BRITISH STANDARD

BS 853-1:
1990+A3:2011

Specification for

Vessels for use in heating systems —

Part 1: Calorifiers and storage vessels for central heating and hot water supply

ICS 27.060.01

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Refrigeration, Heating and Air Conditioning Standards Policy Committee (RHE/-) to Technical Committee RHE/12, upon which the following bodies were represented:

Associated Offices Technical Committee
Boiler and Radiator Manufacturers Association Limited
British Non-Ferrous Metals Federation
Chartered Institution of Building Services Engineers
Copper Development Association
Department of the Environment (Property Services Agency)
Department of Transport (Marine Directorate)
Health and Safety Executive
Hevac Association
Institution of Mechanical Engineers
Waterheater Manufacturers Association

This British Standard, having been prepared under the direction of the the Refrigeration, Heating and Air Conditioning Standards Policy Committee, was published under the authority of the Board of BSI and comes into effect on 30 September 1990

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The following BSI references relate to the work on this standard:
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Amendments issued since publication

Amd. No.	Date	Comments
8157	June 1994	
8979	March 1996	
A3	September 2011	See Foreword

Contents

Foreword

This British Standard has been prepared under the direction of the Refrigeration, Heating and Air Conditioning Standards Policy Committee.

[A3⟩BS 853-1:1990+A3:2011 supersedes BS 853-1:1996, which incorporated Amendment Nos. 1 and 2 and is withdrawn.⟨A3]

[A3⟩ The start and finish of text introduced or altered by Amendment No. 3 is indicated in the text by tags [A3⟩ ⟨A3]. Minor editorial changes are not tagged. ⟨A3]

[A3⟩ When last revised, this British Standard was re-numbered BS 853-1:1996 ⟨A3] and re-tiled "Specification for vessels for use in heating systems — Part 1: Calorifiers and storage vessels for central heating and hot water supply" without any change to the content, as a consequence of the publication of — Part 2 of this standard entitled "Specification for vessels for use in heating systems — Part 2: Tubular heat exchangers and storage vessels for buildings and industrial services".

The standard was first published in 1939 and revised into two parts, covering carbon steel and copper, in 1960. A second revision was carried out in 1981, when the two parts were again combined, and this has now been updated to take account of current practice. No provision has been included for thermal performance tests.

NOTE Information concerning SI units is given in [A3⟩BS ISO 80000-1⟨A3].

[A3⟩ *Text deleted* ⟨A3]

Further information is available in Health and Safety Executive Guidance Note EH/10, Environmental Hygiene, Asbestos.

[A3⟩ Table 1 lists the latest European material designations. The elevated design stress values are based upon equivalent materials that have been listed in previous issues of this British Standard.⟨A3]

[A3⟩Annex⟨A3] B gives guidance for plant layout and installation.

Part 2 of this standard covers tubular heat exchangers and storage vessels for building and industrial services with higher duty requirements than Part 1, but for which the requirements of [A3⟩PD 5500⟨A3] are unnecessarily stringent.

[A3⟩ This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations. ⟨A3]

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 37, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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1 Scope

This British Standard specifies the strength and method of construction of calorifiers and storage vessels designed for central heating and hot water supply. It also specifies suitable safety devices and methods of pressure testing. The standard covers units with shells made from copper or carbon steel.

Reference is made to the protection from corrosion of carbon steel shells, by galvanizing, sealed zinc spraying or copper lining.

This standard covers calorifiers heated by steam, water, heat transfer fluid or electricity, but does not cover calorifiers with steam on the outside of the tube battery.

The information that the purchaser is recommended to supply to the manufacturer at the time of enquiry and order is given in [A3] Annex [A3] A.

NOTE The titles of the publications referred to in this standard are listed on page 36.

2 Definitions

For the purposes of this British Standard the following definitions apply.

2.1
calorifier

a closed cylindrical vessel in which water is indirectly heated under a pressure greater than atmosphere for the supply of hot water services, for central heating purposes and for industrial applications. The water is heated by tubular primary heaters, with hot water, steam or oil as the heating medium, or electric immersion heating elements

2.2
storage vessel

a closed cylindrical vessel containing water at a pressure greater than atmosphere for hot water services, central heating and industrial applications

2.3
design pressure

the value of pressure to be employed for calculation (see **4.1**)

2.4
design temperature

the value of temperature to be employed for calculation (see **4.2**)

2.5
secondary working pressure

the total pressure on the secondary side of the calorifier, i.e. the sum of the static and circulating pressures

2.6
purchaser

the organization or individual who buys the calorifier for its own use or as an agent for the owner

2.7
inspecting authority

the body or association which checks that the design, materials and construction are in accordance with this standard

3 Classification

3.1 General

Calorifiers and storage vessels shall be classified into grade A or B, as specified in **3.2** and **3.3**.

NOTE For calorifiers and storage vessels with operating conditions above those specified in this clause, reference should be made to BS 3274.

3.2 Grade A

Grade A calorifiers and storage vessels shall comply with the following requirements.

a) The working pressure in the shell shall not exceed 0.7 N/mm^2 (7.0 bar)[1)].

b) The design pressure in the shell shall be not less than 0.17 N/mm^2.

c) The operating temperature in the shell shall not exceed 120 °C.

d) The design pressure in the calorifier tube battery shall be not less than 0.17 N/mm^2 nor exceed 1.75 N/mm^2 (17.5 bar).

e) The operating temperature in the calorifier tube battery shall not exceed 300 °C.

3.3 Grade B

The grade B classification shall be used for copper units only. The units shall comply with the following requirements, which specify less severe operating conditions than those required for grade A.

a) The working pressure in the shell shall not exceed 0.45 N/mm^2 (4.5 bar).

b) The design pressure in the shell shall be not less than 0.1 N/mm^2.

c) The operating temperature in the shell shall not exceed 90 °C.

[1)] 1 bar = 0.1 N/mm^2 = 0.1 MPa = 10.2 m head

d) The design pressure in the calorifier tube battery shall be not less than 0.17 N/mm nor exceed 0.45 N/mm^2 (4.5 bar).

e) The operating temperature in the calorifier tube battery shall not exceed 300 °C.

4 Design pressure and design temperature

4.1 Design pressure

4.1.1 The secondary design pressure shall be:

a) not less than two-thirds of the hydraulic test pressure;

b) not less than the secondary working pressure where an open vent is fitted and the working head does not exceed 25 m (see **10.2.3**) and;

c) not less than the pressure at which the safety valve is set to lift when the working head exceeds 25 m and in all cases where an open vent is not fitted (see **10.2.1.4**).

4.1.2 The primary design pressure shall be not less than the highest pressure which can be reached in the primary heater, including any pumping head which may be additional to the set pressure of the boiler safety valve. In no case shall the primary design pressure be less than two-thirds of the hydraulic test pressure.

4.2 Design metal temperature

4.2.1 The design temperature of the shell of the calorifier or storage vessel shall be the maximum operating temperature of its contents unless specified otherwise by the purchaser.

4.2.2 The design temperature of the calorifier primary header, tubes, tubeplates, and other heating surfaces shall be the maximum design inlet temperature of the primary fluid unless specified otherwise by the customer. If the primary fluid is saturated steam, the design metal temperature shall be the saturation temperature at the maximum design pressure.

NOTE For superheated steam, the design metal temperature may be regarded as being the saturation temperature at the maximum design pressure, provided that the superheated steam temperature is not more than 165 °C above the saturation temperature.

5 Materials

5.1 Materials for calorifiers

Table 1 lists the design stress values for the construction of calorifiers and storage vessels that shall be used in the design equations for the relevant design metal temperatures given in the table.

Materials shall not be used at temperatures higher than those for which allowable stresses are given in Table 1.

Where other materials, having properties equivalent to those listed in Table 1, are proposed, the manufacturer shall, on request, show that the properties are comparable with those for materials given in Table 1.

NOTE The formulae are intended to apply to calorifiers and storage vessels for use with fresh water. Special consideration should be given to the selection of materials (both separately and in combination) and to the corrosion allowance required for calorifier and storage vessel components which are likely to be in contact with aggressive, brackish or other impure water.

[A3] Table 1 – Design stress for materials of construction of calorifiers and storage vessels

Material		British Standard designation	Relevant note(s)	Design stress values (f)[a]								
				Design temperature not exceeding								
				50 °C	100 °C	150 °C	175 °C	200 °C	225 °C	250 °C	275 °C	300 °C
				N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2
Shells and branches												
Carbon	steel plate	BS EN 10028-2, grade P265GH		108	108	108	108	108	104	100	93	91
	pipes and tubes	BS EN 10216-1 and BS 10217-1, grade P265TR2		103	103	103	101	96	91	87	82	78
	pipes and tubes	BS EN 10216-2 and BS 10217-2, grade P265GH		103	103	103	103	103	99	95	89	84
Copper	tubes	BS EN 12452, grade CW024A or BS EN 12451, grade CW024A	12	41	40	34	26	18	–	–	–	–
	sheet	BS EN 1653, grade CW024A	12	48	46	34	26	18	–	–	–	–
	plate	BS EN 1653, grade CW024A	12	48	46	34	26	18	–	–	–	–
Bars and sections (for welding)												
Carbon steel		BS EN 10273, grade P265GH		108	108	108	108	108	104	100	93	91
Copper		BS EN 12167 and BS EN 12163, grade CW024A	12	41	40	34	26	18	–	–	–	–
Tubeplates												
Carbon steel		BS EN 10028-2, grade P265GH	2	108	108	108	108	108	104	100	93	91
Aluminium bronze		BS EN 1653, grade CW304G	12	137	127	111	103	94	87	77	71	63
90/10 Cu.Ni.		BS EN 1653, grade CW352H	12	72	70	66	63	60	58	54	49	44
70/30 Cu.Ni.		BS EN 1653, grade CW354H	12	82	79	77	76	75	73	72	71	70
Aluminium brass		BS EN 1653, grade CW702R	12	72	71	69	54	25	15	–	–	–
Naval brass		BS EN 1653, grade CW712R	12	86	79	72	55	17	–	–	–	–
60/40 brass		BS EN 1653, grade CW610N	12	86	79	72	55	17	–	–	–	–
Tubes												
Copper		BS EN 12451, grade CW024R	11, 12	41	40	34	26	18	–	–	–	–
90/10 Cu.Ni.		BS EN 12451, grade CW352H	12	72	70	66	63	60	58	54	49	44
70/30 Cu.Ni.		BS EN 12451, grade CW354H	12	82	79	77	76	75	73	72	71	70
Aluminium brass		BS EN 12451, grade CW702R	10, 11, 12	72	71	69	54	25	15	–	–	–
70/30 arsenical brass		BS EN 12451, grade CW707R	10, 11, 12	72	71	69	54	25	15	–	–	–

[A3]

A3 **Table 1** *Continued*

Material	British Standard designation	Relevant note(s)	Design stress values (f)[a]								
			Design temperature not exceeding								
			50 °C	**100 °C**	**150 °C**	**175 °C**	**200 °C**	**225 °C**	**250 °C**	**275 °C**	**300 °C**
			N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2	N/mm^2
Castings											
Steel	BS EN 10213, grade P265GH		107	97	88	86	83	82	81	77	73
Grey cast iron	BS EN 1561, grade EN-GLJ-150 or ISO 185, grade JL/200	3, 4, 5	16	16	16	16	16	[a]	–	–	–
	BS EN 1561, grade EN-GLJ-200 or ISO 185, grade JL/225	3, 4, 5	19	19	19	19	19	[a]	–	–	–
Cast iron with spheroidal or nodular graphite	BS EN 1563, grade EN-GJS-400-18 U-LT or RT		60	60	60	60	60	60	–	–	–
Admiralty gunmetal	BS 1400, grade G1[2)]	6, 12	55	55	55	52	49	25	25	–	–
Leaded gunmetal	BS EN 1982, grade CuSn5Zn5Pb5-C CC491K	7, 12	48	48	48	47	45	34	34	22	–
	BS EN 1982, grade CuSn7Zn2Pb3-C CC492K		59	59	59	56	51	–	–	–	–
Naval brass	BS 1400, grade SCB4[2)]	8, 9, 12	–	–	–	–	–	–	–	–	–
Brass for brazable castings	BS EN 1982, grade CuZn15As-CCC760S	8, 12	30	30	20	–	–	–	–	–	

[a] See Note 3.

NOTE 1 Linear interpolation may be used to determine the appropriate design stress value when the design metal temperature lies between two temperatures.

NOTE 2 Steel tubeplates may be used in calorifiers and storage vessels with copper shells, provided that they are not galvanized and:

a) the waterside surface is clad, lined or otherwise treated to prevent corrosion;

b) the effective seals are made between the protecting surface treatment of the tubeplate and the other surface of the tubes; and

c) the steel of the tubeplate is at no point in contact with the contained water.

NOTE 3 Grey cast iron is not suitable for pressures exceeding 1.03 N/mm^2 or for temperatures exceeding 220 °C, at which temperature the values for f at 200 °C should be used.

NOTE 4 Refer to BS EN 1561 for estimated thickness of cast iron greater than 30 mm. The design stress used should be 10% of the tensile strength for the grade of material selected and thickness required.

NOTE 5 Iron castings that are stressed by the working pressure should have the number and grade of the relevant British Standard cast upon them so that the maximum operating pressure and temperature for which they are suitable may be assessed at any time.

NOTE 6 May be welded only if the lead content is less than 0.5%.

NOTE 7 Cannot be welded, but may be brazed.

NOTE 8 Not suitable for operating temperatures greater than 150 °C.

NOTE 9 Suitable for non-pressure parts only.

NOTE 10 If these materials are to be screwed they should be ordered in the as-drawn condition instead of the annealed condition.

NOTE 11 The recommended tempers for tubes for expanding and/or bending are half-hard for copper and brasses.

NOTE 12 Refer to Foreword. A3

2) Superseded, withdrawn.

5.2 Filler materials and bolting materials

Filler and brazing materials, forging or hot pressing stock, and bolt and nut materials shall be as detailed in Table 2 or of equivalent quality.

5.3 Material test certificates

Test certificates shall be provided, covering the chemical and mechanical properties of materials used in the construction of calorifiers or storage vessel and for the hydraulic test of tubes, where these are called for in the purchase order.

6 Welding procedure and welder approval tests

A3⟩ *Text deleted* ⟨A3

6.1 Grade A calorifiers and storage vessels

6.1.1 *General*

Manufacture of grade A calorifiers and storage vessels shall be in accordance with approved welding procedures and using approved welders.

6.1.2 *Welding procedures*

The preparation of welding procedures, the approval of welders, testing and the maintenance of records shall be the responsibility of the manufacturer.

6.1.3 *Approval of procedure*

A3⟩ Approval testing of welding procedures for steel shall be conducted, recorded and reported in accordance with BS EN ISO 15614-1.

Approval testing of welding procedures for copper shall use the methods of testing welds given in BS EN 895[3], BS EN ISO 5173, BS EN 1320 or BS EN 1321. The copper test piece shall be subject to visual examination, penetrant testing and destructive tests. The number of test specimens shall be as listed in Table 1a. The welding procedures shall be certified to BS 853 using relevant documentation and records complying with BS EN ISO 15614-1.

Each welding procedure test and the accompanying test results shall be recorded as Welding Procedure Approval Records as defined in BS EN ISO 15614-1.

Each welding procedure test shall be documented to include all items referred to in **6.1.4** or BS EN ISO 15609-1. ⟨A3

6.1.4 *Welder approval*

A3⟩ Approval testing of welders for steel shall be conducted, recorded and reported in accordance with BS EN 287-1 as defined in Annex B of BS EN 287-1:2011.

Approval testing of welders for copper shall use the methods of testing welds given in BS EN 895[3], BS EN ISO 5173, BS EN 1320 or BS EN 1321. The copper test piece shall be subject to visual examination and destructive tests, augmented by penetrant testing if necessary. The number of test specimens shall be as given in Table 1b.

Welder approval shall be certified to BS 853 using relevant documentation and records taken from BS EN 287-1. ⟨A3

6.1.5 *Reapproval of welder*

For the purposes of this standard a welder's approval shall remain valid A3⟩ for a period of two years providing ⟨A3 it can be shown, as signified at intervals of six months by a senior responsible person in the firm that employs the welder, that the welder has, subsequent to the test, been employed with reasonable continuity on work within the extent of his approval and has continued to produce satisfactory welds as verified by traceable records for the type of production work.

Table 1a — Number of test specimens required for procedure approval for copper (see note)

Test specimen	Butt joint in plate of thickness		Butt joint in pipe of thickness		Fillet weld in plate
	Less than 10 mm	10 mm and over	Less than 10 mm	10 mm and over	
Macro-examination	1	1	2	2	2
Transverse tensile	1	1	1	1	1
Root bend	2	0	2	—	—
Face bend	1	0	1	—	—
Side bend	0	2	—	2	—
Fillet weld fracture (for test piece with only single side weld)	0	0	—	—	3

NOTE When more than one specimen of a particular type is A3⟩ required, the specimens have to ⟨A3 be taken as far apart as possible with one specimen for macro-examination taken from that part of the joint considered to have been welded in the most difficult welding position or from a stop/start position.

[3] Superseded, withdrawn.

Table 1b — Number of test specimens required for welder approval for copper (see note)

Test specimen	Butt joint in plate or pipe of thickness		Fillet weld in plate or pipe
	Less than 10 mm	10 mm and over	
Macro-examination	2	2	2
Root bend	1	—	—
Face bend	1	—	—
Side bend	—	2	—
Fillet weld fracture (for test piece with only single side weld)	—	—	3

NOTE When more than one specimen of a particular type is [A3] required, the specimens have to [/A3] be taken as far apart as possible with one specimen for macro-examination taken from that part of the joint considered to have been welded in the most difficult welding position or from a stop/start position.

(Organization's symbol or logo)	Welder approval test certificate	Test record no.
Manufacturer's name	Welder's name and identity no.	Issue no.

Declaration

I, the undersigned, declare that the welder named above has been regularly and satisfactorily employed on work covered by this certificate during the six months preceding the date of my signature.

Date	Personal signature	Position or title

Figure 1a — Example of a history sheet

Reapproval shall be required if any of the following apply.

a) The welder is to be employed on work outside the extent of his current approval.

b) The welder changes his employer without the transfer of his test records.

c) Six months or more have elapsed since the welder was engaged in welding on work within the extent of his approval. However, subject to the agreement of the inspecting authority, a complete reapproval test may be waived provided the first production weld by the welder is supplemented with [A3] *Text deleted* [/A3] a bend test for copper.

d) There is some specific reason to question the welder's ability.

[A3] Reapproval of welders for steel shall be in accordance with BS EN ISO 15614-1. [/A3]

Proof of the welder's continued use of the approved procedure shall be the maintenance of a history sheet such as that illustrated in Figure 1a.

7 Determination of scantlings design

7.1 Cylindrical shells

7.1.1 *Calculated shell thickness*

The calculated thickness t_c (in mm) of a cylindrical shell subject to pressure on its internal surface shall be determined from the following equation:

[A3] $$t_c = \frac{pD_i}{2fJ} + c$$ [/A3]

where

p is the design pressure (in N/mm^2);

D_i is the internal diameter of the shell or, if the shell is made in more than one ring of plates and the circumferential seams are lapped, the diameter inside the outermost ring (in mm);

f is the design stress value for the shell material from Table 1 (in N/mm^2);

c is the corrosion allowance, with a value of 1.0 mm for carbon steel and a value of 0 mm for copper or corrosion protected steel;

J is the joint factor, which has the following values:

a) for carbon steel, J = 0.7 when longitudinal seams are butt-welded (see Figure 1);

b) for copper, J = 0.8 when longitudinal seams are butt-welded (see Figure 2).

c) for copper, J = 0.8 when longitudinal seams are clenched and brazed.

7.1.2 *Actual shell thickness*

7.1.2.1 *Carbon steel shells*

In no case shall the actual thickness of material used for carbon steel shells be less than t_c, 0.005 D_i or 4.5 mm, whichever is the greater.

7.1.2.2 *Copper shells*

In no case shall the actual thickness of material used for copper shells be less than t_c, 0.002 D_i, or the following, whichever is the greater;

a) 1.4 mm for grade A calorifiers and storage vessels;

b) 1.0 mm for grade B calorifiers and storage vessels.

7.2 Endplates

7.2.1 *Domed ends*

7.2.1.1 *Form of domed end*

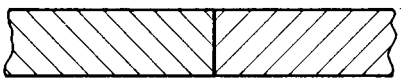
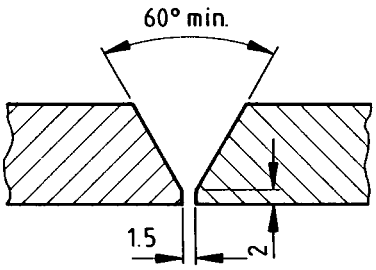
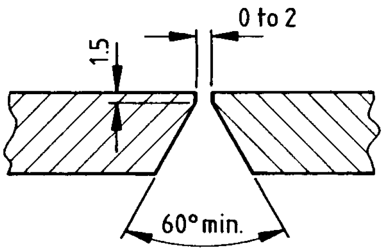
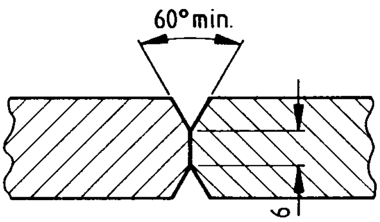
Domed ends shall be torispherical in form as shown in Figure 3.

A3 **Table 2 — Filler and brazing materials, forgings and hot pressing stock, bolt and nut materials**

Material	British Standard designation	Relevant note(s)
Filler rods, wires and fluxes for welding		
For manual metal-arc welding of carbon steel	BS EN ISO 2560	
For submerged arc welding of carbon steel	BS EN ISO 14171 and BS EN 760	
For TIG and MIG welding of carbon steel	BS EN ISO 14341, grade G4Si1 and BS EN ISO 636, grade AW423W3Si1	
For TIG and MIG welding of copper	BS EN ISO 24373 [4)]	
For gas welding of copper	BS 1453, grade C1	
Brazing filler metals		
Copper phosphorus	BS EN ISO 17672, grades CuP 284, CuP 281 and CuP 280	1
Filler alloys for attaching steel non-pressure parts (e.g. support brackets) to copper shells		
For bronze welding	BS 1453, grades C2, C4, C5 or C6	
For flame brazing	BS 1845, grade CZ 112 [5)]	
For soft soldering (tin content exceeding 33 %)	BS EN ISO 9453	2
Forging or hot pressing stock (for handhole fittings, etc.)		
Copper	BS EN 12165, grade CW024A	
Naval brass	BS EN 12165, grade CW712R	
Aluminium bronze	BS EN 12165, grade CW307G	
Bolts, studs, nuts and tie-bars		
Steel	BS 4882, BS 3692, BS 4190 or BS 4439	3 and 4
Leaded brass	BS EN 12167, grade CW614N	
Steel pipe fittings (for screwed connections)	BS EN 10241	

NOTE 1 For brazed seams exposed to aggressive water, which might give rise to dezincification or other forms of selective attack, brazing alloys in accordance with BS EN ISO 17672, grade CuP284 or grade CuP280 should be used.
NOTE 2 Soft solders may be used only for the external attachment of brackets and similar fittings and may only be applied to parts not in contact with either the heated or the heating medium in the calorifier or storage vessel. Soft solder should not be used in the construction or assembly of electrical immersion heater sheaths. The operating temperature for soft solder should not exceed 150 °C.
NOTE 3 Free cutting steels should not be used in the manufacture of calorifiers and storage vessels.
NOTE 4 These standards include details of bolting in addition to details of materials. A3

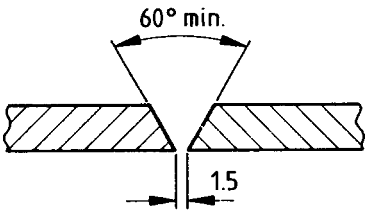
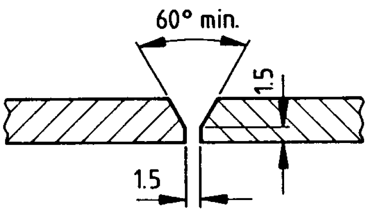
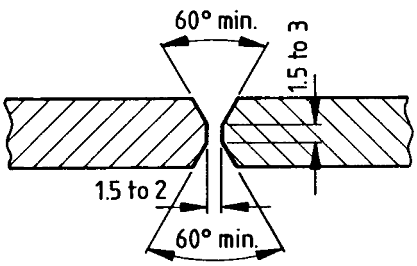
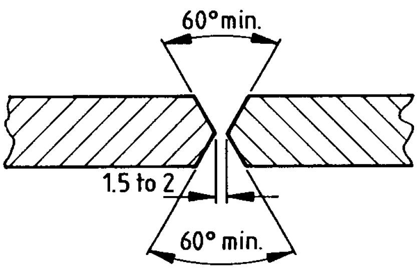
4) Grade not determined.
5) Superseded, withdrawn.

Joint	Preparation	Remarks
a) 	Close square butt	Plates having thickness not greater than 6 mm welded from both sides or up to 10 mm submerged arc welded from both sides
b) 	Single-V butt	Plates having thickness not greater than 16 mm with no inside access. First pass with tungsten inert gas (TIG) root run
c) 	Single-V butt	Plates having thickness not greater than 20 mm second side cut back to sound metal before welding
d) 	Double-V butt	Plates having thickness not greater than 20 mm submerged arc both sides

All dimensions are in millimetres.

NOTE Details of other weld preparations for carbon steel may be obtained from [A3] BS EN 1011-1 and BS EN 1011-2 [A3].

Figure 1 — Typical longitudinal and circumferential weld preparations for carbon steel calorifiers and storage vessels

<table>
<tr><th>Joint</th><th>Preparation</th><th>Remarks</th></tr>
<tr><td>a)
</td><td>Close square butt</td><td>Plates having thickness not greater than 5 mm</td></tr>
<tr><td>b)

</td><td>Single-V butt</td><td rowspan="2">Plates having thickness not greater than 10 mm</td></tr>
<tr><td>c)

</td><td>Single-V butt</td></tr>
<tr><td>d)

</td><td>Double-V butt</td><td rowspan="2">Plates over 6 mm thick</td></tr>
<tr><td>e)

</td><td>Double-V butt</td></tr>
</table>

All dimensions are in millimetres.

Figure 2 — Typical longitudinal and circumferential weld preparations for copper calorifiers and storage vessels

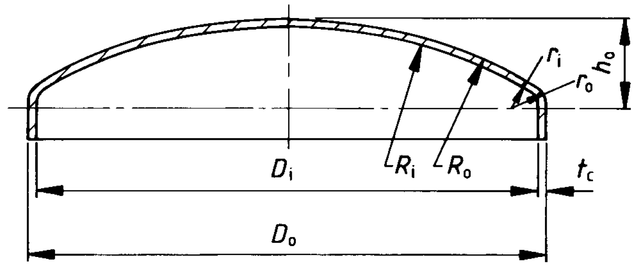


Figure 3 — Domed end

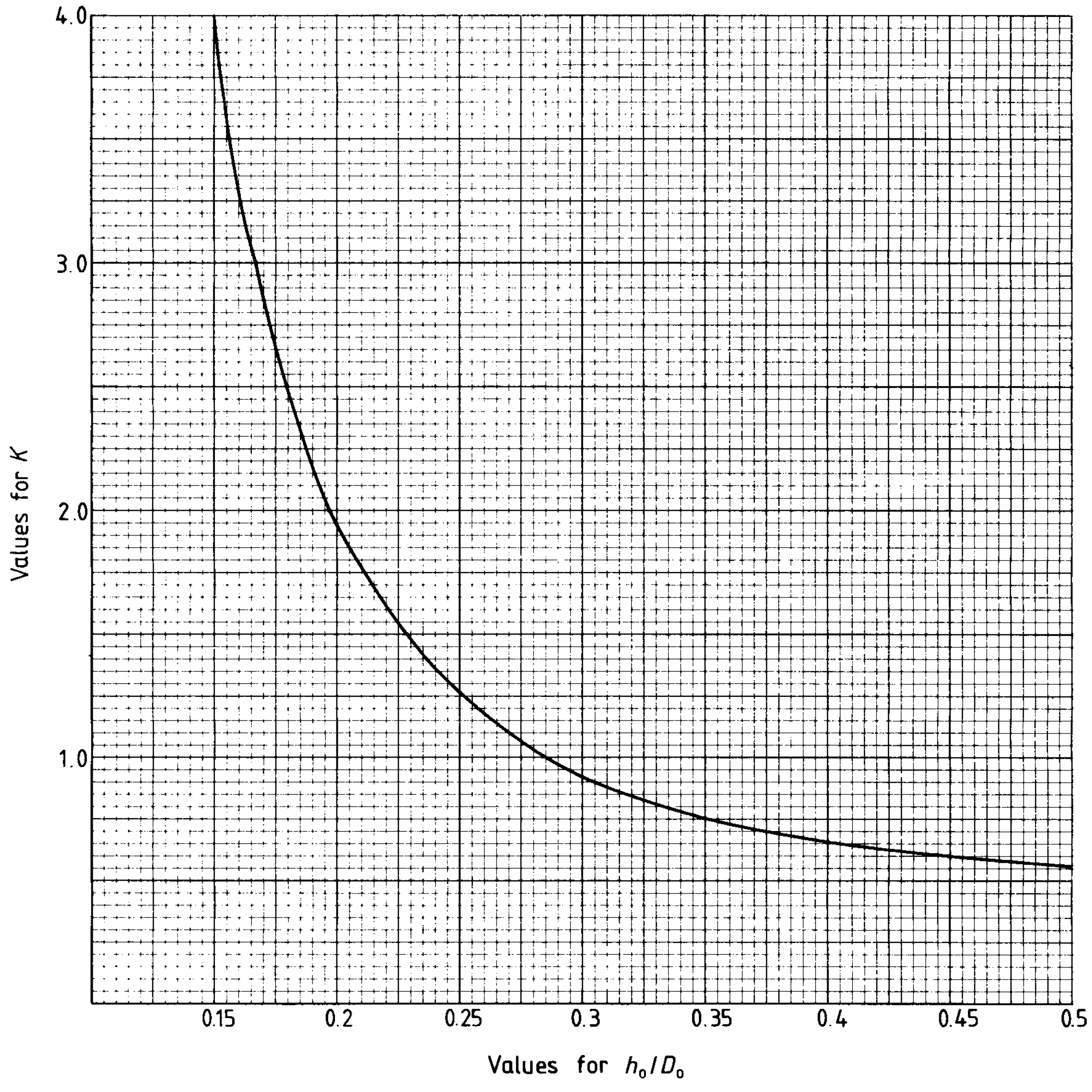


Figure 4 — Values for ***K*** (see **7.2.1.4**)

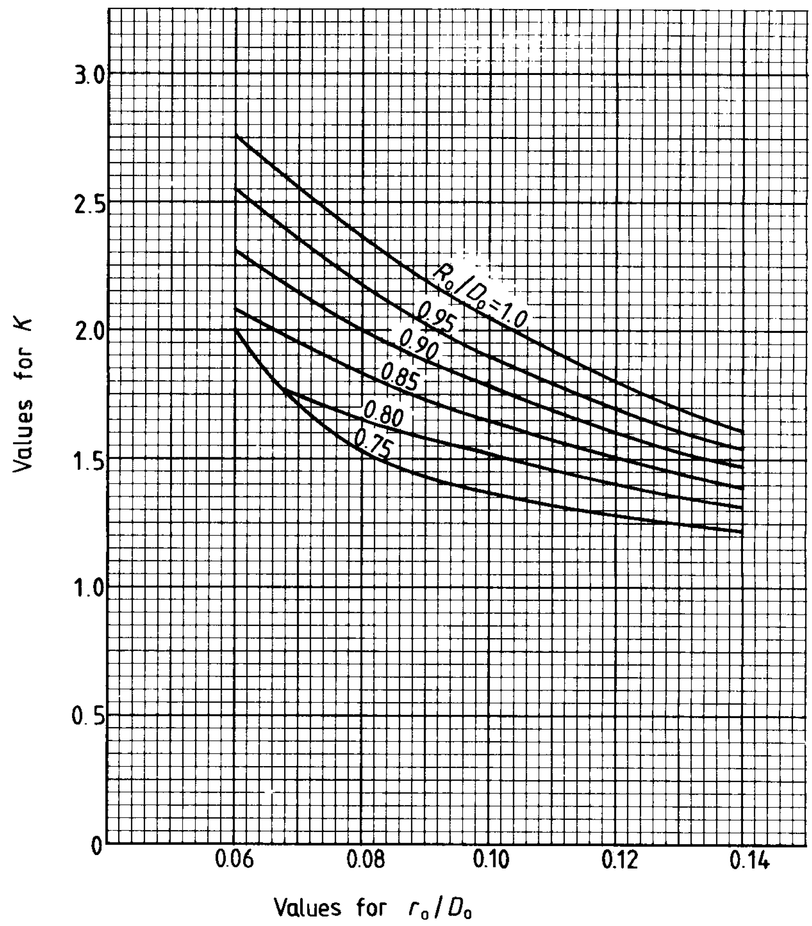


Figure 5 — Shape factors for domed ends (see **7.2.1.4**)

7.2.1.2 *Knuckle radius*

The knuckle radius of copper and carbon steel domed ends shall be as follows.

a) *Copper domed ends.* In no case shall the inside knuckle radius (r_i) be less than 6 % of D_o.

b) *Carbon steel domed ends.* Where the outside diameter of the domed end (D_o) is greater than 1 000 mm, the inside knuckle radius (r_i) shall not be less than 60 mm. Where D_o is less than 1 000 mm, r_i shall be not less than 6 % of D_o.

In no case shall the inside knuckle radius (r_i) be less than 4 t_a, where t_a is the actual thickness of material used for the domed end prior to forming.

7.2.1.3 *Crown radius*

In no case shall the inside crown radius (R_i) be greater than D_o.

7.2.1.4 *Calculated thickness of domed end subject to pressure on the concave side*

The calculated thickness t_c (in mm) of a domed end which is unpierced or has all its openings fully compensated and is subject to pressure on the concave side shall be determined by the following equation:

$$t_c = \frac{pD_oK}{2f} + c$$

where

- p is the design pressure (in N/mm^2);
- D_o is the outside diameter of flange (in mm);
- K is a factor depending on the ratio h_o/D_o and obtained from Figure 4, or alternatively by calculating the ratios R_o/D_o and r_o/D_o and using Figure 5;
- f is the design stress (see Table 1) (in N/mm^2);

c is the corrosion allowance, with a value of 1.0 mm for carbon steel and a value of 0 mm for copper or corrosion protected steel.

h_o is the outside height (in mm) given by the following expression:

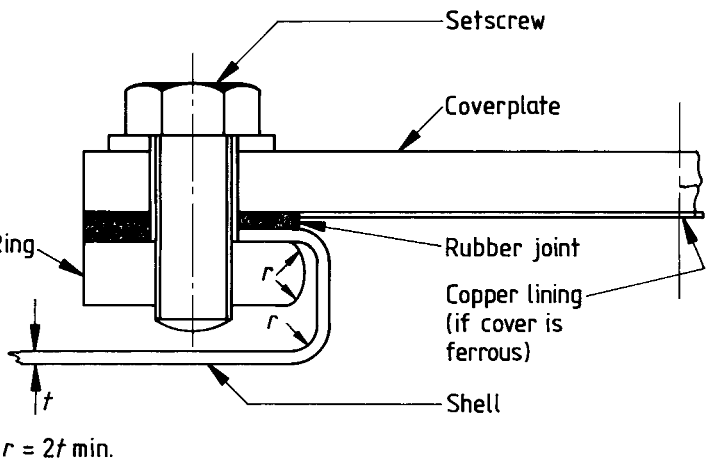
$h_o = R_o - \sqrt{[(R_o - D_o/2)\,(R_o + D_o/2 - 2r_o)]}$

where

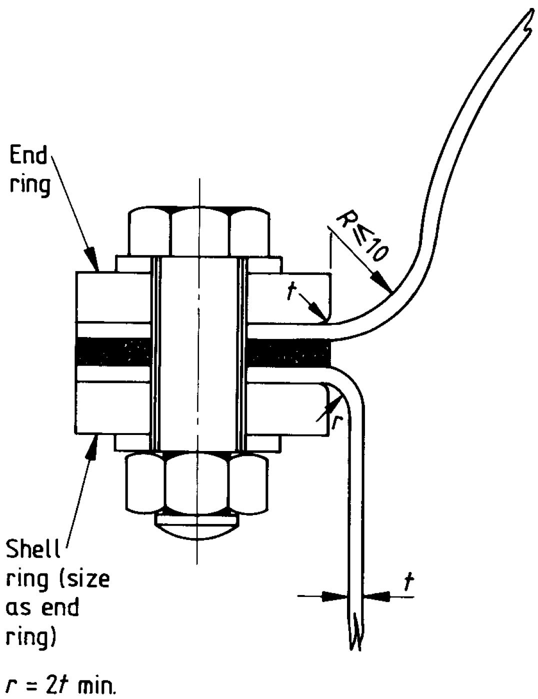
R_o is the outside spherical radius (in mm);

r_o is the outside knuckle radius (in mm);

NOTE For domed ends made from more than one plate refer also to **8.1.4**.



(a) Semi-raised manhole formed from parent shell



(b) Dished and flanged end/shell attachment

All dimensions are in millimetres.

Figure 6 — Typical examples of flange backing rings

7.2.1.5 *Calculated thickness of domed end subject to pressure on the convex side*

The calculated thickness t_c, (in mm), of a domed end which is unpierced and is subject to pressure on the convex side shall be determined by the following equation, but in no case shall the calculated thickness exceed 6 mm.

$$t_c = R_i^2 \frac{(p + 0.15)}{f D_i} + c$$

where

- p is the design pressure (in N/mm^2);
- f is the design stress value (see Table 1) (in N/mm^2);
- R_i is the inside spherical radius (in mm);
- D_i is the internal diameter of end (in mm);
- c is the corrosion allowance, with a value of 1.0 mm for carbon steel and a value of 0 mm for copper and corrosion protected steel.

In no case shall the design pressure exceed 0.45 N/mm^2 (4.5 bar).

NOTE For domed ends made from more than one sheet refer also to **8.1.4**.

7.2.1.6 *Actual thickness of domed end material*

In no case shall the actual thickness of material used for the domed end prior to forming be less than t_c for the type of end concerned (see **7.2.1.4** or **7.2.1.5** as appropriate) nor shall it be less than the thickness of material as defined for the shell in **7.1.2**.

In no case shall the actual thickness at any point after forming be less than:

a) 0.9 t_c for steel; and,

b) 0.7 t_c for copper.

7.2.2 ***Flat endplates***

The calculated thickness for a flat endplate t_c (in mm), shall be determined by the use of the following equations.

a) For bolted-on flat endplates where the jointing surfaces and joint ring extend to the outer periphery of the endplate the following equation shall be used:

$$t_c = \sqrt{\left[\frac{pD_1^2}{4f}\right]} + c$$

where

- p is the shell design pressure (in N/mm^2);
- f is the design stress value (see Table 1) (in N/mm^2);
- D_1 is the diameter of the bolt pitch circle (in mm);
- c is the corrosion allowance, with a value of 1.0 mm for carbon steel and a value of 0 mm for copper or corrosion protected steel.

b) For flat endplates that are flanged at the periphery for butt welding to the shell or header the following equation shall be used:

$$t_c = \sqrt{\left[\frac{pD_i^2}{4f}\right]} + c$$

where

p, f and c have the meanings given in a); D_i is the inside diameter of the shell or header (in mm).

c) For flat endplates that are inserted into, and adequately welded to, the shell or header in accordance with Figure 10, the following equation shall be used:

$$t_c = \sqrt{\left[\frac{pD_i^2}{3f}\right]} + c$$

where

p, f and c have the meanings given in a);

D_i is the inside diameter of the shell or header (in mm).

7.3 Flat tubeplates

7.3.1 *Tubeplates with U-tubes or with floating header*

7.3.1.1 *General*

The thickness of a flat tubeplate to which U-tubes or straight tubes with a floating header are attached shall be calculated in accordance with **7.3.1.2** or **7.3.1.3**.

7.3.1.2 *Tubeplate flange with full face joint*

Where the jointing surface and the joint ring extend to the outer periphery of the tubeplate, the thickness of the tubeplate t_c, (in mm), shall be calculated using the following equation:

$$t_c = \sqrt{\left[\frac{0.16 pD_i^2}{\mu f}\right]} + c$$

where

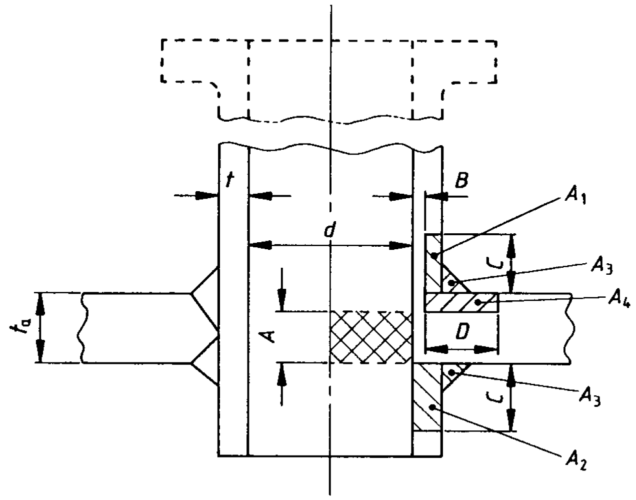
- D_i is the inside diameter of the shell or header (in mm);
- p is the greater of the primary and secondary design pressures (in N/mm^2);
- f is the design stress value for the tubeplate material (see Table 1) (in N/mm^2);
- c is the corrosion factor, with a value of 1.0 mm for carbon steel and a value of 0 mm for copper or corrosion protected steel;

μ is the ligament efficiency of the tubeplate, which is given by the following equation:

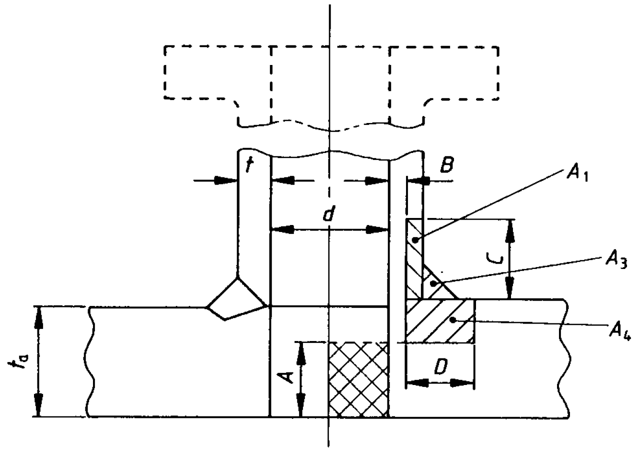
$$\mu = 1 - \frac{d}{P}$$

d is the tube hole diameter in the tubeplate (in mm);

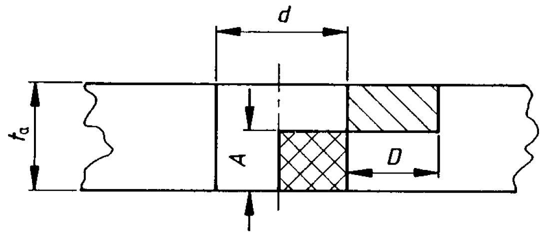
P is the tube pitch (spacing between centres) (in mm).



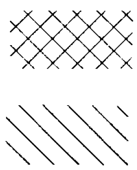
(a) Set-through branch



(b) Set-on branch



(c) Opening



The area to be compensated

The area available for compensation

A is equal to $\frac{pD_i}{2f}$

B is the thicknesses calculated by the equations for pressure loading only in clause 7 for the appropriate shape of sections; C is the smaller of the two values $2.5t$ or $2.5t_a$; and D is the greater of the two values (t_a + 75 mm) or $d/2$.

Figure 7 — Compensation for openings in steel sheels

In no case, however, shall the actual thickness of the tubeplate be less than 12 mm.

7.3.1.3 *Tubeplate flange with narrow faced joint*

Where the jointing surface and the joint ring are contained within the flange bolting circle, the thickness of the tubeplate t_c (in mm), shall be calculated using the following equation:

$$t_c = \sqrt{\left[\frac{0.24pD_i^2}{\mu f}\right]} + c$$

where

p, D_i, c, μ and f have the meanings given in **7.3.1.2**.

In no case, however, shall the actual thickness of the tubeplate be less than 12 mm.

7.3.2 *Fixed tubeplates*

Where straight tubes are secured at both ends to fixed flat tubeplates, the thickness of the tubeplates shall be calculated in accordance with [A3] PD 5500 [A3] using the design stress values in Table 1 of this standard. Consideration shall also be given to tube end loads and stresses in the shell and tubes due to temperature differential. In no case, however, shall the actual thickness of the tubeplate be less than 12 mm.

7.4 Neckpieces

The thickness of a neckpiece greater than 100 mm for attachment of a tubeplate or cover shall be not less than that of the cylindrical shell or dished endplate to which it is attached. In no case, however, shall a carbon steel or a copper neckpiece have a thickness less than d/130, where d is the internal diameter of the neckpiece.

7.5 Screwed connections

7.5.1 Screwed connections for mountings shall not have a screwed portion greater than [A3] R2: BS EN 10226-1 for taper threads, nor greater than G2: BS EN ISO 228-1 and BS EN ISO 228-2 [A3] for parallel threads.

Screwed pipe connections for pipe fittings shall not exceed R4 (taper threads) nor G4 (parallel threads).

The minimum length of all male and female threads shall be as given in Table 3.

Connection bosses shall be attached to the calorifier or storage vessel shell by welding, brazing or mechanical means.

7.5.2 Screwed primary connections that form an integral part of the steam or water chest shall be limited to a design pressure of 1.03 N/mm^2 and a design temperature of 200 °C.

Screwed primary mountings, pipework and fittings that are attached to the calorifier shall be limited by the pressures and temperatures specified in their respective standards if these are less than 1.03 N/mm^2 or 200 °C respectively.

7.6 Flanges and bolting

7.6.1 *General*

Flanges, bolts and studs for branches and pads to which pipes or mountings are to be connected shall comply with the requirements of BS 10 or [A3] the relevant part of BS EN 1092 [A3] for the materials to be used and for the design conditions.

7.6.2 *Flange design*

Main flanges, such as those associated with tubeplates, endplates and covers with joint faces and joint rings that extend from the bore to the outer periphery of the flanges and with [A3] *Text deleted* [A3] gaskets at least 1.6 mm thick, shall have a minimum required thickness t_c (in mm), as given by the following equation, but in no case shall it be less than 8 mm.

$$t_c = \sqrt{\left[\frac{pD_o\,(D_1 - D_o)}{f}\right]}$$

where

- p is the design pressure (this being the greater of the primary and secondary design pressures where a tubeplate is contained in the joint) (in N/mm^2);
- D_o is the outside diameter of the neck piece or shell (in mm);
- D_1 is the diameter of the bolt pitch circle (in mm);
- f is the design stress value for the flange material from Table 1 (in N/mm^2).

[A3] *Text deleted* [A3]

7.6.3 *Alternative flange design*

[A3] *Text deleted* [A3] Flanges shall be designed in accordance with [A3] PD 5500 [A3] using the design stress values in Table 1 of this standard.

Where narrow face joint rings that are located entirely within the inner edges of the bolt holes are used, the flanges shall be designed in accordance with [A3] PD 5500 [A3] using the design stress values in Table 1 of this standard.

[A3] *Text deleted* [A3]

7.6.4 ***Flange backing rings***

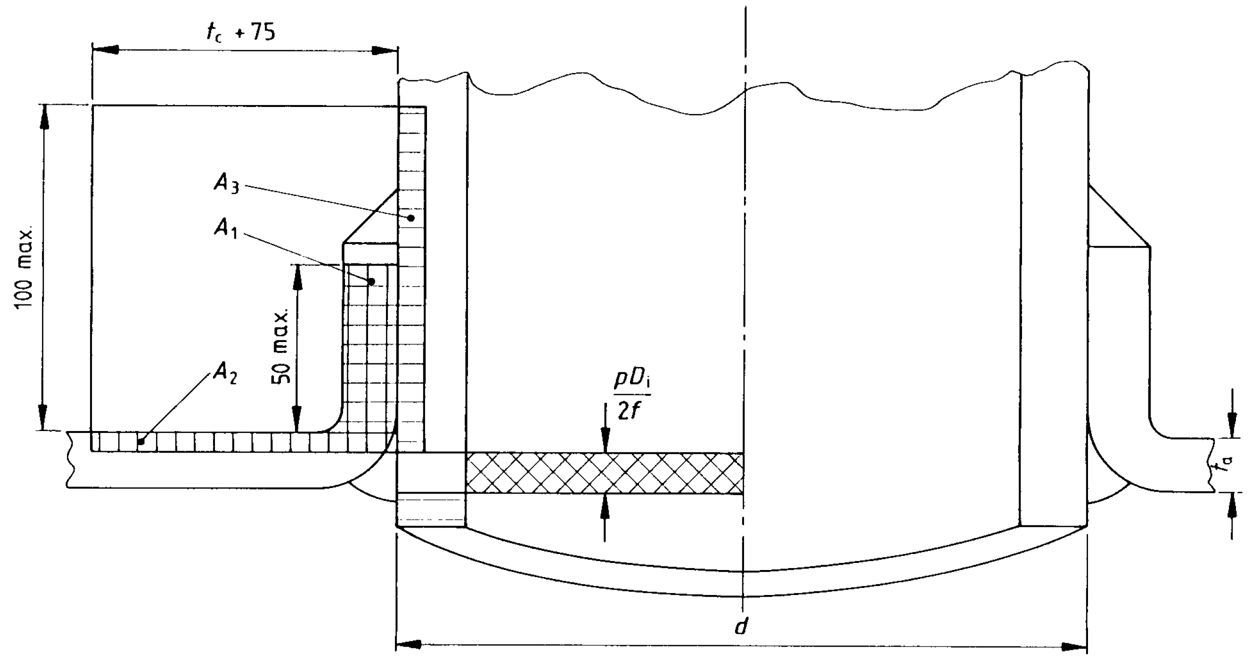
Where the neckpiece or shell is flanged outwards, it shall be supported by a steel ring, either loose or brazed to the flange, the internal diameter of which shall not exceed the outside diameter of the neckpiece or shell by more than 6 mm. The internal radius of the flanged opening shall not be less than twice the thickness of the flanged material and the inner edge of the backing ring shall be machined to suit.

The thickness of the backing ring shall not be less than that obtained by using the equation given in **7.6.2**. Typical examples of flange backing rings are shown in Figure 6(a) and Figure 6(b).

When a dished end is flanged outward to be bolted to a shell flange it shall be supported by a steel ring either loose or brazed to the flange. The internal diameter of the ring shall not exceed the centre point of the flange radius. The internal radius of the flange and the profile of the inner edge of the backing ring are shown typically in Figure 6(b).

Table 3 — Minimum length of thread

Thread designation A3 *Text deleted* A3	Minimum length of thread
	mm
$^1/_4$ and $^3/_8$	8
$^1/_2$ and $^3/_4$	10
1 and $1^1/_4$	16
$1^1/_2$	20
$2 - 2^1/_2$	23
3	26
4	32



Key

t_a = actual thickness of shell

Area to be compensated thus

Allowance area of compensation thus

All dimensions are in millimetres.

Figure 8 — Compensation for opening in cylindrical copper shells (shell flanged)

7.6.5 ***Bolt loading***

The total bolt load shall be determined by multiplying the design pressure by the area contained within the bolt pitch circle. The aggregate cross-sectional area of the bolts measured at the bottom of the thread shall be not less than the total bolt load divided by the maximum permitted nominal bolt stress given in Table 4 for the size of bolt to be used and for the bolt material tabulated.

Table 4 — Maximum permissible stress for bolts and studs

Bolt or stud diameter not less than	Maximum permissible stress	
	BS 4190, grade 4.6	BS 3692, grade 8.8 BS 4882, grade B7
mm	N/mm^2	N/mm^2
12[a]	20	40
16	33	66
20	33	66
22[b]	40	80
24	40	80

NOTE It is recommended that the number of bolts should be divisible by 4, that they should be arranged off the centre lines and that the bolt pitch should not exceed 4½ times the diameter of the bolt.

[a] 12 mm bolts or studs of carbon steel grade 4.6 should be used only when limitations of space make it impracticable to use 16 mm bolts or studs. See **11.4.2**.

[b] 22 mm bolts or studs are not a preferred size and should be used only when it is impracticable to use another size. Attention is drawn to the requirements of **11.4.2** when the bolt material selected has a higher grade than 4.6.

Nuts used with high tensile steel bolts or studs shall have a specified minimum ultimate tensile strength which is not more than 77 N/mm^2 lower than that of the bolts or studs.

7.7 Compensation for openings cut in shells for inspection openings, neckpieces, branches, pads and frames

7.7.1 ***General***

Openings shall as far as possible be placed well clear of any shell seam. Wherever possible, the shorter axis of an elliptical manhole shall be arranged parallel to the longitudinal centre line of the shell.

Where the major axis of any hole, not formed from the parent shell, or the diameter of any hole cut in a cylindrical shell for the purpose of fixing seatings for mountings, etc. is greater than 2½ times the thickness of the shell plate plus 70 mm, compensation shall be provided.

NOTE Cleaning or inspection openings with necks formed from the parent shell without welding but incorporating a steel or brass backing flange may be used without the need for compensation in shells with a maximum shell thickness of up to 6 mm. A typical example is shown in Figure 6(a).

When compensation is required, the cross-sectional area to be compensated shall be the product of half the maximum bore of the branch plus any corrosion allowance, measured parallel to the axis of the shell and a thickness equal to $pD_i/2f$, where p, D_i and f have the meanings given in **7.1.1**.

7.7.2 ***Compensation for openings in carbon steel shells***

7.7.2.1 For cylindrical steel shells, the maximum diameter of the opening shall be not greater than two-thirds of the shell diameter and the cross-sectional area considered available for compensation shall be measured in a plane through the axis of the branch parallel to the longitudinal axis of the drum and should be calculated as follows (see Figure 7).

a) For that part of the branch which projects outside the shell, calculate the full sectional area of the stem up to a distance C from the actual outer surface of the shell plate, and deduct from it the sectional area which the stem would have if its thickness were calculated in accordance with the equation given in **7.1.1** (area A_1).

b) Add to it the full sectional area of that part of the stem which projects inside the shell up to a distance C from the inside surface of the shell (area A_2).

c) Add to it the sectional area of the fillet welds on both sides of the shell (area A_3).

d) Add to it the area obtained by multiplying the difference between the actual shell thickness and the unpierced shell thickness A by length D (area A_4).

7.7.2.2 Where achievement of an adequate area of compensation is not practicable using the above method additional reinforcement shall be provided in the form of a compensation ring welded to the shell see Figure 11(c). The following limitations shall apply.

a) The thickness of the ring shall not exceed the as-built shell thickness.

b) The thickness of the ring shall be not less than one quarter of the shell thickness as calculated for pressure loading only in **7.1.1** and **7.2.1.4**.

c) The radial width of the ring shall be not less than $d/4$ where d is the mean diameter of branch, the diameter of a circular opening not provided with branch or the width of a non-circular opening in the corresponding plane of measurement.

NOTE The compensating ring may be fitted on the inside or outside of the shell plate.

7.7.3 ***Compensation for openings in copper shells***

7.7.3.1 *Openings up to a half of the shell diameter*

For openings not greater than a half of the shell diameter, the cross-sectional area considered available for compensation shall be the sum of the following areas.

a) The cross-sectional area of the portion of the shell flanged outwards and calculated by multiplying the actual thickness (t_a) of the flanged-out portion by the minimum actual height of the flanging at any point measured from the actual surface of the calorifier shell, or by 50 mm, whichever is the lesser (see area A_1 of Figure 8 or Figure 9).

b) The area obtained by multiplying the difference between the actual thickness (t_a) of the shell and a thickness equal to $pD_i/2f$ by a length equal to (t_c + 75) mm where the symbols have the meanings given in **7.1.1** (see area A_2 of Figure 8 or Figure 9).

c) The net cross-sectional area of the wall of the neckpiece minus the sectional area of a shell of the same bore and material having a thickness equal to that calculated in accordance with **7.1.1** for the same design pressure. The area calculated shall not extend more than 100 mm from the outer surface of the calorifier or storage vessel shell and shall not include any part of the bolting flange; in no case, however, shall the area used in the calculation exceed 0.2 dt_a (see area A_3 in Figure 8 and Figure 9).

d) If the neckpiece is flanged to fit inside the shell, as shown in Figure 10, the cross-sectional area of the flanged portion of the neckpiece within the shell and calculated by multiplying the actual thickness (t_a) by the minimum width of flanging at any point measured from the outside surface of the neckpiece; in no case, however, shall the sum of the areas in c) and d) used in the calculation exceed 0.2 dt_a (see area A_4 in Figure 9).

If the sum of the allowable compensating areas defined in a), b), c) and d) is less than the area to be compensated as specified in **7.7.1**, additional compensating area shall be provided by increasing the thickness of the neckpiece where a neckpiece is involved, or by increasing the branch thickness, or by adding a compensating ring in the case of a branch, or in the case of a pad or frame by increasing its thickness.

7.7.3.2 *Openings over a half of the shell diameter*

The diameter of the opening can be increased to a maximum of two-thirds of the shell diameter, but in this case that portion of cross-sectional area considered available for compensation under **7.7.3.1** c) shall be reduced as follows.

The area shall be the net cross-sectional area of wall of the neckpiece minus the sectional area of a shell of the same bore and material having a thickness equal to that calculated in accordance with **7.1.1** for the same design pressure. The area calculated shall not extend more than 50 mm from the outer surface of the calorifier or storage vessel shell and shall not include any part of the bolting flange. In no case, however, shall the area used in the calculation exceed 0.2 dt_a (see area A_3 in Figure 8 and Figure 9).

7.7.4 ***Compensation for openings cut in domed ends***

Compensation for openings cut in domed ends shall be calculated in a similar manner to that adopted for openings in cylindrical shells, see **7.7.1** except that the shell diameter, D_i, shall be replaced in the formula by the inside spherical radius R_i (in mm).

When compensation is required, the cross-sectional area to be compensated shall be half of the maximum width of the openings cut in the end of a thickness equal to $pR_i/2f$.

Similarly the thickness of the end available for providing compensation shall be the difference between the actual thickness and ($pR_i/2f + c$), where all symbols have the meanings given in **7.2.1.4**.

7.7.5 ***Inspection openings***

Calorifiers and storage vessels above 0.5 m diameter shall be provided with inspection openings placed so that an examination of the inside of the shell can be made. The minimum number and dimensions of openings shall be as given in Table 5.

If calorifiers and storage vessels are not provided with openings which comply with Section 30 of the Factories Act 1961, (see note to Table 5), the manufacturer shall inform the purchaser that precautions need to be taken to ensure that dangerous fumes are not liable to be present to such extent as to involve risk of persons being overcome.

Oval openings shall be fitted with internal doors. Circular openings other than screwed bosses shall be fitted with external covers secured by setscrews, studs or bolts which shall be in accordance with the values of permissible stress given in Table 4.

The spigot of an internal door when it is in central position in an inspection opening, shall have a clearance of not more than 1.5 mm all round.

8 Construction

8.1 Plate preparation

8.1.1 *Plate cutting*

Plates shall be cut to size and shape by shearing, flame cutting or machining.

8.1.2 *Edge examination*

All plate edges, after cutting and before carrying out further work upon them, shall be visually examined for laminations and significant edge distortion and also to make certain that cracks have not been caused by shearing. Such blemishes shall be cause for rejection or rectification. Plate thickness shall be maintained up to the edge of the weld preparation.

8.1.3 *Forming cylindrical shells*

All plain cylindrical portions shall be bent to cylindrical form to the extreme ends of the plates without damage.

Each ring shall normally be formed from one plate.

8.1.4 *Forming endplates*

All flanged endplates, whether flat or dished, shall be formed in one piece and normally be made from one rolled plate without a weld seam. If the dimensions of the endplate make it necessary to use two plates butt-welded together, the required minimum thickness shall be multiplied by the ratio $1/J$, where J is the relevant joint factor (see **7.1.1**) and the welding of the plates shall be done in the flat and the plates dressed flush before the composite plate is pressed to shape. Flanges shall have good surfaces and shall be circular, free from irregularities and a good fit to connecting parts.

8.1.5 *Post forming heat treatment*

8.1.5.1 *Heat treatment of carbon steel endplates*

Carbon steel end plates that have been cold formed to shape shall be subject to an appropriate post forming heat treatment to restore the material properties to the levels assumed in design.

NOTE Hot formed ends should be normalized unless it can be shown that the hot forming operation was carried out in the normalizing temperature range.

8.1.5.2 *Hot working of copper*

Copper which has to be worked hot shall be heated uniformly to a temperature not exceeding 900 °C. Hot forming shall be discontinued when the temperature of the metal has fallen to 650 °C.

8.1.6 *Edge preparation of openings*

Weld preparations and profiled openings of the required shapes shall be formed by one of the following methods:

a) shearing, machining, chipping, grinding; or

b) flame-cutting by machine; or

c) flame-cutting by hand followed by machining or chipping back for a distance equal to one-quarter of the plate thickness but in no case less than 3 mm.

8.2 Typical welded and brazed joints

Typical welded and brazed joints used in the construction of calorifiers are shown in Figure 1, Figure 2 and Figure 7 to Figure 17.

8.3 Welding of seams

8.3.1 *Production welding*

Production welding shall be carried out by approved welders using welding procedures approved in accordance with clause **6**.

8.3.2 *Filler and brazing materials*

Filler and brazing materials shall be in accordance with the British Standards given in Table 2 and, together with fluxes and together with other welding consumables they shall be the same as those used in the welding procedure and welder approval tests.

8.4 Copper lining of carbon steel shells

8.4.1 *General*

Where carbon steel shells are lined with copper for corrosion protection purposes, the lining shall be in the form of sheet or strip and shall be loose, mechanically attached or welded to the steel surface.

NOTE Typical methods of fitting a copper lining are given in BS 5624, but these are not exclusive and alternative methods and reduced lining thicknesses may be used. Copper tube may be used to line flanged connections. Screwed connections may be manufactured from the non-ferrous cast materials listed in Table 1.

8.4.2 *Welding or brazing of lining*

Linings shall be welded or brazed. Filler and brazing materials, where necessary, shall be chosen from those given in Table 2.

8.4.3 *Shell design*

The shell shall be designed and manufactured in accordance with clauses **7** and **8**, ignoring any contribution to strength which may be made by the copper lining.

NOTE It is not necessary to add any corrosion allowance in assessing the thickness of lined parts.

8.4.4 ***Mechanical requirements***

The internal surfaces of the shell to be lined shall be of smooth contour, thoroughly cleaned and free from scale or other foreign matter. The lining shall make good contact against the inner walls of the shell over the whole area. At least one test hole shall be drilled and tapped through the bottom of the shell before the lining is fitted so that the integrity of the lining and the continuity of the welds can be checked. One of the procedures given in **8.4.5** or **8.4.6** shall be used for checking the soundness of the lining unless an alternative method has been agreed with the purchaser.

8.4.5 ***Pneumatic leakage test***

A low pressure pneumatic test shall be made either:

a) from inside the lined shell, using the test hole to sense any leak outwards; or

b) by using the test hole to pressurize the space between the shell and lining, in which case the lining shall be adequately supported during the test to prevent collapse.

NOTE The method covered by b) has the advantage that any leakage can be accurately located, but the pressure should not exceed 0.03 N/mm^2 to avoid damage to the lining.

8.4.6 ***Leak detection***

Leak detection shall be carried out using one of the following methods:

a) using a soap solution;

b) introducing a tracer element into compressed air and using a detection device which is sensitive to the tracer element;

c) using a refrigerent [A3] and appropriate leak detection equipment. [/A3]

WARNING. Suitable precautions should be taken against the hazards introduced by the presence of active elements of toxic gases.

8.4.7 ***Shell hydraulic test***

When the quality of the lining has been confirmed (see **8.4.4**), the vessel shall be subjected to a full hydraulic pressure test with the test hole remaining open. Upon satisfactorily completing the hydraulic test, any air or moisture remaining between the shell and lining shall be evacuated and the test hole sealed.

8.5 Galvanizing of carbon steel shells

When carbon steel shells are hot dipped galvanized after manufacture, the galvanizing process shall be in accordance with [A3] BS EN ISO 1461 [/A3].

The integrity of the galvanizing is dependent on the design of the shell, and the recommendations of [A3] BS EN ISO 14713-2 [/A3] shall therefore be taken into account.

NOTE The hot dipped galvanizing process normally operates at approximately 450 °C, and precautions should be taken to ensure the safety of operators.

8.6 Carbon steel shells protected by sealed zinc metal spray

Where large steel shells are protected by sealed zinc metal spray, surface preparation and metal spraying shall be carried out in accordance with [A3] BS 7079 and BS EN ISO 2063 [/A3], to give equal protection to that afforded by galvanizing.

The integrity of the metal spray coating is dependent on the design of the shell, and the recommendations of BS 4479 shall therefore be taken into account. Adequate provision shall be made for access into the shell to carry out the spraying process.

The zinc spray coating shall be in accordance with [A3] BS EN ISO 12944 (all parts) and BS EN ISO 14713 (all parts) [/A3], with a nominal metal thickness of 150 μm.

9 Heating batteries

9.1 General

Materials used in heating batteries shall be in accordance with Table 1.

9.2 Plain tubes

9.2.1 ***Preferred size and nominal wall thickness***

9.2.1.1 *General*

Tubes shall be one of the preferred sizes given in [A3] BS EN 1057, BS EN 12449 or BS EN 12451 [/A3]. The actual wall thickness shall be not less than $t_c + b + c$ and;

a) not less than 1 mm for grade A calorifiers; or

b) not less than 0.5 mm for grade B calorifiers.

where

t_c is the calculated wall thickness for straight tubes (in mm), (see **9.2.1.2**);

b is the bending allowance (in mm), (see **9.2.1.3**);

c is the corrosion allowance (in mm), (see **9.2.1.4**).

9.2.1.2 *Calculated wall thickness*

The calculated wall thickness t_c (in mm) to be used in **9.2.1.1**, for straight tubes, shall be determined from the following equations;

a) *Grade A calorifiers*

$$t_c = \frac{pd}{0.9(p + 2f)} \quad \text{or} \quad t_c = \frac{d}{26}$$

whichever is the greater

where

- d is the outside diameter of the tube (in mm);
- p is the design pressure (in N/mm^2);
- f is the design stress value (in N/mm^2) (see Table 1).

b) *Grade B calorifiers*

$$t_c = \frac{pd}{0.9(p + 2f)} \quad \text{or} \quad t_c = \frac{d}{54}$$

whichever is the greater

where

d, p and f have the meanings given in a).

9.2.1.3 *Bending allowance*

For coils and U-tubes, the bending allowance b (in mm), shall be either such that, after bending, the calculated stress resulting from internal pressure does not exceed the design stress value given in Table 1, or be calculated from the following equation:

$$b = \frac{dt_c}{2.5r}$$

where

- t_c is the calculated wall thickness for straight tube (in mm) (see **9.2.1.2**);
- d is the outside diameter of the tube (in mm);
- r is the radius of curvature measured to the centre line of the bend (in mm).

9.2.1.4 *Corrosion allowance*

If no corrosion allowance is specified by the purchaser, the manufacturer shall either:

a) select a material which is suitable for the service conditions without a corrosion allowance; or

b) include a corrosion allowance suitable for the material selected and the service conditions.

9.2.2 ***Tubes that are screwed***

Tubes that are to be screwed into tubeplates shall have a residual thickness beneath the thread of not less than the thickness calculated in **9.2.1**.

9.2.3 ***Tubular elements***

Each tubular element of a heating coil or battery shall be, where possible, a single length of tube without intermediate joint. The ends of the tube shall be secured to the shell or tubeplate by one of the methods given in **9.6**.

9.3 Extended surface tubes

Extended surface tubes shall be formed from tubes complying with [A3] BS EN 12452 [A3].

The nominal wall thickness of a tube with external fins shall be in accordance with **9.2.1.2**, where d is taken to be the diameter (at the root of the fins).

The nominal wall thickness of an internally finned tube with plain external surface shall be in accordance with **9.2.1.1**, where the thickness, t, is taken to be half the difference between the external diameter of the tube and the diameter at the contact point of the fin and tube.

9.4 Indented tubes

Indented tubes shall be formed from tubes conforming to [A3] BS EN 12451 [A3].

The minimum wall thickness of indented tubes or other straight tubes of similar form shall be determined in accordance with **9.2.1.1**.

9.5 Spacing of tubes and coils

For storage calorifiers, the tube pitch, i.e. the distance between centre lines of adjacent tubes, measured at the tube plate shall be not less than the nominal outside diameter of the tube plus 19 mm.

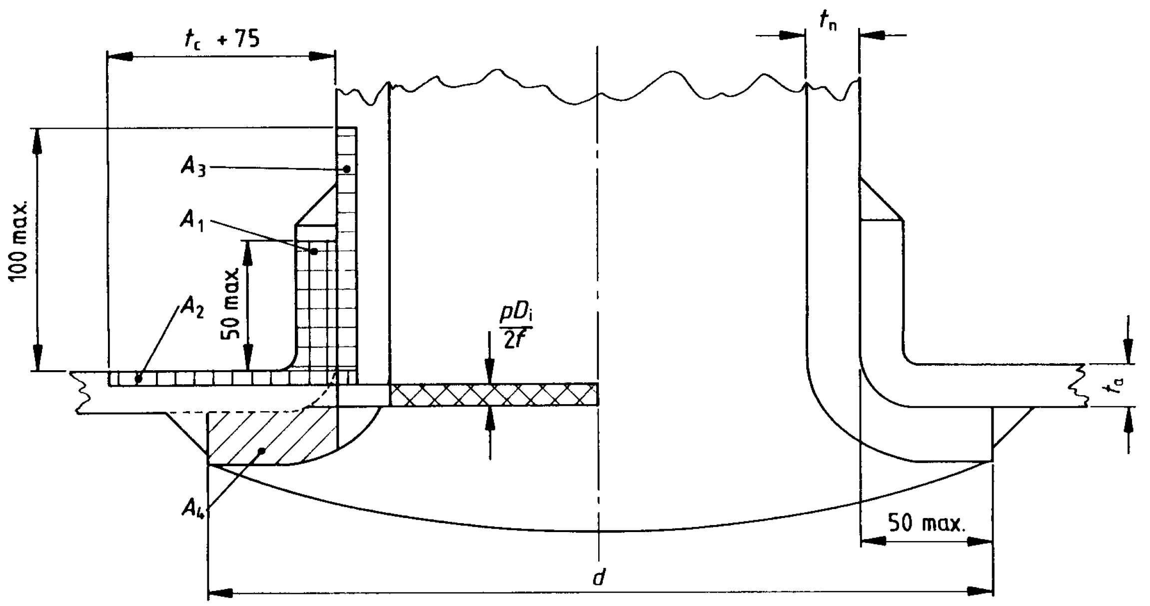
For heating (non-storage) calorifiers, square or equilateral spacing of tubes shall be used. In either case, the tube pitch shall be not less than $1^1/_4$ times the nominal outside diameter of the tubes.

Where provision for external cleaning is necessary, the tube bundle shall be removable and the tube shall be assembled on a square pitch with a minimum ligament of 6 mm.

9.6 Tube attachment

9.6.1 ***General***

Tubes shall be attached to tube plates (or internal headers) by one of the methods given in **9.6.2** to **9.6.5**.



Key
t_a = actual thickness of shell

Area to be compensated thus

Allowances of compensation thus

All dimensions are in millimetres.

Figure 9 — Compensation for opening in cylindrical copper shells (neckpiece and shell flanged)

9.6.2 ***Expanding***

Attachment shall be made by expanding the tubes directly into the plate or header [see Figure 18(a) and Figure 19(b)].

NOTE If the thickness of the tube plate is less than half the outside diameter of the tube, it is recommended that the tubes be fitted with taper ferrules driven into the tube [see Figure 18(b)].

The edges of the holes shall be free from burrs. The external surface of the tubes and the surface of the holes shall be reasonably smooth before the tubes are inserted into the tube plate. The ends of the tubes shall project, when expanded, not less than 3 mm from the tube plate.

Table 5 — Minimum requirements for inspection openings

Internal diameter of calorifier or storage vessel	Sizes of openings[a]	
	Storage vessels	Non-storage calorifiers
m	mm	mm
Up to and including 0.5	Optional	Optional
Over 0.5 and up to and including 0.6	Two oval openings each 100 × 75 or one circular opening 200 diameter	Two 75 diameter screwed bosses fitted with plugs or one circular opening 200 diameter
Over 0.6 up to and including 0.75	Two oval openings each 125 × 85 or one circular opening 250 diameter	Two circular openings each 125 diameter or one circular opening 250 in diameter
Over 0.75 up to and including 0.9	Two oval openings each 200 × 100 or one circular opening 300 diameter or one oval opening 375 × 275	Two circular openings each 150 diameter or one circular opening 300 diameter
Over 0.9 up to and including 1.0	Two circular openings each 225 diameter or one circular opening 375 diameter of one oval opening 375 × 275	Two circular openings 225 diameter or one circular opening 375 diameter
Over 1.0	Two circular openings each 250 diameter or one circular opening 450 diameter or one oval opening 400 × 300 diameter	Two circular openings each 250 diameter or one circular opening 450 in diameter

NOTE Section 30 of the Factories Act 1961 applies if there is a likelihood of dangerous fumes being present within a vessel to such an extent as to involve risk of persons being overcome.

The relevant part of Section 30 of the Factories Act 1961 states:

> "The confined space shall, unless there is other adequate means of egress, be provided with a manhole, which may be rectangular, oval or circular in shape, and shall be not less than 18 in long and 16 in wide or (if circular) not less than 18 in diameter."

These sizes are equivalent to 457.2 mm × 406.4 mm and 457.2 mm diameter respectively.

Section 30 also applies to the lack of oxygen within a confined space. Reference may be made to sub-sections (9) and (10) of Section 30 for the full legal requriements.

[a] All dimensions are inside (i.e. "clear hole".)

For parallel-expanded tubes, the holes in the tube plate shall be drilled not more than 0.3 mm greater in diameter than the outside diameter of the tubes. The expanding process shall be carried out with roller expanders and the expanded portion of the tubes shall be parallel through the full thickness of the tube plate.

If taper expanding machines are used, the holes shall be reamed to suit the taper angle of the machine to ensure expanding over the entire surface.

When the tubes are secured by means of ferrules, the hole preparations and the expanding of the tubes shall be as specified in this clause. The ferrules shall be driven in either by hand or by power operation.

9.6.3 ***Screwed nipple and nut***

Attachment(a) shall be made by securing the tubes to the tubeplate by means of a screwed nipple and a nut [see Figure 18(c)] or nipple screwed directly into the header [see Figure 19(a)], the nipple being attached to, and secured against rotation in, the tube end.

The clearance holes through the plate to take the nipples shall be not more than 0.3 mm greater in diameter than the diameter at the top of the nipple thread, and the preparation of the holes shall be as described in **9.6.2**, except that the tubeplate shall be spot faced on each side to make a joint with the tube ends on the one side and the nuts on the other. Similarly, where tubes are secured by nipples screwed directly into the tubeplate, the tubeplate shall be spot faced to make a joint with the tube ends and the screwed nipples shall be prevented from turning in the tubes.

9.6.4 ***Brazing***

Attachment shall be made by brazing, in accordance with [A3) BS EN 14324 (A3].

9.6.5 ***Screwing***

Attachment shall be made by screwing, preferably followed by expanding.

9.7 Attachment of coils

Where coils pass through a cylindrical shellplate, or a domed endplate, and are secured by back nuts inside and out, the plate shall be provided with suitable bosses or seatings to ensure flat and parallel jointing surfaces inside and outside.

9.8 Supports for coils and tubes

Heating coils and batteries shall be adequately supported. Horizontal batteries of U-tubes having an overhang exceeding 900 mm shall be supported and, where necessary for easy withdrawal, shall be fitted with a suitable type of skid or runner wheels to run on rails secured to the body of the calorifier. Where the internal diameter of the steam or water chest exceeds 500 mm, an eye bolt shall be provided on the tubeplate for supporting purposes during removal.

9.9 Steam chests, water chests and internal headers

9.9.1 ***General***

The chest or header shall be machined on the flange joint face.

NOTE 1 The mid-feather should have a suitable joint face and be provided with a drain hole.

NOTE 2 It is recommended that some means, e.g. a number of collar stud bolts, be provided to enable the battery as a whole to be removed without breaking the joint between the header and the tubeplate. To enable the header to be removed without breaking the joint between the tubeplate and the neckpiece, suitable starting screws are also recommended.

9.9.2 ***Spherically shaped cast chests***

9.9.2.1 *General*

Circular cast spherically shaped chests with bolting flanges and full face gaskets similar to Figure 20 shall be designed in accordance with **9.9.2.2** and **9.9.2.3**.

9.9.2.2 *Chest thickness*

The chest thickness t (in mm), shall be calculated from the following equation:

$$t = \frac{5pR}{6f} + c$$

where

- p is the chest design pressure (in N/mm^2);
- R is the internal spherical or crown radius (in mm);
- f is the design stress value from Table 1 (in N/mm^2);
- c is the corrosion allowance of 1.0 mm for cast iron and cast steel and 0 for non ferrous castings.

9.9.2.3 *Flange thickness.* The flange thickness T (in mm), shall be calculated from the following equation but in no case shall it less than the chest thickness t, or 8 mm, whichever is the greater

$$T = K + \sqrt{\left[K^2 + \frac{3DK\,(D_b - D)}{R}\right]}$$

where

- D is the inside diameter of flange (in mm);
- D_b is the bolt pitch circle diameter (in mm);
- K is a factor given by the following equation:

$$K = \frac{pR}{4f}\left[\frac{D_b + D}{7D_b - 5D}\right]$$

where p, R and f have the meanings given in **9.9.2.2**.

9.9.3 ***Fabricated headers or chests***

Headers or chests fabricated in steel or copper shall be designed using the appropriate equation in clause **7**.

9.9.4 ***Other forms of cast chest***

The use of other forms of cast chest not covered by **9.9.2** is permitted but such forms shall be proof tested in accordance with **11.3**.

9.10 Electrical immersion heaters

9.10.1 ***General***

Immersion heaters shall be self contained and designed to suit the design temperature and working pressure of the calorifier.

The heads of immersion heaters shall be made of metal compatible with the design of the calorifier and the outer sheaths of the heating elements shall be of metal compatible with the heat exchange medium.

9.10.2 ***Method of attachment to calorifier***

The immersion heater shall be provided with flanges or screwed connections for its attachment to the calorifier. Joint gaskets shall be provided except where taper thread connections are used.

Each immersion heater shall be provided with a suitable earth terminal of adequate cross-sectional area in addition to the normal supply terminals.

Cable entry shall be by means of conduit bush or other suitable gland of adequate size to accept a cable of suitable rating or as specified by the purchaser. Domestic pattern cable entries shall not be permitted.

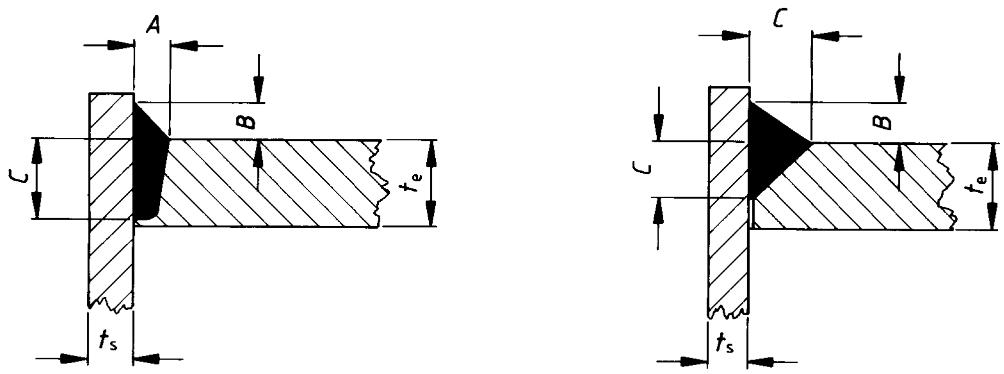
Terminal covers shall be designed so that access to electrical components cannot be made without the use of tools and no dismantling of electrical components is necessary for electrical inspection.

9.10.2.1 *Flanged joints*

Flanged joints shall be designed to withstand safely the load resulting from the working pressure within the calorifier. If the studs or bolts pass through the heater head, the pressure joint shall be designed such that it is not possible, even if the joint leaks, for water to pass along the bolt holes into the heater head and adversely affect the electrical connections, insulation and components located within the head.

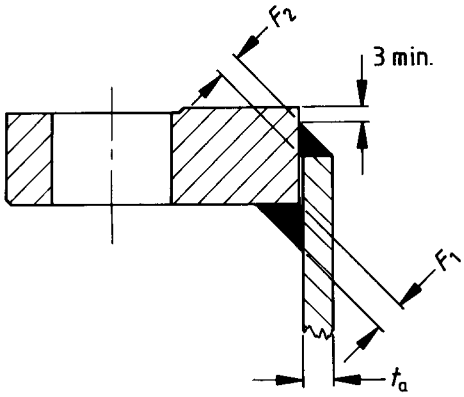
9.10.2.2 *Screwed connections*

The threads for screwed connections shall be in accordance with [A3] BS EN ISO 228-1 and BS EN ISO 228-2 or BS EN 10226-1 [A3], as applicable. The length of thread shall be adequate to withstand the design pressure of the calorifier or storage vessel.



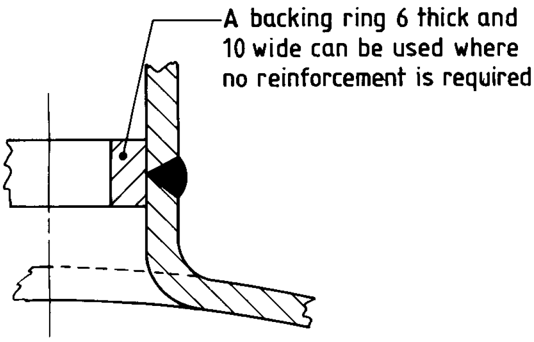
NOTE
$A = t_s$
$B = t_s$
$C = 2t_s$ or $(t_e - 1.5)$, whichever is less

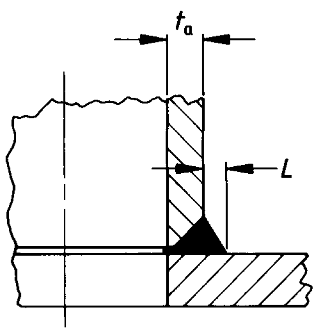
Figure 10 — Welds for unflanged flat endplates



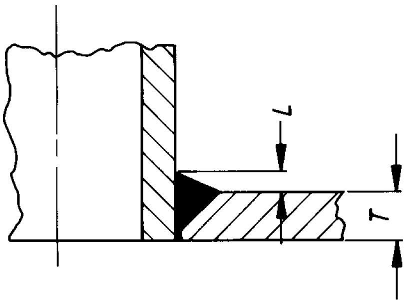
NOTE 1.
F_2 = 0.7 t_a min.
F_1 = t_a (min.), but should not exceed 13 mm.

(a) Typical flange construction





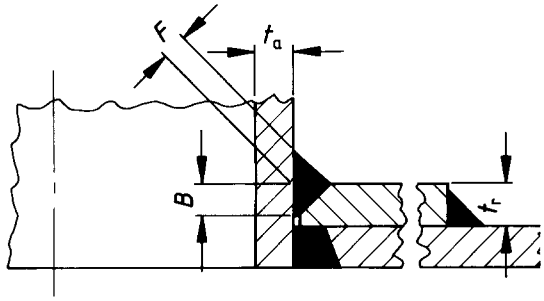
NOTE 3.
L = t_a/3 (min.), but not less than 6 mm



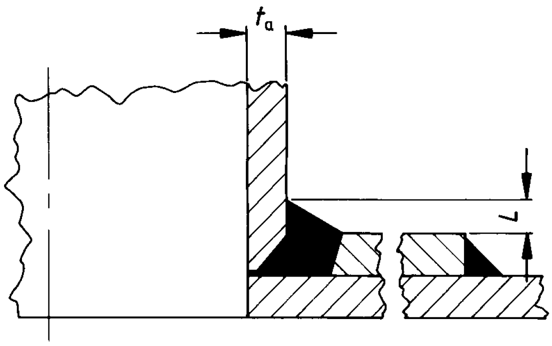
NOTE 2.
L = T/3 (min.), but not less than 3 mm.

(b) Typical branch connections

Figure 11 — Welding of carbon steel flanges and branches

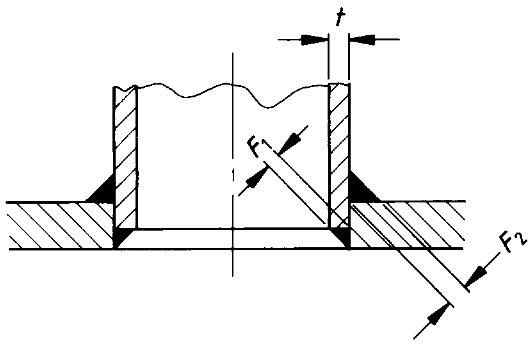


NOTE 4.
$B + F = t_a$ or t_r whichever is the lesser



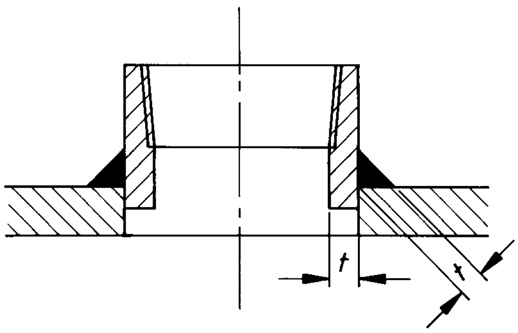
NOTE 5.
$L = t_a/3$ (min), but not less than 6 mm.

(c) Typical reinforced branch or neckpiece connections



NOTE 6.
$F_1 + F_2 = 2t$

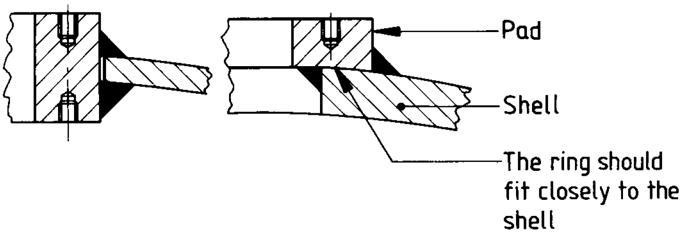
(d) Flanged nozzle



(e) Screwed nozzle (up to 75 mm)

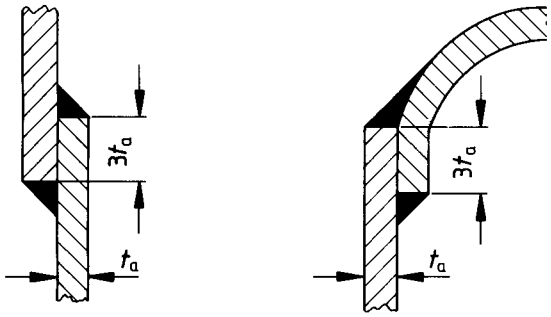
All dimensions are in millimetres.

Figure 11 — Welding of carbon steel flanges and branches *(concluded)*

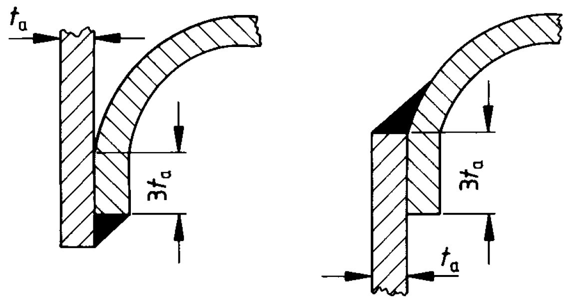


NOTE. The gap should not exceed 3 mm at any point.

Figure 12 — Welding of carbon steel pads



(a) For operating pressures above 0.45 N/mm^2 (4.5 bar)



(b) For operating pressures up to 0.45 N/mm^2 (4.5 bar)

Figure 13 — Overlap of plates in lapped circumferential seams for copper and carbon steel

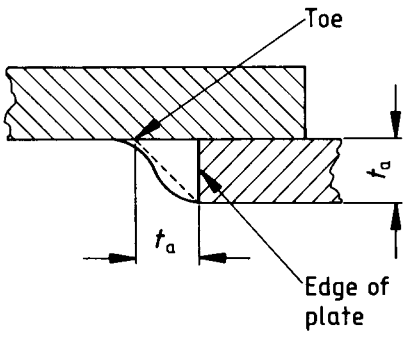


Figure 14 — Fillet welds

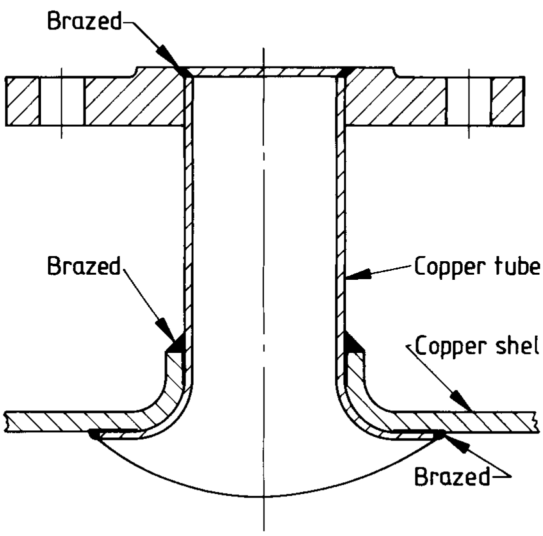


Figure 15 — Brazing of copper flanged connection up to 100 mm diameter

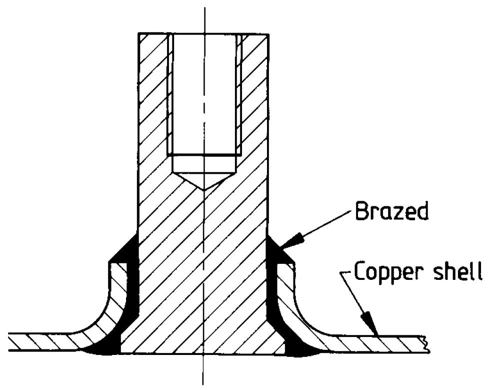


Figure 16 — Brazing of copper lifting eye

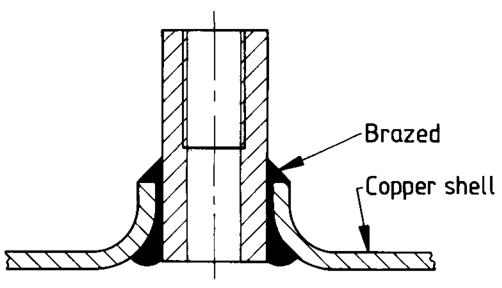


Figure 17 — Brazing of copper screwed connection

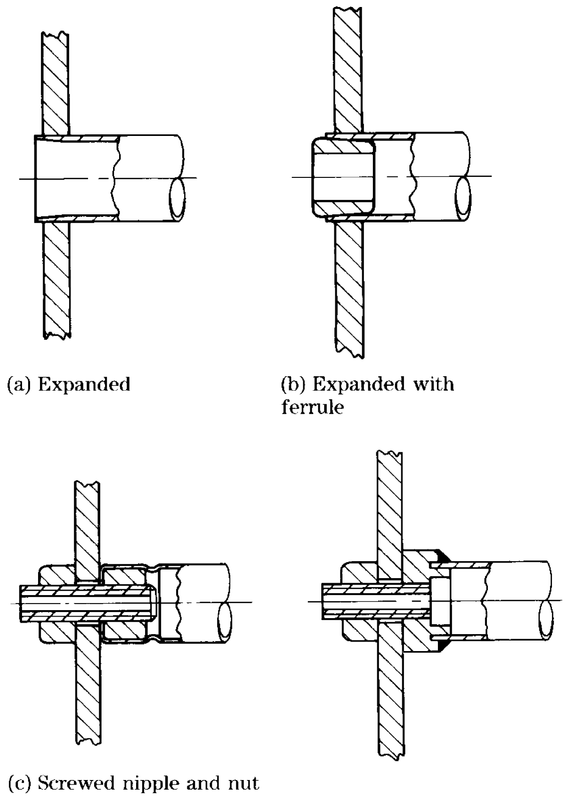


Figure 18 — Typical tube attachment to tubeplates

10 Mountings

10.1 General

Where mountings are fitted by the manufacturer they shall be in accordance with **10.2** to **10.7**. Where not fitted by the manufacturer provision shall be made for their attachment (see [A3⟩ Annex ⟨A3] A).

Screwed connections for mountings shall conform with **7.5**.

NOTE Attention is drawn to [A3⟩ Annex ⟨A3] B for guidance on plant layout and installation of mountings.

10.2 Pressure relief devices

10.2.1 *Safety valves for calorifiers*

10.2.1.1 *General*

A safety valve in accordance with the requirements of [A3⟩ BS EN ISO 4126-1 ⟨A3] shall be arranged vertically and attached directly to, or as close as possible to, the calorifier shell.

The connection shall have a bore area at least equal to the area of the safety valve with no intervening valves between the calorifier shell and the safety valve.

[A3⟩ NOTE For systems requiring compliance with Building Regulations, attention is drawn to The Building Regulations Approved Document G, G3. ⟨A3]

10.2.1.2 *Sizing for pressurized (unvented) systems*

The safety valve shall be selected from those made in accordance with [A3⟩ BS EN ISO 4126-1:2004, **NA.2.1.1** ⟨A3] as a result of the application of the following equation:

$$A = \frac{R}{0.329 P K_{\mathrm{dr}}}$$

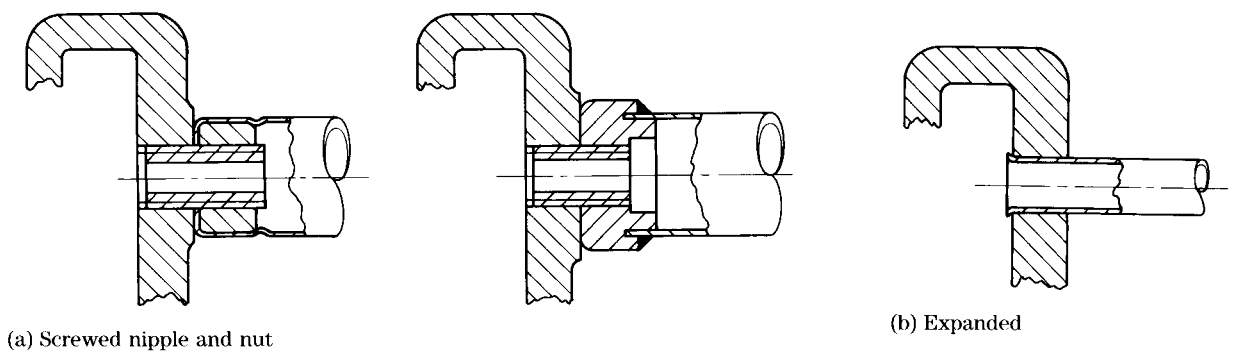


Figure 19 — Typical tube attachment in headers

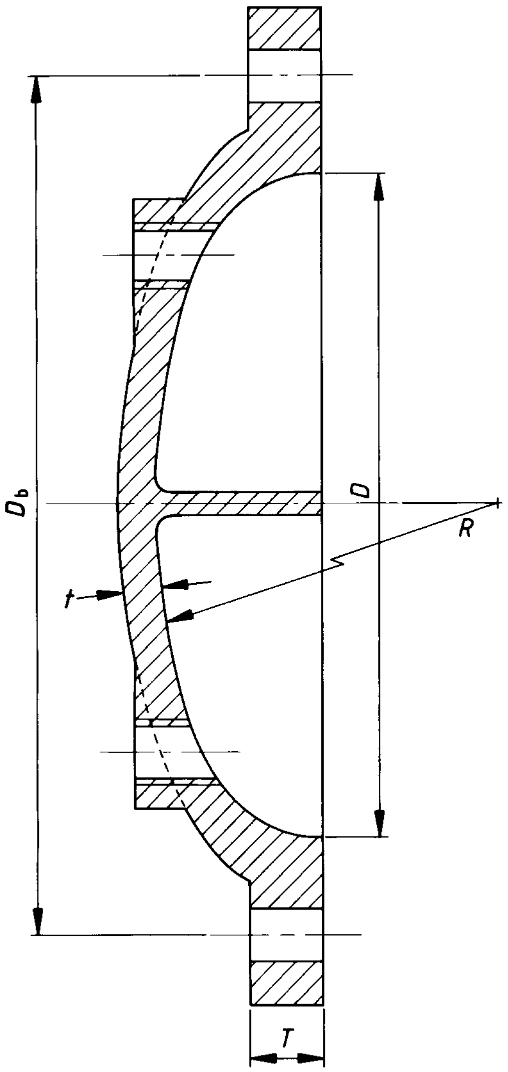


Figure 20 — Circular cast iron spherically shaped chest

where

R is the rating of the safety valve (in kW);

P is the maximum absolute relieving pressure (shell design pressure × 1.10) + 1.0 (in bar absolute);

A is the flow area (in mm^2);

K_{dr} is derated coefficient of discharge (i.e. the coefficient of discharge as stated for a particular valve by the manufacturer).

The nominal size of the safety valve shall be not less than 20 mm ($^3/_4$ in).

10.2.1.3 *Sizing for open vented systems*

The safety valve shall be selected as a result of the application of the following equation:

$$A = \frac{0.5R}{0.329PK_{dr}}$$

where

R is the rating of the safety valve (in kW);

P is the maximum absolute relieving pressure (shell design pressure × 1.10) + 1.0 (in bar absolute)

A is the flow area (in mm^2);

K_{dr} is the derated coefficient of discharge (i.e. the coefficient of discharge as stated for a particular valve by the manufacturer).

The nominal size of the valve shall not be less than 20 mm ($^3/_4$ in).

NOTE The value of 0.5R takes account of the extra discharge capacity of the vent.

10.2.1.4 *Set pressure*

The minimum set pressure (in bar) shall be determined in accordance with the following equation:

set pressure = 1.10 × working pressure[6)]

In no case shall the margin between the working pressure and that at which the safety valve is set be less than [A3] 0.05 N/mm^2 (0.5 bar) [/A3]. In hot water heating systems with accelerated circulation, the set pressure shall be not less than 0.07 N/mm^2 (0.7 bar) in excess of the working pressure.

10.2.2 ***Bursting discs for calorifiers heated by hot water coils***

10.2.2.1 *Specification*

Where the design pressure of the shell is less than the primary working pressure, the calorifier shell shall be provided with a bursting disc in accordance with [A3] BS EN ISO 4126-2 [/A3], mounted as close as possible to the calorifier shell and designed to fail at a pressure not greater than 1.3 times the design pressure in the calorifier shell and capable of discharging all the water that could pass into the shell through a rupture in one of the coils. In no case shall the effective discharge area of the ruptured disc A (in mm^2), be less than the value given by the following equation:

$$A = 2a\sqrt{\left[\frac{p_1 - p}{p}\right]}$$

[6)] If working pressure is in metres head, multiply by 0.0098 to obtain the working pressure in N/mm^2.

where

a is the area of the bore of the coil, or element tube, or area of the primary hot water supply pipe, whichever is the less, (in mm^2);

p_1 is the primary pressure (in N/mm^2).

p is the design pressure of the shell (in N/mm^2).

10.2.2.2 *Discharge pipe*

Each bursting disc shall be provided with means for being connected to a discharge pipe of adequate size. The size and provision of the discharge pipe shall be the responsibility of the installer.

10.2.3 ***Vented systems***

Where the secondary system is open to atmosphere, there shall be an open vent pipe fitted to the calorifier or from the draw-off pipe immediately adjacent to the calorifier.

The vent pipe shall have an unrestricted bore not less than the appropriate size given in Table 6.

Table 6 — Sizes of vent pipes

Rated output of calorifier	Minimum bore
kW	mm
Up to 60	25
Over 60 up to 150	32
Over 150 up to 300	38
Over 300 up to 600	50
Over 600	63

10.3 Stop valves

Calorifiers heated by steam shall be provided with a stop valve at the steam inlet and calorifiers heated by hot water shall be provided with a stop valve on both the inlet and outlet connections to the battery.

10.4 Pressure gauges

Each steam heated calorifier shall be fitted with a pressure gauge with syphon and cock on the steam side. A pressure gauge shall be fitted on the primary side adjacent to each calorifier heated by high pressure hot water.

10.5 Thermometers

Provision shall be made for the fitting of a thermometer on the secondary side to measure the temperature at or near the outlet from the calorifier. The thermometer shall be arranged so that it is easily readable, and the scale shall be calibrated in degrees Celsius.

NOTE The thermometers should be of such a type and fitted so that it may be replaced readily without emptying the calorifier.

10.6 Drains

Each calorifier or storage vessel shall have an emptying valve or cock fitted at the lowest practical point in the shell.

10.7 Vacuum breaker valve

A vacuum breaker valve shall be fitted to the secondary side of copper lined calorifiers and storage vessels.

NOTE It is recommended that a vacuum breaker valve is fitted on the secondary side of copper calorifiers and storage vessels.

The minimum aggregate area of the orifices through the seats of the anti-vacuum valves fitted to each copper lined calorifier or storage vessel shall not be less than 0.25 A_c, where A_c, is the cross-sectional area of the largest secondary connection or drain on the shell (in mm^2).

11 Inspection, testing, marking and manufacturer's certificate

11.1 Inspection and testing

Calorifers and storage vessels shall be subject to independent inspection as required by the purchaser [see [A3]Annex[/A3] A item t)].

11.2 Hydraulic test

Before despatch from the manufacturer's works, each calorifer or storage vessel shall be hydraulically tested. This testing is to be carried out in the presence of a representative of the manufacturer or the inspecting authority as required by the purchaser and advised at the time of order (see item s) of [A3]Annex[/A3] A).

The shell, and tubes where applicable, shall be hydraulically pressure tested to 1.5 times their design pressures.

In all cases the hydraulic test pressure shall be maintained for a period of not less than 30 min, during which time there shall be no signs of leakage.

11.3 Proof hydraulic testing of cast chests and other components

The maximum design pressure p_R (in N/mm^2), of cast chests of other than spherical shape (see **9.9.2**) and of other cast components shall be based on testing identical components to destruction and shall be calculated using the following equation:

$$p_R = 0.15\ p_B$$

where

p_R is the maximum design pressure within the limits of service conditions for temperature and pressure listed in the notes to Table 1;

p_B is the destruction test pressure (in N/mm^2).

If a hydraulic proof test pressure of 7.0 N/mm^2 (70 bar) is reached without destruction of the component a maximum design pressure of 1.03 N/mm^2 (10.3 bar) can be used for identical components.

All components of the same material, design and construction shall be hydraulically tested in accordance with **11.2**.

NOTE Attention is drawn to the hazards involved in the proof testing of components and precautions should be taken to protect personnel against injury.

11.4 Marking

11.4.1 Each calorifier and storage vessel shall have a metal plate attached bearing legible and durable indication of the following:

a) the name and/or mark of the manufacturer;

b) the thickness of shell;

c) the design pressures of the calorifier or storage vessel;

d) the hydraulic test pressures;

e) the date of hydraulic test;

f) the number of this British Standard, i.e. BS 853[7] and the grade of manufacture, i.e. A or B, as appropriate.

11.4.2 If bolts or studs material selected is of a higher grade than grade 4.6 of BS 4190 (see Table 4) this shall be clearly indicated on a separate plate to be attached to the cover, as near as possible to the bolts or studs.

11.5 Manufacturer's certificate

The manufacturer shall issue either a signed and dated certificate of construction and test, or a certified drawing, covering each calorifier or storage vessel, certifying that the calorifier or storage vessel complies in all respects with the requirements of this standard. This certificate shall give the following particulars:

a) the manufacturer's reference number on the calorifier;

b) the thickness of the shell;

c) the thickness of the ends;

d) the diameter and overall length of the shell;

e) the design pressure and temperatures;

f) the hydraulic test pressures;

g) the thickness of the neckpiece(s);

h) the material and thickness of the tubeplate;

i) the outside diameter and thickness of the heater tubes;

j) the number of tubes and the centre-to-centre dimensions;

k) the number of this British Standard, i.e. BS 853[8] and the grade of manufacturer, i.e. A or B, as appropriate;

l) the type of corrosion protection and the thickness of the copper lining, where fitted.

[7] Marking BS 853 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. is a claim by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is therefore solely the responsibility of the person making the claim. Such a delcaration is not to be confused with third party certification of conformity, which may also be desirable.

A3 [8] Referred to in the foreword only. A3

A3 Annex A3 A Information supplied by the purchaser

The purchaser should supply the manufacturer with the following details at the time of enquiry or order, to enable the most suitable equipment to be supplied.

a) The storage capacity (in litres) and/or the overall length (in mm) and the diameter (in mm).

b) The type of calorifier or storage vessel, e.g. vertical or horizontal.

c) The type of end, e.g. fixed or bolted.

d) The size and position of the inspection opening.

e) The duty of the calorifier as follows.

1) The storage heat up time (in h).

2) The heating output (in kW).

3) The secondary inlet temperature (in °C).

4) The secondary outlet temperature (in °C).

f) The method of heating, i.e. by hot water or heat transfer fluid, by steam or electrically.

g) If the heating is by hot water or heat transfer fluid, the following information relating to the heating medium should be supplied.

1) The pressure (in N/mm^2).

2) The flow temperature (in °C).

3) The return temperature (in °C).

h) If the heating is by steam, the following information relating to the steam should be supplied.

1) The pressure at the calorifier (in N/mm^2).

2) The temperature at the calorifier (in °C).

i) If the heating is electrical, the following information should be supplied.

1) The voltage of the supply (in V).

2) The frequency of the supply (in Hz).

3) The number of phases of the supply.

4) The number of wires of the supply.

j) The type of heater, i.e. helical coil (withdrawable or fixed), U-tube battery or other tubular construction.

k) The connections and mounting sketch, showing the size, type, position and purpose and whether the purchaser or the manufacturer is to supply the mountings.

l) For gravity system secondary circuits, the following information should be supplied.

1) The working pressure (in N/mm^2).

2) The design water pressure (in N/mm^2).

m) For pumped system secondary circuits, the maximum secondary circuit pressure at the calorifier or storage vessel, including the pumping head where applicable (in N/mm^2), should be supplied.

n) Whether the secondary system is vented or unvented.

o) For an unvented system fitted with an expansion vessel, the maximum pressure after allowance for thermal expansion.

p) The materials of construction, particularly on the secondary side where local water conditions will determine the most suitable material and the need for protective anodes and corrosion allowances. Guidance is given on this subject in A3 Annex A3 B.

q) Any special circumstances or regulations affecting the calorifier or storage vessel, e.g. local water bye-laws, local building regulations.

r) Whether material test certificates are required (see **5.3**).

s) Whether hydraulic test certificates are required (see **11.2**).

t) The details of independent inspection and requirements (see **11.1**).

A3 Annex A3 B Guidance for plant layout and installation

B.1 Vent pipe

Where the secondary system is open to atmosphere the vent pipe performs a number of functions. It allows escape and entry of air during filling and draining down operations. It allows for thermal expansion and contraction of the water and provides an outlet for steam should the secondary water be overheated.

Non-vertical pipe runs should be avoided where possible but all should have a continuous upward slope. No isolating valve should be fitted in the vent pipe but where two or more calorifiers share a common vent, a 3-way escape valve may be fitted to each calorifier.

B.2 Discharge pipe

The safety valve and any bursting disc both require a discharge pipe equal in size to the outlet port of the safety device.

Precaution. It is important for safety reasons that the discharge pipe is laid with a continuous downward gradient clear of the calorifier or storage vessel to a place where the discharge is visible and cannot injure any person.

B.3 Pipe supports

All pipework should be independently supported to minimize external loads on the calorifier or storage vessel. Provision should be made for movement due to expansion and contraction of the pipework.

B.4 Temperature regulation

A control should be fitted to prevent the temperature of the water rising above a safe working temperature. This is particularly important when the primary medium is above 100 °C and for the control of electric immersion heaters. In the case of electric immersion heaters there should be a high temperature safety switch for added protection.

Electronic controls should be designed so that in the case of a power failure the control system will fail safe, e.g. where high temperature primary water is controlled by an electrically driven valve. Then in the event of power failure when the valve is open there should be a device to move the valve to the closed position.

B.5 Unvented systems

If the secondary system is not open to atmosphere, careful consideration should be given to expansion and contraction of the water. It is recommended that all unvented systems are provided with an expansion vessel. For added protection of the calorifier, it is advisable to fit some form of energy cut out and for domestic hot water calorifiers to be fitted with a temperature relief valve set below 100 °C.

Due to the lack of a vent pipe, provision should be made for release of air when filling the system and for the entry of air when draining down. Vent cocks and anti-vacuum valves are required for this purpose.

Precautions should be taken to prevent operation of the calorifier when it is isolated from the system.

Provision should be made for the fitting of a pressure gauge on the secondary water side of each calorifier.

Attention is drawn to mandatory requirements of local authorities and particularly to Building Regulations which may apply to unvented systems.

B.6 Water quality

It is important that the water quality is established with respect to the materials being selected for the construction and protection of the calorifier.

As a general guide galvanized cylinders are used with hard water and a sacrificial anode may be advisable if scale deposits are slow forming. Galvanized cylinders should not be used with soft water. Water should not be stored in galvanized cylinders above 60 °C until after scale formation. Galvanized surfaces provide sacrificial protection to steel. In water conditions that do not produce scale careful consideration should be given to material selection.

Certain waters of high organic purity are known to cause pitting corrosion in copper storage calorifiers. For these areas protection is afforded by the insertion of an aluminium anode in the cylinder.

B.7 Access

It is essential that sufficient clearance is left around the calorifier for access to the inspection opening and for removal of the heater battery. Similarly, space should be left for withdrawal of the thermostat and other such probes. Large heater batteries may require lifting tackle or a wheeled carrier for maintenance.

Publications referred to

A3 BS 10, *Specification for flanges and bolting for pipes, valves and fittings*

BS 1400, *Specification for copper alloy ingots and copper alloy and high conductivity copper castings*[9)]

BS 1453, *Specification for filler materials for gas welding*

BS 1845, *Specification for filler metals for brazing*[9)]

BS 3274, *Specification for tubular heat exchangers for general purposes*[10)]

BS 3692, *ISO metric hexagon bolts, screws and nuts – Specification*

BS 4190, *ISO metric black hexagon bolts, screws and nuts – Specification*

BS 4439, *Specification for screwed studs for general purposes – Metric screws*

BS 4479, *Design of articles that are to be coated*

BS 4882, *Specification for bolting for flanges and pressure containing purposes*

BS 5624, *Code of practice for the lining of vessels and equipment for chemical processes: copper and copper alloys*[10)]

BS 7079, *General introduction to standards for preparation of steel substrates before application of paints and related products*

BS 10217-1, *Welded steel tubes for pressure purposes – Technical delivery conditions – Part 1: Non-alloy steel tubes with specified room temperature properties*

BS 10217-2, *Welded steel tubes for pressure purposes – Technical delivery conditions – Part 2: Electric welded non-alloy and alloy steel tubes with specified elevated temperature properties*

BS EN 287-1:2004, *Qualification test of welders – Part 1: Fusion welding – Steels*

BS EN 760, *Welding consumables – Fluxes for submerged arc welding – Classification*

BS EN 895, *Destructive tests on welds in metallic materials – Transverse tensile test*

BS EN 1011-1, *Welding – Recommendations for welding of metallic materials – Part 1: General guidance for arc welding*

BS EN 1011-2, *Welding – Recommendations for welding of metallic materials – Part 2: Arc welding of ferritic steels*

BS EN 1057, *Copper and copper alloys – Seamless, round copper tubes for water and gas in sanitary and heating applications*

BS EN 1092, *Flanges and their joints – Circular flanges for pipes, valves, fittings and accessories, PN designation*

BS EN 1320, *Destructive tests on welds in metallic materials – Fracture tests*

BS EN 1321, *Destructive test on welds in metallic materials – Macroscopic and microscopic examination of welds*

BS EN 1561, *Founding – Grey cast irons*

BS EN 1563, *Founding – Spheroidal graphite cast iron*

BS EN 1653, *Copper and copper alloys – Plate, sheet and circles for boilers, pressure vessels and hot water storage units*

BS EN 1982, *Copper and copper alloys – Ingots and castings*

BS EN 10028-2, *Flat products made of steels for pressure purposes – Part 2: Non-alloy and alloy steels with specified elevated temperature properties*

BS EN 10213, *Steel castings for pressure purposes*

BS EN 10216-1, *Seamless steel tubes for pressure purposes – Part 1: Technical delivery conditions*

BS EN 10216-2, *Seamless steel tubes for pressure purposes – Part 2: Technical delivery conditions – Non-alloy and alloy steel tubes with specified elevated temperature properties*

[9)] Superseded, withdrawn.
[10)] Current, obsolescent.

BS EN 10226-1, *Pipe threads where pressure tight joints are made on the threads – Part 1: Taper external threads and parallel internal threads. Dimensions, tolerances and designation*

BS EN 10241, *Steel threaded pipe fittings*

BS EN 10273, *Hot rolled weldable steel bars for pressure purposes with specified elevated temperature properties*

BS EN 12163, *Copper and copper alloys – Rod for general purposes*

BS EN 12165, *Copper and copper alloys – Wrought and unwrought forging stock*

BS EN 12167, *Copper and copper alloys – Profiles and rectangular bar for general purposes*

BS EN 12449, *Copper and copper alloys – Seamless, round tubes for general purposes*

BS EN 12451, *Copper and copper alloys – Seamless, round tubes for heat exchangers*

BS EN 12452, *Copper and copper alloys – Rolled, finned, seamless tubes for heat exchangers*

BS EN 14324, *Brazing – Guidance on the application of brazed joints*

BS EN ISO 228-1, *Pipe threads where pressure-tight joints are not made on the threads – Part 1: Dimensions, tolerances and designation*

BS EN ISO 228-2, *Pipe threads where pressure-tight joints are not made on the threads – Part 2: Verification by means of limit gauges*

BS EN ISO 636, *Welding consumables – Rods, wires and deposits for tungsten inert gas welding of non-alloy and fine-grain steels – Classification*

BS EN ISO 1461, *Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods*

BS EN ISO 2063, *Thermal spraying – Metallic and other inorganic coatings – Zinc, aluminium and their alloys*

BS EN ISO 2560, *Welding consumables – Covered electrodes for manual metal arc welding of non-alloy and fine grain steels – Classification*

BS EN ISO 4126-1:2004 (NA), *Safety devices for protection against excessive pressure – Part 1: Safety valves*

BS EN ISO 4126-2, *Safety devices for protection against excessive pressure – Part 2: Bursting disc safety devices*

BS EN ISO 5173, *Destructive tests on welds in metallic materials – Bend tests*

BS EN ISO 9453, *Soft solder alloys – Chemical compositions and forms*

BS EN ISO 12944 (all parts), *Paints and varnishes – Corrosion protection of steel structures by protective paint systems*

BS EN ISO 14171, *Welding consumables – Solid wire electrodes, tubular cored electrodes and electrode/flux combinations for submerged arc welding of non alloy and fine grain steels – Classification (ISO 14171:2010)*

BS EN ISO 14341, *Welding consumables – Wire electrodes and weld deposits for gas shielded metal arc welding of non alloy and fine grain steels – Classification*

BS EN ISO 14713 (all parts), *Zinc coatings – Guidelines and recommendations for the protection against corrosion of iron and steel in structures*

BS EN ISO 15609-1, *Specification and qualification of welding procedures for metallic materials. Welding procedure specification – Arc welding*

BS EN ISO 15614-1, *Specification and qualification of welding procedures for metallic materials – Welding procedure test – Arc and gas welding of steels and arc welding of nickel and nickel alloys*

BS EN ISO 17672, *Brazing – Filler metals*

BS EN ISO 24373, *Welding consumables – Solid wires and rods for fusion welding of copper and copper alloys – Classification*

BS ISO 80000-1, *Quantities and units – General*

ISO 185, *Grey cast irons – Classification*

PD 5500, *Specification for unfired fusion welded pressure vessels* A3

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