Specification for

Plastics laboratory ware —

Part 2: Graduated measuring cylinders

Confirmed
November 2011

UDC [542.2:678.5] + 542.3:531.732

Cooperating organizations

The Laboratory Apparatus Standards Committee, under whose direction this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

Agricultural Research Council
Association for Science Education*
Association of Scientific, Technical and Managerial Staffs
British Laboratory Ware Association*
British Lampblown Scientific Glassware Manufacturers' Association
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This British Standard, having been prepared under the direction of the Laboratory Apparatus Standards Committee, was published under the authority of the Executive Board on 30 September 1977

The following BSI references relate to the work on this standard:
Committee reference LBC/28
Draft for comment 76/51532 DC

ISBN 0 580 09724 2

Amendments issued since publication

Amd. No.	Date of issue	Comments

Contents

Foreword

This British Standard has been prepared under the direction of the Laboratory Apparatus Standards Committee to provide for plastics graduated measuring cylinders of the type in general use in laboratories. It has been drawn up with reference to a Draft International Standard on laboratory glass graduated measuring cylinders, which, at the time of preparation of this British Standard, was being studied in ISO Technical Committee ISO/TC 48, Laboratory glassware and related apparatus. The details specified conform with ISO/R 384.

Differences between this British Standard and the Draft International Standard on glass graduated measuring cylinders have been limited, in most instances, to those arising from the differences in physical properties of the respective materials used in their construction. This British Standard specifies measuring cylinders intended for use with aqueous solutions at the reference temperature. **Before using these measuring cylinders for strong acids and alkalis, oxidizing agents or non-aqueous solutions or at other temperatures, users should satisfy themselves that the cylinders are suitable for such applications either by laboratory tests or by reference to the manufacturer or supplier.**

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 8, 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.

1 Scope

This British Standard specifies requirements for a series of plastics cylinders with a graduated volumetric scale and a pouring lip.

2 References

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

3 Basis of graduation

3.1 Unit of volume. The unit of volume shall be the cubic centimetre (cm^3), for which the name millilitre (ml) may be used.

NOTE The term millilitre (ml) is commonly used as a special name for the cubic centimetre (cm^3), in accordance with a decision of the twelfth Conférence Générale des Poids et Mesures. The term millilitre is acceptable, in general, for reference to capacities of volumetric glassware and is used in the present text.

3.2 Reference temperature. The standard reference temperature, i.e. the temperature at which the cylinder is intended to contain its nominal volume (nominal capacity), should be 20 °C.

NOTE When it is necessary as in tropical countries to work at an ambient temperature considerably above 20 °C, and users do not wish to use the standard temperature of 20 °C, it is recommended that the reference temperature be 27 °C.

4 Series of nominal capacities

The series of nominal capacities of graduated measuring cylinders shall be as shown in Table 1.

Table 1 — Series of capacities, divisions and tolerances

Nominal capacity	Smallest scale division	Maximum permitted error	Maximum ungraduated capacity at base
ml	ml	ml	ml
10	0.2	± 0.2	1
25	0.5	± 0.5	2.5
50	1	± 1	5
100	1	± 1	10
250	2	± 2	20
500	5	± 5	50
1 000	10	± 10	100
2 000	20	± 20	200

5 Definition of capacity

5.1 General case. The capacity corresponding to any graduation line shall be defined as the volume of water at 20 °C, expressed in millilitres, contained by the cylinder at 20 °C when filled to that graduation line in accordance with the procedure given in **A.1**.

5.2 Special case. Where, exceptionally, the reference temperature is 27 °C, this value shall be substituted for 20 °C.

6 Accuracy

There shall be one class of accuracy.

When tested in accordance with Appendix A the errors on capacity shall not exceed the maximum permitted errors shown in Table 1. The error represents the maximum permissible error at any point and also the maximum permissible algebraic difference between the errors at any two points.

7 Material

7.1 General. Cylinders shall be rigidly constructed of generally non-brittle transparent or translucent plastics material of suitable chemical and thermal properties and shall be as free as possible from moulding defects and stress.

7.2 Resistance to extraction of ionic material by water at 20 °C. When tested in accordance with the procedure given in Appendix B, the cylinder shall give an aqueous extract, free of suspended matter, and having a conductivity not more than 200 µS/m greater than that of the original water used for the extraction.

NOTE 200 µS/m is equivalent to the conductivity of water containing approximately one part per million of sodium chloride.

8 Details of construction
(see also Figure 1)

8.1 Stability. The cylinders shall stand vertically without rocking or spinning when placed on a level surface. They shall not topple when placed empty on a non-slip surface inclined at an angle of 12 ± 1° to the horizontal.

8.2 Base. The base shall be of a suitable plastics material, and may be integral with the body. It may be either polygonal with five or more equal sides, or circular.

8.3 Spout. The spout shall be so formed as to enable the contents of the cylinder to be poured out in a narrow stream without spilling or running down the outside of the cylinder.

8.4 Dimensions

8.4.1 Cylinders shall comply with the dimensional requirements shown in Table 2.

Table 2 — Dimensions

Nominal capacity	Internal height to highest graduation line min.	Overall height max.	Distance from highest graduation line to top of cylinder min.
ml	mm	mm	mm
10	90	150	40
25	90	170	40
50	115	200	50
100	145	260	60
250	200	340	60
500	250	390	75
1 000	315	470	75
2 000	400	570	75

8.4.2 The wall thickness shall be such that when tested for flexibility in accordance with the procedure detailed in Appendix C, the diameter of the cylinder shall not decrease by more than 10 % and the change in indication arising from any permanent distortion caused by the test procedure shall not result in the maximum permitted error given in Table 1 being exceeded.

8.5 Translucency. The cylinder shall be constructed in such a manner that when containing transparent liquids, the meniscus can be seen through the cylinder.

9 Graduation and figuring
(see also Figure 2 and Figure 3)

9.1 Graduation lines. Graduation lines shall be clean, durable, uniform lines of thickness not exceeding 0.3 mm for capacities up to and including 250 ml and not exceeding 0.5 mm for capacities of 500 ml and above.

9.2 Spacing of graduation lines. There shall be no evident irregularity in the spacing of the graduation lines.

9.3 Length of graduation lines

9.3.1 The length of the short lines shall lie between 10 % and 12.5 % of the circumference of the cylinder.

9.3.2 The length of the medium lines (where used), shall lie between 15 % and 18 % of the circumference of the cylinder.

9.3.3 The length of the long lines shall be at least 20 % of the circumference of the cylinder.

9.3.4 The medium and long lines should extend symmetrically at each end beyond the ends of the short lines.

9.4 Sequence of graduation lines

9.4.1 On cylinders of capacity 50 ml and 100 ml divided in 1 ml, and capacity 1 000 ml divided in 10 ml:

a) every tenth graduation line shall be a long line;

b) there shall be a medium line between two consecutive long lines;

c) there shall be four short lines between consecutive medium and long lines.

9.4.2 On cylinders of capacity 10 ml divided in 0.2 ml, capacity 250 ml divided in 2 ml, and capacity 2 000 ml divided in 20 ml:

a) every fifth graduation line shall be a long line;

b) there shall be four short lines between two consecutive long lines.

9.4.3 On cylinders of capacity 25 ml divided in 0.5 ml, and capacity 500 ml divided in 5 ml:

a) every tenth graduation line shall be a long line;

b) there shall be four medium lines between two consecutive long lines;

c) there shall be one short line between two consecutive medium lines and between consecutive medium and long lines.

9.5 Position of graduation lines. The graduation lines shall lie in planes at right angles to the longitudinal axis of the cylinder and shall form a vertical scale on the cylinder on the side facing the viewer when the cylinder is positioned with the spout facing to the left.

9.6 Figuring of graduation lines. Graduation lines shall be figured as illustrated in Figure 2 and Figure 3, in accordance with the following principles.

9.6.1 On all cylinders other than 250 ml and 2 000 ml every long line shall be figured.

9.6.2 On a cylinder of 250 ml capacity, alternate long lines shall be figured from 20 to 240 with an additional Figure 250. On the cylinder of 2 000 ml capacity, alternate long lines shall be figured, but the figuring of all long lines is permitted.

9.6.3 The scheme of figuring shall be such that the figure representing the nominal capacity refers to the highest graduation line.

9.6.4 The figures shall either be placed slightly to the right of the end of the line to which they refer in such a way that an extension of the line would bisect them, or be placed immediately above the long lines to which they refer and slightly to the right of the adjacent shorter lines.

If the long lines are extended so as almost to encircle the cylinder, the figures shall either be placed immediately above the line or there shall be a break in each long line, slightly to the right of the right-hand ends of the shorter lines, and the figures for that line shall occupy the break and be placed in such a manner that the line would bisect them.

10 Inscriptions

The following inscriptions shall be durably and legibly marked on all cylinders.

a) The symbol "cm^3" or the symbol "ml" to indicate the unit of volume (see note to **3.1**).

b) The inscription "In 20 °C" to indicate that the cylinder is graduated for content at 20 °C.

NOTE Where, exceptionally, the reference temperature is 27 °C, this value should be substituted for 20 °C.

c) The maker's and/or vendor's name or readily identifiable mark.

d) The name of the material (or its recognized abbreviation as given in BS 3502) from which the cylinder is made, e.g. "PP".

e) The number of this British Standard, i.e. BS 5404.

Appendix A Calibration of plastics measuring cylinders

A.1 Thoroughly clean and dry the measuring cylinder. Fill the clean weighed cylinder with distilled water to a few millimetres above the graduation mark to be tested, care being taken to avoid wetting the cylinder above the water surface. Ensure that the cylinder settles down to room temperature before testing, and determine the water temperature, t °C. Adjust the lowest point of the water meniscus to the top edge of the graduation mark in question by withdrawing small amounts of water by means of a glass tube drawn out to a jet at its lower end.

If the meniscus is curved, set it by one of the two methods detailed below.

a) Set the meniscus so that the plane of the upper edge of the graduation line is horizontally tangential to the lowest point of the meniscus, the line of sight being in the same plane.

b) Set the meniscus so that the plane of the centre of the graduation line is horizontally tangential to the lowest point of the meniscus. Raise the eye towards the plane and observe the front and back portions of the line apparently meeting simultaneously the lowest point of the meniscus.

Determine the mass of the water in the cylinder. Calculate the volume of water at 20 °C contained by the cylinder up to the graduation mark tested from the mass thus determined by applying a correction for water temperature as described in **A.2**.

A.2 Obtain the capacity in millilitres of the plastics measuring cylinder at 20 °C, by multiplying the mass of pure water in grams contained at t °C by the factor $(1 + c)$.

The quantity c is given in Table 3 in units of 10^{-5} ml/g for plastics materials having various values for the coefficient of cubical thermal expansion.

NOTE Manufacturers should be consulted for the appropriate value for this coefficient. The value can be used by linear interpolation in the table.

The values of c given in the table are applicable at a barometric pressure of 1.013 bar[1)] and a temperature of 20 °C. When large deviations from these values occur, it may be necessary to take account of second order effects arising from changes in the buoyancy correction caused by variations in atmospheric pressure and temperature, and these may be obtained from Tables 2 of BS 1797:1968. These tables are headed, "Soda and borosilicate glass" but are applicable to materials having any value for the coefficient of cubical thermal expansion.

[1)] 1 bar = 10^5 N/m² = 100 kPa.

Table 3 — Values of the quantity c in units of 10^{-5} ml/g used in calibration

Temperature	Coefficient of cubical thermal expansion of the plastics material in units of 10^{-5} (°C)$^{-1}$				
	20	30	40	50	60
°C					
5	410	561	713	865	1 018
6	392	533	675	817	959
7	376	507	638	770	902
8	361	482	603	725	846
9	348	459	570	681	792
10	336	437	537	639	738
11	325	416	507	598	689
12	316	397	477	558	639
13	308	379	449	520	590
14	301	362	422	483	543
15	296	346	396	447	497
16	292	332	372	412	452
17	288	319	349	379	409
18	286	306	327	347	367
19	285	296	306	316	326
20	286	286	286	286	286
21	287	277	267	257	247
22	289	269	249	229	209
23	292	262	232	202	172
24	297	257	217	177	137
25	302	252	202	152	102
26	308	248	188	128	68
27	316	246	176	106	36
28	324	244	164	84	4
29	333	243	153	63	– 27
30	343	243	143	43	– 56
31	354	244	134	24	– 85
32	365	245	126	6	– 113
33	378	248	118	– 11	– 140
34	392	252	112	– 27	– 166
35	406	256	106	– 43	– 191

Basis of table

When weighing a quantity of water at t °C, equilibrium is expressed by:

$$W - \frac{W}{\Delta}\sigma = V_t \rho_t - V_t \sigma$$

where

W is the apparent mass of the water in air (in g)

σ is the density of the air at the time of weighing (taken as 1.1994×10^{-3} g/cm³)

Δ is the density of the masses (taken as 8.0 g/cm³)

V_t is the volume of the water at t °C (in cm³)

ρ_t is the density of the water at t °C (in g/cm³) taken from the table in BS 718.[a]

[a] Revision in course of preparation.

If α is the coefficient of cubical thermal expansion of the plastics material, then:

$$V_t = V_{20}\,[1 + \alpha\,(t - 20)]$$

Eliminating V_t from these two equations leads to:

$$1 + c = \frac{1 - \frac{\sigma}{\Delta}}{(\rho_t - \sigma)\,[1 + \alpha\,(t - 20)]} = \frac{V_{20}}{W}$$

Appendix B Test for ionic material extracted by water at 20 °C

B.1 Apparatus and solutions required

The following items are required.

B.1.1 *Clock glasses,* made of borosilicate glass, sizes appropriate to the cylinders under test.

B.1.2 *Conductivity meter,* suitable for measurement of the electrical conductivity of water.

B.1.3 *De-ionized water,* complying with the requirements of BS 3978 except that the conductivity shall be less than 200 µS/m.

B.1.4 *Detergent solution*

B.2 Procedure

Thoroughly wash each cylinder under test with hot water and detergent solution, then rinse well with hot, followed by cold water, and finally with liberal quantities of de-ionized water. Fill each cylinder to its nominal capacity with de-ionized water at 20 ± 2 °C. Cover with a clean clock glass and allow to stand for 3 h.

Measure the electrical conductivity of each extract by the procedure detailed in method 6 of BS 2690-9:1970 and deduct from the value obtained the conductivity of the original water used to prepare the extract, also measured at 20 °C. Note the difference in conductivity in microsiemens per metre.

Appendix C Flexibility and recovery test for plastics cylinders (see Figure 4)

C.1 Apparatus

The general arrangement of the apparatus is shown in Figure 4. The following items are required.

C.1.1 *Square blocks of wood,* up to 29 in number, each 19 mm thick, having a square with up to 110 mm sides cut from one corner and not exceeding one quarter of the original block.

C.1.2 *A test finger III* complying with the requirements of BS 3042.

C.1.3 *A guide for the test finger* consisting of a stout plate with a 13 mm hole, adjustable in distance (from 10 mm to 200 mm) from the inside corner of the blocks and adjustable in height (from 60 mm to 300 mm).

C.1.4 *A thermometer,* covering the range from – 5 °C to + 105 °C, graduated at each degree Celsius.

C.1.5 *Inside calipers* opening from 10 mm to 80 mm.

C.1.6 *A G-clamp*

C.1.7 *Tongs or holding device* for introducing calipers into the measuring cylinder.

C.2 Procedure

C.2.1 Stack sufficient of the L-shaped blocks to bring the highest just below the brim of the measuring cylinder to be tested.

C.2.2 Adjust the blocks so that the lower ones accommodate the base of the measuring cylinder and each of the others touches the measuring cylinder at two points and then clamp the stack to the working surface.

C.2.3 Adjust the brackets bearing the guide so that the test finger, when inserted through the hole, will touch the measuring cylinder at a height equal to half of the total height of the measuring cylinder.

C.2.4 Adjust the brackets or other fixing bearing the guide so that it is fixed 20 mm from the measuring cylinder.

C.2.5 Place the assembly in an enclosure maintained at 20 ± 2 °C, and by using the calipers, measure the inside diameter (d mm) of the measuring cylinder at the point of application and in the direction of the force to be applied. Set the calipers at 0.9 d mm.

C.2.6 Insert the test finger and apply a steady force of 30 N as shown by the force indicator of the test finger, horizontally and towards the axis of the measuring cylinder.

C.2.7 If, after the force has been applied for 60 s and while still maintaining the force, the calipers cannot be positioned inside the measuring cylinder at the point of application and in the direction of the applied force, then the diameter has decreased by more than 10 % and the cylinder has failed the test.

C.2.8 Remove the test finger.

C.2.9 Rotate the measuring cylinder 90° and repeat from **C.2.5** to **C.2.8**.

C.2.10 Fill the measuring cylinder to just below its nominal capacity with water at 20 ± 2 °C, and note the exact reading (V_1 ml).

C.2.11 Repeat **C.2.6**.

C.2.12 After the force has been applied for 60 s, remove the test finger, wait a further 60 s, read the volume of the water (V_2 ml), and record the difference ($V_2 - V_1$) arising from any permanent distortion.

C.2.13 Compare the difference ($V_2 - V_1$) with the appropriate value of the maximum permitted error given in Table 1.

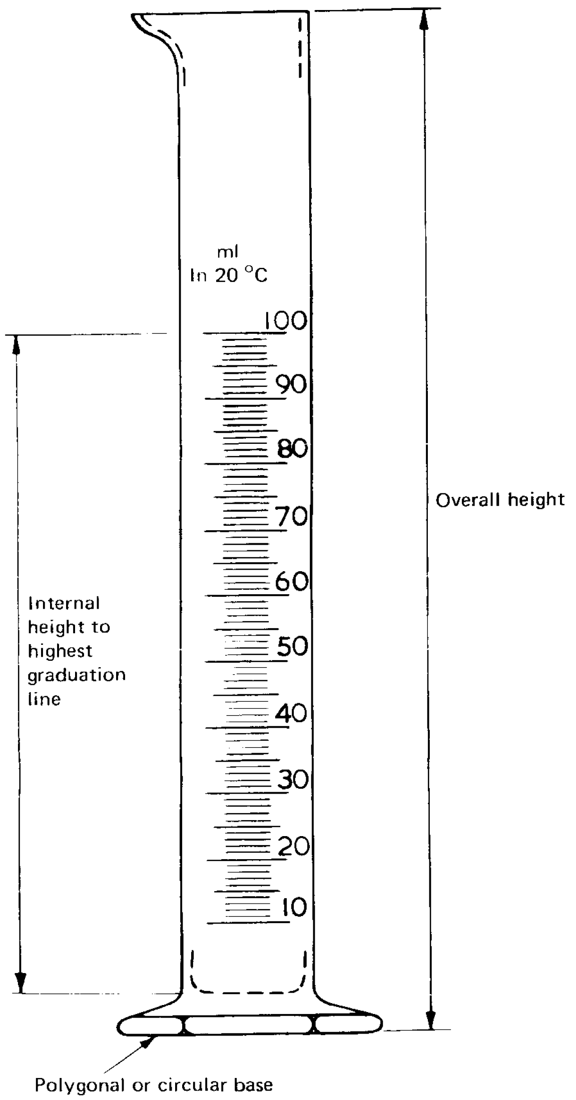

Figure 1 — General appearance of measuring cylinder

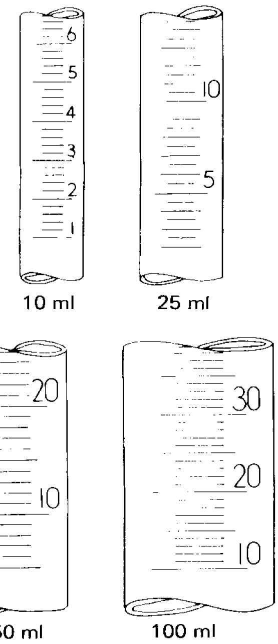

Figure 2 — Scales of measuring cylinders

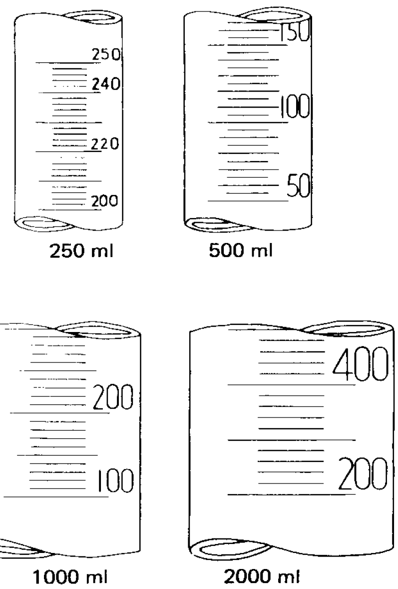

Figure 3 — Scales of measuring cylinders

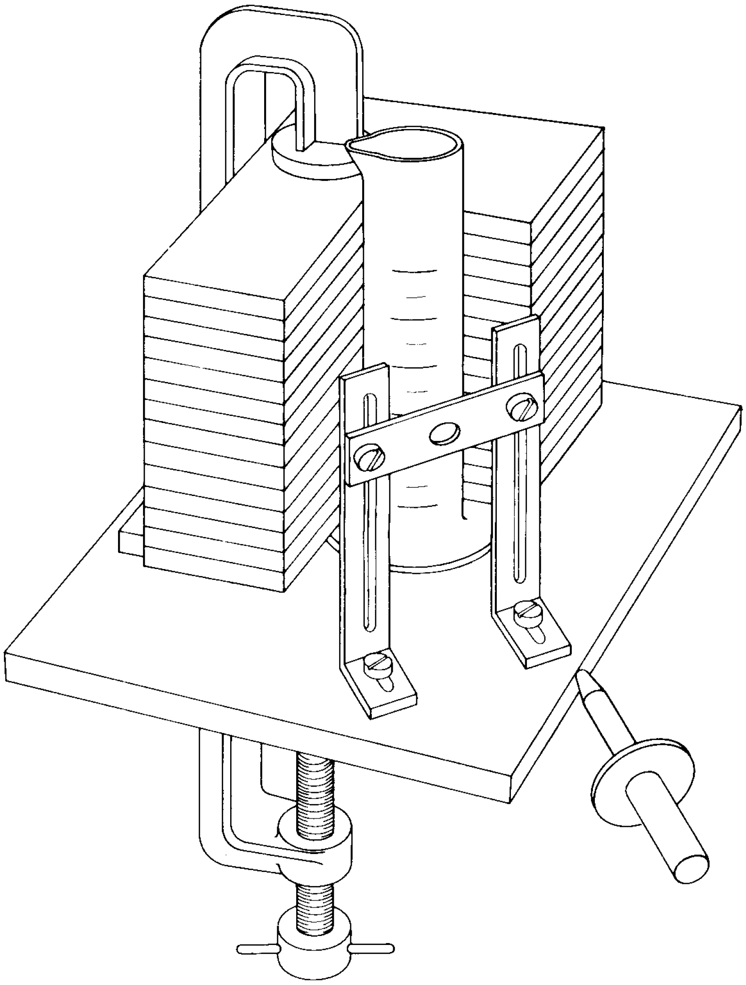

Figure 4 — General arrangement of equipment for flexibility test (not to scale)

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Publications referred to

BS 718, *Density hydrometers and specific gravity hydrometers*[2].

BS 1797, *Tables for use in the calibration of volumetric glassware.*

BS 2690, *Methods of testing water used in industry.*

BS 2690-9, *Appearance (colour and turbidity), odour, suspended and dissolved solids and electrical conductivity.*

BS 3042, *Standard test fingers and probes for checking protection against electrical, mechanical and thermal hazard.*

BS 3502, *Schedule of common names and abbreviations for plastics and rubbers.*

BS 3978, *Water for laboratory use.*

ISO/R384, *Principles of construction and adjustment of volumetric glassware.*

[2] Revision in course of preparation

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