2 Additional bilge suctions

5.2.1 Additional bilge suctions may be required for the drainage of wells or other recesses.

■ *Section 6* Emergency bilge drainage

6.1 Emergency bilge drainage

6.1.1 In machinery spaces the emergency bilge suction required by 4.1.5 and 5.1.4 is to be led to the largest available power pump, which is not a bilge, propulsion or oil pump, from a suitable low level in the machinery space and is to be fitted with a screw-down non-return valve with an extended spindle and hand wheel situated above the floor plating.

6.1.2 As an alternative to 6.1.1, or in compartments other than machinery spaces, the emergency bilge pumping arrangements may be provided by a portable submersible self-priming pump of capacity not less than that required by 8.3.5.

6.1.3 The pump referred to in 6.1.2 together with its suction and delivery hoses is to be stored in a locker marked 'For emergency use only' and is to be available for immediate use. Arrangements to facilitate safe handling under adverse conditions are to be provided. If the pump is electrically driven it is to be supplied from the emergency switchboard.

■ *Section 7* Size of bilge suction pipes

7.1 Bilge main

7.1.1 Where a bilge main is fitted, its internal diameter d_m is to be not less than that required by the following formula:

$$d_m = 1{,}68\sqrt{L\,(B + D)} + 25 \text{ mm}$$

where

B = breadth of craft, in metres
D = moulded depth to the watertight deck, in metres
L = length of craft, in metres

The actual internal diameter of the bilge main may be rounded off to the nearest pipe size of a recognised standard, but d_m is in no case to be less than 50 mm.

7.2 Branch bilge suctions

7.2.1 The diameter d_b of branch bilge suction pipes is to be not less than that required by the following formula:

$$d_b = 2{,}15\sqrt{C\,(B + D)} + 12{,}5 \text{ mm}$$

where

B and D are as defined in 7.1.1
C = length of compartment, in metres.

The actual internal diameter of branch bilge suction pipes may be rounded off to the nearest pipe size of a recognised standard, but d_b is in no case to be less than 25 mm.

■ *Section 8* Pumps on bilge service

8.1 Number of pumps

8.1.1 For craft fitted with a bilge main, at least two power bilge pumping units are to be provided. One of these units may be worked from the main engines and the other is to be independently driven.

8.1.2 Each unit may consist of one or more pumps connected to the main bilge line, provided that their combined capacity is not less than that required by 8.3.2.

8.1.3 A bilge ejector in combination with a high pressure sea-water pump may be accepted as a substitute for an independent bilge pump as required by 8.1.1.

8.1.4 For craft fitted with fixed submersible bilge pumps, one pump is to be provided for each watertight compartment.

8.1.5 For the bilge pumping requirements for multi-hull craft, *see* Section 12.

8.2 General service pumps

8.2.1 The bilge pumping units or pumps required by 8.1 may also be used for ballast, fire or general service duties of an intermittent nature, but not for pumping fuel or other flammable liquids. These pumps are to be immediately available for bilge duty when required. For the use of bilge pumping units for fire-extinguishing duties, *see* Part 17.

8.3 Capacity of pumps

8.3.1 Each bilge pumping unit is to be connected to the bilge main and is to be capable of giving a speed of water through the Rule size of bilge main of not less than 2 m/s.

8.3.2 To achieve the flow velocity required by 8.3.1, the capacity *Q* of each bilge pumping unit or bilge pump is to be not less than that required by the following formula:

$$Q = \frac{5,75}{10^3} d_m^2 \quad m^3/hour$$

where

d_m is as defined in 7.1.1.

Q = Rule minimum capacity, in m^3/hour.

8.3.3 Where one bilge pumping unit is of slightly less than Rule capacity, the deficiency may be made good by an excess capacity of the other unit. In general, the deficiency is to be limited to 30 per cent.

8.3.4 Where fixed submersible bilge pumps are fitted, the total capacity Q_t of the pumps is to be not less than that required by the following formula:

$$Q_t = \frac{13,8}{10^3} d_m^2 \quad m^3/hour$$

where

d_m is as defined in 7.1.1.

Q_t = Rule minimum total capacity, in m^3/hour.

8.3.5 The capacity Q_n of each submersible bilge pump is to be not less than that required by the following formula:

$$Q_n = \frac{Q_t}{(N - 1)} \quad m^3/hour$$

where

N = number of fixed submersible pumps

Q_t is as defined in 8.3.4

Q_n = Rule minimum submersible pump capacity, in m^3/hour

Q_n is in no case to be less than 8 m^3/hour.

8.4 Self-priming pumps

8.4.1 All power pumps which are essential for bilge services are to be of the self-priming type, unless an approved central priming system is provided for these pumps.

8.5 Pump connections

8.5.1 The connections at the bilge pumps are to be such that one unit may continue in operation when the other unit is being opened up for overhaul.

8.5.2 Pumps required for essential services are not to be connected to a common suction or discharge chest or pipe unless the arrangements are such that the working of any pumps so connected is unaffected by the other pumps being in operation at the same time.

8.6 Direct bilge suctions

8.6.1 The direct bilge suction in the machinery space required by 5.1.2 and referred to in 5.1.3 is to be led to an independent power pump, and the arrangements are to be such that the direct suction can be used independently of the main bilge line suctions.

8.6.2 The machinery space direct bilge suction is not to be of a diameter less than that required for the machinery space branch bilge suction and arranged as detailed in 8.6.1.

■ *Section 9* Bilge main arrangements and materials

9.1 General

9.1.1 Bilge mains, branch bilge suctions and bilge overboard discharge arrangements within machinery spaces are to be of steel or other equivalent material.

9.1.2 Where bilge suction pipework outside machinery spaces is manufactured from material sensitive to heat then the arrangements are to be such that pipe failure in one compartment will not render the bilge suction pipework in another compartment inoperable.

9.1.3 Bilge pipework is to be mounted inboard such that in the event of the maximum assumed damage the pipework will remain intact.

9.2 Prevention of communication between compartments

9.2.1 The arrangement of valves, cocks and their connections is to be such as to prevent the possibility of one watertight compartment being placed in communication with another, or of dry cargo spaces, machinery spaces or other dry compartments being placed in communication with the sea or with tanks. For this purpose, screw-down non-return valves are to be provided in the following fittings:

- Bilge valve distribution chests
- Bilge suction hose connections, whether fitted direct to the pump or on the main bilge line.
- Direct bilge suctions and bilge pump connections to the main bilge line.

9.3 Isolation of bilge system

9.3.1 Bilge suction pipes are to be entirely separate from sea inlet pipes or from pipes which may be used for filling or emptying spaces where water or oil is carried.

9.4 Bilge suction strainers

9.4.1 The open ends of bilge suctions are to be enclosed in strum boxes having perforations of not more than 10 mm diameter, whose combined area is not less than twice that required for the suction pipe. The boxes are to be so constructed that they can be cleared without breaking any joint of the suction pipe.

■ *Section 10* Submersible bilge pump arrangements

10.1 General

10.1.1 Arrangements are to be such that at least two automatic non-return devices are fitted between the over-board discharge and the watertight space being served by the pump.

10.1.2 One of these devices is to be an automatic non-return valve situated at or near the shell and the other may be a pipework loop taken up to the highest practicable point below the watertight deck. The arrangements are to be effective in the maximum assumed damaged condition.

■ *Section 11* Air, overflow and sounding pipes

11.1 Air pipes

11.1.1 Air pipes are to be fitted to all tanks, cofferdams, tunnels and other compartments which are not fitted with alternative ventilation arrangements.

11.1.2 Air pipes are to be fitted at the opposite end of the tank to that which the filling pipes are placed and/or at the highest part of the tank. Where the tank top is of unusual or irregular profile, special consideration will be given to the number and position of the air pipes.

11.1.3 Air pipes to oil fuel, lubricating oil and other tanks containing flammable liquids which are located in or pass through compartments of high fire risk or on open deck are to be of steel or other equivalent material.

11.2 Termination of air pipes

11.2.1 Air pipes to double bottom tanks, deep tanks extending to the shell plating, or tanks which can be run up from the sea are to be led to above the watertight deck. Air pipes to oil fuel tanks, cofferdams and all tanks which can be pumped up are to be led to the open.

11.2.2 Air pipes from storage tanks containing lubricating or hydraulic oil may terminate in the machinery space, provided that the open ends are so situated that issuing oil cannot come into contact with electrical equipment or heated surfaces.

11.2.3 The open ends of air pipes to oil fuel tanks are to be situated where no danger will be incurred from issuing oil vapour when the tank is being filled.

11.2.4 The location and arrangement of air pipes for oil fuel service, settling and lubricating oil tanks are to be such that in the event of a broken vent pipe, this does not directly lead to the risk of ingress of sea-water or rainwater.

11.3 Gauze diaphragms

11.3.1 The open ends of air pipes to oil fuel tanks are to be fitted with a wire gauze diaphragm of non-corrodible material which can be readily removed for cleaning or renewal.

11.3.2 Where wire gauze diaphragms are fitted at air pipe openings, the area of the opening through the gauze is to be not less than the cross-sectional area required for the pipe, *see* 11.6.

11.4 Air pipe closing appliances

11.4.1 Closing appliances fitted to tank air pipes are to be of an automatic opening type which will allow the free passage of air or liquid to prevent the tanks being subjected to a pressure or vacuum greater than that for which they are designed, *see also* Pt 3, Ch 4,12.3.

11.4.2 Air pipe closing devices are to be of a type acceptable to LR and are to be tested in accordance with a National or International Standard recognized by LR. The flow characteristic of the closing device is to be determined using water, *see* 11.6.1.

11.4.3 Wood plugs and other devices which can be secured closed are not to be fitted at the outlets.

11.5 Nameplates

11.5.1 Nameplates are to be affixed to the upper ends of all air and sounding pipes.

11.6 Size of air pipes

11.6.1 For every tank which can be filled by on-board pumps, the total cross-sectional area of the air pipes and the air pipe closing devices is to be such that when the tank is overflowing at the maximum pumping capacity available for the tank, it will not be subjected to a pressure greater than that for which it is designed.

11.6.2 In all cases, whether a tank is filled by on-board pumps or other means, the total cross-sectional area of the pipes is to be not less than 25 per cent greater than the effective area of the respective filling pipe.

11.6.3 Air pipes are to be generally not less than 38 mm bore. In the case of small gravity filled tanks smaller bore pipes may be accepted but in no case is the bore to be less than 25 mm.

11.7 Overflow pipes

11.7.1 For all tanks which can be pumped up, overflow pipes are to be fitted where:

(a) The total cross-sectional area of the air pipes is less than that required by 11.6.

(b) The pressure head corresponding to the height of the air pipe is greater than that for which the tank is designed.

11.7.2 In the case of oil fuel tanks, lubricating oil tanks and other tanks containing flammable liquids, the overflow pipe is to be led to an overflow tank of adequate capacity or to a storage tank having a space reserved for overflow purposes. Suitable means is to be provided to indicate when overflowing is occurring.

11.7.3 Overflow pipes are to be self draining under normal conditions of trim.

11.7.4 Where overflow sight glasses are provided, they are to be in a vertical dropping line and designed such that the oil does not impinge on the glass. The glass is to be of heat resisting quality and be adequately protected from mechanical damage. Overflow sight glasses are not permitted in oil fuel systems for craft required to comply with the HSC Code.

11.8 Combined air and overflow systems

11.8.1 Where a combined air or overflow system is fitted, the arrangement is to be such that in the event of any one of the tanks being bilged, the other tanks cannot be flooded from the sea through combined air pipes or the overflow main. For this purpose, it will normally be necessary to lead the overflow pipe to a point above the waterline in the maximum assumed damage condition.

11.8.2 Where a common overflow main is provided, the main is to be sized to allow any two tanks connected to that main to overflow simultaneously.

11.9 Sounding arrangements

11.9.1 Provision is to be made for sounding all tanks and the bilges of those compartments which are not at all times readily accessible. The soundings are to be taken as near the suction pipes as practicable.

11.9.2 Sounding devices of an approved type (i.e. level gauge or remote reading level device) may be used in lieu of sounding pipes.

11.9.3 Bilges of compartments which are not at all times readily accessible are to be provided with sounding pipes.

11.9.4 Where fitted, sounding pipes are to be as straight as practicable, and if curved to suit the structure of the craft, the curvature is to be sufficiently easy to permit the ready passage of the sounding rod or chain.

11.9.5 Striking plates of adequate thickness and size are to be fitted under open ended sounding pipes.

11.9.6 Where slotted sounding pipes having closed ends are employed, the closing plugs are to be of substantial construction.

11.9.7 Sounding pipes are to be not less than 32 mm bore.

11.10 Termination of sounding pipes

11.10.1 Except as permitted by 11.11, sounding pipes are to be led to positions above the bulkhead deck which are at all times accessible and, in the case of oil fuel tanks, cargo oil tanks and lubricating oil tanks, the sounding pipes are to be led to safe positions on the open deck.

11.10.2 For closing requirements, *see also* Pt 3, Ch 4,12.3.1.

11.11 Short sounding pipes

11.11.1 In machinery spaces, where it is not practicable to extend sounding pipes as mentioned in 11.10 short sounding pipes extending to readily accessible positions above the platform may be fitted.

11.11.2 Short sounding pipes are not permitted in machinery spaces for tanks containing oil fuel or other flammable oils used in power transmission systems, control and activating systems and heating systems, except as permitted by 11.13.6.

11.11.3 Short sounding pipes may be fitted to tanks used for the storage, distribution and utilization of lubricating oil in machinery spaces. These sounding pipes are to be fitted with cocks having parallel plugs with permanently attached handles located such that, on being released, they automatically close the cocks.

11.12 Elbow sounding pipes

11.12.1 In passenger craft, elbow sounding pipes are not permitted.

11.12.2 Elbow sounding pipes are not to be used for deep tanks, unless the elbows and pipes are situated within closed cofferdams or within tanks containing similar liquids. They may, however, be fitted to other tanks and may be used for sounding bilges, provided that it is not practicable to lead them direct to the tanks or compartments, and subject to any subdivision and damage stability requirements that may apply.

11.12.3 The elbows are to be of heavy construction and adequately supported.

11.13 Sounding arrangements for oil fuel, lubricating oil and other flammable liquids

11.13.1 Safe and efficient means of ascertaining the amount of oil in any storage tank are to be provided.

11.13.2 For oil fuel, lubricating oil and other flammable liquids, closed sounding devices are preferred. Design details of such devices are to be submitted and they are to be tested after fitting on board, to the satisfaction of the Surveyors.

11.13.3 If closed sounding devices are fitted, failure of the device or over filling of the tank is not to result in the release of tank contents. In passenger craft and yachts that are 500 gt or more, such means are not to require penetration below the top of the tank.

11.13.4 Where sounding pipes are used they are not to terminate in any space where risk of ignition or spillage from the sounding pipe might arise. In particular they are not to terminate in public spaces or crew accommodation. Additionally for oil fuel tanks they are not to terminate in machinery spaces. Terminations are to be provided with a suitable means of closure and provision to prevent spillage during refuelling/refilling operations.

11.13.5 Where gauge glasses are used they are to be of the flat type of heat resisting quality, adequately protected from mechanical damage and fitted with self closing valves at the lower ends and at the top ends if these are connected to the tanks below the maximum liquid level.

11.13.6 In yachts and service craft which are not required to comply with the HSC Code, short sounding pipes extending to well-lighted, readily accessible positions above the platform may be fitted in machinery spaces and tunnels. Sounding pipes are to be fitted with cocks having parallel plugs with permanently attached handles located such that, on being released, they automatically close the cocks.

11.13.7 For yachts that are 500 gt or more, where short sounding pipes serve tanks containing oil fuel, an additional sounding device of approved type is to be fitted. In addition, a small diameter self-closing test cock is to be fitted below the cock mentioned in 11.13.6, in order to ensure that the sounding pipe is not under pressure from oil fuel before opening up the sounding pipe.

■ *Section 12* Requirements for multi-hull craft

12.1 General

12.1.1 The requirements of Sections 2 to 11 apply to multi-hull craft except where modified by the requirements of this Section.

12.2 Drainage of raft void spaces

12.2.1 Arrangements are to be provided for venting, sounding and draining raft void spaces generally as required by Sections 1 to 11.

12.2.2 Where the raft void space is located above the water line in the maximum assumed damage condition then it may be drained directly overboard through scuppers fitted with non-return valves.

12.2.3 Raft void spaces which are not located above the water line in the worst expected damage condition are to be provided with pumping arrangements in accordance with Section 4.

12.3 Size of bilge suction pipes

12.3.1 Where a bilge main is fitted in each hull, its internal diameter d_m is to be not less than that required by the following formula:

$$d_m = 1,68\sqrt{L(B+D)} + 25 \text{ mm}$$

where

B = breadth of a hull in metres
D = moulded depth to the watertight deck, in metres
L = length of craft, in metres

The actual internal diameter of the bilge main may be rounded off to the nearest pipe size of a recognised standard, but d_m is in no case to be less than 50 mm.

12.3.2 The diameter d_b of branch bilge suction pipes is to be not less than that required by the following formula:

$$d_b = 2{,}15 \sqrt{C\,(B + D)} + 12{,}5 \text{ mm}$$

where

C = length of compartment, in metres

B and D are as defined in 12.3.1

The actual internal diameter of branch bilge suction pipes may be rounded off to the nearest pipe size of a recognised standard, but d_b is in no case to be less than 25 mm.

12.4 Capacity and number of pumps on bilge main services

12.4.1 Each power bilge pump should be capable of pumping water through the required size of bilge main at a speed of not less than 2 m/s.

12.4.2 To achieve the flow velocity required by 12.4.1, the capacity Q of each bilge pumping unit or bilge pump is to be not less than that required by the following formula:

$$Q = \frac{5{,}75}{10^3} d_m^2 \text{ m}^3\text{/hour}$$

where

d_m is as defined in 12.3.1.

12.4.3 Not less than two power bilge pumping units taking suction from the bilge main in each hull are to be provided.

12.4.4 Where the bilge system in each hull is entirely separate then two bilge pumping units in each hull are to be provided.

12.4.5 Where fixed submersible bilge pumps are fitted, the total capacity Q_t of the pumps in each hull is to be not less than that required by the following formula:

$$Q_t = \frac{13{,}8}{10^3} d_m^2 \text{ m}^3\text{/hour}$$

where

d_m is as defined in 12.3.1.

12.4.6 The capacity Q_n of each submersible pump is to be not less than that required by the following formula:

$$Q_n = \frac{Q_t}{(N - 1)} \text{ m}^3\text{/hour}$$

where

N = number of fixed submersible pumps in each hull

Q_t is as defined in 12.4.5

Q_n is in no case to be less than 8 m^3/hour.

■ *Section 13* Additional requirements for Passenger (B) Craft

13.1 Bilge pumping arrangements

13.1.1 At least three power bilge pumping units are to be fitted connected to the bilge main, one of which may be driven by the propulsion machinery.

13.1.2 For multi-hull craft the bilge pumping units are to be capable of taking suction from the bilge main in any hull of the craft.

13.1.3 The arrangements are to be such that at least one power bilge pump is to be available for use in all flooding conditions which the craft is required to withstand as follows:

(a) one of the required bilge pumps is to be an emergency pump of a reliable submersible type having a source of power located above the waterline after the craft has sustained the maximum assumed damage; or

(b) the bilge pumps and their sources of power are to be so distributed throughout the length of the craft that at least one pump in an undamaged compartment will be available.

13.1.4 Alternatively fixed submersible bilge pumps may be provided in accordance with the requirements of 8.3.4 for monohull craft or 12.4.5 for multihull craft.

13.1.5 Distribution boxes, cocks and valves in connection with the bilge pumping system are to be so arranged that, in the event of flooding, one of the bilge pumps may take suction from any compartment.

13.1.6 Damage to a pump or its pipe connecting to the bilge main is not to put the bilge system out of action.

13.1.7 When in addition to the main bilge pumping system an emergency bilge pumping system is provided, it is to be independent of the main system and so arranged that a pump is capable of operating in any compartment under the maximum assumed flooding conditions. In that case only the valves necessary for the operation of the emergency system need be capable of remote operation.

13.1.8 All cocks and valves referred to in 13.1.5 which can be remotely operated are to have their controls at their place of operation clearly marked and are to be provided with means to indicate whether they are open or closed.

■ *Section 14* Requirements for small craft which are not required to comply with the HSC Code

14.1 General

14.1.1 These requirements replace Sections 1 to 10, 12 and 13 of this Chapter. In general the requirements of Section 11 are to be complied with, however 11.4.1 and 11.9.3 do not apply.

14.1.2 Bilge and cooling water pipework systems are to be of an approved material, *see* Ch 1,15.

14.2 Shell valves and fittings

14.2.1 All sea inlet and overboard discharges are to be provided with shut off valves or cocks arranged in positions where they are readily accessible at all times.

14.2.2 Where valves, cocks, inlet chests, distance pieces and other sea connections are made of steel or other approved materials of low corrosion resistance, they are to be suitably protected against wastage.

14.3 Fittings for steel and aluminium hulls

14.3.1 All suction and discharge valves and cocks secured direct to the plating are to be fitted with spigots passing through the plating, but spigots on the valves and cocks may be omitted if these fittings are attached to pads or distance pieces which themselves form spigots in way of the plating.

14.4 Fittings for wood and glass reinforced plastics hulls

14.4.1 The openings in the shell or planking are to have suitably reinforced areas or pads into which the attached fittings are to be spigoted.

14.4.2 Valves or fittings are to be secured with an external ring under the bolt heads. The ring is to be of copper nickel alloy, bronze, dezincification resistant brass or other material approved for use in sea-water.

14.4.3 Valves or cocks up to 50 mm bore may be attached to spigot pieces or hull fittings having an external collar and internal nut.

14.4.4 Valves or cocks over 50 mm bore are to be flanged and attached as per 14.4.2.

14.5 Bilge pumping arrangements

14.5.1 An efficient bilge pumping system is to be fitted having suctions and means of drainage so arranged that any water which may enter any compartment can be pumped overboard.

14.5.2 The system is to be tested on completion of the craft to ensure that all limber holes are free and that under normal conditions of trim any bilge water can drain to an appropriate suction.

14.5.3 The arrangement of pumps, valves, cocks, pipes and sea connections is to be such as to prevent water entering the craft accidentally or the possibility of one watertight compartment being placed in communication with another.

14.5.4 Readily accessible strum boxes are to be fitted at the open ends of tail pipes.

14.5.5 The perforations in the strum boxes are to be not greater than 10 mm diameter and the combined area is to be not less than twice that required for the bilge suction pipe.

14.5.6 Where a collision bulkhead is fitted, the fore peak dry space is to be drained either by a branch suction to the main bilge line or by a manual pump. Alternatively, it may be drained to the adjacent compartment by means of a self closing drain cock which is to be readily accessible under all conditions.

14.5.7 Where a bilge main is fitted, the internal diameter d of the main and the branch suction pipes is to be not less than that required by the following formula:

$$d = \frac{L}{1,2} + 25 \text{ mm}$$

where
L = length of craft, in metres.

14.6 Pumps on bilge service and their connections

14.6.1 Not less than one power pump and one manual bilge pump are to be provided. Both pumps are to be arranged to take suction from the bilge main or suction valve chest as applicable.

14.6.2 The power driven pumps may be used for other services such as deck washing, fire extinguishing or standby cooling water duty but not for pumping oil fuel or other flammable liquids.

14.6.3 The total capacity Q_t of the bilge pumps is to be not less than required by the following formula:

$$Q_t = 1,5 (d - 25) - 6,7 \text{ m}^3\text{/hour}$$

where
d is as defined in 14.5.7
Q_t is in no case to be less than 3 m^3/hour.

14.6.4 A reduction in capacity of one pump may be permitted provided the deficiency is made good by an excess capacity of the other pump or by an additional pump. In no case is this deficiency to be more than 40 per cent of the Rule capacity.

14.6.5 Pumps on bilge service are to be of the self-priming type.

14.6.6 The bilge pumps are to be connected to a common bilge line provided with a branch connection to each compartment.

14.6.7 A non-return valve is to be fitted between each bilge pump and the bilge main.

14.6.8 Non-return valves are to be fitted in each branch bilge suction from the main bilge line.

14.6.9 Power pumps may be driven by the main engine, an auxiliary engine or by an electric motor.

14.6.10 The power pump is to be provided with a suction enabling it to pump directly from the engine space in addition to the suction from the main bilge line. This direct bilge suction is to be controlled by a screw down non-return valve or equivalent.

14.6.11 Manual bilge pumps are to be capable of being operated from readily accessible positions above the waterline.

14.6.12 As an alternative to fitting a bilge main, individual submersible pumps may be fitted. In this case the arrangements are to be in accordance with the requirements of Sections 8, 10 and 12 of this Chapter, as applicable.

■ *Section 15* Requirements for yachts and service craft of 24 m or greater in length, which are not required to comply with the HSC Code

15.1 General

15.1.1 The requirements of Sections 1, 2, 3, 11 and 12 of this Chapter are generally applicable. The remaining Sections concerning the requirements for bilge pumping and drainage systems are replaced by the requirements given in 15.2 to 15.28.

15.2 Bilge pumping and drainage systems

15.2.1 The following requirements replace Sections 4 to 10 of this Chapter.

15.3 Drainage of compartments, other than machinery spaces

15.3.1 All craft are to be provided with efficient pumping plant having the suctions and means for drainage so arranged that any water within any compartment of the craft, or any watertight section of any compartment, can be pumped out through at least one suction when the craft is on an even keel and is either upright or has a list of not more than 5°. For this purpose, wing suctions will generally be necessary, except in short, narrow compartments where one suction can provide effective drainage under the above conditions.

15.3.2 In the case of dry compartments, the suctions required by 15.3.1 are, except where otherwise stated, to be branch bilge suctions, i.e. suctions connected to a main bilge line.

15.4 Tanks and cofferdams

15.4.1 All tanks (including double bottom tanks), whether used for water ballast, oil fuel or liquid cargoes, are to be provided with suction pipes, led to suitable power pumps, from the after end of each tank.

15.4.2 In general, the drainage arrangements are to be in accordance with 15.3. However, where the tanks are divided by longitudinal watertight bulkheads or girders into two or more tanks, a single suction pipe, led to the after end of each tank, will normally be acceptable.

15.4.3 Similar drainage arrangements are to be provided for cofferdams, except that the suctions may be led to the main bilge line.

15.5 Fore and after peaks

15.5.1 Where the peaks are used as tanks, a power pump suction is to be led to each tank, except in the case of small tanks used for the carriage of domestic fresh water, where hand pumps may be used.

15.5.2 Where the peaks are not used as tanks, and main bilge line suctions are not fitted, drainage of both peaks may be effected by hand pump suctions, provided that the suction lift is well within the capacity of the pumps. Drainage of the after peak may be effected by means of a self-closing cock fitted in a well lighted and readily accessible position.

15.5.3 Pipes piercing the collision bulkhead are to be fitted with suitable valves secured to the bulkhead. The valves are to be operable from above the freeboard deck.

15.6 Spaces above fore peaks, after peaks and machinery spaces

15.6.1 Provision is to be made for the drainage of the chain locker and watertight compartments above the fore peak tank by hand or power pump suctions.

15.6.2 Steering gear compartments or other small enclosed spaces situated above the after peak tank are to be provided with suitable means of drainage, either by hand or power pump bilge suctions.

15.6.3 The compartments referred to in 15.6.2 may be drained by scuppers of not less than 38 mm bore, discharging to the tunnel or machinery space and fitted with self-closing cocks situated in well lighted and visible positions.

15.7 Maintenance of integrity of bulkheads

15.7.1 The intactness of the machinery space bulkheads, and of tunnel plating required to be of watertight construction, is not to be impaired by the fitting of scuppers discharging to machinery space or tunnels from adjacent compartments which are situated below the bulkhead deck.

15.7.2 No drain valve or cock is to be fitted to the collision bulkhead. Drain valves or cocks are not to be fitted to other watertight bulkheads if alternative means of drainage are practicable.

15.8 Bilge drainage of machinery space

15.8.1 The bilge drainage arrangements in the machinery space are to comply with 15.3 except that the arrangements are to be such that any water which may enter this compartment can be pumped out through at least two bilge suctions when the craft is on an even keel, and is either upright or has a list of not more than 5°. One of these suctions is to be a branch bilge suction, i.e. a suction connected to the main bilge line, and the other is to be a direct bilge suction, i.e. a suction led direct to an independent power pump.

15.9 Separate machinery spaces

15.9.1 Where the machinery space is divided by watertight bulkheads to separate the auxiliary engine room(s) from the main engine room, the bilge drainage arrangements for the auxiliary engine room(s) are to be the same as for compartments, other than machinery spaces, referred to in 15.3.1.

15.9.2 In addition to the requirements of 15.9.1, at least one direct suction, led to an independent power pump, is to be fitted in each compartment.

15.10 Machinery space with double bottom

15.10.1 Where the double bottom extends the full length of the machinery space and forms bilges at the wings, it will be necessary to provide one branch and one direct bilge suction at each side.

15.10.2 Where the double bottom plating extends the full length and breadth of the compartment, one branch bilge suction and one direct bilge suction are to be led to each of two bilge wells, situated one at each side.

15.10.3 Where there is no double bottom and the rise of floor is not less than 5°, one branch and one direct bilge suction are to be led to accessible positions as near to the centreline as practicable.

15.11 Machinery space – Emergency bilge drainage

15.11.1 In addition to the bilge suctions detailed in 15.8 and 15.9, an emergency bilge suction is to be provided in each main machinery space. This suction is to be led to the main cooling water pump from a suitable low level in the machinery space and is to be fitted with a screw-down non-return valve having the spindle so extended that the hand wheel is not less than 460 mm above the bottom platform.

15.11.2 Where two or more cooling water pumps are provided, each capable of supplying cooling water for normal power, only one pump need be fitted with an emergency bilge suction.

15.11.3 Where main cooling water pumps are not suitable for bilge pumping duties, the emergency bilge suction is to be led to the largest available power pump, which is not a bilge pump.

15.11.4 Emergency bilge suction valve nameplates are to be marked 'For emergency use only'.

15.12 Sizes of bilge suction pipes

15.12.1 The diameter, d_m, of the main bilge line is to be not less than that required by the following formula, to the nearest 5 mm, but in no case is the diameter to be less than that required for any branch bilge suction:

$$d_m = 1{,}68 \sqrt{L\,(B + D)} + 25 \text{ mm}$$

where

d_m = internal diameter of main bilge line, in mm
B = greatest moulded breadth of craft, in metres
D = moulded depth to bulkhead deck, in metres
L = Rule length of craft in metres.

15.12.2 The diameter d_b, of branch bilge suction pipes to cargo and machinery spaces is to be not less than required by the following formula, to the nearest 5 mm, but in no case is the diameter of any suction to be less than 50 mm:

$$d_b = 2{,}15 \sqrt{C\,(B + D)} + 25 \text{ mm}$$

where

d_b = internal diameter of branch bilge suction, in mm
C = length of compartment, in metres
B and D are as defined in 15.12.1.

15.12.3 The direct bilge suctions in the machinery space are not to be of a diameter less than that required for the main bilge line.

15.12.4 For sizes of emergency bilge suctions, *see* 15.11.

15.13 Distribution chest branch pipes

15.13.1 The area of each branch pipe connecting the bilge main to a distribution chest is to be not less than the sum of the areas required by the Rules for the two largest branch bilge suction pipes connected to that chest, but need not be greater than that required for the main bilge line.

15.14 Pumps on bilge service and their connections

15.14.1 At least two power bilge pumping units are to be provided in the machinery space. One of these units may be worked from the main engines and the other is to be independently driven.

15.14.2 Each unit may consist of one or more pumps connected to the main bilge line, provided that their combined capacity is adequate.

15.14.3 A bilge ejector in combination with a high pressure sea-water pump may be accepted as a substitute for an independent bilge pump as required by 15.14.1.

15.14.4 Special consideration will be given to the number of pumps for small craft and, in general, if there is a class notation restricting a small craft to harbour or river service, a hand pump may be accepted in lieu of one of the bilge pumping units.

15.15 General service pumps

15.15.1 The bilge pumping units, or pumps, required by 15.14 may also be used for ballast, fire or general service duties of an intermittent nature, but they are to be immediately available for bilge duty when required.

15.16 Capacity of pumps

15.16.1 Each bilge pumping unit is to be connected to the main bilge line and is to be capable of giving a speed of water through the Rule size of main bilge pipe of not less than 122 m/min.

15.16.2 The capacity of each bilge pumping unit or bilge pump is to be not less than required by the following formula:

$$Q = \frac{5,75}{10^3} d_m^2$$

where

d_m = Rule internal diameter of main bilge line, in mm

Q = capacity, in m^3/hour.

15.16.3 Where one bilge pumping unit is of slightly less than Rule capacity, the deficiency may be made good by an excess capacity of the other unit. In general, the deficiency is to be limited to 30 per cent.

15.17 Self-priming pumps

15.17.1 All power pumps which are essential for bilge services are to be of the self-priming type, unless an approved central priming system is provided for these pumps. Details of this system are to be submitted.

15.17.2 Cooling water pumps having emergency bilge suctions need not be of the self-priming type.

15.18 Pump connections

15.18.1 The connections at the bilge pumps are to be such that one unit may continue in operation when the other unit is being opened up for overhaul.

15.18.2 Pumps required for essential services are not to be connected to a common suction or discharge chest or pipe unless the arrangements are such that the working of any pumps so connected is unaffected by the other pumps being in operation at the same time.

15.19 Direct bilge suctions

15.19.1 The direct bilge suctions in the machinery space are to be led to independent power pumps, and the arrangements are to be such that these direct suctions can be used independently of the main bilge line suctions.

15.20 Main bilge line suctions

15.20.1 Suctions from the main bilge line, i.e. branch bilge suctions, are to be arranged to draw water from any hold or machinery compartment within the craft, excepting small spaces such as those mentioned in 15.5 and 15.6 where manual pump suctions are accepted, and are not to be of smaller diameter than that required by the formula in 15.12.2.

15.21 Prevention of communication between compartments

15.21.1 The arrangement of valves, cocks and their connections is to be such as to prevent the possibility of one watertight compartment being placed in communication with another, or of dry cargo spaces, machinery spaces or other dry compartments being placed in communication with the sea or with tanks. For this purpose, screw-down non-return valves are to be provided in the following fittings:

- Bilge valve distribution chests.
- Bilge suction hose connections, whether fitted directly to the pump or on the main bilge line.
- Direct bilge suctions and bilge pump connections to main bilge line.

15.22 Isolation of bilge system

15.22.1 Bilge pipes which are required for draining cargo or machinery spaces are to be entirely distinct from sea inlet pipes or from pipes which may be used for filling or emptying spaces where water or oil is carried. This does not, however, exclude a bilge ejection connection, a connecting pipe from a pump to its suction valve chest, or a deep tank suction pipe suitably connected through a change-over device to a bilge, ballast or oil line.

15.23 Machinery space suctions – Mud boxes

15.23.1 Suctions for bilge drainage in machinery spaces and tunnels, other than emergency suctions, are to be led from easily accessible mud boxes fitted with straight tail pipes to the bilges and having covers secured in such a manner as to permit their being expeditiously opened or closed. Strum boxes are not to be fitted to the lower ends of these tail pipes or to the emergency bilge suctions.

15.24 Hold suctions – Strum boxes

15.24.1 The open ends of bilge suctions in holds and other compartments outside machinery spaces and tunnels are to be enclosed in strum boxes having perforations of not more than 10 mm diameter, whose combined area is not less than twice that required for the suction pipe. The boxes are to be so constructed that they can be cleared without breaking any joint of the suction pipe.

15.25 Tail pipes

15.25.1 The distance between the foot of all bilge tail pipes and the bottom of the bilge well is to be adequate to allow a full flow of water and to facilitate cleaning.

15.26 Location of fittings

15.26.1 Bilge valves, cocks and mud boxes are to be fitted at, or above, the machinery space platforms.

15.26.2 Where relief valves are fitted to pumps having sea connections, these valves are to be fitted in readily visible positions above the platform. The arrangements are to be such that any discharge from the relief valves will also be readily visible.

15.27 Bilge pipes in way of double bottom tanks

15.27.1 Bilge suction pipes are not to be led through double bottom tanks if it is possible to avoid doing so.

15.27.2 Bilge pipes which have to pass through these tanks are to have a minimum wall thickness of 6,3 mm. The thickness of pipes made from material other than steel will be specially considered.

15.27.3 Expansion bends, not glands, are to be fitted to these pipes within the tanks, and the pipes are to be tested, after installation, to the same pressure as the tanks through which they pass.

15.28 Hold bilge non-return valves

15.28.1 Where non-return valves are fitted to the open ends of bilge suction pipes in cargo holds in order to decrease the risk of flooding, they are to be of an approved type which does not offer undue obstruction to the flow of water.

■ *Section 16* Additional requirements for yachts that are 500 gt or more

16.1 General

16.1.1 Yachts that are 500 gt or more are to comply with Section 15 of this Chapter and in addition the following requirements.

16.2 Location of bilge pumps and bilge main

16.2.1 At least three power bilge pumps are to be provided, one of which may be operated from the main engines. Wherever practicable they are to be located in separate watertight compartments which will not readily be flooded by the same damage. If the engines are in two or more watertight compartments, the bilge pumps are to be distributed throughout these compartments so far as possible.

16.2.2 Where compliance with 16.2.1 is impractical, two independently driven bilge pumps may be accepted provided they are located in separate watertight compartments. If both pumps are necessarily located in the machinery space then one is to be of the submersible type with its source of power located above the bulkhead deck.

16.2.3 The bilge main is to be so arranged that no part is situated nearer the side of the craft than *B*/5, measured at right angles to the centreline at the level of the deepest sub-division load line, where *B* is the breadth of the craft.

16.2.4 Where any bilge pump or its pipe connection to the bilge main is situated outboard of the *B*/5 line, then a non-return valve is to be provided in the pipe connection at the junction with the bilge main.

16.2.5 Each independent bilge pump is to have a direct bilge suction from the space in which it is situated, but not more than two such suctions are required in any one space. The suctions are to be arranged such that each side of the space is fitted with at least one suction.

16.3 Prevention of communication between compartments in the event of damage

16.3.1 Provision is to be made to prevent the compartment served by any bilge suction pipe being flooded, in the event of the pipe being severed, or otherwise damaged by collision or grounding in any other compartment. For this purpose, where any part of a branch bilge pipe is situated outboard of the *B*/5 line or in a duct keel, a non-return valve is to be fitted to the pipe in the compartment containing the open end.

16.4 Arrangement and control of bilge valves

16.4.1 Distribution boxes, valves and cocks in connection with the bilge pumping arrangements are to be so arranged that, in the event of flooding, one of the bilge pumps may be operative on any compartment.

16.4.2 Where there is only one system of pipes common to all pumps, the arrangements are to be such that if the machinery space or other compartment is flooded then it is possible to operate the necessary valves and cocks in order to take suction from that compartment. For this purpose it may be necessary to arrange for remote control of the bilge suction valves from above the bulkhead deck.

16.4.3 Where, in addition to the main bilge pumping system, an emergency bilge pumping system is provided, it is to be independent of the main system and so arranged that a pump is capable of operating on any compartment under flooding conditions. In this case, only the valves and cocks necessary for the operation of the emergency system need to be capable of being operated from above the bulkhead deck.

16.4.4 All valves and cocks mentioned in 16.4.2 which can be operated from above the bulkhead deck are to have their controls at their place of operation clearly marked and provided with means to indicate whether they are open or closed.

16.5 Cross flooding arrangements

16.5.1 Where divided deep tanks or side tanks are provided with cross flooding arrangements to limit the angle of heel after side damage, the arrangements are to be self-acting where practicable. In any case, where controls to cross flooding fittings are provided, they are to be operable from above the bulkhead deck.

■ *Section 17* Requirements for Air Cushion Vehicles

17.1 General

17.1.1 At least three copies of the following diagrammatic plans are to be submitted together with a general description of each system, indicating operating pressures and temperatures, etc., safety devices incorporated and means of protection against corrosion and contamination:

- Oil fuel.
- Lubricating oil.
- Hydraulic and pneumatic systems.
- Pumping arrangements for draining and trimming.
- Air filtering to power units.

17.1.2 Reference is to be made to the *Guidance Notes and Requirements for the Classification of Air Cushion Vehicles (ACV) 1970*.

■ *Section 1* Application

1.1 Applicability of requirements

1.1.1 The requirements of Sections 2 to 8 of this Chapter apply to piping systems on mono-hull and multi-hull craft except where modified by Sections 9 to 11 as applicable.

1.1.2 Special requirements for multi-hull craft are given in Section 9.

1.1.3 These requirements satisfy the relevant design and construction requirements of the HSC Code. They are also applicable to yachts and service craft of more than 24 m not required to comply with the Code.

1.1.4 Requirements for Passenger (A) Craft are given in Section 10.

1.1.5 Requirements for small craft not required to comply with the HSC Code are given in Section 11.

1.1.6 In addition to the requirements of this Chapter, attention is to be given to any relevant statutory requirements of the National Authority of the country in which the craft is to be registered.

■ *Section 2* General requirements

2.1 General

2.1.1 The maximum working pressure in any part of a fluid system is not to be greater than the design pressure.

2.1.2 Where the design pressure of a system component, such as a valve or a fitting, is less than that for the pipe or tubing, the system pressure is to be limited to the lowest of the component design pressures. Every system which may be exposed to pressures higher than the design pressure is to be safeguarded by appropriate relief devices.

2.1.3 Materials used in piping systems are to be compatible with the fluid conveyed and due regard given to the risk of fire. Non-metallic piping material may be permitted in certain systems, provided the integrity of the hull and watertight decks and bulkheads is maintained.

2.1.4 The design of pipework systems is to be in accordance with the requirements of Chapter 1.

■ *Section 3* Oil fuel storage

3.1 Flash point

3.1.1 The flash point (closed cup test) of oil fuel for use in craft classed for unrestricted service is in general to be not less than 60°C. For emergency generator engines, a flash point of not less than 43°C is permissible.

3.1.2 Oil fuel with a flash point lower than 60°C may be used in craft intended for restricted service where it can be demonstrated that the temperature of machinery spaces will always be 10°C below the flash point of the oil fuel.

3.1.3 The use of oil fuel with a flash point below 43°C is not recommended. However, oil fuel with a lower flash point, but not lower than 35°C, may be used in gas turbines only subject to compliance with the provisions specified in Section 5.

3.1.4 Proposals for the use or carriage of oil fuel with a lower flash point will be specially considered.

3.2 Oil fuel storage arrangements

3.2.1 Tanks containing oil fuel are to be separated from passenger, crew and baggage compartments by vapour-proof enclosures or cofferdams which are suitably ventilated and drained.

3.2.2 Oil fuel tanks are not to be located in or adjacent to major fire hazard areas.

3.2.3 Oil fuel is not to be carried forward of the area for which public spaces or crew accommodation are permitted.

3.2.4 No oil fuel tank is to be situated where spillage or leakage therefrom can constitute a hazard by falling on heated surfaces.

3.2.5 Safe and efficient means of ascertaining the amount of oil fuel contained in any oil fuel tank is to be provided, *see also* Ch 2,11.9 to 11.12.

3.2.6 Oil fuel tanks are to be provided with self-closing valves or cocks for draining water from the bottom of the tanks.

3.2.7 As far as practicable, all parts of the oil fuel system containing heated oil under pressure exceeding 2 bar are not to be placed in a concealed position such that defects and leakage cannot be readily observed. The machinery spaces in way of such parts of the oil fuel system are to be adequately illuminated.

3.2.8 Oil fuel tanks are to be provided with oil-tight drip trays of sufficient capacity having suitable drainage arrangements.

3.2.9 In general oil fuel tanks are not to be used for carriage of water ballast. Where this is unavoidable the fuel transfer system is to be isolated from the ballast system and either oily water separating equipment is to be installed, or discharge to shore facilities provided, in accordance with the requirements of the *International Convention for the Prevention of Pollution from Ships* in force.

3.3 Oil fuel storage arrangements for yachts and service craft of 24 m or greater in length, which are not required to comply with the HSC Code

3.3.1 Oil fuel tanks are normally to be located outside machinery spaces and other areas of major fire hazard.

3.3.2 Where structural tanks are located adjacent to machinery spaces they are to be arranged such that the area of the tank common with the machinery space is kept to a minimum. In craft constructed of aluminium or other heat sensitive material the tanks are to be suitably protected against the effect of fire in the machinery space.

3.3.3 Where free standing tanks are fitted in machinery spaces they are to be of steel or equivalent material and positioned in an oil tight drip tray of ample size having suitable drainage arrangements to a spill oil tank.

3.3.4 For yachts that are 500 gt or more, free standing oil fuel tanks are not to be fitted in machinery spaces, *see* Pt 17, Ch 3,3.17.3.

3.3.5 The requirements of 3.2.4 to 3.2.8 are to be complied with. Where free standing tanks are fitted they are to comply with the requirements of 11.3.1 to 11.3.3.

3.4 Unattended machinery

3.4.1 Where machinery is fitted with automatic or remote controls so that under normal operating conditions it does not require any manual intervention by the operators, the requirements of 3.4.2 to 3.4.5 apply.

3.4.2 Where daily service tanks are filled automatically or by remote control, means are to be provided to prevent overflow spillages.

3.4.3 Other equipment which treats flammable liquid automatically, such as oil fuel purifiers, are to have arrangements to prevent spillage of the liquid through overflow or malfunction of seals.

3.4.4 Alarms are to be provided for purifier broken water seal and high oil inlet temperature.

3.4.5 Where daily service oil fuel tanks or settling tanks are fitted with heating arrangements, a high temperature alarm is to be provided if the flash point of the oil can be exceeded. This alarm is to be separate from the temperature control system.

3.4.6 Oil fuel service tanks are to be provided with high and low level alarms. Where a common overflow tank is fitted, a high level alarm in the common overflow tank may be accepted.

3.4.7 Oil and gas dual-fired systems for boilers and engines are to be provided with indication to show which fuel is in use.

■ *Section 4* Oil fuel systems

4.1 Oil fuel supply to main and auxiliary engines

4.1.1 Two or more filters are to be fitted in the oil fuel supply lines to the main and auxiliary engines, and the arrangements are to be such that any filter can be cleaned without interrupting the supply of filtered oil fuel to the engines.

4.2 Booster pumps

4.2.1 Where an oil fuel booster pump is fitted, which is essential to the operation of the main engine, a standby pump is to be provided.

4.2.2 The standby pump is to be connected ready for immediate use, but where two or more main engines are fitted, each with its own pump, a complete spare pump may be accepted provided that it is readily accessible and can easily be installed.

4.3 Fuel valve cooling pumps

4.3.1 Where pumps are provided for fuel valve cooling, the arrangements are to be in accordance with 4.2.1 and 4.2.2.

4.4 Transfer pumps

4.4.1 Where a power driven pump is necessary for transferring oil fuel, a standby pump is to be provided and connected ready for use. The standby pump may be a manual pump. Alternatively, emergency connections may be made to another suitable power driven pump.

4.5 Control of pumps

4.5.1 All independently driven oil fuel transfer and pressure pumps are to be capable of being stopped locally and from a position outside of the space in which they are located. The remote stop position is always to be accessible in the event of fire occurring in the space in which these pumps are located.

4.6 Relief valves on pumps

4.6.1 All pumps which are capable of developing a pressure exceeding the design pressure of the system are to be provided with relief valves. Each relief valve is to be in close circuit, i.e. arranged to discharge back to the suction side of the pump and to effectively limit the pump discharge pressure to the design pressure of the system.

4.7 Pump connections

4.7.1 Valves or cocks are to be interposed between the pumps and the suction and discharge pipes, in order that any pump may be shut off for opening up and overhauling.

4.8 Low pressure pipes

4.8.1 Transfer, suction and other low pressure oil pipes and all pipes passing through oil storage tanks are to be suitable for a working pressure of not less than 7 bar.

4.9 Valves on deep tanks and their control arrangements

4.9.1 Every oil fuel suction pipe from a storage, settling or daily service tank situated above the double bottom, and every oil fuel levelling pipe, is to be fitted with a valve or cock secured to the tank.

4.9.2 In machinery spaces such valves and cocks are to be capable of being closed locally and from positions outside these spaces which will always be accessible in the event of fire occurring in these spaces. Instructions for closing the valves or cocks are to be indicated at the valves and cocks and at the remote control positions.

4.9.3 In the case of tanks of less than 0,5 m^3, consideration will be given to the omission of remote controls for craft not required to comply with the HSC Code.

4.9.4 Every oil fuel suction pipe which is led into the machinery spaces, from a deep tank outside these spaces, is to be fitted in the machinery space with a valve controlled as in 4.9.2 except where the valve on the tank is already capable of being closed from an accessible position above the bulkhead deck.

4.9.5 Where the filling pipes to deep oil tanks are not connected to the tanks near the top, they are to be provided with non-return valves at the tanks or with valves or cocks fitted and controlled as in 4.9.2.

4.10 Filling arrangements

4.10.1 Filling stations are to be isolated from other spaces and are to be efficiently drained and ventilated.

4.10.2 Provision is to be made against over-pressure in the filling pipelines. Any relief valve fitted for this purpose is to discharge to an overflow tank or other safe position.

4.11 Precautions against fire

4.11.1 Pipes, valves and couplings conveying flammable fluids are to be installed, screened or otherwise suitably protected, to avoid spray or leakages onto hot surfaces, into machinery air intakes, or other sources of ignition such as electrical equipment. The number of joints in such systems is to be kept to a minimum.

■ *Section 5* Low flash point fuels

5.1 General

5.1.1 For craft having oil fuel with a flash point below 43°C the arrangements for the storage, distribution and utilisation of the oil fuel are to be such that the safety of the craft and persons on board is preserved, having regard to fire and explosion hazards. The arrangements are to comply with Sections 3, 4 and 5.1.2 to 5.1.6.

5.1.2 Tanks for the storage of such oil fuel are to be located outside any machinery space and at a distance of not less than 760 mm inboard from the shell and bottom plating, and from decks and bulkheads.

5.1.3 The spaces in which oil fuel tanks are located are to be mechanically ventilated using exhaust fans providing not less than six air changes per hour. The fans are to be such as to avoid the possibility of ignition of flammable gas air mixtures. Suitable wire mesh guards are to be fitted over inlet and outlet ventilation openings. The outlets for such exhausts are to discharge to a safe position.

5.1.4 A fixed vapour detection system is to be installed in each space through which oil fuel lines pass, with alarms provided at a continuously manned control station.

5.1.5 Safe and efficient means of ascertaining the amount of oil fuel contained in any tank is to be provided. Gauge glasses are not to be used. Other means of ascertaining the amount of oil fuel contained in any tank may be permitted if such means do not require penetration below the top of the tank, and providing their failure or overfilling of the tanks will not permit the release of oil fuel.

5.1.6 Vessel to shore oil fuel connections are to be of closed type and suitably grounded during bunkering operations.

5.1.7 Air pipes shall discharge to a safe position and terminate with flame arresters in accordance with MSC/ Circ. 677.

■ *Section 6* **Lubricating/hydraulic oil systems**

6.1 Lubricating oil arrangements

6.1.1 The arrangements for the storage, distribution and utilization of oil used in pressure lubrication systems in machinery spaces and, whenever practicable, in auxiliary machinery spaces are to comply with the provisions of 3.2 (except 3.2.2), 3.4 and 4.9 (except 4.9.3).

6.1.2 Tanks containing lubricating oil located within major fire hazard areas are to be of steel or other equivalent material.

6.1.3 Where lubricating oil tanks have a capacity of less than 0,5 m^3, consideration will be given to relaxing the requirements for remote controls to be fitted.

6.1.4 Where the lubricating oil for main propelling engines is circulated under pressure, provision is to be made for the efficient filtration of the oil. The filters are to be capable of being cleaned without stopping the engine or reducing supply of filtered oil to the engine. Proposals for an automatic by-pass for emergency purposes in high speed engines are to be submiited for consideration.

6.1.5 In addition, craft of 24 m or greater in length are to comply with the requirements of 4.5 to 4.7.

6.2 Arrangements for other flammable oils

6.2.1 The arrangements for storage, distribution and utilization of other flammable oils employed under pressure in power transmission, control/activating and heating systems, in locations where means of ignition are present, are to comply with the applicable provisions of 6.1.

6.3 Lubricating/hydraulic oil standby arrangements

6.3.1 Where lubricating oil for the main engine(s) is circulated under pressure, a standby lubricating oil pump is to be provided where the following conditions apply:

(a) The lubricating oil pump is independently driven and the total output of the main engine(s) exceeds 500 kW.
(b) One main engine with its own pump is fitted and the output of the engine exceeds 500 kW.
(c) More than one engine each with its own lubricating oil pump is fitted and the output of each engine exceeds 500 kW.

6.3.2 The standby pump is to be of sufficient capacity to maintain the supply of oil for normal conditions with any one pump out of action. The pump is to be fitted and connected ready for immediate use, except that where the conditions referred to in 6.3.1(c) apply, a complete spare pump may be accepted. In all cases, satisfactory lubrication of the engines is to be ensured while starting and manoeuvring.

6.3.3 Similar provisions to those of 6.3.1 and 6.3.2 are to be made where separate lubricating/hydraulic oil systems are employed for piston cooling, reduction gears, oil operated couplings controllable pitch propellers and steering systems etc., unless approved alternative arrangements are provided.

6.3.4 Independently driven pumps of rotary type are to be fitted with a non-return valve on the discharge side of the pump.

6.4 Lubricating oil contamination

6.4.1 The materials used in the storage and distribution of lubricating oil are to be selected such that they do not introduce or modify the properties of the oil. The use of cadmium or zinc in lubricating oil systems where they may come into contact with the oil is not permitted.

6.4.2 Arrangements are to be made for each forced lubrication system, renovation system, ready to use tank(s) and their associated rundown lines to drain tanks to be flushed after system installation and prior to running of machinery. The flushing arrangements are to be in accordance with the equipment manufacturer's procedures and recommendations.

6.4.3 The design and construction of engine and gear box piping arrangements are to prevent as far as practicable, contamination of engine lubricating oil systems by leakage of cooling water or from bilge water where engines or gearboxes are partly installed below the lower platform.

6.4.4 Where a lubricating oil filling pipe and cap are provided for engines and other machinery, provision is to be made for the topping up oil to pass through a gauze strainer. The caps are to be capable of being secured in the closed position.

6.4.5 Sampling points are to be provided that enable samples of lubricating oil to be taken in a safe manner. The sampling arrangements are to have the capability to provide samples when machinery is running and are to be provided with valves and cocks of the self-closing type and located in positions as far removed as possible from any heated surface or electrical equipment.

■ *Section 7* Engine cooling water systems

7.1 General

7.1.1 The cooling arrangements provided are to be adequate to maintain all lubricating and hydraulic fluid temperatures within the manufacturer's recommended limits.

7.2 Main supply

7.2.1 Provision is to be made for an adequate supply of cooling water to the main propelling machinery and essential auxiliary engines, also to the lubricating oil and fresh water coolers and air coolers for electric propelling machinery, where these coolers are fitted. The cooling water pump(s) may be worked from the engines or be driven independently.

7.3 Standby supply

7.3.1 Provision is also to be made for a separate supply of cooling water from a suitable independent pump of adequate capacity.

7.3.2 The following arrangements are acceptable depending on the purpose for which the cooling water is intended:

(a) Where only one main engine is fitted, the standby pump is to be connected ready for immediate use.

(b) Where more than one main engine is fitted, each with its own pump, a complete spare pump of each type may be accepted.

(c) Where fresh water cooling is employed for main and/or auxiliary engines, a standby fresh water pump need not be fitted if there are suitable emergency connections from a salt water system.

(d) Where each auxiliary engine is fitted with a cooling water pump, standby means of cooling need not be provided. Where, however, a group auxiliary engine is supplied with cooling water from a common system, a standby cooling water pump is to be provided for this system.

This pump is to be connected ready for immediate use and may be a suitable general service pump.

7.4 Selection of standby pumps

7.4.1 When selecting a pump for standby purposes, consideration is to be given to the maximum pressure which it can develop if the overboard discharge valve is partly or fully closed. Where necessary, water boxes, etc., are to be protected against inadvertent over-pressure by an approved device.

7.5 Relief valves on main cooling water pumps

7.5.1 Where cooling water pumps can develop a pressure head greater than the design pressure of the system, they are to be provided with relief valves on the pump discharge to effectively limit the pump discharge pressure to the design pressure of the system.

7.6 Sea inlets

7.6.1 Not less than two sea inlets are to be provided for the pumps supplying the sea water cooling system, one for the main pump and one for the standby pump. Alternatively, the sea inlets may be connected to a suction line available to main and standby pumps.

7.6.2 Where standby pumps are not connected ready for immediate use (*see* 7.3.2(b) and (d)), the main pump is to be connected to both sea inlets.

7.6.3 The auxiliary cooling water sea inlets are to be located one on each side of the craft.

7.7 Strainers

7.7.1 Where sea water is used for the direct cooling of the main engines and essential auxiliary engines, the cooling water suction pipes are to be provided with strainers which can be cleaned without interruption to the cooling water supply.

■ *Section 8* Miscellaneous machinery

8.1 General

8.1.1 Alarms and safeguards are indicated in Table 1.8.1.

Table 1.8.1 Miscellaneous machinery: Alarms and safeguards

Item	Alarm	Note
Coolant tanks level	Low	—
Sludge tanks level	High	—
Feed water tanks level	Low	Service tank only
Hydraulic control system pressure	Low	—
Pneumatic control system pressure	Low	—

Section 9
Special requirements for multi-hull craft

9.1 General

9.1.1 The requirements of Sections 1 to 8 are generally applicable to multi-hull craft except where these are modified by the requirements of this Section.

9.1.2 Where the machinery piping arrangements in each hull of a multi-hull craft are separate, the machinery piping and standby requirements for each hull are to be as detailed in 6.3.1(c) and 7.3.2(b), i.e. the requirements for a twin-engined mono-hull craft apply.

9.1.3 Where a multi-hull craft cannot navigate safely with the main propulsion machinery in one hull out of action, the machinery piping and standby requirements are to be as detailed in 6.3.1(a) or (b), and 7.3.2(a), i.e. the requirements for a single-engined mono-hull craft apply to the machinery in each hull.

Section 10
Requirements for Passenger (A) Craft

10.1 General

10.1.1 The requirements of Sections 1 to 9 apply except that the standby machinery arrangements detailed in Sections 6 and 7 are not required.

Section 11
Requirements for small craft which are not required to comply with the HSC Code

11.1 General

11.1.1 The requirements of this Section replace Sections 3.2 to 3.4 and 4, 5, 6 and 7 of this Chapter, *see also* Ch 1,15.

11.2 Oil fuel system

11.2.1 Where a power driven oil fuel transfer pump is fitted, it is to be capable of being stopped from a position outside the space which will always be accessible in the event of fire occurring in the compartment in which the pump is situated, as well as from the compartment itself.

11.2.2 Where a power driven pump is necessary for transferring oil fuel, a standby pump is to be provided and connected ready for use.

11.3 Separate oil fuel tanks

11.3.1 Except for very small tanks separate oil fuel tanks are to be not less than 3 mm in thickness. The seams are to be welded or brazed. Steel tanks are to be protected from corrosion.

11.3.2 Before installation, all tanks are to be tested by a head of water equal to the maximum to which the tanks may be subjected, but not less than 2,5 m above the crown of the tank.

11.3.3 Separate oil fuel tanks are to be securely fixed in position, and located as remote as practicable from exhaust manifolds and exhaust pipes or other hot surfaces and not above any electrical apparatus. Where this cannot be avoided, a drip tray is to be fitted under the tank and extended sufficiently to catch any drips from fittings attached to the tank.

11.3.4 Oil fuel tanks are not to be fitted above or adjacent to oil fired heaters, cooking stoves, equipment using naked flames or electrical equipment unless this is suitably constructed or enclosed.

11.4 Oil fuel filling

11.4.1 The filling pipe is to be of metallic construction and is to be a permanent fixture led from the deck and secured to the tank by an approved connection. A screwed cap and name plate inscribed ‘Oil Fuel’ is to be provided at the filling point.

11.4.2 Flexible hoses are not permitted as filling pipes. In wood or composite craft short lengths may be employed at the deck connection to accommodate any movement between the tank and the deck fitting.

11.5 Oil fuel supply

11.5.1 Provision is to be made for efficient filtration of the oil fuel supply to the engine.

11.6 Oil fuel valves and cocks

11.6.1 Outlet valves or cocks are to be fitted to all deep tanks. The valves are to be fitted directly to the tank plating and are to be capable of being closed locally and from positions which will always be readily accessible in the event of fire.

11.6.2 Valve covers are to be so constructed that they will not become slack when the valves are operated.

11.6.3 Heat sensitive materials are not to be used in the construction of valves and cocks.

11.6.4 Where drain cocks or valves are fitted to oil fuel tanks they are to be of the self-closing type and suitable provision is to be made for collecting the oil discharge.

11.7 Flexible hoses for oil fuel systems

11.7.1 Where necessary, flexible pipes of approved type may be used as short joining lengths to the engine.

11.8 Pipe joints for oil fuel systems

11.8.1 Where flanged joints are used the jointing material is to be impervious to oil. Cone type joints and approved types of compression fittings may be permitted for pipes having a bore not exceeding 40 mm.

11.8.2 Soft solder is not to be used for attaching pipe fittings.

11.9 Engine cooling system

11.9.1 Where sea water is used for the direct cooling of the engine, an efficient strainer which can be cleared from inside the craft is to be fitted between the sea inlet valve and the pump.

11.9.2 Means are to be provided for cleaning the strainer without interruption to the cooling water supply, where necessary.

11.9.3 Means are to be provided for indicating the temperature of the engine cooling media.

11.9.4 Alarms for the engine cooling water system are to be provided in accordance with Part 10.

11.10 Lubricating oil system

11.10.1 Where the lubricating oil for main propelling engines is circulated under pressure, provision is to be made for the efficient filtration of the oil.

11.10.2 Where necessary, flexible pipes of approved type may be used as short joining lengths to the engine.

11.10.3 In general, joints are to be of the flanged type with jointing materials which are impervious to oil. Cone type joints and approved types of compression fittings may be permitted for pipes having a bore not exceeding 40 mm.

11.10.4 Soft solder is not to be used for attaching pipe fittings.

11.10.5 Means are to be provided for indicating the lubricating oil pressure.

11.10.6 Alarms for the lubricating oil systems are to be provided in accordance with Part 10.

■ *Section 1* General requirements

1.1 Application

1.1.1 The requirements of this Chapter are applicable to fusion welded pressure vessels and their mountings and fittings, where plans have to be submitted in accordance with 1.2.

1.1.2 Seamless pressure vessels are to be manufactured in accordance with the requirements of the *Rules for the Manufacture, Testing and Certification of Materials* (hereinafter referred to as the Rules for Materials) where applicable.

1.1.3 Steam raising plant and associated pressure vessels should be designed and constructed in accordance with Pt 5, Ch 10 of the *Rules and Regulations for the Classification of Ships* (hereinafter referred to as the Rules for Ships).

1.2 Details to be submitted

1.2.1 Plans of pressure vessels are to be submitted in triplicate for consideration where all the conditions in (a) or (b) are satisfied:

(a) The vessel contains vapours or gases, e.g. air receivers, hydrophore or similar vessels and gaseous CO_2 vessels for fire-fighting, and
$pV > 600$
$p > 1$
$V > 100$
V = volume (litres) of gas or vapour space

(b) The vessel contains liquefied gases for fire-fighting, or flammable liquids, and
$p > 7$
$V > 100$
V = volume (litres)
p = design pressure (bar).

1.3 Materials

1.3.1 Materials used in the construction are to be manufactured and tested in accordance with the requirements of the Rules for Materials.

1.3.2 The specified minimum tensile strength of carbon and carbon-manganese steel plates, pipes, forgings and castings is to be within the following general limits:
(a) For seamless and Class 1 and Class 2/1 fusion welded pressure vessels:
340 to 520 N/mm^2.
(b) For Class 2/2 and Class 3 fusion welded pressure vessels:
340 to 430 N/mm^2.

1.3.3 Where it is proposed to use materials other than those specified in the Rules for Materials, details of the chemical compositions, heat treatment and mechanical properties are to be submitted for approval. In such cases, the values of the mechanical properties used for deriving the allowable stress are to be subject to agreement by Lloyd's Register (hereinafter referred to as 'LR').

1.4 Classification of fusion welded pressure vessels

1.4.1 Fusion welded pressure vessels are graded as Class 1 where the shell thickness exceeds 38 mm.

1.4.2 Fusion welded pressure vessels are graded as Class 2/1 and Class 2/2 if they comply with the following conditions:
(a) where the design pressure exceeds 17,2 bar, or
(b) where the metal temperature exceeds 150°C, or
(c) where the design pressure, in bar, multiplied by the actual thickness of the shell, in mm exceeds 157, or
(d) where the shell thickness does not exceed 38 mm.

1.4.3 For Rule purposes, Class 3 pressure vessels are to have a maximum shell thickness of 16 mm, and are pressure vessels not included in Classes 1, 2/1 or 2/2.

1.5 Design pressure

1.5.1 The design pressure is the maximum permissible working pressure and is to be not less than the highest set pressure of any safety valve.

1.6 Metal temperature

1.6.1 The metal temperature, T, used to evaluate the allowable stress, σ, is to be taken as the actual mean wall metal temperature expected under operating conditions for the pressure part concerned, and is to be stated by the manufacturer when plans of the pressure parts are submitted for consideration.

1.6.2 For fusion welded pressure vessels the minimum design temperature, T, is not to be less than 50°C.

1.7 Definition of symbols

1.7.1 The symbols used in the various formulae in Sections 2 to 6, unless otherwise stated, are defined as follows and are applicable to the specific part of the pressure vessel under consideration:

p = design pressure, in bar, *see* 1.5
r_i = inside knuckle radius, in mm
r_o = outside knuckle radius, in mm
t = minimum thickness, in mm
D_i = inside diameter, in mm
D_o = outside diameter, in mm
J = joint factor applicable to welded seams
R_i = inside radius, in mm
R_o = outside radius, in mm
T = design temperature, in °C
σ = allowable stress, in N/mm^2, *see* 1.8.

1.7.2 Where reference is made to calculated or actual plate thickness for the derivation of other values, these thicknesses are to be minus the standard Rule corrosion allowance of 0,75 mm, if not so stated.

1.8 Allowable stress

1.8.1 The term 'allowable stress', σ, is the stress to be used in the formulae for the calculation of scantlings of pressure parts.

1.8.2 The allowable stress, σ, is to be the lowest of the following values:

$$\sigma = \frac{E_t}{1,5}$$

$$\sigma = \frac{R_{20}}{2,7}$$

$$\sigma = \frac{S_R}{1,5}$$

where

E_t = specified minimum lower yield stress or 0,2 per cent proof stress at temperature, T, for carbon and carbon-manganese steels. In the case of austenitic steels, the 1,0 per cent proof stress at temperature, T, is to be used
R_{20} = specified minimum tensile strength at room temperature
S_R = average stress to produce rupture in 100 000 hours at temperature, T
T = metal temperature, *see* 1.6.

1.8.3 The allowable stress for steel castings is to be taken as 80 per cent of the value determined by the method indicated in 1.8.2, using the appropriate values for cast steel.

1.8.4 Where steels castings, which have been tested in accordance with Part 2, are also subjected to non-destructive tests, consideration will be given to increasing the allowable stress using a factor up to 90 per cent in lieu of the 80 per cent referred to in 1.8.3. Particulars of the non-destructive test proposals are to be submitted for consideration.

1.9 Joint factors

1.9.1 The following joint factors are to be used in the equations in Sections 2 to 6, where applicable. Fusion welded pressure parts are to be made in accordance with Section 8.

Class of pressure vessel	Joint factor
Class 1	1,0
Class 2/1	0,85
Class 2/2	0,75
Class 3	0,6

1.9.2 The longitudinal joints for all Classes of vessels are to be butt joints. Circumferential joints for Class 1 vessels and all classes of vessel for the production and storage of steam are also to be butt welds. Circumferential joints for Class 2/1, 2/2 and 3 vessels should also be butt joints with the following exceptions:

(a) Circumferential joints for Class 2/1, 2/2 and 3 vessels may be of the joggle type provided neither plate at the joints exceeds 16 mm thickness.
(b) Circumferential joints for Class 3 vessels may be of the lap type provided neither plate at the joint exceeds 16 mm thickness nor the internal diameter of the vessel exceeds 610 mm.

For typical acceptable methods of attaching dished ends, *see* Fig. 4.6.1.

1.10 Pressure parts of irregular shape

1.10.1 Where pressure parts are of such irregular shape that it is impracticable to design their scantlings by the application of formulae in this Chapter, the suitability of their construction is to be determined by hydraulic proof test of a prototype or by agreed alternative method.

Section 2
Cylindrical shells subject to internal pressure

2.1 Minimum thickness

2.1.1 Minimum thickness, t, of a cylindrical shell is to be determined by the following formula:

$$t = \frac{p R_i}{10\sigma J - 0{,}5p} + 0{,}75 \text{ mm}$$

where

t, p, R_i and σ are defined in 1.7

J = the joint factor of the longitudinal joints (expressed as a fraction), *see* 1.9.1. In the case of seamless shells clear of openings, J = 1,0.

2.1.2 The formula in 2.1.1 is applicable only where the resulting thickness does not exceed half the internal radius, i.e. where R_o is not greater than $1{,}5R_i$.

2.1.3 For fusion welded pressure vessels, t, is to be not less than $3 + \dfrac{D_i}{1500}$ mm,

where

D_i is as defined in 1.7.

2.1.4 The minimum thickness of vessels manufactured of corrosion resistant steels will be the subject of special consideration.

2.2 Unreinforced openings

2.2.1 The maximum diameter, d, of any unreinforced isolated openings is to be determined by the following formula:

$$d = 8{,}08\,[D_o\, t\,(1 - K)]^{1/3} \text{ in mm}$$

The value of K to be used is calculated from the following formula:

$$K = \frac{p D_o}{18{,}2\sigma t}$$ but is not to be taken as greater than 0,99

where

p, D_o and σ are as defined in 1.7

t = actual thickness of shell, in mm.

2.2.2 For elliptical or oval holes, d, for the purposes of 2.2.1, refers to the major axis when this lies longitudinally or to the mean of the major and minor axes when the minor axis lies longitudinally.

2.2.3 No unreinforced opening is to exceed 200 mm in diameter.

2.2.4 Holes may be considered isolated if the centre distance between two holes on the longitudinal axis of a cylindrical shell is not less than:

$$d + 1{,}1\sqrt{D\,t} \text{ with a minimum } 5d$$

where

d = diameter of openings in shell (mean diameter if dissimilarly sized holes are involved)

D = mean diameter of shell

t = actual thickness of shell

Where the centre distance is less than so derived, the holes are to be fully compensated.

2.3 Reinforced openings

2.3.1 Openings larger than those permitted by 2.2 are to be compensated in accordance with Fig. 4.2.1(a) or (b). The following symbols are used in Fig. 4.2.1(a) and (b):

t_s = calculated thickness of a shell without joint or opening or corrosion allowance, in mm

t_d = thickness calculated in accordance with 3.1 without corrosion allowance, in mm

t_a = actual thickness of shell plate without corrosion allowance, in mm

t_b = actual thickness of standpipe without minus tolerances and corrosion allowance, in mm

t_r = thickness of added reinforcement, in mm

D_i = internal diameter of cylindrical shell, in mm

d_o = diameter of hole in shell, in mm

L = width of added reinforcement not exceeding D, in mm

C = $\sqrt{d_o\, t_b}$ in mm

D = $\sqrt{D_i\, t_a}$ and is not to exceed $0{,}5d_o$, in mm

σ = shell plate allowable stress, N/mm^2

σ_p = standpipe allowable stress, N/mm^2

σ_r = added reinforcement allowable stress, N/mm^2

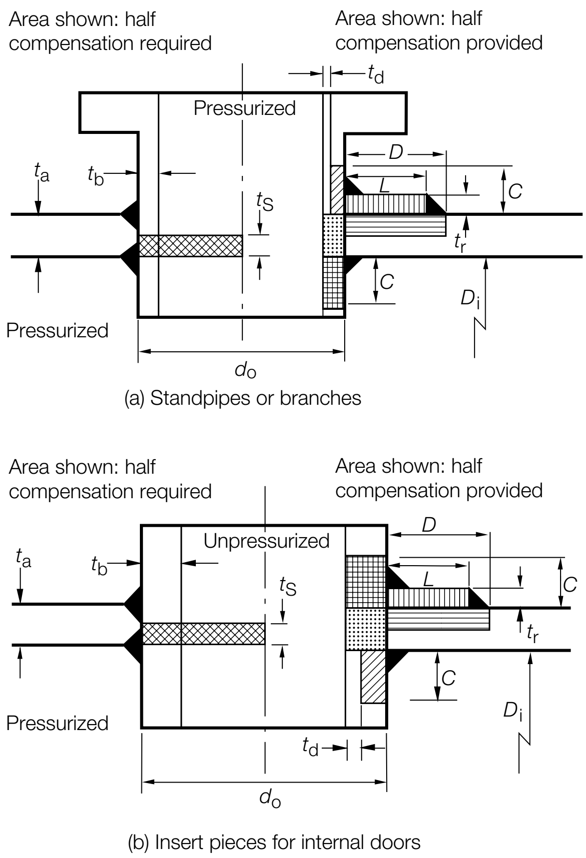
σ_w = weld metal allowable stress, N/mm^2

NOTE

σ_p, σ_r and σ_w are not to be taken as greater than σ.

2.3.2 For elliptical or oval holes, the dimension on the meridian of the shell is to be used for d_o in 2.3.1.

2.3.3 The welds attaching standpipes and reinforcing plates to the shell are to be of sufficient size to transmit the full strength of the reinforcing areas and all other loadings to which they may be subjected.



Compensation required:

$A_1 = d_o\, t_S$ mm²

Compensation provided:

$A_2 = 2D\,(t_a - t_S)$ mm²

$A_3 = 2\, t_b\, t_a \dfrac{\sigma_p}{\sigma}$ mm²

$A_4 = 2C\, t_b \dfrac{\sigma_p}{\sigma}$ mm²

$A_5 = 2C\,(t_b - t_d) \dfrac{\sigma_p}{\sigma}$ mm²

$A_6 = 2L\, t_r \dfrac{\sigma_r}{\sigma}$ mm²

A_7 = (Area of fillet welds) $\dfrac{\sigma_w}{\sigma}$ mm²

$A_2 + A_3 + A_4 + A_5 + A_6 + A_7 \geq A_1$

Fig. 4.2.1
Compensation for welded standpipes or branches in cylindrical shells

■ *Section 3* Spherical shells subject to internal pressure

3.1 Minimum thickness

3.1.1 The minimum thickness, *t*, of a spherical shell is to be determined by the following formula:

$$t = \frac{p\, R_i}{20\sigma\, J - 0{,}5p} + 0{,}75 \text{ mm}$$

where

t, p, R_i, σ and J are as defined in 1.7.

3.1.2 The formula in 3.1.1 is applicable only where the resulting thickness does not exceed half the internal radius.

3.1.3 Irrespective of the thickness determined by the formula in 3.1.1, *t* is to be not less than $\dfrac{D_i}{1500}$ + 3 mm for other pressure vessels, where D_i is as defined in 1.7.

3.1.4 The minimum thickness permitted for vessels manufactured in corrosion resistant steels will be the subject of special consideration.

3.1.5 Openings in spherical shells requiring compensation are to comply, in general, with 2.3, using the calculated and actual thicknesses of the spherical shell as applicable.

■ *Section 4* Dished ends subject to internal pressure

4.1 Minimum thickness

4.1.1 The thickness, *t*, of semi-ellipsoidal and hemispherical unstayed ends, and the knuckle section of torispherical ends, dished from plate, having pressure on the concave side and satisfying the conditions listed below, is to be determined by the following formula:

$$t = \frac{p\, D_o\, K}{20\sigma\, J} + 0{,}75 \text{ mm}$$

where

t, p, D_o, σ and J are as defined in 1.7

K = a shape factor, *see* 4.2 and Fig. 4.4.1.

4.1.2 For semi-ellipsoidal ends:

the external height, $H \geq 0{,}18D_o$

where

D_o = the external diameter of the parallel portion of the end, in mm.

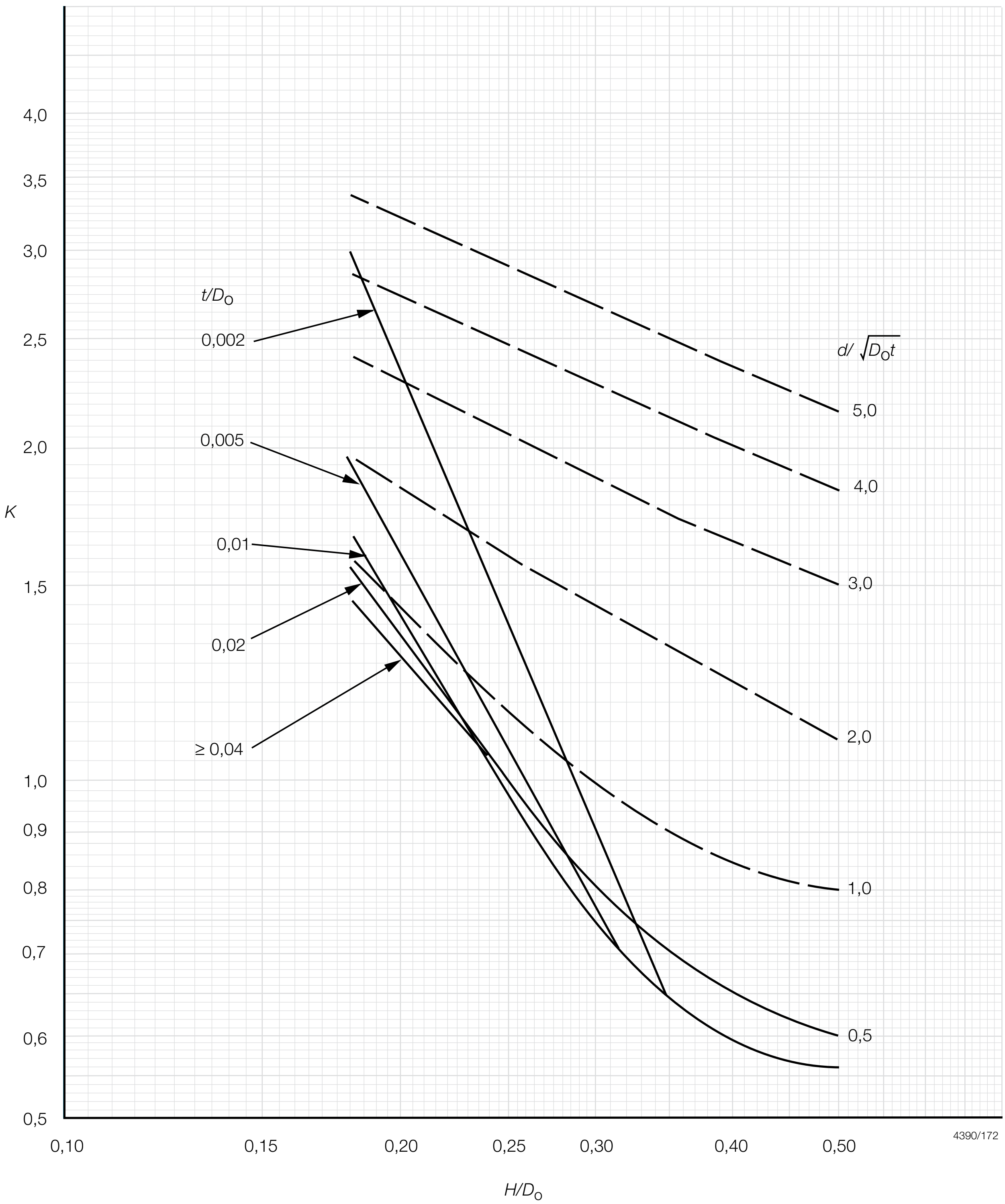


Fig. 4.4.1 Shape factor

4.1.3 For torispherical ends:

- the internal radius, $R_i \leq D_o$
- the internal knuckle radius, $r_i \geq 0{,}1D_o$
- the internal knuckle radius, $r_i \geq 3t$
- the external height, $H \geq 0{,}18D_o$ and is determined as follows:

$$H = R_o - \sqrt{(R_o - 0{,}5D_o)\,(R_o + 0{,}5D_o - 2r_o)}$$

4.1.4 In addition to the formula in 4.1.1 the thickness, t, of a torispherical head, made from more than one plate, in the crown section is to be not less than that determined by the following formula:

$$t = \frac{p\,R_i}{20\sigma J - 0{,}5p} + 0{,}75 \text{ mm}$$

where

t, p, R_i, σ and J are as defined in 1.7.

4.1.5 The thickness required by 4.1.1 for the knuckle section of a torispherical head is to extend past the common tangent point of the knuckle and crown radii into the crown section for a distance not less than $0{,}5\sqrt{R_i\,t}$ mm, before reducing to the crown thickness permitted by 4.1.4,

where

t = the required thickness from 4.1.1.

4.1.6 In all cases, H, is to be measured from the commencement of curvature, *see* Fig. 4.4.2.

4.1.7 For fusion welded pressure vessels the minimum thickness of the head, t, is to be not less than $3 + \frac{D_i}{1500}$ mm

where

D_i is as defined in 1.7.

4.1.8 For ends which are butt welded to the shell the thickness of the edge of the flange for connection to the shell is to be not less than the thickness of an unpierced seamless or welded shell, whichever is applicable, of the same diameter and material and determined by 2.1.

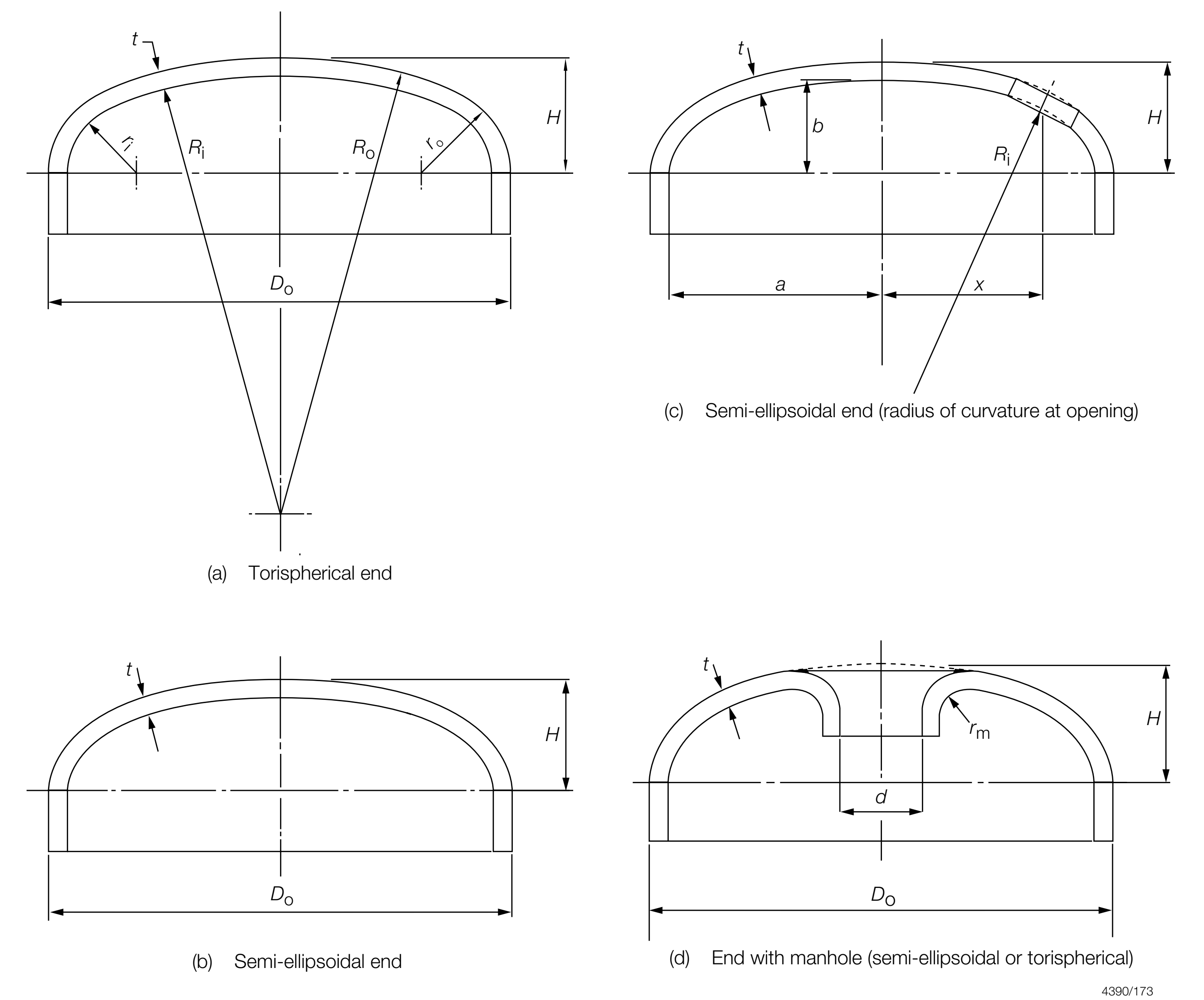


Fig. 4.4.2 Typical dished ends

4.2 Shape factors for dished ends

4.2.1 The shape factor, *K*, to be used in 4.1.1 is to be obtained from the curves in Fig. 4.4.1, and depends on the ratio of height to diameter $\frac{H}{D_o}$.

4.2.2 The lowest curve in the series provides the factor, *K*, for plain (i.e. unpierced) ends. For lower values of $\frac{H}{D_o}$, *K* depends upon the ratio of thickness to diameter, $\frac{t}{D_o}$, as well as on the ratio $\frac{H}{D_o}$, and a trial calculation may be necessary to arrive at the correct value of *K*.

4.3 Dished ends with unreinforced openings

4.3.1 Openings in dished ends may be circular, obround or approximately elliptical.

4.3.2 The upper curves in Fig. 4.4.1 provide values of *K*, to be used in 4.1.1, for ends with unreinforced openings. The selection of the correct curve depends on the value of $\frac{d}{\sqrt{D_o\, t}}$ and a trial calculation is necessary to select the correct curve,

where

d = the diameter of the largest opening in the end plate, in mm (in the case of an elliptical opening, the larger axis of the ellipse)

t = minimum thickness, after dishing, in mm

D_o = outside diameter of dished end, in mm.

4.3.3 The following requirements must in any case be satisfied:

$$\frac{t}{D_o} \leq 0{,}1$$

$$\frac{d}{D_o} \leq 0{,}7$$

4.3.4 From Fig. 4.4.1 for any selected ratio of $\frac{H}{D_o}$ the curve for unpierced ends gives a value for $\frac{d}{\sqrt{D_o\, t}}$ as well as for *K*. Openings giving a value of $\frac{d}{\sqrt{D_o\, t}}$ not greater than the value so obtained may thus be pierced through an end designed as unpierced without any increase in thickness.

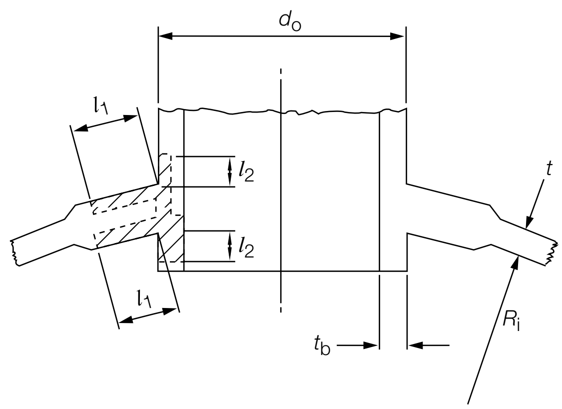
4.4 Flanged openings in dished ends

4.4.1 The requirements in 4.3 apply equally to flanged openings and to unflanged openings cut in the plate of an end. No reduction may be made in end plate thickness on account of flanging.

4.4.2 Where openings are flanged, the radius, r_m of the flanging is to be not less than 25 mm, *see* Fig. 4.4.2(d). The thickness of the flanged portion may be less than the calculated thickness.

4.5 Location of unreinforced and flanged openings in dished ends

4.5.1 Unreinforced and flanged openings in dished ends are to be so arranged that the distance from the edge of the hole to the outside edge of the plate and the distance between openings are not less than those shown in Fig. 4.4.3.



$l_1 = \sqrt{2R_i t}$ or $0{,}5d_o$ whichever is the lesser
l_2 is not to exceed $\sqrt{d_o t_b}$

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Fig. 4.4.3 Limits for reinforcement

4.6 Dished ends with reinforced openings

4.6.1 Where it is desired to use a large opening in a dished end of less thickness than would be required by 4.3, the end is to be reinforced. This reinforcement may consist of a ring or standpipe welded into the hole, or of reinforcing plates welded to the outside and/or inside of the end in the vicinity of the hole, or a combination of both methods, *see* Fig. 4.4.4. Forged reinforcements may be used.

4.6.2 Reinforcing material with the following limits may be taken as effective reinforcement:

(a) The effective width, l_1 of reinforcement is not to exceed $\sqrt{2R_i\, t}$ or $0{,}5d_o$ whichever is the lesser.

(b) The effective length, l_2 of a reinforcing ring is not to exceed $\sqrt{d_o\, t_b}$

where

R_i = the internal radius of the spherical part of a torispherical end, in mm, or

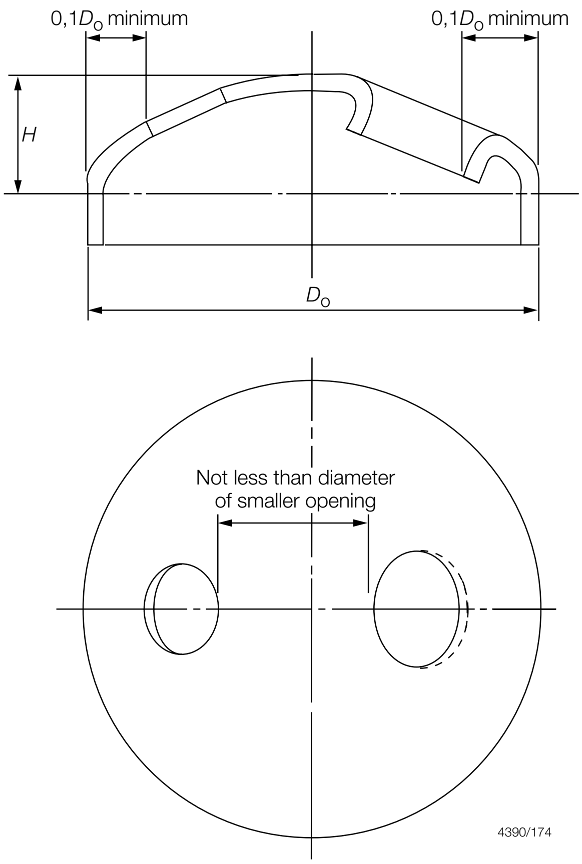


Fig. 4.4.4 Opening in dished ends

R_i = internal radius of the meridian of the ellipse at the centre of the opening, of a semi-ellipsoidal end, in mm, and is given by the following formula:

$$\frac{\left[a^4 - x^2\left(a^2 - b^2\right)\right]^{3/2}}{a^4\, b}$$

where

a, b and x are shown in Fig. 4.4.2(c)

d_o = external diameter of ring or standpipe, in mm

l_1 and l_2 are shown in Fig. 4.4.3

t_b = actual thickness of ring or standpipe, in mm.

4.6.3 The shape factor, K, for a dished end having a reinforced opening can be read from Fig. 4.4.1 using the value obtained from:

$$\frac{d_o - \frac{A}{t}}{\sqrt{D_o\, t}} \text{ instead of from } \frac{d}{\sqrt{D_o\, t}}$$

where

A = the effective cross-sectional area of reinforcement and is to be twice the area shown shaded on Fig. 4.4.3

As in 4.3, a trial calculation is necessary in order to select the correct curve.

4.6.4 The area shown in Fig. 4.4.3 is to be obtained as follows:

- Calculate the cross-sectional area of reinforcement both inside and outside the end plate within the length, l_1, plus the full cross-sectional area of that part of the ring or standpipe which projects inside the end plate up to a distance, l_2, plus the full cross-sectional area of that part of the ring or standpipe which projects outside the internal surface of the end plate up to a distance, l_2, and deduct the sectional area which the ring or standpipe would have if its thickness were as calculated in accordance with 5.1.

4.6.5 If the material of the ring or the reinforcing plates has an allowable stress value lower than that of the end plate, then the effective cross-sectional area, A, is to be multiplied by the ratio:

$$\frac{\text{allowable stress of reinforcing plate at design temperature}}{\text{allowable stress of end plate at design temperature}}$$

4.7 Torispherical dished ends with reinforced openings

4.7.1 If an opening and its reinforcement are positioned entirely within the crown section, the compensation requirements are to be as for a spherical shell, using the crown radius as the spherical shell radius. Otherwise, the requirements of 4.6 are to be applied.

■ *Section 5*
Standpipes and branches

5.1 Minimum thickness

5.1.1 The minimum wall thickness, t, of standpipes and branches is to be not less than the greater of the two values determined by the following formulae, making such additions as may be necessary on account of bending, static loads and vibrations:

$$t = \frac{p\, D_o}{20\sigma + p} + 0{,}75 \text{ mm}$$

$$t = 0{,}04 D_o + 2{,}5 \text{ mm}$$

where

t, p, D_o and σ are defined in 1.7.

If the second formula applies, the thickness need only be maintained for a length, L, from the outside surface of the vessel, but need not extend past the first connection, butt weld or flange, where:

$$L = 3{,}5\sqrt{D_o\, t} \text{ mm}$$

5.1.2 In no case does the wall thickness need to exceed that of the shell as required by 2.1, 3.1 or 4.1 as applicable.

■ *Section 6*
Unstayed circular flat end plates

6.1 Minimum thickness

6.1.1 Ends attached by welding are to be designed such that the minimum thickness of flat end plates is to be determined by the following formula:

$$t = d_i \sqrt{\frac{pC}{\sigma}} + 0{,}75 \text{ mm}$$

where

p and σ are as defined in 1.7.

t = minimum thickness of end plate, in mm

d_i = internal diameter of circular shell, in mm

C = a constant depending on method of end attachment, *see* Fig. 4.6.1

(a) For end plates welded as shown in Fig. 4.6.1(a):

C = 0,019 for circular shells.

(b) For end plates welded as shown in Figs. 4.6.1(b) and (c):

C = 0,028 for circular shells.

6.1.2 Where flat end plates are bolted to flanges attached to the ends of headers, the flanges and end plates are to be in accordance with recognized pipe flange standards.

6.1.3 Openings in flat plates are to be compensated in accordance with Fig. 4.2.1(a) or (b) with the value of A_1, the compensation required, calculated as follows:

$$A_1 = \frac{d_o}{2{,}4} t_f \text{ mm}^2$$

where

d_o = diameter of hole in flat plate, in mm

t_f = required thickness of the flat plate in the area under consideration, in mm, calculated in accordance with 6.1.1, as applicable, without corrosion allowance

Limit D = $0{,}5d_o$.

■ *Section 7*
Construction

7.1 Access arrangements

7.1.1 Pressure vessels are to be so made that the internal surfaces may be examined. Wherever practicable, the openings for this purpose are to be sufficiently large for access and for cleaning the inner surfaces.

7.1.2 Manholes in cylindrical shells should preferably have their shorter axes arranged longitudinally.

7.1.3 Doors for manholes and sightholes are to be formed from the steel plate or of other approved construction, and all jointing surfaces are to be machined.

7.1.4 Doors of the internal type are to be provided with spigots which have a clearance of not more than 1,5 mm all round, i.e. the axes of opening are not to exceed those of the door by more than 3 mm. The width of the manhole gasket seat is not to be less than 16 mm.

7.1.5 Doors of the internal type for openings not larger than 230 x 180 mm need be fitted with only one stud, which may be forged integral with the door. Doors for openings larger than 230 mm x 180 mm are to be fitted with two studs or bolts. The strength of the attachment to the door is not to be less than the strength of the stud or bolt.

7.1.6 The crossbars or dogs for doors are to be of steel.

7.1.7 External circular flat cover plates are to be in accordance with a recognized standard.

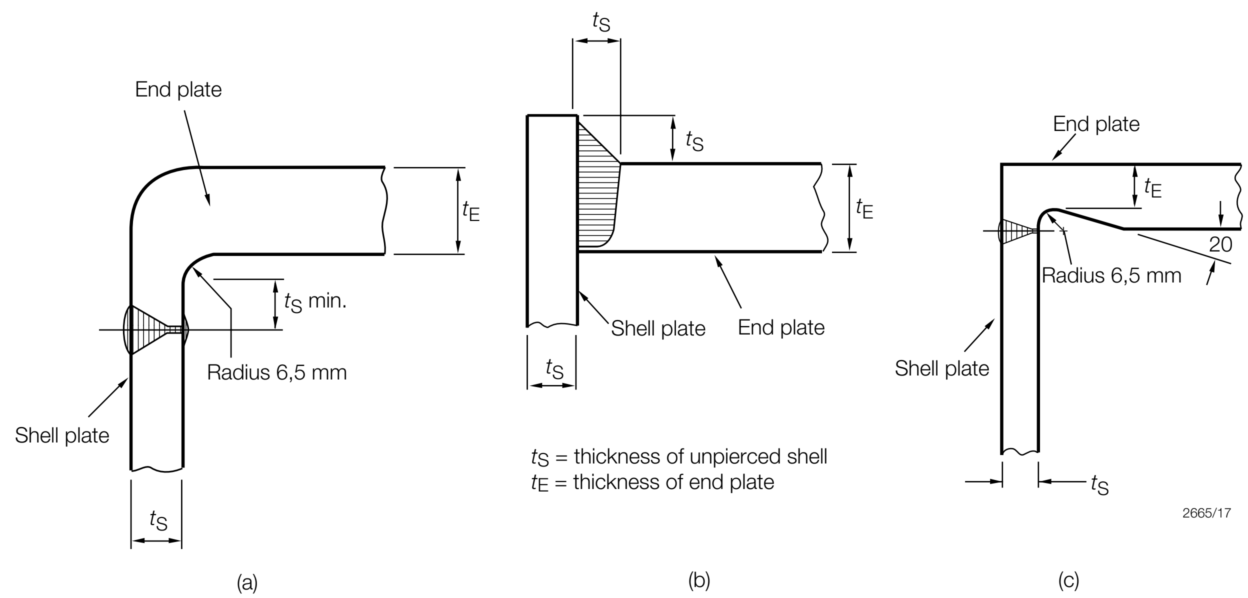


Fig. 4.6.1 Typical methods of attachment of unstayed circular flat end plates

7.2 Torispherical and semi-ellipsoidal ends

7.2.1 For typically acceptable types of attachment for dished ends to cylindrical shells, *see* Fig. 4.7.1. Types (d) and (e) are to be made a tight fit in the cylindrical shell.

7.2.2 Where the difference in thickness is the same throughout the circumference, the thicker plate is to be reduced in thickness by machining to a taper for a distance not less than four times the offset, so that the two plates are of equal thickness at the position of the circumferential weld. A parallel portion may be provided between the end of the taper and the weld edge preparation; alternatively, if so desired, the width of the weld may be included as part of the smooth taper of the thicker plate.

7.2.3 The thickness of the plates at the position of the circumferential weld is to be not less than that of an unpierced cylindrical shell of seamless or welded construction, whichever is applicable, of the same diameter and material, *see* 2.1.

7.3 Welded-on flanges, butt welded joints and fabricated branch pieces

7.3.1 Flanges may be cut from plates or may be forged or cast. Hubbed flanges are not to be machined from plate. Flanges are to be attached to branches by welding. Alternative methods of flange attachment will be subject to special consideration.

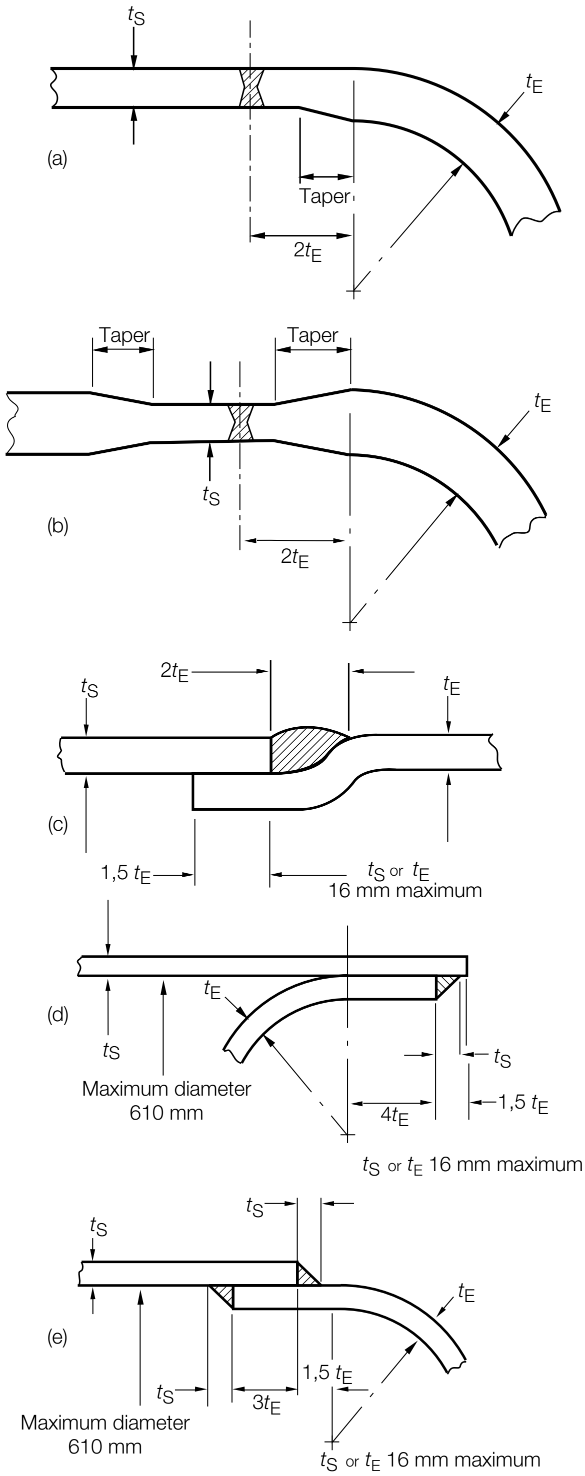
7.3.2 The types of welded-on flanges are to be suitable for the pressure, temperature and service for which the branches are intended.

7.3.3 Flange attachments and pressure-temperature ratings in accordance with materials and design of recognized standards will be accepted.

7.3.4 Typical examples of welded-on flange connections are shown in Fig. 4.7.2(a) to (f), and limiting design conditions for the flange types are shown in Table 4.7.1. In Fig. 4.7.2, *t* is the minimum Rule thickness of the standpipe or branch.

7.3.5 Welded-on flanges are not to be a tight fit on the branch. The maximum clearance between the bore of the flange and the outside diameter of the branch is to be 3 mm at any point, and the sum of the clearances diametrically opposite is not to exceed 5 mm.

7.3.6 Where butt welds are employed in the attachment of flange type (a), or in the construction of standpipes or branch pieces, the adjacent pieces are to be matched at the bores. This may be effected by drifting, roller expanding or machining, provided the pipe wall is not reduced below the designed thickness. If the parts to be joined differ in wall thickness, the thicker wall is to be gradually tapered to that of the thinner at the butt joint.



Type of end attachment	Acceptable for
(a) and (b)	All classes
(c)	2/1, 2/2 and 3
(d) and (e)	Class 3 only

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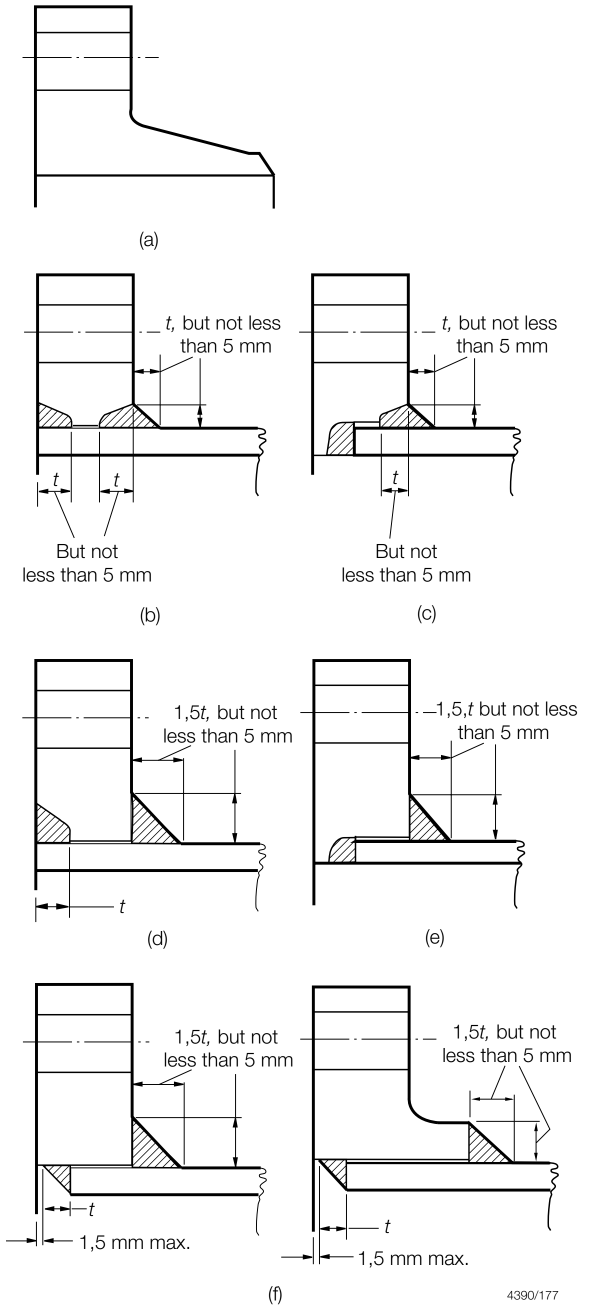
Fig. 4.7.1
Typical attachment of dished ends to cylindrical shell



'*t*' is the minimum Rule thickness of standpipe or branch

Fig. 4.7.2
Typical example of welded flange connections

7.3.7 Welding may be carried out by means of the shielded metal arc, inert gas metal arc, oxy-acetylene or other approved process, but in general, oxy-acetylene welding is suitable only for flange type (a) and is not to be applied to branches exceeding 100 mm diameter or 9,5 mm thick.

7.3.8 Threaded sleeve joints complying with Ch 1,5.5.1 may be used on the steam and water piping of small oil fired package boilers of the once through coil type, used for auxiliary or domestic purposes, where the feed pump capacity limits the output.

7.3.9 Socket weld joints are not to be used where fatigue, severe erosion, crevice corrosion or stress corrosion are expected to occur, for example, blow down, drain, scum and chemical dosing connections.

7.4 Welded attachments to pressure vessels

7.4.1 Unless the actual thickness of the shell or end is at least twice that required by calculation for a seamless shell or end, whichever is applicable, doubling plates with well rounded corners are to be fitted in way of attachments such as lifting lugs, supporting brackets and feet, to minimize load concentrations on pressure shells and ends. Compensating plates, pads, brackets and supporting feet are to be bedded closely to the surface before being welded, and are to be provided with a ‘tell-tale’ hole not greater than 9,5 mm in diameter, open to the atmosphere to provide for the release of entrapped air during heat treatment of the vessel, or as a means of indicating any leakage during hydraulic testing and in service.

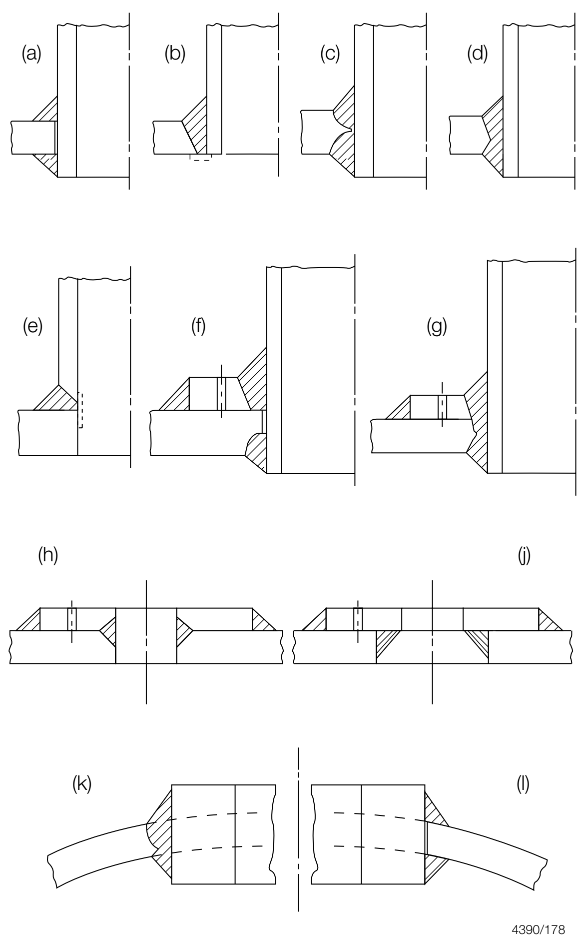
7.4.2 For acceptable methods of attaching standpipes, branches, compensating plates and pads, *see* Fig. 4.7.3. Alternative methods of attachment may be accepted provided details are submitted for consideration.

7.4.3 Where fillet welds are used to attach standpipes, there are to be equal sized welds both inside and outside the vessel shell, *see* Fig. 4.7.3(a) and (l). The leg length of each of the fillet welds is to be not less than the actual thickness of the thinner of the parts being joined.

Table 4.7.1 Limiting design conditions for flanges

Flange type	Maximum pressure	Maximum temperature	Maximum pipe o.d.	Minimum pipe bore
		°C	mm	mm
(a)	Pressure temperature ratings to be in accordance with a recognized standard	No restriction	No restriction	No restriction
(b)		No restriction	168,3 for alloy steels*	No restriction
(c)		No restriction	168,3 for alloy steels*	75
(d)		425	No restriction	No restriction
(e)		425	No restriction	75
(f)		425	No restriction	No restriction

NOTE
* No restriction for carbon steels



Type (a) and (l) attachments are not to be used for openings which require to be compensated. Backing rings may be used with types (b) and (e).

Fig. 4.7.3
Typical acceptable methods of attaching branches and pads

Section 8
Requirements for fusion welded pressure vessels

8.1 Class 1 and Class 2/1

8.1.1 Fusion welded pressure vessels constructed to Class 1 and Class 2/1 requirements will be accepted only if manufactured by firms equipped and competent to undertake high quality welding. In order that firms may be approved for this purpose, it will be necessary for the Surveyors to visit the works for the purpose of inspecting the welding plant equipment and procedures, and to arrange for the carrying out of preliminary tests as stated in Pt 5, Ch 17,3 of the Rules for Ships.

8.1.2 The welding plant and equipment are to be suitable for undertaking work of the standards required for Class 1 and Class 2/1 welding.

8.1.3 The works are to have an efficient testing laboratory, suitably equipped to carry out tensile, bend and impact tests, the X-ray examination of pressure vessels, and the metallographic examination of welds. The works are also to be equipped with a suitable heat treating furnace with satisfactory means of temperature control.

8.1.4 Alternative arrangements which, in the opinion of the Surveyors, ensure an equally high standard of quality control may be submitted for consideration.

8.1.5 On completion of the inspection and tests, the Surveyor's report, including the results of the preliminary tests is to be submitted for consideration. The report should also include the radiographs and particulars of any fusion welded pressure vessels previously constructed at these works.

8.2 Class 2/2

8.2.1 Pressure vessels made in accordance with Class 2/2 requirements will be accepted only if constructed by firms whose works are properly equipped to undertake the welding of pressure vessels of this Class.

8.2.2 It will be necessary for the Surveyors to visit the works for the purpose of inspecting the welding plant, equipment and procedures, and to arrange for the carrying out of preliminary tests as stated in 8.1.

8.2.3 On completion of the inspection and tests, the Surveyor's report, together with the results of the preliminary tests and particulars of fusion welded pressure vessels previously constructed at these works, is to be submitted for the consideration of the Committee.

8.3 Class 3

8.3.1 Class 3 pressure vessels will be accepted if constructed by firms whose works are equipped to undertake the welding of pressure vessels of this Class.

8.3.2 It will be necessary for the Surveyors to visit the works for the purpose of inspecting the welding plant, equipment and procedures, and to arrange for the carrying out of preliminary tests as stated in 7.1.

■ *Section 9* Mountings and fittings for pressure vessels

9.1 General

9.1.1 Each pressure vessel or system is to be fitted with a stop valve situated as close as possible to the shell.

9.1.2 Adequate arrangements are to be provided to prevent over-pressure of any part of a pressure vessel which can be isolated. Pressure gauges are to be fitted in positions where they can be easily read.

9.1.3 Adequate arrangements are to be provided for draining and venting the separate parts of each pressure vessel.

9.2 Receivers containing pressurized gases

9.2.1 Each air receiver is to be fitted with a drain arrangement at its lowest part, permitting oil and water to be blown out.

9.2.2 Each receiver which can be isolated from a relief valve is to be provided with a suitable fusible plug to discharge the contents in case of fire. The melting point of the fusible plug is to be approximately 150°C. *See also* 9.2.3 and 9.2.4.

9.2.3 Where a fixed system utilizing fire-extinguishing gas is fitted, to protect a machinery space containing an air receiver(s), fitted with a fusible plug, it is recommended that the discharge from the fusible plug be piped to the open deck.

9.2.4 Receivers used for the storage of air for the control of remotely operated valves are to be fitted with relief valves and not fusible plugs.

■ *Section 10* Hydraulic tests

10.1 Fusion welded pressure vessels

10.1.1 Fusion welded pressure vessels are to be tested on completion to a pressure, p_T, determined by the following formula, without showing signs of weakness or defect:

$$p_T = 1{,}3 \frac{\sigma_{50}}{\sigma_t} \frac{t}{(t - 0{,}75)} p$$

but in no case is to exceed

$$1{,}5 \frac{t}{(t - 0{,}75)} p$$

where

p = design pressure, in bar
p_T = test pressure, in bar
t = nominal thickness of shell as indicated on the plan, in mm
σ_T = allowable stress at design temperature, in N/mm^2
σ_{50} = allowable stress at 50°C, in N/mm^2.

10.2 Mountings

10.2.1 Mountings are to be subjected to a hydraulic test of twice the approved design pressure.

■ *Section 11* Fibre reinforced plastics pressure vessels

11.1 General

11.1.1 Pressure vessels may be constructed in fibre reinforced plastics provided the manufacturer is competent and suitably equipped for this purpose.

11.1.2 Pressure vessels are to be of standard design whose suitability has been established by fatigue and burst tests on a prototype.

11.2 Prototype testing

11.2.1 For the fatigue test the pressure shall be cycled from atmospheric to design pressure 100 000 times at the design temperature.

11.2.2 For the burst test the minimum bursting pressure shall be six times the design pressure.

11.3 Production hydraulic test

11.3.1 Vessels subject to internal pressure shall be hydraulically tested to not less than 1,5 times the design pressure.

■ *Section 12* Requirements for craft which are not required to comply with the HSC Code

12.1 Fibre reinforced plastics pressure vessels

12.1.1 Fibre reinforced plastics pressure vessels, where the product of the design pressure in bar and volume in litres exceeds 600, are not to be situated in machinery spaces or high risk areas on yachts and service craft less than 24 m.

12.1.2 Small fibre reinforced plastics pressure vessels will receive special consideration in relation to their intended duty and service conditions.