



BS 853 : 1981

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Specification for
**Calorifiers and storage vessels
for central heating and
hot water supply**

Spécification pour les réservoirs à eau chaude et récipients de stockage
pour systèmes de chauffage central et eau chaude sanitaire

Spezifikation für Warmwasserboiler und Aufbewahrungsbehälter
für Zentralheizung und Warmwasserversorgung

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Foreword

This British Standard, prepared under the direction of the Refrigeration, Heating and Air Conditioning Standards Committee, covers both carbon steel and copper calorifiers and supersedes BS 853 : Part 1 : 1960 and BS 853 : Part 2 : 1960, which are now withdrawn.

In preparing this standard, account has been taken of current practice and, in particular, careful attention has been given to the clauses covering scantlings, which lay

down the minimum requirements regarded as representing good practice. While the standard deals fully with the strength and method of construction and also deals extensively with safety devices and pressure testing, no provision has been included for thermal performance tests.

NOTE. Information concerning SI units is given in BS 3763, BS 5555, BS 5775 and PD 5686.

British Standard Specification for Calorifiers and storage vessels for central heating and hot water supply

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 and also suitable safety devices and methods of pressure testing. The shells of these units are made from copper or carbon steel.

Provision is made for 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 appendix A.

2. References

The titles of the standards publications referred to in this standard are listed on the inside back cover.

3. Definitions

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

3.1 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.

3.2 design pressure. The value of pressure to be employed for calculation (see 5.1).

3.3 design temperature. The value of temperature to be employed for calculation (see 5.2).

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

3.5 purchaser. The organization or individual who buys the calorifier for its own use or as an agent for the owner.

3.6 inspecting authority. The body or association, acting on behalf of the purchaser, which checks that the design, materials and construction comply with the requirements of this standard.

4. Classification

4.1 General. Calorifiers shall be classified into grade A or B, as specified in 4.2 and 4.3.

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

4.2 Grade A. Grade A units shall comply with the following requirements.

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

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

(c) The design pressure in the tube battery shall not exceed 1.75 N/mm^2 (17.5 bar).

(d) The operating temperature in the tube battery shall not exceed 300°C .

4.3 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.

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

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

(c) The design pressure in the tube battery shall not exceed 0.45 N/mm^2 (4.5 bar).

(d) The operating temperature in the tube battery shall not exceed 300°C .

5. Design pressure and design temperature

5.1 Design pressure

5.1.1 For a vessel fitted with an open vent, the secondary design pressure shall be equal to the secondary working pressure, providing that the working head, including the effect of horizontal vent sections, does not exceed 25 m (see 11.2.3).

In all other cases, a safety valve shall be fitted on the secondary side (see 11.2) and the design pressure shall be not less than the pressure at which this is set to lift and in no case less than two-thirds of the minimum hydraulic test pressures specified in 12.2.

5.1.2 The primary design pressure shall not be less than the highest pressure which can be reached in the primary

*1 bar = 10^5 N/m^2 = 0.1 MPa.

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 minimum hydraulic test pressure specified in 12.2.

5.2 Design metal temperature

5.2.1 If the purchaser does not specify a value for the design temperature of the calorifier parts, it shall normally be taken as the maximum metal temperature of the parts under operating conditions.

NOTE. In establishing the metal temperature, due consideration should be given to such factors as the relative heat transfer coefficients of the two fluids contacting the metal and the relative heat transfer area of the metal contacted by the two fluids.

5.2.2 If the design metal temperatures are not determined as in 5.2.1, they shall be assumed to be as follows.

(a) The design metal temperature for the calorifier shell shall be the maximum design temperature of its contents.

(b) The design metal temperature of the primary header, tubes, tubeplates and other heating surfaces shall be the maximum design inlet temperature of the primary fluid. 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.

6. Materials

6.1 Materials for calorifiers. Table 1 lists materials that are recommended for the construction of calorifiers, together with the design stress values (f) 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 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 components which are likely to be in contact with aggressive, brackish or other impure waters.

6.2 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.

6.3 Material test certificates. Test certificates shall be

provided, covering the chemical and mechanical properties of materials used in the construction of calorifiers and for the hydraulic test of tubes, where these are called for in the purchase order.

7. Welding procedure and welder approval tests

7.1 Grade A calorifiers

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

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

Approval testing of procedures and welders shall be witnessed and the records signed by an authorized person within the manufacturer's employment.

7.1.2 Welding procedure tests. Weld procedure tests for steel shall be in accordance with BS 4870 : Part 1, except that testing shall be limited as shown in table 3.

NOTE 1. Weld procedure tests for copper should be based on BS 1077 for the tests shown in table 3.

Each welding procedure test and the accompanying test results shall be recorded in accordance with appendix B of BS 4870 : Part 1 : 1981.

Each welding procedure test shall be documented to include all the items referred to in 4.2, and where applicable 4.3, of BS 4870 : Part 1 : 1981.

An approved welding procedure test shall only require requalifying when any of the changes referred to in BS 4870 : Part 1 are made.

Approval of welding procedure tests shall be obtained from an independent inspecting authority who will witness the procedure tests specified in this standard and endorse the procedure accordingly.

NOTE 2. Welding procedure tests carried out in accordance with this standard and witnessed by an independent inspecting authority should normally be accepted by other inspecting authorities, provided that all the provisions have been fulfilled.

7.1.3 Welder approval tests. Welder approval tests shall be in accordance with BS 4871 : Part 1 for steel, except that testing shall be limited as shown in table 3. Weld procedure tests for copper shall be in accordance with BS 1077 for the tests shown in table 3.

Welder approval tests and the accompanying results shall be recorded in accordance with appendix A of BS 4871 : Part 1 : 1974.

A welder's approval to weld to a particular procedure shall remain valid unless there are changes in the procedure for the reasons specified in clause 6 of BS 4871 : Part 1 : 1974.

7.2 Grade B calorifiers. Manufacture of grade B calorifiers shall be carried out using competent welders, but welding procedure and welder approval tests are not required.

Table 1. Materials recommended for construction of calorifiers (with design stress values f)

Material	British Standard designation	Relevant note(s)	Design stress values (f) for metal (see note 1)								
			Design temperature not exceeding								
			°C 50	°C 100	°C 150	°C 175	°C 200	°C 225	°C 250	°C 275	°C 300
Plates, sheets and pipe for shells and branches			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
Carbon steel	BS 1501-151 or 161, grade 430A		108	108	108	108	108	108	108	108	108
	BS 3601-410		157	144	132	126	120	114	109	104	98
Copper	BS 2871-C 106-0		41	40	34	26	18	—	—	—	—
	BS 2870-C 106-0		48	46	34	26	18	—	—	—	—
	BS 2875-C 106-0		48	46	34	26	18	—	—	—	—
Bars and sections (for welding)											
Carbon steel	BS 1502-151 or 161, grade 430A		108	108	108	108	108	108	108	108	108
Copper	BS 2874-C 106-0		41	40	34	26	18	—	—	—	—
Tubeplates											
Carbon steel	BS 1501-151 or 161, grade 430A	2	108	108	108	108	108	108	108	108	108
70/30 brass	BS 2875-CZ 105-0		72	71	69	54	25	15	—	—	—
Aluminium bronze	BS 2875-CA 105-0		137	127	111	103	94	87	77	71	63
90/10 Cu.Ni.Fe	BS 2875-CN 102-0		72	70	66	63	60	58	54	49	44
70/30 Cu.Ni.Fe	BS 2875-CN 107-0		82	79	77	76	75	73	72	71	70
Aluminium brass	BS 2875-CZ 110-0		72	71	69	54	25	15	—	—	—
Naval brass	BS 2875-CZ 112-0		86	79	72	55	17	—	—	—	—
60/40 brass	BS 2875-CZ 123-0		86	79	72	55	17	—	—	—	—
Tubes											
Copper	BS 2871-C 106-0		41	40	34	26	18	—	—	—	—
Copper	BS 2871-C 106-½ H		62	59	55	34	18	—	—	—	—
Copper	BS 2871-C 106-M		70	69	55	34	18	—	—	—	—
Aluminium bronze	BS 2871-CA 102-0		85	82	80	67	44	31	18	—	—
90/10 Cu.Ni.Fe	BS 2871-CN 102-0		72	70	66	63	60	58	54	49	44
70/30 Cu.Ni.Fe	BS 2871-CN 107-0		82	79	77	76	75	73	72	71	70
Aluminium brass	BS 2871-CZ 110-0	10	72	71	69	54	25	15	—	—	—
70/30 arsenical brass	BS 2871-CZ 105-0	10	70	69	67	57	25	15	—	—	—
Special 70/30 arsenical brass	BS 2871-CZ 126-0	10	72	71	69	54	25	15	—	—	—
Castings											
Steel	BS 1504-161 grade 430A		107	97	88	86	83	82	81	77	73
Grey cast iron	BS 1452 grade 180	3, 4, 5	16	16	16	16	16	*	—	—	—
	BS 1452 grade 220	3, 4, 5	19	19	19	19	19	*	—	—	—
Cast iron with spheroidal or nodular graphite	BS 2789-SNG 24/17		60	60	60	60	60	60	—	—	—
Admiralty gunmetal	BS 1400-G1	6	55	55	55	52	49	46	25	—	—
Leaded gunmetal	BS 1400-LG2	7	48	48	48	47	45	43	34	22	—
Leaded gunmetal	BS 1400-LG4	7	59	59	59	56	51	—	—	—	—
Naval brass	BS 1400-SCB4	8 and 9	—	—	—	—	—	—	—	—	—
Brass for brazable castings	BS 1400-SCB6	8	30	30	20	—	—	—	—	—	—

*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 with copper shells, provided that they are not galvanized and:

- (a) the waterside surface is clad, lined or otherwise treated to prevent corrosion;
- (b) effective seals are made between the protecting surface treatment of the tubeplate and the outer 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/mm² or for temperatures exceeding 220 °C, at which temperature the values for f at 200 °C should be used.

NOTE 4. Refer to figure 3 of BS 1452 : 1977 for estimated thicknesses of cast iron greater than 30 mm. The design stress used should be 10 % of the tensile stress 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 'M' instead of the 'O' condition.

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 For submerged arc welding of carbon steel For TIG and MIG welding of carbon steel For TIG and MIG welding of copper For gas welding of copper	BS 639 BS 4165 BS 2901 : Part 1—A18 BS 2901 : Part 3—C7, C8 or C21 BS 1453—C1	
Brazing filler metals Copper-phosphorus Silver	BS 1845—CP1, CP2 or CP4 BS 1845—AG1 to AG18	1 1
Filler alloys for attaching steel non-pressure parts (e.g. support brackets) to copper shells For bronze welding For flame brazing For soft soldering (tin content exceeding 33 %)	BS 1453—C2, C4, C5 or C6 BS 1845—CZ 3 to CZ 8 BS 219	2
Forging or hot pressing stock (for handhole fittings, etc.) Copper Naval brass Aluminium bronze	BS 2872—C106 BS 2872—CZ 112 BS 2872—CA 103 or CA 104	
Bolts, studs, nuts and tie-bars Steel Leaded brass	BS 4882, BS 3692, BS 4190 or BS 4439 BS 2874—CZ 121 3Pb/4Pb	3 and 4

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 1845—CP1 or CP2 should be used. For brazed seams which will not be subject to such forms of attack brazing alloys in accordance with BS 1845—AG1 to AG7 may 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. Soft solder may 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.

NOTE 4. These standards include details of bolting in addition to details of materials.

Table 3. Tests required for weld procedure and welder approval tests

Test	Procedure	Welder
Visual examination	Yes	Yes
Transverse tensile test	One	No
Face bend test for plate less than 10 mm thick	One	No
Side bend test for plate more than 10 mm thick	One	One
Root bend test for plate less than 10 mm thick	One	One
Macro examination	Yes	Yes

8. Determination of scantlings design

8.1 Cylindrical shells

8.1.1 Calculated shell thickness. The calculated thickness of a cylindrical shell subject to pressure on its internal surface shall be determined from the following formula:

$$t_c = \frac{pD_i}{2fJ} + c$$

where

t_c is the calculated thickness, in mm;

p is the design pressure, in N/mm²;

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;

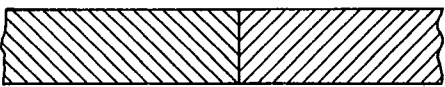
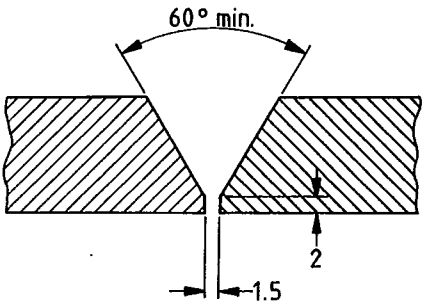
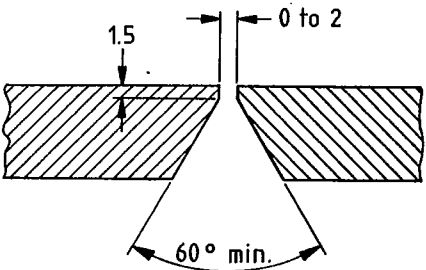
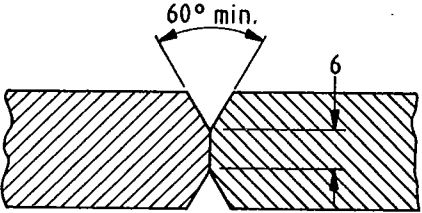
f is the design stress value for the shell material from table 1, in N/mm²;

c is the corrosion allowance, with a value of 1.00 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, $J = 0.70$ when longitudinal seams are butt-welded (see figure 1);

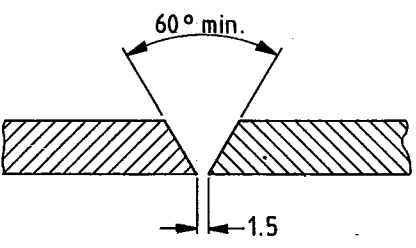
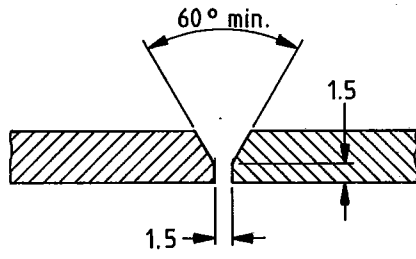
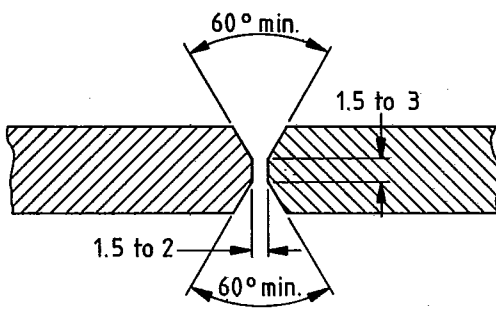
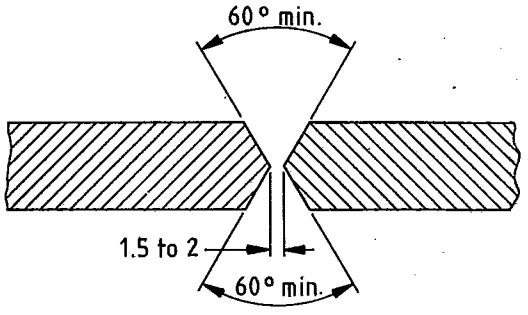
(b) for copper, $J = 0.80$ when longitudinal seams are butt-welded or clenched and brazed (see figure 2).

Joint	Preparation	Remarks
(a) 	Square-edge butt	Plates having a thickness not greater than 6 mm welded from both sides or up to 10 mm submerged arc welded from both sides
(b) 	Single welded butt	Plates having thickness not greater than 16 mm with no inside access. First pass with tungsten inert gas (TIG) root run
(c) 	Double welded butt joint with single V	Plates having thickness not greater than 20 mm second side cut back to sound metal before welding
(d) 	Double welded butt joint with double V	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 BS 5135.

Figure 1. Typical longitudinal and circumferential weld preparations for carbon steel calorifiers

Joint	Preparation	Remarks
(a) 	Close square butt	Plates having thickness not greater than 3 mm
(b) 	Single-V butt	Plates having thickness not greater than 6 mm
(c) 	Single-V butt with root face	
(d) 	Double-V butt with root face	Plates over 6 mm thick
(e) 	Double-V butt	

All dimensions are in millimetres.

Figure 2. Typical longitudinal and circumferential weld preparations for copper calorifiers