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Copper indirect cylinders for domestic purposes

Part 1: Open vented copper cylinders — Requirements and test methods

ICS 91.140.60

Committees responsible for this British Standard

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BSI Product Services
Copper Development Association
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Contents

Foreword

This part of BS 1566 has been prepared by Subcommittee B/504/10. It supersedes BS 1566-1:2002, which is withdrawn.

The start and finish of text introduced or altered by Amendment No. 1 is indicated in the text by tags [A1⟩ ⟨A1].

This part of BS 1566 now includes both directly and indirectly heated cylinders. The original cylinder grades 1, 2 and 3 are included. Grade 4 cylinders are no longer included. The reheat performance requirements of indirectly heated cylinders have been increased and the average insulation requirements for all cylinders have been increased. Three types of cylinder construction (G, P and D) have been identified, with type P cylinders having been introduced in this edition as an option with no restriction placed on their height or diameter (in contrast to type G and type D cylinders, which are restricted to the sizes given in Table 1) and their hot water capacity and heat exchanger efficiency determined in accordance with the type tests given in Annex A. For corrosion resistance, aluminium protector rods have been replaced by an increase in the thickness of the cylinder base and corrosion resistance testing.

This part of BS 1566 is complementary to BS 1566-2.

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 does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 17 and a back cover.

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1 Scope

This part of BS 1566 specifies requirements for open vented, vertically mounted copper cylinders for the storage of hot water where the water is either heated indirectly by primary (boiler) water circulating in an integral primary heater and/or directly via either an external heat source or an electric immersion heater fitted inside the cylinder.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 2779:1986, *Specification for pipe threads for tubes and fittings where pressure-tight joints are not made on the threads (metric dimensions).*

BS 2901-3:1990, *Filler rods and wires for gas-shielded arc welding — Part 3: Specification for copper and copper alloys.*

BS EN 1044:1999, *Brazing — Filler metals.*

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

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

BS EN 1982:1999, *Copper and copper alloys — Ingots and castings.*

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

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

3 Terms and definitions

For the purposes of this part of BS 1566, the following terms and definitions apply.

3.1
cylinder
closed cylindrical vessel for the heating and storage of hot water

3.2
hot water capacity
volume of water that can be heated by the heat source

3.3
metal thickness before forming
minimum nominal thickness of copper from which cylinders are manufactured

3.4
model range
cylinders which share the same common diameter, heat exchanger design and general overall configuration

3.5
nominal storage capacity
total volume of water, in litres, that can be stored in the cylinder, excluding the primary water in type G and type P cylinders

3.6
primary heater
heat exchanger mounted inside a type G or type P cylinder for the transfer of heat from the primary water to the stored water

3.7
primary water
water circulating through the primary heater in type G and type P cylinders

3.8
reheat performance
primary heater performance, measured in kilowatts

3.9
reheat time
time taken for the hot water capacity of type P (or type G) cylinders to reheat to 60 °C

3.10
stored water
water contained in the body shell of the cylinder, excluding the primary water

4 Information to be supplied by the purchaser

The following information shall be supplied by the purchaser at the time of enquiry or order:

a) where applicable, the BS 1566 type reference of the cylinder as specified in Table 1;

b) for type P cylinders, the height, diameter and nominal storage capacity of the cylinder if other than as specified in Table 1 (see **7.3** and Clause **13**);

NOTE 1 If the type P cylinder ordered by the purchaser conforms to Table 1, the BS 1566 type reference may be given.

c) the grade of cylinder (see Clause **5**);

d) the metal thickness of the top and bottom of the cylinder and the rest of the cylinder shell if they are required to be thicker than as specified in Table 1 (see Clause **7**);

e) the designation and height above datum of the secondary feed connection if other than as specified in Table 1 (see **8.2**);

f) for type G and type P cylinders, the designation and height above datum of the primary flow and return connections (if other than those specified in Table 3 in the case of type G cylinders) (see **8.4**);

g) whether a secondary return connection is required and, if required, its designation and height above datum if other than those specified in Table 1 (see **8.5**);

h) whether an immersion heater connection is required and, if required, whether it is to be located in the cylinder top or body. If an immersion heater connection is to be located in the cylinder body, the purchaser shall also indicate the required height above datum if other than as specified in Table 1 (see **8.7**);

i) The internal working pressure of the primary heater if greater than as specified in **10.2.1**.

j) Whether the cylinder is required to be corrosion resistant in accordance with this standard (see Clause **11**) or whether an aluminium protector rod is required as the means of corrosion protection (see Note 2 to Clause **11**);

NOTE 2 The manufacturer should advise the purchaser to consult the manufacturer's literature prior to ordering. This is particularly important for type P cylinders.

5 Grades and types of cylinders

Cylinders shall conform to one of three grades (1, 2 or 3, according to the maximum working head of the cylinder), as given in Table 1. Cylinders of each grade shall also conform to one of three types of construction (G, P or D) as given in Table 2.

Table 1 — Dimensional requirements for all cylinders

BS 1566 type reference[a]	Diameter	Height	Nominal storage capacity	Metal thickness before forming						Height of connections above datum			Secondary feed and return connection designation[a]
				Grade 1 (maximum working head 25 m)		Grade 2 (maximum working head 15 m)		Grade 3 (maximum working head 10 m)		Secondary return (if required)	Secondary feed	Immersion heater connection	
				[A1⟩Domed bottom section	Top and rest of shell	[A1⟩Domed bottom section	Top and rest of shell	[A1⟩Domed bottom section	Top and rest of shell				
	mm	mm	l	mm ⟨A1]	mm	mm ⟨A1]	mm	mm ⟨A1]	mm	mm	mm	mm	
0	300	1 600	96	1.6	1.2	1.6	0.9	1.6	0.7	1 250	100	150	G1
1	350	900	72	1.6	1.2	1.6	0.9	1.6	0.7	700	100	150	G1
2	400	900	96	1.8	1.2	1.6	0.9	1.6	0.7	700	100	150	G1
3	400	1 050	114	1.8	1.2	1.6	0.9	1.6	0.7	800	100	150	G1
4	450	675	84	2.0	1.6	1.6	1.0	1.6	0.7	450	100	150	G1
5	450	750	95	2.0	1.6	1.6	1.0	1.6	0.7	550	100	150	G1
6	450	825	106	2.0	1.6	1.6	1.0	1.6	0.7	625	100	150	G1
7	450	900	117	2.0	1.6	1.6	1.0	1.6	0.7	700	100	150	G1
8	450	1 050	140	2.0	1.6	1.6	1.0	1.6	0.7	800	100	150	G1
9	450	1 200	162	2.0	1.6	1.6	1.0	1.6	0.7	950	100	150	G1
9E	450	1 500	206	2.0	1.6	1.6	1.0	1.6	0.7	1 200	100	150	G1
10	500	1 200	190	2.5	1.8	1.8	1.2	1.6	0.9	950	150	200	G1½
11	500	1 500	245	2.5	1.8	1.8	1.2	1.6	0.9	1 200	150	200	G1½
12	600	1 200	280	2.8	2.0	2.5	1.4	2.0	1.2	950	150	200	G2
13	600	1 500	360	2.8	2.0	2.5	1.4	2.0	1.2	1 200	150	200	G2
14	600	1 800	440	2.8	2.0	2.5	1.4	2.0	1.2	1 350	150	200	G2

[a] The secondary connection designations are in accordance with BS 2779.

Table 2 — Types of open vented copper cylinder for the storage of hot water

Type	Construction	Use
G	Double feed indirectly heated cylinders	Suitable for either gravity or pumped primary systems
P	Double feed indirectly heated cylinders	Suitable for pumped primary systems only
D	Directly heated cylinders heated by an external source or internal immersion heater	Suitable for gravity-fed systems
NOTE Type G and type P cylinders can also include provision for direct heating.		

6 Materials

6.1 Cylinder shells

Cylinder shells shall be manufactured from copper sheet conforming to BS EN 1653.

6.2 Tubing for primary heaters

For type G cylinders, tubing for primary heaters shall conform to BS EN 1057.

For type P cylinders, tubing for primary heaters shall conform to BS EN 1057 or BS EN 12452.

6.3 Connections

All connections shall be manufactured from one of the following materials:

a) copper tube conforming to BS EN 12449;

b) copper-zinc alloys CC751S or CC752S with either grade A or grade B de-zincification resistance conforming to BS EN 1982:1999.

6.4 Filler rods

Filler rods for brazing shall be of the copper-phosphorus type conforming to BS EN 1044:1999, Table 4. Filler rods for welding shall be type C1A, C7 or C8 conforming to BS 2901-3:1990.

7 Height, diameter and metal thickness before forming

7.1 General

The height and diameter of a cylinder shall be measured externally, excluding any insulation. The height shall be measured from the base to the top of the cylinder excluding any connection or insulation.

NOTE Thicknesses of copper which are greater than the metal thickness before forming given in Table 1 may be used.

7.2 Type G cylinders

The height and diameter of type G cylinders shall be as specified in Table 1.

The metal thickness before forming for type G cylinders shall be as specified in Table 1 unless a greater thickness is specified by the purchaser at the time of order (see Clause **4**).

7.3 Type P cylinders

Unless otherwise specified by the purchaser at the time of enquiry or order (see Clause **4**), the height and diameter of type P cylinders shall be as specified in Table 1.

Unless a greater metal thickness is specified by the purchaser at the time of order (see Clause **4**), the metal thickness before forming shall be as specified in Table 1 for the chosen cylinder diameter. For cylinder diameters not given in Table 1, the metal thickness before forming shall be as for the cylinder with the next largest diameter given in Table 1.

7.4 Type D cylinders

The height and diameter of type D cylinders shall be as specified in Table 1.

The metal thickness before forming for type D cylinders shall be as specified in Table 1 unless a greater thickness is specified by the purchaser at the time of order (see Clause **4**).

Table 3 — Additional dimensional requirements of type G cylinders

BS 1566 type reference[a]	Minimum heating surface area m²	Tube diameter of primary heater mm	Height of primary return connection above datum mm	Minimum height of primary flow connection above datum[b] mm	Primary flow and return connection designation[a]
0	0.42	28	100	540	G1B
1	0.31	28	100	400	G1B
2	0.42	28	100	400	G1B
3	0.50	28	100	470	G1B
4	0.37	28	100	300	G1B
5	0.48	28	100	340	G1B
6	0.53	28	100	370	G1B
7	0.61	28	100	400	G1B
8	0.70	28	100	470	G1B
9	0.79	28	100	540	G1B
9E	0.96	28	100	620	G1B
10	0.88	35	150	540	G1¼ B
11	1.10	35	150	670	G1¼ B
12	1.18	42	150	540	G1½ B
13	1.57	42	150	670	G1½ B
14	1.97	42	150	800	G1½ B

[a] The primary connection designations are in accordance with BS 2779.
[b] If the cylinder is to be used on a gravity circulation primary circuit it is recommended that the height of the primary flow connection above datum should be larger [see Clause **4**f)].

8 Connections

8.1 General

Connections shall be either threaded or plain, with the exception of the immersion heater connection, which shall be threaded.

8.2 Secondary feed (cold water inlet)

All cylinders shall have a secondary feed to deliver cold water into the cylinder. The designation and height above datum of the secondary feed connection shall be as given in Table 1, unless otherwise specified by the purchaser (see Clause **4**).

8.3 Hot water draw off connection

All cylinders shall have a hot water draw off connection positioned at the highest point of the cylinder.

8.4 Primary flow and primary return connections

Type G and type P cylinders shall have a primary flow and a primary return connection. For type G cylinders, unless otherwise specified by the purchaser (see Clause **4**), the designation and height above datum of the primary flow and primary return connections shall be as given in Table 3. For type P cylinders, unless specified by the purchaser (see Clause **4**), the designation and height above datum shall be at the discretion of the manufacturer.

8.5 Secondary return connection

Where a secondary return connection is specified by the purchaser, the designation and height above datum shall be as given in Table 1 unless otherwise specified by the purchaser (see Clause **4**).

NOTE It is recommended that a secondary return connection be provided where the cylinder is to be used in a system incorporating secondary circulation.

8.6 Drain connection

All cylinders shall have provision for draining off at least 85 % of their nominal storage capacity. This shall be achieved either by means of a separate drain connection or by means of a drain tap fitted to the cold water inlet where this inlet is fitted in an appropriate position.

NOTE Use of a separate drain connection is preferred.

8.7 Immersion heater connection

One or more optional connections may be provided for fitting an immersion heater or heaters. Unless otherwise specified by the purchaser (see Clause **4**), the connection shall be a G2¼ boss connection threaded internally and conforming to BS 2779:1986, Table 4. The length of the threaded portion shall be a minimum of 13 mm. The thickness of metal below the root of the thread, with the exclusion of one pitch from the free end, shall be not less than 0.7 mm. The height above datum shall be as given in Table 1, unless otherwise specified by the purchaser (see Clause **4**).

NOTE When a top mounted immersion heater connection is provided it should be fitted in a position that avoids the formation of an air pocket.

9 Tolerances

For all cylinder types, the tolerance on the cylinder diameter, cylinder height and positions of connections specified in Table 1 (and Table 3 for type G cylinders) shall be 6 mm.

For all cylinders, the tolerances on metal thickness before forming for cylinder shells shall be as specified in BS EN 1653.

For type G cylinders, the tolerances on metal thickness before forming for primary heater tubing shall be as specified in BS EN 1057.

For type P cylinders, the tolerances on metal thickness before forming for primary heater tubing shall be as specified in either BS EN 1057 or BS EN 12452.

10 Manufacture

10.1 Cylinder construction

All domed surfaces shall be blended by means of smooth radii. The cylinder shall be self supporting on a level surface when mounted in a vertical position such that, when empty, it is able to resist tilting of up to 5 ° from the vertical without falling over.

For the curved sections of the top and bottom of all cylinders, the metal thickness after forming shall be not less than 67 % of the metal thickness before forming given in Table 1 or specified by the purchaser (see Clause **4**). For the non-curved sections of the tops and bottoms of all cylinders, the metal thickness after forming shall not be less than 67 % of the metal thickness before forming of the body sheet for the rest of the cylinder shell as given in Table 1 or as specified by the purchaser (see Clause **4**). See also Clause **7**.

The body sheet of the rest of the cylinder shell shall have no more than two rounded swages and/or recesses required to locate the ends of the cylinder. Apart from these swages/recesses, the body sheet shall be plain sided. Where the cylinder body is swaged or manipulated to form a seam, the metal thickness after forming shall not be less than 67 % of the metal thickness before forming.

10.2 Primary heater construction

10.2.1 *Internal working pressure and pressure drop*

The primary heater shall withstand an internal working pressure of at least 3.5 bar[1)].

NOTE The purchaser may specify a greater internal working pressure (see Clause **4**).

In the case of type G cylinders the completed coil, excluding end fittings, shall be capable of accommodating the passage of a steel ball of the diameter given in Table 4, throughout its length. In the case of type P cylinders, the primary heaters shall be constructed such that the internal pressure drop does not exceed 0.5 bar at a flow rate of 0.25 l/s when measured in accordance with Annex A.

Table 4 — Ball diameter for testing of type G cylinders

Tube diameter of primary heater mm	**Ball diameter** mm
28	22 ± 0.5
35	28 ± 0.5
42	35 ± 0.5

10.2.2 *Minimum heating surface area and tube diameter for type G cylinders*

Primary heaters for type G cylinders shall have a minimum heating surface area and tube diameter as given in Table 3.

11 Corrosion resistance

Type G and type P cylinders shall be deemed to be corrosion resistant if the metal surface temperature measured at the base of the cylinder (temperature sensor T4) is greater than or equal to 40 °C at the end of the reheat time when tested in accordance with Annex A.

Type D cylinders shall be deemed to be corrosion resistant if the metal surface temperature measured at the lowest point of the base of the cylinder (thermocouple T5) is greater than or equal to 40 °C when the temperature of the stored water reaches (65 ± 2) °C when measured at thermocouple T4 in accordance with **B.3.3**.

Where the corrosion resistance test is carried out, it shall be performed on all cylinders of 120 l nominal storage capacity (or the next closest capacity where 120 l is not available) in each diameter range. Cylinders of other nominal storage capacities that share the same diameter shall be deemed to have the same corrosion resistance provided that the distance between the bottom of the coil and the base of the cylinder is not larger.

NOTE 1 The designation of corrosion resistant cylinders in accordance with this standard is preferred to the use of aluminium protector rods to prevent pitting corrosion.

NOTE 2 Where specified by the purchaser (see Clause **4**), an aluminium protector rod may be fitted, but the cylinder may not be designated as corrosion resistant in accordance with this standard.

[1)] 1 bar = 100 kPa.

12 [A1] *Clause deleted* [A1]

13 Nominal storage capacity

The nominal storage capacity of all cylinders shall be measured in accordance with **A.3.1** and shall conform to Table 1 or (for type P cylinders), the value specified by the purchaser (see Clause **4**).

14 Hot water capacity

Type P cylinders (and type G cylinders, where required) shall be capable of delivering at least [A1] 75 % [A1] of the nominal storage capacity at a temperature of above [A1] 40 °C [A1] when tested in accordance with Annex A.

15 Reheat time

[A1] For indirect type P cylinders where capacity *V* in litres is less than 200, the ratio of *V* to heat exchanger performance (in kW) shall not exceed 10; e.g. a 150 litre cylinder shall have a minimum heat exchanger performance of 15 kW. Where *V* is 200 or above the cylinder shall have a minimum heat exchanger performance of 20 kW. [A1]

16 Production testing

16.1 Internal pressure testing of primary heaters

Before assembly into the cylinders, all primary heaters shall be subjected to an internal test pressure of 1.5 times the required internal working pressure of the primary heater (see **10.2.1**) and held at that pressure for at least 1 min. The primary heater shall, after testing, show no leakage or any significant distortion that is likely to be detrimental to its performance.

16.2 Internal pressure testing of complete cylinders

After assembly but before insulation, each cylinder shall be tested by subjecting it to an internal pressure according to the grade of cylinder, as follows:

- — Grade 1: 3.65 bar;
- — Grade 2: 2.20 bar;
- — Grade 3: 1.45 bar.

This test shall be carried out either hydraulically or pneumatically for a period of at least 1 min. The complete cylinder shall, after testing, show no leakage or any significant distortion that is likely to be detrimental to its performance.

17 Designation of open vented copper cylinders for ordering purposes

17.1 Double feed indirectly heated cylinders

17.1.1 *Type G cylinders*

For ordering purposes type G cylinders shall be designated by the number of this British Standard, followed by "DFG" to indicate cylinder type and the appropriate BS 1566 type reference and grade as given in Table 1 and Table 3, e.g. BS 1566 DFG, Ref.3, Gr 2.

17.1.2 *Type P cylinders*

For ordering purposes, type P cylinders shall be designated by the number of this British Standard, followed by "DFP" for cylinder type and shall also indicate the cylinder diameter and height in millimetres, the nominal storage capacity and, where applicable, the appropriate BS 1566 type reference as given in Table 1, e.g. BS 1566 DFP, Ref.7, 450 mm, 900 mm, 117 l, Gr 3.

17.1.3 *Corrosion resistance*

For ordering purposes, cylinders which have been corrosion resistance tested in accordance with Annex A and meet the corrosion resistance requirements given in Clause **11** shall be designated using the suffix "CR", which shall appear after the grade number.

17.2 Directly heated cylinders

Type D cylinders shall be designated by the number of this British Standard and "D" to indicate cylinder type, followed by the appropriate BS 1566 type reference and grade as given in Table 1, e.g. BS 1566 D, Ref.9, Gr 3.

18 Marking

18.1 Permanent marking

Cylinders shall be permanently and clearly marked with the following information, which shall be stamped, etched or embossed on the body of the cylinder or on a copper or brass plate permanently attached to the body of the cylinder:

a) the number of this British Standard, i.e. BS 1566[2)];

b) the type of cylinder, i.e. "DFG" for type G cylinders, "DFP" for type P cylinders or "D" for type D cylinders;

NOTE Cylinders manufactured to BS 1566-2 are marked "SF" in place of "DFG", "DFP and "D".

c) the BS 1566 type reference (where applicable);

d) for type P cylinders, the nominal storage capacity;

e) the grade;

f) "CR", where the cylinder is corrosion resistant in accordance with Clause **11**.

EXAMPLE 1

For a corrosion resistant type G double feed indirectly heated cylinder:

BS 1566 DFG, Ref.7, Gr 3, CR

EXAMPLE 2

For a non-corrosion resistant type P double feed indirectly heated cylinder:

BS 1566 DFP, 117 l, Gr 2

EXAMPLE 3

For a type D directly heated cylinder:

BS 1566 D, Ref.7, Gr 1

g) The manufacturers name or identification mark.

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2) Marking BS 1566 on or in relation to a product represents a manufacturer's declaration of conformity, i.e. a clam by or on behalf of the manufacturer that the product meets the requirements of the standard. The accuracy of the claim is solely the claimant's responsibility. Such a declaration is not to be confused with third-party certification of conformity.

18.2 Other marking

In addition to the permanent marking given in **18.1**, all cylinders shall have a label firmly stuck to the outside of the cylinder insulation or case, which shall be marked, in indelible ink, with the information specified in **18.1** together with the following:

a) the maximum permissible working head of the cylinder in metres;

b) for type G and type P cylinders, the maximum permissible internal working pressure of the primary heater in bars;

c) the nominal storage capacity in litres;

d) for type G and type D cylinders, the height in millimetres, followed by the diameter in millimetres;

e) the maximum length, in millimetres, of immersion heater that the cylinder is designed to accept;

f) for type P cylinders, the pressure drop through the primary heater in bars;

g) the standing heat loss in kilowatt hours per 24 hours (kW h/24 h) as determined in accordance with Annex B;

h) for type P cylinders (or type G cylinders, where required) the reheat performance in kilowatts as determined in accordance with Annex A.

Annex A (normative)
Type testing of cylinders

A.1 General

This Annex specifies the test methods necessary to determine:

a) the nominal storage capacity of cylinders;

b) the corrosion resistance of cylinders where required;

c) whether type P cylinders give a satisfactory hot water delivery and have a primary heater performance such that wastage of energy is minimized.

Type testing of cylinders shall be carried out in accordance with Table A.1.

Table A.1 — Requirements for type testing of cylinders

Clause	Test	Type G	Type P	Type D
A.4.1	Nominal storage capacity	Yes	Yes	Yes
A.4.2	Hot water capacity	Optional	Yes	No
A.4.2	Reheat performance	Optional	Yes	No
A.4.2	Primary heater pressure drop	Optional	Yes	No
A.4.2	Corrosion resistance	Optional	Optional	see **B.3.3**

A.2 Apparatus

A.2.1 *Primary heat source*, comprising a thermostatically controlled heat source capable of providing a primary flow temperature of (82 + 0-2) °C at 0.25 l/s to the inlet of the primary heater

A.2.2 *Circulator*, capable of maintaining a primary flow of (0.25 ± 0.01) l/s to the primary heater.

A.2.3 *Flow meters*, comprising flow meter (FL1) calibrated for water at 82 °C and accurate to ±0.01 l/s at a flow rate of 0.25 l/s, and an optional second flow meter (FL2), calibrated for water at 60 °C which may be used to speed up calibration of the test rig.

A.2.4 *Primary by-pass arrangement*, employing two full flow lever operated, quarter turn spherical valves (V1 and V2).

A.2.5 *Cold feed cistern*, connected to a cold water supply with a temperature not exceeding 15 °C and with a suitable means of filling (normally via a float operated valve), mounted at a suitable head above the cylinder to ensure that an adequate flow (at least 0.25 l/s) is available from the cylinder.

A.2.6 *Outlet valve*, comprising a full flow lever operated, quarter turn spherical valve (V5).

A.2.7 *Flow control valves*, comprising two needle valves or similar devices (V3 and V4) for regulating the primary and secondary flows respectively.

A.2.8 *Two pressure gauges*, or similar devices such as differential manometers, (P1 and P2) capable of measuring the pressure drop across the primary heater to an accuracy of ±2 %.

A.2.9 *Temperature sensors*, comprising four thermometers or thermocouple type devices (T1 to T4) capable of measuring the temperature of water (or metal surface temperature in the case of T4) to an accuracy of ±1 °C. The temperature sensors shall be positioned as follows:

— T1: in the primary flow pipe from the circulator to sense the primary water temperature immediately prior to the tee off to the by-pass arrangement;

— T2: inside the cylinder to sense the stored water temperature at a point [A1) (25 ± 20) (A1] mm below the hot water outlet;

— T3: in the outlet pipe, no more than 150 mm from the cylinder outlet, to sense the temperature of hot water leaving the cylinder;

— T4: in contact with the external surface of the copper cylinder at its lowest point.

NOTE A small wad of insulating material may be applied locally behind sensor T4 to minimize conduction of heat into the atmosphere or the supporting base of the test apparatus.

A.2.10 *Weighing machine*, fitted with a suitable container (with draining mechanism), capable of indicating the mass of hot water drawn off to an accuracy of ±1 % of that mass. If desired, an automatic system such as a data logger may be used to record the temperature/draw off data. It is essential that any such equipment has an accuracy at least equal to that specified for the weighing machine and temperature sensor.

A.2.11 *Cylinder support*, comprising a flat sheet of medium density fibreboard 22 mm thick.

A.2.12 *Cylinder under test*, the cylinder shall be tested complete with factory-applied insulation and/or casing. The length of any interconnecting pipework shall be kept to a minimum and the primary and draw off pipework shall be insulated. If desired, additional valves may be fitted for servicing and set up purposes.

A.3 Procedure

A.3.1 *Nominal storage capacity*

Weigh the cylinder empty, using a weighing machine capable of indicating the mass to an accuracy of ±1 % and record the mass. Fill the cylinder with cold water until it emerges from the hot water draw off pipe and weigh the cylinder again, recording the mass. The difference in mass between the full cylinder and the empty cylinder in kilograms is deemed to be the nominal storage capacity in litres.

A.3.2 *Hot water performance*

A.3.2.1 Set up the apparatus as shown in Figure A.1.

A.3.2.2 Fill the primary heater and associated primary circuit and expel all excess air.

A.3.2.3 Switch on the primary heater and allow the primary water to heat up to a flow temperature of 82 °C, as measured at T1, with valves V1, V2 and V3 open and any excess air allowed to escape.

A.3.2.4 Close valve V2, leave valve V1 open and adjust valve V3 to give a primary flow rate of 0.25 l/s through the primary heater as measured by flow meter FL1. Once this is achieved, open valve V2 and close valve V1.

A.3.2.5 Turn on the water supply to the cold feed cistern, open valves V4 and V5 and expel any excess air from the system until water flows freely from the cylinder outlet.

A.3.2.6 With valve V5 fully open, adjust valve V4 to give a primary flow rate of 0.25 l/s as measured either by flow meter FL2 or by timing the rate of increase in discharged water mass using a timer in conjunction with the weighing machine. Once a flow rate of 0.25 l/s is achieved, close valve V5.

A.3.2.7 Start the test cycle when the temperature of water as measured using temperature sensor T2 is between 13 °C and 15 °C. This might require fresh water to be drawn off via valve V5 or (in exceptionally cold conditions) the cylinder to receive a "pulse" of heat from the primary heater.

A.3.2.8 With valves V5 and V1 closed and V2 open, allow the primary heater to heat the water up to a primary flow temperature of 82 °C.

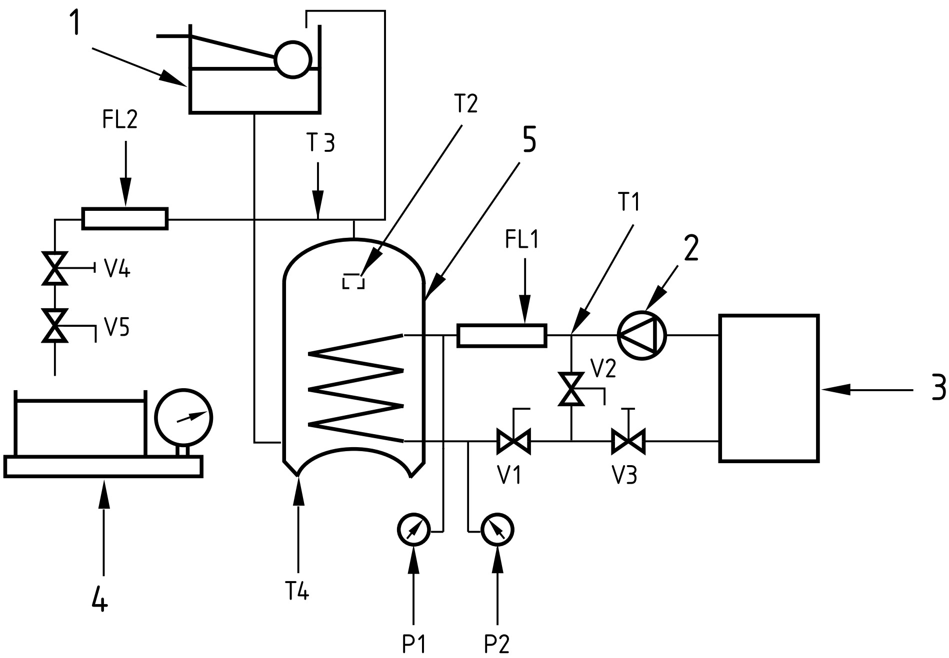
A.3.2.9 Once stable primary conditions are established at 82 °C and 0.25 l/s, open valve V1 and then immediately close valve V2. Once the temperature of water at the top of the cylinder, as measured using temperature sensor T2, reaches 15 °C start a timer for the reheat period. If necessary, adjust valve V3 to maintain a primary flow rate, as measured at FL1 of 0.25 l/s.

A.3.2.10 During the reheat period, record the pressure drop across the coil at P1 and P2 by calculating the difference between the readings.

A.3.2.11 [A1⟩ Once the temperature of water measured using temperature sensor T2 reaches 60 °C, disconnect the heat source by opening valve V2 and immediately closing valve V1. Note the time taken for the temperature at T2 to reach 60 °C and record this as the reheat time. Allow the system to stabilize for one minute. ⟨A1]

A.3.2.12 At this stage if the corrosion resistance of the cylinder is to be determined, record the metal surface temperature at T4.

A.3.2.13 One minute after closing valve V1 commence the draw off by opening valve V5. Measure the flow rate either by means of flow meter FL2 or by starting a timer as V5 is opened and using weighing machine W to record the mass. If necessary adjust valve V4 in order to maintain the 0.25 l/s flow rate. Record the temperature of the water drawn off in 5 l increments at T2. Once the water temperature at T2 drops to below 40 °C then at the end of the 5 l increment when this occurs, immediately close valve V5.



Key

1	Cold feed cistern
2	Circulator
3	Primary heat source
4	Weighing machine
5	Cylinder under test
FL1, FL2	Flow meters
V1, V2	Spherical valves
V3, V4	Flow control valves
V5	Outlet valve
P1, P2	Pressure gauges
T1, T2, T3, T4	Temperature sensors

Figure A.1 — Apparatus

A.4 Calculation of results

A.4.1 *Hot water capacity*

The hot water capacity shall be derived from the hot water draw off profile as determined by **A.3.2.13**.

The hot water draw off shall be plotted graphically with draw off in litres plotted in 5 l increments on the horizontal axis, and temperature at T2 on the vertical axis.

If automatic recording equipment was used, a continuous plot can be substituted for the manual 5 l incremental plot.

For the cylinder to be deemed as satisfying the requirements of BS 1566-1 then at least 85 % of the nominal storage capacity (as measured in accordance with **A.3.1**) shall be drawn off as hot water at [A1⟩ 40 °C ⟨A1] or above. The volume drawn off at [A1⟩ 40 °C ⟨A1] or above shall be determined by reference to the graph of the draw off profile.

A.4.2 *Reheat performance*

The reheat performance *P*, expressed in kilowatts, is given by the equation:

$$P = \frac{v(T_{av} - 15)}{14.3\ t}$$

where

- T_{av} is the average temperature of the water drawn off at 40 °C or above, established from the graph of the draw off profile in degrees centigrade (°C);
- v is the volume of water drawn off at 40 °C or above in litres;
- t is the reheat time in minutes (min).

Annex B (normative) Standing heat loss measurement of hot water cylinders

[A1⟩ B.1 General

This annex specifies the requirements for measuring the heat loss of vented hot water cylinders.

Where a range of cylinders is to be tested which are of constant diameter and utilise changes in height as a means of achieving different capacities then by agreement between the manufacturer and the test house, it is permitted to use interpolation as a means of assessing the heat loss of intermediate sizes. The heat loss of the largest and smallest model in the range shall always be measured plus at least one cylinder in the capacity range from 120 to 180 litres.

The test is carried out by heating the cylinder using an immersed electrical element (immersion heater) fitted horizontally into the cylinder at a height above base datum as specified in column 13 in Table 1 of this standard. This immersion heater shall normally be rated at 3kW but for cylinders of above 250 litres capacity a higher output may be used if normally specified by the manufacturer. The assessment of heated capacity using indirect heating is covered in **A.4.1**, the electrically heated volume shall be assessed using the same procedure except that the immersion heater rather than the indirect heating coil is used to heat the cylinder until a temperature of 65°C is achieved at the top (T_2 on Figure A.1).

At the option of the manufacturer and depending on the immersion heater position, the heat loss test is normally carried out on a direct unit type D but may also be carried out on type P or G indirect units. It is important that apart from the possible omission of the indirect heating coil connections the insulation characteristics of the indirect test unit are as identical as possible to the production direct unit.

B.2 Apparatus

B.2.1 *Cylinder support*

The unit to be tested shall be mounted on a base of at least 20mm thick medium density fibreboard at a height of (400mm ± 100mm) above floor level positioned such that there is al least 250mm behind the unit and at least 700mm from any wall or other vertical surface. ⟨A1]

[A1) B.2.2 *Test connections*

The cylinder shall be provided with a means of filling with cold water and a vent/expansion pipe as shown on Figure B.1. The expansion/vent pipe shall rise vertically from the top connection for no more than 35mm then branch sideways for a length equivalent to the cylinder radius plus 50mm. The sideways branch shall be sloped slightly downwards but by no more than 35mm.

In order to measure the temperature of stored water Tw, a sensor T4 shall be positioned such as to register the temperature at a point 25mm ± 20mm below the level of the hot water draw off. This can be inserted via a thermostat pocket fitted in the expansion vent pipe, or by a suitable contact probe on the vessel wall. The accuracy of all temperature sensors shall be ±1°C.

During the test it will be necessary to control the temperature at Tw to 65°C ± 3°C, this may require an electronic thermostat which may either use the same sensor or an additional sensor mounted in the same vicinity.

Three additional sensors are required to measure ambient temperature; they shall be positioned at a height of half way up the cylinder wall and at a distance of 350 ±25 mm from the exterior of the unit under test. These sensors shall be positioned at the sides and front of the unit as shown in Figure B.1.

During the test the ambient temperature as measured by the mean of readings taken at T1, T2 and T3 shall be 20°C (+5°C –2°C)

All four sensors shall be connected to a data logging device capable of recording the individual temperatures at intervals not exceeding 5 minutes.

In order to measure electricity consumption the supply to the immersion heater shall be connected via a kilowatt hour meter with an accuracy of ± 0.01kWh.

B.3 Test procedure

The cylinder to be tested is filled with cold water until it emerges from the vent and expansion pipe. Once excess air is expelled then the inlet valve is closed.

The immersion heater (or external circuit) is then switched on and the temperature of the stored water brought up to 65°C ± 3°C.

At this point the data logging shall begin to monitor all changes in temperature.

The test unit is then allowed to stabilize under thermostatic control for a period of at least 24 hours.

After the 24 hour stabilization period the cylinder temperature and control thermostat shall be monitored and at a point when the thermostat trips out (maximum temperature), a note shall be taken of the time (to the nearest minute) and the reading on the electricity meter noted.

The cylinder shall then be left to cycle on the thermostat for a minimum period of 72 hours. At the end of the 72 hour period the system shall be closely monitored to determine the next time that the thermostat trips out (maximum temperature). The time shall be noted together with the electricity meter reading.

B.4 Calculation of results

The difference between the two meter readings Q_m gives the power consumption during the test period. This will exceed 72 hours due to the wait for a suitable thermostat trip point. The meter reading needs correcting pro-rata for this additional period.

As an example if the measurement period was 74 hours and 6.5 Kwh of power was consumed then the corrected figure will be 6.5 x 72 ÷ 74 = 6.324 Kwh.

NOTE figures should be to at least three decimal points.

This corrected figure can now be divided by three to give the heat lost Q_c in kwh/day
i.e. 6.324 ÷ 3 = 2.108 Kwh/day.

The readings from the data logger shall now be analysed in order to establish the mean temperature differential between cylinder temperature and mean ambient. This is calculated at each data logging interval (maximum of 5 minutes) as follows.

Differential at each interval is Tw – ((Ta1 + Ta2 + Ta3) ÷ 3)

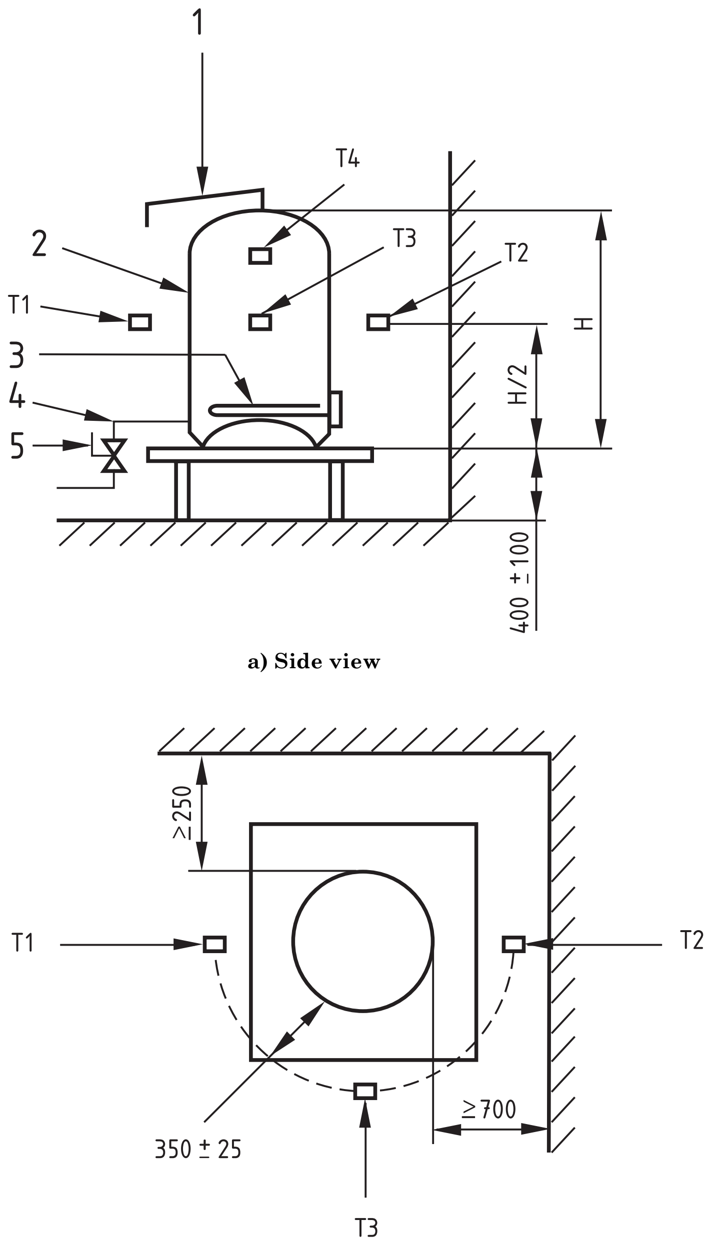
The mean of all the differentials is calculated to arrive at an overall average differential Td.

Finally a correction is made for the difference between the nominal differential of 45°C and the measured average differential Td.

Heat Loss Q_{st} = Qc x 45 ÷ Td

The final figure of Q_{st} shall be rounded down for declaration purposes to two decimal points. (A1]

All dimensions are in millimetres



b) Plan view (pipework omitted)

Key

1	Insulated vent and expansion pipework
2	Insulated cylinder under test
3	Immersion heater
4	Insulated feed pipework
5	Cold water inlet valve
T1, T2, T3, T4	Thermocouples
H	Half cylinder height ± 25 mm

Figure B.1 — Heat loss apparatus

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