BRITISH STANDARD

BS 4161-4: 1970

Incorporating Amendment No. 1

Specification for

Gas meters —

Part 4: Plate constructed positive displacement diaphragm meters for a pressure of 350 mbar (5 lbf/in^2) and up to 170 cubic metres (6000 cubic feet) per hour rating

Co-operating organizations

The Gas Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government department and scientific and industrial organizations:

Gas Council*

Heating and Ventilating Contractors' Association

Institution of Gas Engineers*

Liquefied Petroleum Gas Industry Technical Committee*

Ministry of Technology*

Society of British Gas Industries*

The Government department and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

British Non-ferrous Metals Federation

This British Standard, having been approved by the Gas Industry Standards Committee, was published under the authority of the Executive Board on
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Foreword

This standard makes reference to the following British Standards:

BS 10, *Flanges and bolting for pipes, valves and fittings.*

BS 21, *Pipe threads.*

BS 143 & BS 1256, *Malleable cast iron and cast copper alloy screwed pipe fittings for steam, air, water, gas and oil.*

BS 381C, *Colours for specific purposes.*

BS 746, *Gas meter unions and adaptors.*

BS 1179, *Glossary of terms used in the gas industry.*

BS 1250, *Domestic appliances burning town gas — Part 1: General requirements.*

BS 1387, *Steel tubes and tubulars suitable for screwing to BS 21 pipe threads.*

BS 1452, *Grey iron castings.*

BS 2045, *Preferred numbers.*

BS 2660, *Colours for building and decorative paints.*

BS 2782, *Methods of testing plastics — Part 5: Miscellaneous methods.*

B8 2797, *Leather for gas meter diaphragms — Part 1: E.L. sheep skin leather. Part 2, Split hide leather.*

BS 3900, *Methods of test for paints — Part F2: Resistance to humidity under condensation conditions.*

This British Standard is the fourth of a series relating to meters for gaseous fuels for registering the volume of gas passed.

These meters may be used for metering gases other than gaseous fuels, but the suitability of a meter for this purpose should be verified with the manufacturer.

As higher pressures are being adopted for piped supplies a demand is created for a meter to withstand these higher pressures. This standard is based on the meters specified in Parts 1 and 2, sizes P.6 to P.60, which are for pressures up to 50 mbar [1)], and suitably strengthened for a working pressure of 350 mbar [1)] (5 lbf/in^2).

Although at the time of publication legislation did not permit the use of metric units as a basis for charging for gas consumed the committee prepared this standard for reading in cubic metres in anticipation of legislation being granted. Cubic feet indexes have also been included to comply with the current legislation.

Temperature and pressure compensating devices are not generally required for meters working at a constant inlet pressure of 350 mbar [1)], therefore no details for such devices are included in this standard. If a device is required it is anticipated that some guidance will be given in a separate standard to follow.

The method of ordering meters adopted in earlier Parts has been extended to these high pressure meters and is explained in Appendix A. Further Parts covering other pressures and types of gas meter are envisaged. Those already published are:

— *Part 1: Meters of plate construction up to 1 000 cubic feet per hour rating;*

— *Part 2: Meters of plate construction above 1 000 cubic feet per hour rating;*

— *Part 3: Unit construction meter of 6 cubic metres (212 cubic feet) per hour rating.*

NOTE 1 Factors for the conversion of metric into imperial units are given in Appendix M. More comprehensive conversions will be found in BS 350, *"Conversion factors and tables"*.

NOTE 2 These meters are considered to be a product which is not dimensionally related to those products for which dimensional co-ordination is essential and thus come within the category of Item 6 in PD 6030, *"Programme for the change to the metric system in the construction industry"*.

[1)] 1 mbar = 10^2 N/m^2.

Obsolescent (by Amendment No. 1)

The need for the equipment covered by this Part of this British Standard has been reviewed and although it was decided not to amend or revise the text, the standard should be regarded as obsolescent and not therefore used for new designs. The standard will be withdrawn in due course.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their 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 to iv, pages 1 to 21 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

1.1 General. This part of BS 4161 covers the construction and performance of plate constructed high pressure positive displacement diaphragm meters for a working gas pressure of 350 mbar [2] and case sizes 5P.6 to 5P.60 inclusive.

It includes the requirements for top connection bosses conforming to BS 746[3] (for the 5P.6 size), flanges and connector sockets.

1.2 Installation. The installation of high pressure meters may later be dealt with in a British Standard Code of Practice[4].

1.3 New developments. Notwithstanding the requirements specified in this standard, any new designs, materials and methods of assembly giving at least equivalent results are acceptable.

2 Definitions

2.1 The terms used in this British Standard are defined in BS 1179[5].

3 Ratings

3.1 A meter shall be badged at one of the badged ratings shown in Table 1 or at another badged rating conforming to the R40 series of preferred numbers (see BS 2045[6]) for m^3/h or conforming to the R20 series, rounded to the nearest thousand ft^3/h, for ft^3/h meters.

NOTE The badged rating as defined in BS 1179[5] is determined on air at low pressure.

4 Materials

4.1 General requirements. The meter shall be constructed of materials of good quality complying, where applicable, with British Standards. The materials used shall not be adversely affected by the conditions arising in that part of the meter in which they are used.

4.2 Tinning. All steel components, unless inherently corrosion resistant, shall be tinned as follows:

1) *Pretinned steel sheet for case and valve plate assembly.* The tinning shall be evenly applied on both sides, the two coatings having a combined weight of not less than 180 g/m^2 (a coat thickness each side of 0.013 mm).

2) *Internal mild steel sheet components.* The tinning shall be evenly applied on both sides, the two coatings having a combined weight of not less than 120 g/m^2 (a coat thickness each side of 0.008 mm).

3) *Other steel components,* e.g. flag rods which are tinned shall have an equivalent coating of tin of not less than 45 g/m^2 of the surface area (a coat thickness of 0.006 mm).

4.3 Diaphragms. Leather diaphragms shall comply with the requirements of BS 2797-1[7] or BS 2797-2[7] as appropriate. The dressing shall be non-acid, covering the surface and filling the pores and any stitches, and it shall be suitable for the gas for which the meter is to be used. The dressed leather, when fitted, shall be impermeable to air at a differential pressure of 5 mbar [2].

Synthetic or reinforced synthetic diaphragms shall have a performance and useful life not less than that of leather diaphragms and shall withstand the test requirements of Appendix B.

4.4 Index window. The index window shall be of 6 mm (minimum) plate glass, or materials of equivalent performance and useful life, and shall satisfy the requirements and tests in Appendix C.

4.5 Bearings. All linkage, pivot and other bearings shall be made of corrosion and wear resistant material.

[2] 1 mbar = 10^2 N/m^2.
[3] BS 746, *"Gas meter unions and adaptors"*.
[4] Recommendations under consideration by the Institution of Gas Engineers.
[5] BS 1179, *"Glossary of terms used in the gas industry"*.
[6] BS 2045, *"Preferred numbers"*.
[7] BS 2797, *"Leather for gas meter diaphragms"*, Part 1, *"E.I. sheep skin leather"*, Part 2, *"Split hide leather"*.

4.6 Valves. The faces of the valve cover shall be made of phenolformaldehyde with an inert filler and graphite impregnated or of a material having equivalent properties, such as wear resistance, breakage resistance and low coefficient of friction.

The valve grids shall be made of a material compatible with that of the valve covers. A suitable combination is graphited phenolformaldehyde for the faces of the valve covers and an alloy of tin, antimony and lead for the valve grids.

4.7 Gearing. The gearing shall be made of materials which are compatible, wear resistant and dimensionally stable.

4.8 Grease. Where grease is used for lubricating bearings and gears it shall not contain solids unless the solids have lubricating properties. Metallic soap-base greases shall not be used.

4.9 Sealing gland. The gland seal shall be made of a material that will satisfy the tests specified in Appendix D.

4.10 Motion wires and components. Where motion wires are fitted, they and their guides and bearings shall be made of wear and corrosion resistant material.

4.11 Bosses. Meter bosses shall be made of a material specified in BS 746[8)].

4.12 Connector socket. Sockets shall be made from cast iron to BS 1452[9)], Grade 10, or of a material at least equivalent in mechanical strength and durability.

Longscrew material shall comply with the requirements of BS 1387[10)].

4.13 Flanges. Flanges shall be made of a material complying with the requirements of BS 10[11)].

5 Design and dimensions

5.1 Case. The meter shall have a case size conforming to Table 1.

When looked at from the front (see Figure 8) the inlet connection shall be located on the left-hand side of the meter and the outlet connection shall be on the right-hand side, both located on the vertical centre line of the side.

A 5P.6 meter shall be provided with inlet and outlet side pipes with bosses for top connection.

The meter case shall be made of pre-tinned steel sheet. The total thickness of the tinned steel sheet shall be not less than that shown in Table 2.

The seams shall be soft soldered to obtain a gas-tight joint and to permit removal of panels without damage for repair purposes. In addition all the panels shall be fixed mechanically.

The meter shall be supported on feet firmly attached to the case. The feet shall be sealed to prevent ingress of moisture. They shall not be positioned over a soldered seam and preferably not under a flag rod bearing.

There shall be adequate working clearance between moving components and stationary parts of the meter not intended to make contact. These clearances shall make allowance for readjustment of the mechanism.

When the meter is in an upright position it shall not be possible for liquid to be trapped on the case.

5.2 Purging point. A meter outlet flange, or socket fitted integral with the case, shall be provided with a purging plug. The internal thread for this plug shall be screwed ½ in BSP for a meter with a 3 in BSP outlet connection and screwed ¾ in for 4 in and larger BSP outlet connections (except where indicated in Figure 1, Table 5, Column 10). These threads shall conform to BS 21[12)], and should be of taper form.

The purging plug shall be of malleable cast iron, complying with the requirements of BS 143[13)], solid type, and shall be easily accessible.

NOTE A purging point for a 5P.6 meter is provided in the associated installation pipework.

8) BS 746, *"Gas meter unions and adaptors"*.
9) BS 1452, *"Grey iron castings"*.
10) BS 1387, *"Steel tubes and tubulars suitable for screwing to BS 21 pipe threads"*.
11) BS 10, *"Flanges and bolting for pipes, valves and fittings"*.
12) BS 21, *"Pipe threads"*.
13) BS 143 & BS 1256, *"Malleable cast iron and cast copper alloy screwed pipe fittings for steam, air, water, gas and oil"*.

Table 1 — Case dimensions and ratings

1	2	3	4	5	6	7	8	9
BS case reference number	Badged rating	Alternative badged rating	Connection size BSP		Overall width (over connections or between boss centres[a])	Height of centre of connections (or to top of bosses[a])	Overall height	Overall depth
			Flanges (or bosses[a])	Connector sockets				
	m^3/h	ft^3/h	in	in	mm	mm	mm	mm
					limits	limits		
5P.6	20	700	[a]2	—	+ 8, – 5 [a]430	+ 8, – 5 [a]570	max. see Column 7	max. 380
					limits + 0, – 12	limits + 0, – 12		
5P.12	34	1 200	3	3	610	438	635	380
5P.18	50	1 800	3	3	692	515	737	432
5P.30	85	3 000	4	4	768	515	864	610
5P.60	170	6 000	— 6	4 —	833 895	686	1 092	686

[a] Top connections to BS 746, "*Gas meter unions and adaptors*".

Table 2 — Case thickness

BS case reference number	Minimum thickness of tinned steel sheet
	mm
5P.6 up to and including 5P.18	0.90
5P.30 and 5P.60	1.20

5.3 Index

5.3.1 ***General.*** The index of the meter shall be sealed from the gas inside the meter by a sealing gland. The index window shall be sealed in its frame but the index may be vented to the atmosphere by a small hole in the frame, positioned to prevent the entry of water. The window and frame shall be designed to prevent unauthorized access to the index.

The index face shall have black printing (except the red noughts or the red portion of the visor; see **5.3.2** and **5.3.3**) on a white background.

The index shall not fade when used during the test in Appendix **C.2.2.1**.

The recording numerals shall be arranged as shown in Figure 2, Figure 3, Figure 4 or Figure 5. They shall be of uniform size, shall have minimum dimensions of 5 mm high and 2.6 mm wide. Except as specified in **5.3.2**, they shall be white in colour on a black background and surrounded by a black visor as shown in the appropriate Figure.

The numerals shall move in an upward direction and shall be clearly visible at an angle of 15° (to the normal) when viewed from any direction from the front of the meter.

A complete revolution of a drum shall, during the last $^1/_{10}$ of its travel, i.e. from 9 to 0, cause the advance of the next higher drum by one unit.

5.3.2 ***Cubic metre index.*** The index for a meter with a badged rating in cubic metres shall conform to Figure 2 or Figure 3 and shall have a test drum. This drum shall move continuously while the meter is recording. It shall have a minimum diameter of 16 mm with subdivisions of uniform length 1 mm (minimum) apart.

The unit divisions commencing with a numeral 0, shall be distinguished from the subdivisions by longer lines. These graduation lines shall be fine, uniformly drawn and white in colour. (See enlarged view at Figure 2.) For the application of photo-electric meter testing techniques, a white line as thick as practicable shall be drawn across the drum and positioned between any recording numerals.

The window for the test drum shall have a projection, with a horizontal lower edge, projecting two-thirds of the way across the subdivisions of the test drum. (See enlarged view at Figure 3.)

The recording numerals for submultiples of m^3 shall be red in colour surrounded by a red visor and separated from recording numerals in m^3 by a clear decimal point.

5.3.3 ***Cubic feet index.*** The index for a meter with a badged rating in cubic feet shall conform to Figure 4 or Figure 5 and shall have a test dial, the diameter of which shall be not less than 28 mm. The diameter and subdivisions of the test dial shall enable accurate readings to be made when the meter is working at the badged rating.

The value (ft^3 per revolution) chosen for this test dial shall permit one complete revolution of the test dial hand to indicate one or more full working cycles of the meter.

NOTE The test dial as shown in Figure 4 and Figure 5 is to indicate the type, not necessarily the cubic range.

The direction of rotation of the test dial hand shall be indicated and may be either clockwise or anti-clockwise. The hand shall be red and shall be of sufficient length to indicate between the two concentric circles.

The test dial hand shall be sharply pointed and shall lie as close to the dial as practicable.

The index face shall have two numeral noughts in red on the white background in line with the recording numerals.

5.4 Remote reading take-off point. Where a remote reading take-off point is provided, the free end shall be covered and there shall be provision for sealing when it is not used.

The value per revolution of the take-off shaft, i.e. 1 rev = ... m^3 (or ft^3), shall be marked on the shaft or at an adjacent point on the meter.

5.5 Sealing gland assemblies. The design of all sealing glands shall be such as to satisfy the tests in Appendix D. All seals within any sealing gland shall be capable of replacement.

The threads of the gland nuts shall tighten in the direction of rotation of the spindle passing through them, or the nut shall be suitably locked to prevent slackening off. For repair purposes, the nut of the index sealing gland shall be accessible from the outside of the gas carrying compartments of the meter.

Where the spindle passes through the case the thrust of this spindle has not to act against the seal in the gland. A thrust bearer shall be provided to minimize the frictional resistance.

5.6 Worm gear assembly. Where the gears of the worm gear assembly do not require external lubrication, they shall be enclosed within a housing. The assembly, through its supporting members, shall be firmly secured to the valve plate.

5.7 Bonding. Adhesive as the means of fixing components shall have adequate bonding strength. In addition, where failure of the adhesive would cause mechanical failure or leakage, mechanical means shall be provided to secure components. The adhesive shall be effective throughout the life of the meter, and it shall not be affected by the gas for which the meter is intended to be used, or by water vapour.

5.8 Adjustment. Facilities for adjusting the registration of the meter shall be incorporated and an effective means of locking the adjustments shall be provided. Adjustments shall be conveniently accessible for repair purposes and shall be designed for easy resetting.

5.9 Bearings. Where bushes are used, they shall be fitted in a manner to avert wear to their anchorages or housings.

5.10 Drainage. Except as below, provision shall be made for the case and diaphragm chambers to be drained while pressurized. All four chambers shall be drained individually to one and the same side of the meter. Each drain point shall be capped or plugged and the external cover of the four points shall also be capped or plugged and sealed.

There need be no provision for draining 5P.6 and 5P.12 meters unless this is specified by the purchaser.

5.11 Shocks. The meter shall be designed to withstand normal transit shock.

6 Assembly and workmanship

6.1 General. The interior of the meter shall be free from loose solder, swarf, grinding material and other foreign matter. Any surplus soldering flux or spirit shall be removed.

6.2 Diaphragm assembly. The diaphragm assembly shall be gas tight. The diaphragms shall be undamaged and assembled without folds to the diaphragm pans. Grease or similar sealing medium shall not be used to effect a seal between the dressed diaphragm and the diaphragm pan rim.

6.3 Valves. Lubricants shall not be applied to valves.

6.4 Internal security. The flag bracket, diaphragm disk and associated parts, where manufactured as separate components, shall be securely fitted and locked together. The method of securing the flag to the flag rod shall give adequate mechanical strength.

6.5 Alignment. The assembled gear box and index driving shafts shall be correctly aligned. The test drum or dial hand shall rotate smoothly.

6.6 Lubrication. Non-self-lubricating linkage pivot bearings shall be lubricated with grease conforming to **4.8**.

7 Connections

7.1 General. The connections shall comprise one of the following:

1) Flanges conforming to Table A in BS 10[14].

2) Connector sockets complying with this specification, Figure 1 and Table 5. Connector socket threads shall conform to BS 21[15].

3) Bosses to BS 746[16] (5P.6 only)

7.2 Longscrew. When longscrews are ordered with the meter, they shall comply with the requirements of BS 1387[17] for single longscrews without a socket. They shall have a 25 mm length of unthreaded pipe between the connecting threads. A longscrew shall run in its connector socket hand-tight without perceptible shake.

There shall be sufficient clearance within the meter for the connector socket to accept the full length of the longscrew parallel thread.

7.3 Companion flanges. When companion flanges are ordered, their dimensions shall comply with BS 10[14], and they shall be suitable for connections to the flanges provided on the meter. The sizes of the connecting threads shall be specified by the purchaser, but the threads shall comply with BS 21[18] and shall be of parallel form.

8 External leakage and distortion

8.1 The meter shall not leak externally when subjected to an internal pressure of 440 mbar [19]. When this pressure is applied to the meter, no panel shall flex at its centre by more than 0.2 mm for each 25 mm of its shortest side. When the meter is depressurized, there shall be no permanent deformation and it shall be capable of passing the test specified in **9.1**.

NOTE 1 IMPORTANT. To prevent damage to the meter it is recommended that the method or part of the method of test given in Appendix E should be used.

NOTE 2 Where temperature differences and changes may affect test results significantly, testing should be carried out in a room having a controlled temperature and with the meter, apparatus and test air stabilized to room temperature. A period of three hours may be necessary to achieve this stability.

NOTE 3 Notwithstanding the requirements of **9.1** in BS 746:1967, *"Gas meter unions and adaptors"*, the bosses are required to withstand the requirements of **8.1** in this standard.

9 Internal leakage (See Note 2 in **8.1**)

9.1 The meter shall register when air is passed through it at the rate given in Table 3.

For the purpose of this test, the volume of air passed as indicated by the test drum or dial shall be not less than that equivalent to one working cycle of the diaphragms.

Table 3 — Internal leakage test rates

Index units	Badged rating		Air test rate
Cubic metres	m^3/h		l/h
	Up to	21	28
	Above 21 and up to	56	56
	Above	56	140
Cubic feet	ft^3/h		ft^3/h
	Up to	750	1.0
	Above 750 and up to 2 000		2.0
	Above 2 000		5.0

10 Performance (See Note 2 in **8.1**)

10.1 Accuracy of registration. At the badged rating and at one-fifth of the badged rating the meter shall be accurate within the limits + 2 % and – 3 % when tested with air by the method described in Appendix F.

The accuracy of registration at one-fifth of the badged rating shall not differ from that at the badged rating by more than 2 units of percentage.

10.2 Pressure loss. The mean pressure loss of the meter when air is passing through it at its badged rating shall not exceed that given in Table 4 when tested by the method described in Appendix G.

10.3 Pressure oscillation. When tested by the method described in Appendix G, the pressure oscillation at one-fifth of the badged rating and at the badged rating on air shall not exceed that given in Table 4.

10.4 Noise. The meter shall be quiet in operation.

[14] BS 10, *"Flanges and bolting for pipes, valves and fittings"*.
[15] BS 21, *"Pipe threads"*.
[16] BS 746, "*Gas meter unions and adaptors*".
[17] BS 1387, *"Steel tubes and tubulars suitable for screwing to BS 21 pipe threads"*.
[18] BS 21, *"Pipe threads"*.
[19] 1 mbar = 10^2 N/m^2.

Table 4 — Pressure loss and oscillation

Badged rating			Pressure loss	Pressure oscillation
	m^3/h	(or ft^3/h)	mbar[a]	mbar[a]
Not exceeding	140	(5 000)	1.25	0.75
Exceeding	140	(5 000)	2.0	1.0

[a] 1 mbar = 10^2 N/m^2.

11 Type tests

11.1 Life test. A life test shall be carried out on a sample meter in accordance with the requirements of Appendix H which shall be satisfied.

11.2 Case durability test. The meter shall withstand an alternating pressure of 0 mbar to 440 mbar [20] and back to 0 mbar for 10 000 cycles, each cycle taking 100 seconds to 150 seconds, after which it shall comply with the requirements of **8.1**.

The test apparatus layout is shown in Figure 6.

11.3 Mechanical strength. The meter shall withstand a weight of 80 kg, applied without shock, to any 100 mm square of the top panel for one minute. When the load is removed, the meter shall not be deformed; also it shall not leak externally when subjected to the test in **8.1**.

11.4 Connections. A 5P.6 meter with top connections shall withstand the following tests, and during and after them it shall not leak, as required by **8.1**.

Fit the meter with nuts and liners. Hold the meter firmly and with a straight lever fitted into one liner, apply a force of 500 N at right angles to the lever at a distance of 1.5 m from where the boss enters the side pipe of the meter in a direction away from the other boss. Repeat this test on the other boss.

12 Finish

12.1 Paint. The meter shall be finished with a good quality gloss paint, dark grey in colour to BS 2660[21] No. 9-097 or BS 381C[22] No. 632 (unless otherwise ordered) and it shall meet the following requirements:

1) After 7 days, the painted meter (or sample part thereof) when tested by the method described in Appendix J shall resist penetration. Any scratch mark shall be free from jagged edges of a width greater than 1 mm.

2) Following the previous test, the painted meter (or parts thereof) when tested by the method described in Appendix K shall not show evidence of lifting, blistering or deterioration of the paint finish after a minimum of 4 days' exposure.

NOTE This test 2) may be carried out on a second sample or on the original sample with the original scratch protected.

3) After 24 hours, following the previous test, the paint shall again resist penetration as required by 1).

13 Transit disc or cap

13.1 The connections shall be provided with suitable non-sealing discs or screwed caps to prevent the entry of foreign matter in transit and storage.

14 Marking

14.1 Inlet. The meter shall be clearly and permanently marked with the direction of flow either by an arrow between the connections or the word "INLET" as near as possible to the inlet connection.

14.2 Escape badge. All meters shall be supplied with an escape badge, Figure 7, readable from the front. This badge may be of a transfer or self adhesive type with black and red wording on a yellow background; the words "ESCAPES" and "GAS BOARD" being those in red.

14.3 Identity marking. The meter shall bear the following marking, readable from the front of the meter:

1) Manufacturer's name
2) Manufacturer's number
3) Year of manufacture
4) Maximum working pressure, 350 mbar
5) Badged rating, m^3/h (or ft^3/h)
6) Capacity per revolution, m^3 (or ft^3).

The marking shall be shown either on the index face or on an embossed metal badge or badges firmly and securely attached to the meter.

14.4 Property marking. The meter, unless otherwise ordered, shall in addition be clearly and permanently marked with the words "GAS BOARD PROPERTY".

14.5 Badge fixing. Any badge fixed to the meter case shall be sealed around its edges to prevent the ingress of water. Any means used for securing a badge shall not pierce the case.

[20] 1 mbar = 10^2 N/m^2.

[21] BS 2660, *"Colours for building and decorative paints"*.

[22] BS 381C, *"Colours for specific purposes"*.

14.6 Synthetic diaphragms. A meter provided with synthetic diaphragms shall be marked with a yellow transfer to the right of the index, carrying the letter "S" in black and of minimum height of 25 mm.

14.7 Special conditions. A meter shall be suitably and permanently marked if it is designed for use on a gas, other than gas containing aromatic hydro-carbons, where special conditions apply. For example, a meter provided with synthetic diaphragms for use on 2nd family gas, but not for gas containing aromatic hydrocarbons, shall be provided with a durable label printed with the words "SUITABLE FOR 2ND OR 3RD FAMILY GAS ONLY", printed in 6 mm high black letters on a yellow background and fitted to the right of the index.

NOTE This marking is additional to the requirement in **14.6**.

Appendix A Method of ordering

Apart from the BS number, the information should be given in the following order, each item of it being separated by a solidus:

1) BS case reference number (see Table 1)
2) Badged rating (m^3/h or ft^3/h, abbreviated to "M" or "F") (see **3.1**, **5.3.2** and **5.3.3**)
3) Size of connections (in) (see Table 1)
4) Flange or connector socket (F or CS) (see Table 1)
5) Any special requirements (written in full).

Example. 5P.60/170 M/4/CS to BS 4161-4

i.e. a 5P.60 case size meter suitable for a working pressure of 350 mbar [23)] with a 170 m^3/h badged rating, direct reading metric index, 4 in BSP connector sockets, painted dark grey and complying with this standard.

Appendix B Test requirements for synthetic diaphragms (See **4.3**)

B.1 Chemical resistance

A sample diaphragm or suitable test piece shall resist chemical attack by any of the constituents of the gas for which the meter is intended.

NOTE Chemical resistance tests are under consideration.

B.2 Fatigue resistance

A sample diaphragm or suitable piece shall not show signs of cracking, perforation, permanent deformation or delamination after it has been subjected to 10 million cycles of operation external to the meter. This cycling shall be effected by varying the pressure differential across the diaphragm by 1.25 mbar [23)] and the stroke shall be that which would be applicable when the diaphragm is incorporated in the meter for which it is designed. Air is used for the test, the temperature of which shall be ambient for a period of 1¼ million cycles, and then reduced to – 5 °C for ½ million cycles. This sequence is repeated until the completion of the test.

B.3 Temperature effect

B.3.1 When the meter is exposed to a variation in ambient temperature between – 5 °C and + 40 °C, the pressure loss and oscillation at the badged rating on air shall remain within the limits given in **10.2** and **10.3**.

B.3.2 After running at half the badged rating on air for 400 hours at a temperature of – 5 °C the performance of the meter shall satisfy the requirements of **9.1** and when restored to the test conditions described in Appendix F, the requirements of **10.1**. Care should be taken during the cold running test to prevent condensation in the meter.

B.4 Flexibility

When a meter, fitted with a synthetic diaphragm is subjected to a change of internal friction of the moving components the registration shall not be affected more than if it were fitted with leather diaphragms.

B.5 Dimensional stability (additional requirements if the diaphragm is to be used in a meter for gas containing aromatic hydrocarbons)

Immediately after a period of exposure of 100 hours working at a minimum rate of flow of 0.3 m^3/h at a temperature of 18 ± 3 °C on a gaseous fuel containing 1¼ % by volume of benzene vapour and having a relative humidity of not less than 95 %, any change in diaphragm dimensions or flexibility shall not result in a change of meter registration of more than ± 2 % at the badged rating.

For the purpose of this test, the initial registration at the badged rating shall be determined on the gaseous fuel before adding the stated benzene and water vapour.

WARNING. Repeated inhalation of benzene vapour even to a modest degree can, over a period of several months, result in fatal toxic effects. Any benzene process should be enclosed or carried out in a fume cupboard if practicable.

[23)] 1 mbar = 10^2 N/m^2.

Appendix C Requirements and tests for plastics index windows (See 4.4)

NOTE **C.1.4** also applies to plate glass windows.

C.1 Requirements

C.1.1 ***General.*** Both as supplied and after being subjected to the accelerated deterioration tests in **C.2**, samples of window panes or mouldings shall meet the following requirements. The accelerated deterioration tests shall be performed on samples which have not been previously subjected to the flammability test.

C.1.2 ***Visual inspection.*** The window pane or moulding shall show no crazing or blisters. The portion through which the index is viewed shall be colourless, transparent, have a high polish, and cause no visual distortion of the matter to be viewed within an angle of 15° from the normal to the window when viewed from any direction from the front of the meter.

C.1.3 ***Rigidity.*** With the window fitted on the meter as in operation and at a temperature of 30 ± 2 °C, a 10 mm diameter timber rod applied normal to any external part of the window or moulding with a force of 200 N shall not cause it to touch any moving part of the mechanism.

C.1.4 ***Impact.*** The window, fitted in the meter as in operation and at a temperature of – 5 ± 1 °C, shall withstand the impact of a 25 mm diameter steel ball dropped from a height of 350 mm three times, striking the centre of the window and falling normal to its plane.

C.1.5 ***Flammability.*** The material shall be of very low flammability when tested in accordance with Method 508D, Flammability (Alcohol cup test) of BS 2782-5[24)]. For this test the specimen shall be a complete window and the centre of the window shall be positioned with its external face downwards on the centre of the wire grid.

C.2 Accelerated deterioration tests

C.2.1 ***General.*** One sample is given the deterioration tests in **C.2.2**. Another sample is given the tests in **C.2.3**. After these deterioration tests and before being given the flammability test the samples shall still fit the meter.

C.2.2 ***Effect of ultraviolet light and loss of volatile plasticizer***

C.2.2.1 *Radiation test.* The window shall be exposed for 5 periods of 8 hours' duration to the radiation of a suspended "sun lamp" which has been in use for not less than 50 hours and not more than 400 hours. The light source shall be a combination tungsten filament mercury-arc enclosed in glass which has a low transmission below 280 nm. The glass envelope shall be conical in shape and silvered internally to form a reflector. The lamp shall be rated at 275–300 W. The window shall be positioned on the white index with its outer face towards the lamp, and 400 mm from the bottom and on the axis of the lamp. The surrounding air shall not be confined and shall be free to circulate.

After each exposure except the last the window shall be immersed completely in distilled water for 16 hours. It shall be cleaned with distilled water and carefully dried with cotton wool after each immersion period.

C.2.2.2 *Loss of volatile plasticizer.* The window shall be heated in air at 100 ± 3 °C for 24 hours. In this test the window shall be reasonably supported so as not to encourage deformation.

C.2.3 ***Resistance to chemical substances.*** The window shall be constrained as it will be in the meter and then totally immersed in the following technically pure substances in turn, in the order listed, at 20 ± 3 °C:

1) Sodium carbonate (20 % concentration by mass) for 2 hours

2) Paint thinners (approximately 50 % aromatic and 50 % aliphatic hydrocarbons) for one hour.

The window shall be cleaned with distilled water and carefully dried with cotton wool after each immersion.

[24)] BS 2782, *"Methods of testing plastics"*, Part 5, *"Miscellaneous methods"*.

Appendix D Test requirements for sealing glands (See **5.5**)

D.1 General

Sample seals shall be unlubricated and housed and tested as used in the meter.

D.2 Chemical resistance

A sample seal shall resist chemical attack by any of the constituents of the gas for which the meter is intended.

Constrain the seal in a manner similar to its fixing in the meter and suspend it for a period of not less than 100 hours in an atmosphere fully saturated with the constitutent[25)] being considered. At the end of this test the seal shall not exhibit any change that would affect the performance of the meter for which it is intended.

D.3 Wear resistance

A seal shall not show signs of deterioration or permanent deformation after it has been subjected to 2 million revolutions or cycles, as applicable, at 1 000 revolutions or cycles per hour.

The test shall alternate every 7 days in gaseous fuel (complying with the requirements of Appendix **B.5**[26)]) and dry air.

Check the seal for soundness at the beginning of the test and at the end of each 7 day period.

The internal seals shall be tested at 5 mbar [27)], and external seals tested from the pressure side at 5 mbar and 440 mbar [27)].

Check the turning resistance before beginning the test and after each 7 day period. This resistance shall not exceed 0.015 N m or vary by more than 80 %.

D.4 Temperature effect

Expose a further sample to an ambient temperature of – 5 °C for 100 hours followed by a second period at + 40 °C. Check the seal for soundness and turning resistance as described in **D.3** at 20 °C before and after each temperature test.

Appendix E External leakage test (See **8.1**)

WARNING NOTE. To avoid damage to the interior of the meter when applying an internal pressure, the pressure should be applied to the meter *outlet* and be applied *gradually* and without fluctuation. When the pressure is released it should be released *slowly* at the meter inlet.

E.1 Method

The method given below avoids variations in pressure and/or volume due to small changes in temperature. Also it is not subject to long periods of time to register small leaks from a large volume. If other methods are employed these points should be considered.

E.2 Apparatus (See Figure 8)

An air supply or pump capable of supplying air up to 440 mbar [27)] (6.4 lbf/in^2). A suitable means for connecting the air supply to the meter outlet, whilst the meter is within a water tank; the supply being fitted with a control valve and a reliable pressure gauge on the down stream side of this valve. A connection for the meter inlet to an outlet control valve; both valves being above the water line in the tank. A water supply and a water tank, with a drainage system and inspection window as required, capable of containing the meter with sufficient room left to observe any leaks. Mechanical means for holding the meter underwater with a minimum of contacts with the meter. The contacts should not be detrimental to the meter or affect the test.

[25)] Benzene (see WARNING in Appendix **B.5**) for gas containing aromatic hydrocarbons and pentane for liquefied petroleum gases.

[26)] Alternative gaseous fuels may be used by arrangement between the purchaser and the manufacturer.

[27)] 1 mbar = 10^2 N/m^2.

E.3 Procedure

Secure the assembled meter in the empty water tank, connect the air supply to the meter *outlet* and the outlet valve to the meter *inlet*.

Open the outlet valve. *Slowly* open the inlet control valve. Close the outlet valve and raise the pressure to 440 mbar [28)]. Close the inlet control valve for a few minutes and by using the pressure gauge, check the system for apparent soundness.

If the meter is apparently sound, fill the tank slowly with clean water with the minimum of turbulence and watch for leaks as the water rises until the meter is completely submerged. Take precautions that water does not enter the meter index.

Maintain the pressure for ten minutes, then lower the water while still inspecting for leaks.

When the check is complete, decompress the meter through the outlet control valve.

Appendix F Accuracy test for registration (See **10.1**)

F.1 Principle

A meter of the type covered by this specification shall be tested for accuracy of registration by passing a known volume of air through it and comparing this volume with the volume as registered by the meter test drum or dial.

This test should be carried out in a room having a controlled temperature of nominally 20 °C, but care shall be taken to ensure that the temperatures of the water in the holder, the ambient air and the meter under test do not differ by more than 1 degC.

F.2 Apparatus

A water sealed calibrated bell type holder maintaining a pressure of 5 mbar [28)] (2 in w.g.) and having sufficient capacity to allow at least one complete revolution of the test drum or dial of the meter to be tested, or a calibrated positive displacement apparatus which will give at least equivalent results, is required for this test.

The holder or apparatus is provided with a flexible tube to which the inlet of the meter can be connected. A similar flexible tube should also be provided for the meter outlet to permit the metered air to pass through a rate control valve and an ON/OFF control valve (hereafter referred to as an outlet control) and thence to exhaust.

The inlet connection should be as large as possible to keep its pressure loss to a minimum when a meter is tested at the maximum rate.

F.3 Procedure

Carry out this test after the meter has passed the test required by **8.1**. Keep the meter in the room for a period of at least three hours before testing it for accuracy of registration. Connect the flexible tubing to the meter inlet and outlet connections. Pass sufficient room air through the meter to complete at least 100 working cycles of the diaphragms and check that the relationship of a test dial to its index is correct. Close the outlet control and close the holder outlet valve. Check the connections for soundness and, if sound, continue the test.

Open the holder outlet and outlet control valves and set the rate control valve to pass the required rate. When the test dial drum or dial hand is positioned at a convenient point for reading, close the outlet control. Charge the holder with air. Note the scale reading of the holder. Open the outlet control and allow air to pass through the meter to complete one revolution of the test drum or dial hand, then close the outlet control. Note the scale reading of the holder. Determine the volume of air which has passed by taking the difference between the two scale readings.

[28)] 1 mbar = 10^2 N/m^2.

Calculate any inaccuracy of registration and express it as a percentage to the first place of decimals, i.e:

Percentage inaccuracy of registration =

$$\frac{(\text{Volume registered in one revolution of test drum or dial hand} - \text{Actual volume of air passed}) \times 100}{\text{Actual volume of air passed}}$$

A negative answer indicates a slow meter and a positive answer a FAST meter.

Appendix G Tests for pressure loss and pressure oscillation (See **10.2** and **10.3**)

G.1 Apparatus

The apparatus described in Appendix F may be used when determining the pressure loss and the pressure oscillation of a meter. The pressure gauge described in Appendix L is used as a differential gauge by connecting the meter to its limbs.

G.2 Procedure

G.2.1 *Pressure loss.* Connect the differential pressure gauge close to the inlet and outlet of the meter by flexible tubing. Pass air through the meter at the required rate and observe the minimum and maximum readings of the gauge. Deduct any pressure loss caused by the inlet and outlet connections external to the meter from the mean of the above minimum and maximum readings.

NOTE The pressure readings should be taken at points as close as practicable to the face of the bosses (5P.6 meter) or the face of the other types of connections.

G.2.2 *Pressure oscillation.* Measure the pressure oscillation by recording the difference between the highest and the lowest readings of the differential gauge observed during the test for pressure loss.

If this exceeds the permissible pressure oscillation specified for a meter of that badged rating, disconnect the differential pressure gauge and connect its appropriate limb to the meter outlet. Measure the pressure oscillation by recording the difference between the highest and the lowest reading of the gauge.

Appendix H Life test (See **11.1**)

Select a meter in a new condition. Run it on air at its badged rating for at least half an hour. Check it on air for compliance with **8.1** and **10.1**.

Test the meter for 100 days in a controlled ambient temperature of 20 °C and operating at 115 % of the badged rating on the gas for which it is intended.

NOTE The gas may be recirculated but in this case arrangements have to be made to renew continuously by feeding in a small proportion of fresh gas to maintain the gas characteristics.

After every 14 days and at the end of the test, purge the meter on air for half an hour at its badged rating or with an equivalent volume of air. At the end of the test check that the meter still complies with the requirements of **8.1**. Test the registration of the meter as in **10.1**. To satisfy this test, the accuracy of registration in relation to the initial accuracy shall have changed by not more than 2½ units of percentage.

NOTE Early failures may be observed by checking compliance with the requirements of **8.1** for leakage and **10.1** for registration at some or all of the 14 day periods.

Appendix J Paint scratch test [See **12.1** 1)]

J.1 Apparatus

For this test a suggested form of apparatus, in which a 1 mm diameter steel ball is mounted by soft soldering in a suitable housing, is shown in Figure 9. Another apparatus is shown in BS 1250-1[29)].

J.2 Procedure

Clip the crocodile terminal to an unpainted part of the meter and make good electrical contact. Draw the apparatus evenly over the surface under test at a speed of 30–40 mm/s, keeping it upright and pressed to the surface throughout the movement. If the indicator bulb lights, the surface is deemed to have been penetrated.

[29)] BS 1250, *"Domestic appliances burning town gas"*, Part 1, *"General requirements"*.

Clean the ball after each test and inspect it frequently to verify that it remains a 1 mm sphere.

Check periodically that the spring loading (equivalent to a weight of 1 kg) is accurate.

Appendix K Paint resistance to humidity test [See **12.1** 2)]

K.1 Apparatus

The apparatus consists of a closed cabinet, in which the relative humidity is maintained at approximately 100 % by cycling the temperature of a water bath continuously over a range from 42 °C to 48 °C thereby ensuring that copious condensation occurs on the samples under test.

Details of the cabinet and the temperature requirements are given in BS 3900-F2[30)].

K.2 Procedure

Paint the unprotected edges of any test samples which are not normally exposed in practice with a good protective paint. Vertically position the painted samples within the cabinet. Examine the samples after 48 hours and at the completion of the test for evidence of corrosion beneath the paint film or deterioration of this film.

After the samples have been finally removed from the cabinet leave them to stand for 24 hours at room temperature. Then give them a further visual examination and a scratch test as required by **12.1** 3).

Appendix L Requirements for the inclined pressure gauge (See Appendix **G.1**)

L.1 General

The design and the main dimensions for the inclined pressure gauge, in which dibutyl oxalate of 0.985 relative density is used, are shown in Figure 10.

Each new gauge shall be calibrated with its glassware. It shall be recalibrated if a new glass if fitted.

It is essential to level the gauge before calibration and use.

L.2 Cleaning

To clean the glass drain out the dibutyl oxalate and wash it out with suitable cleansing solvent. Blow air through the tube to remove the solvent. Then wash the tube in strong washing soda solution or caustic soda solution. Flush the tube with tap water, rinse with distilled water and dry by means of an air stream.

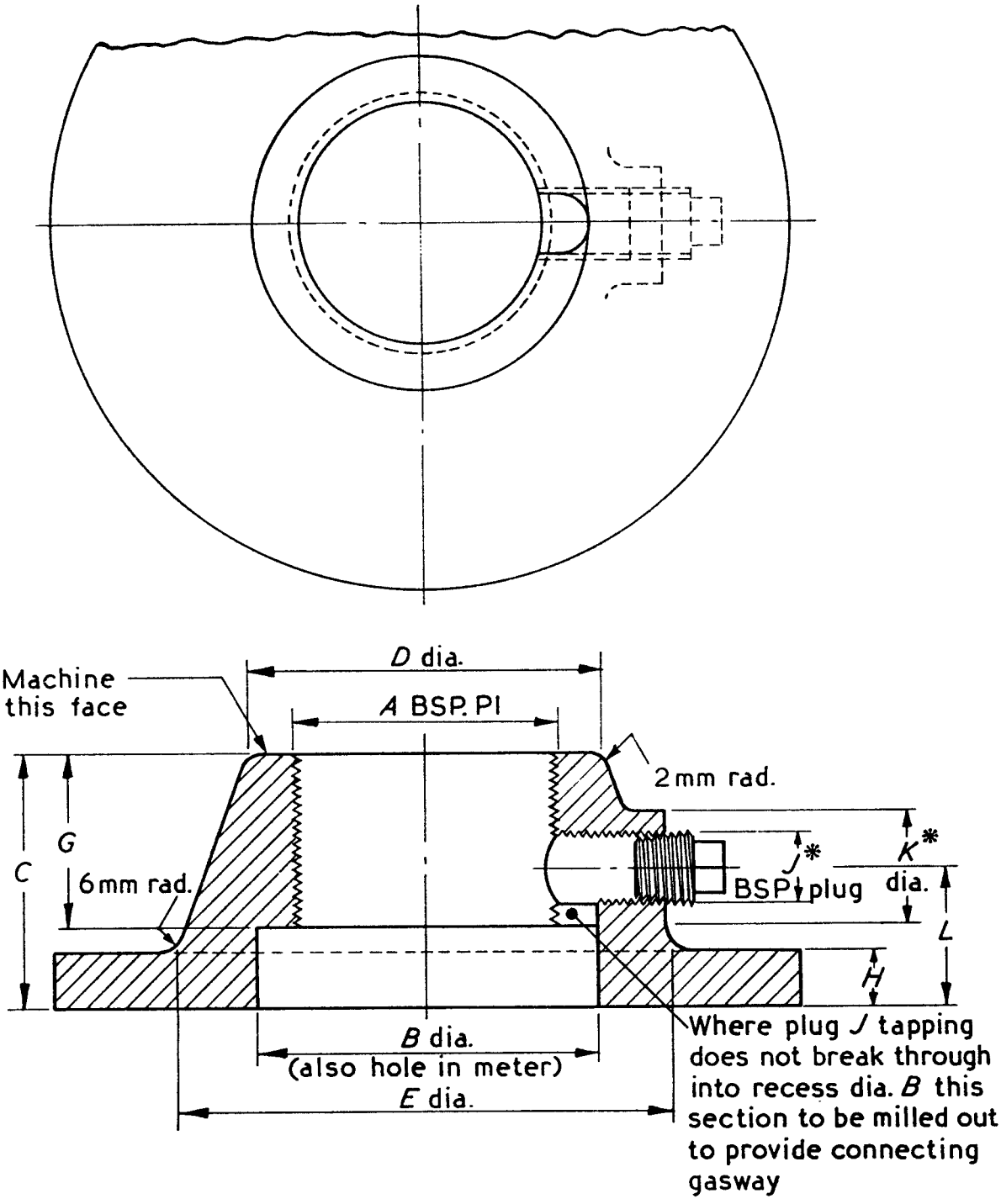
Appendix M Conversion factors

Metric	Imperial
1 mm	0.039 370 1 in
1 l	0.035 315 7 ft^3
1 m^3	35.314 7 ft^3
1 kg	2.204 62 lb
1 g/m^2	3.277 06 × 10^{-3} oz/ft^2
1 N	0.224 809 lbf
1 N m	8.850 75 lbf in
1 mbar ($10^2 N/m^2$)	0.401 463 inH_2O
	0.014 503 8 lbf/in^2
20 °C	68 °F
5 degC	9 degF

[30)] BS 3900, *"Methods of test for paints"*, Part F2, *"Resistance to humidity under condensation conditions"*.

Table 5 — Connector socket dimensions (to be read in conjunction with Figure 1)

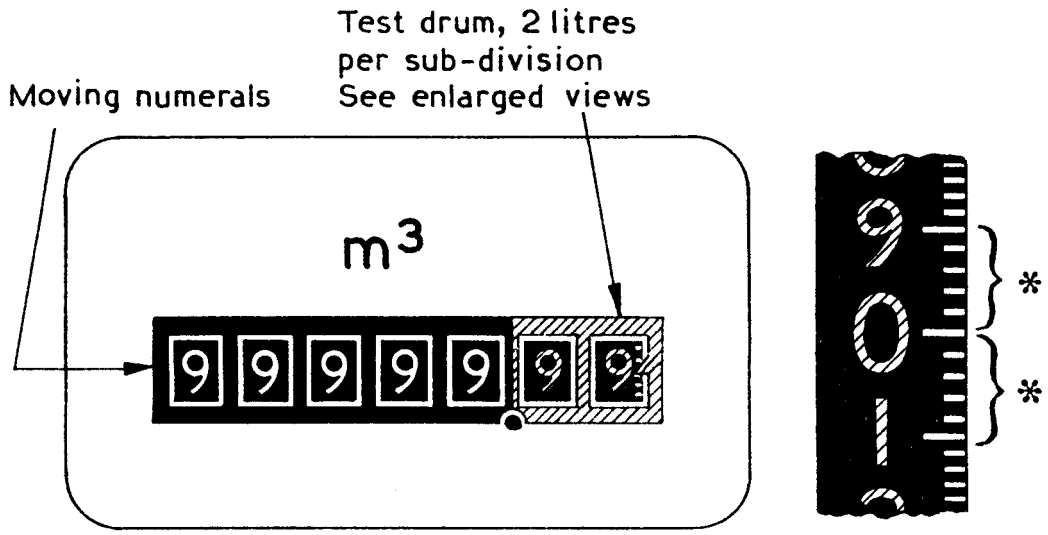
1	2	3	4	5	6	7	8	9	10	11	12
BS case reference number	*A*	*B*	*C*		*D*	*E*	*G*	*H*	*J**	*K**	*L*
			min.	**max.**			**min.**				
		mm	mm	mm	mm	mm	mm	mm	in	mm	mm
5P.12, 5P.18	3 in BSP	100	48	75	115	160	38	13	½	32	32
5P.30, 5P.60	4 in BSP	135	60	90	140	190	45	16	½	32	38
Dimensions not shown are arranged to suit meter Similar socket dimensions in inches will be found in Part 2											



*Plug *J* and boss *K* omitted from inlet flange.

For dimensions see Table 5

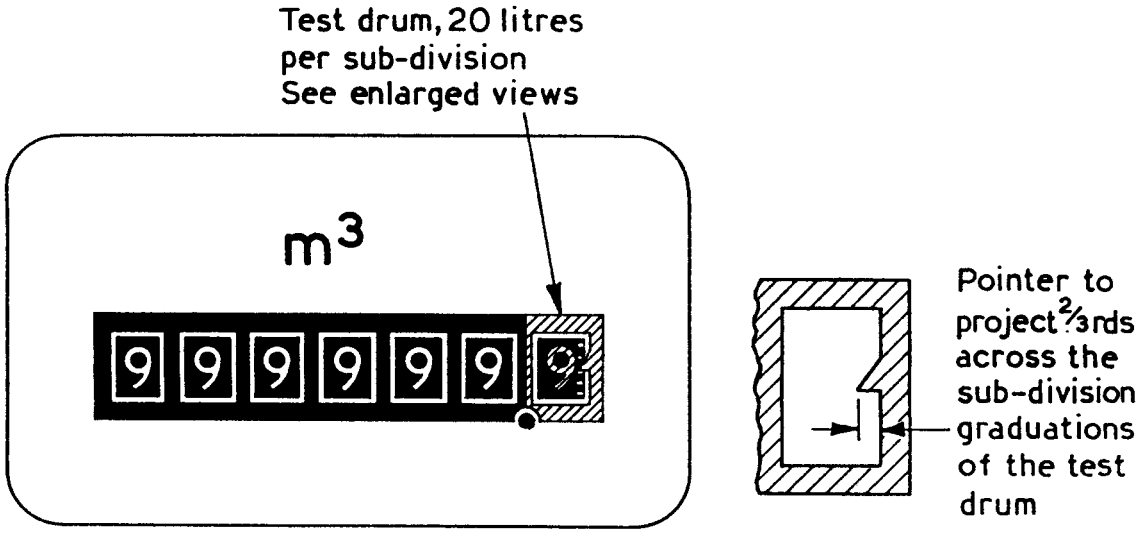
Figure 1 — Connector sockets



Enlarged view of test drum,
Figure 2 & Figure 3

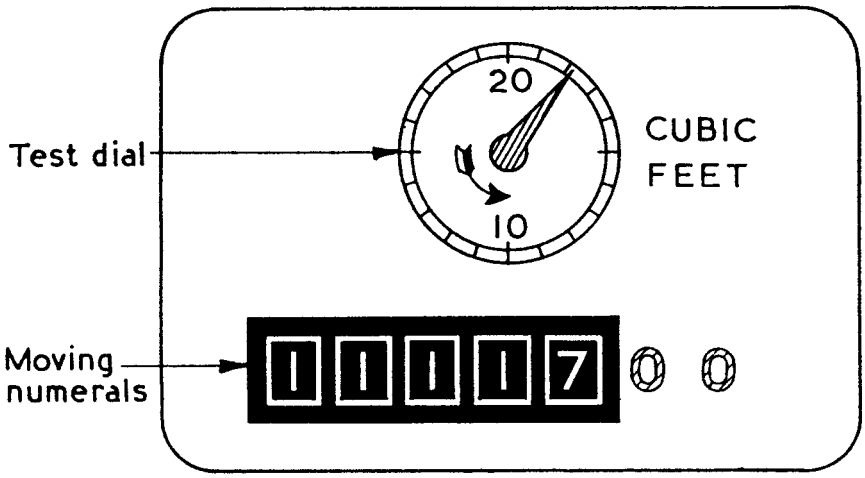
* Four sub-division graduations, each 1 mm (min.) apart, between each pair of unit division graduations

Figure 2 — Meter index, direct reading with test drum, from 20 m^3/h up to 100 m^3/h badged rating (see 5.3)



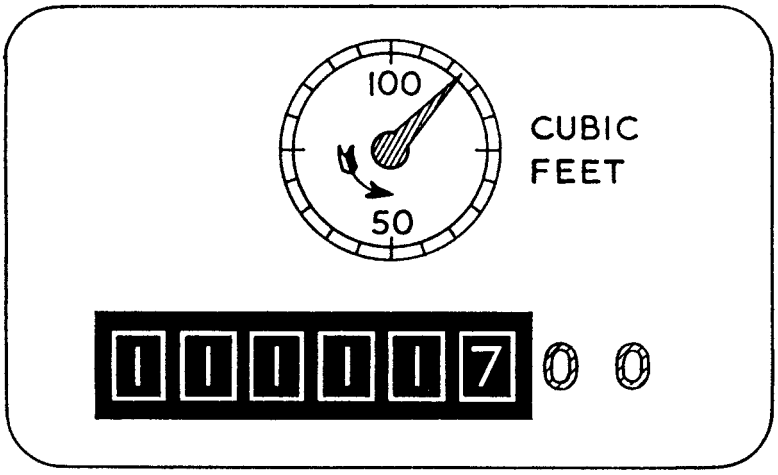
Enlarged view of test drum
port hole, Figure 2 & Figure 3

Figure 3 — Meter index, direct reading with test drum, over 100 m^3/h badged rating (see 5.3)



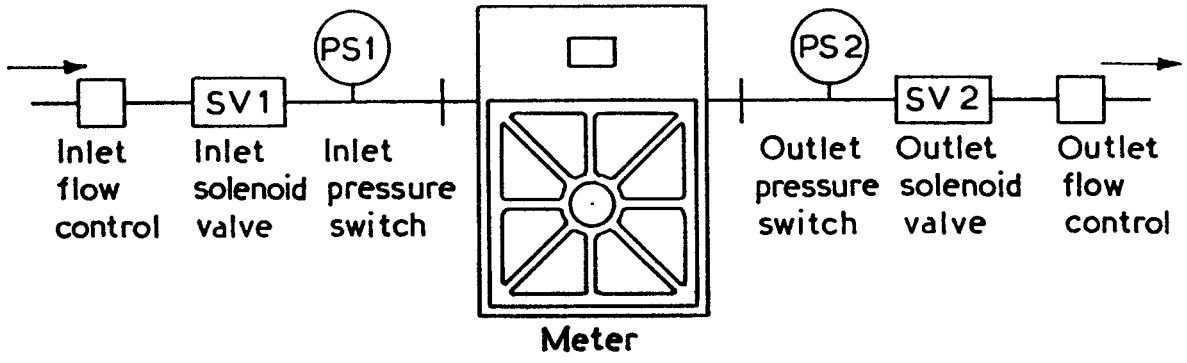
NOTE The test dial hand may rotate in either clockwise or anti-clockwise direction. Its direction of rotation is required to be indicated on the test dial.

Figure 4 — Meter index, direct reading with test dial, from 700 ft³/h up to 3 000 ft³/h badged rating (see 5.3)

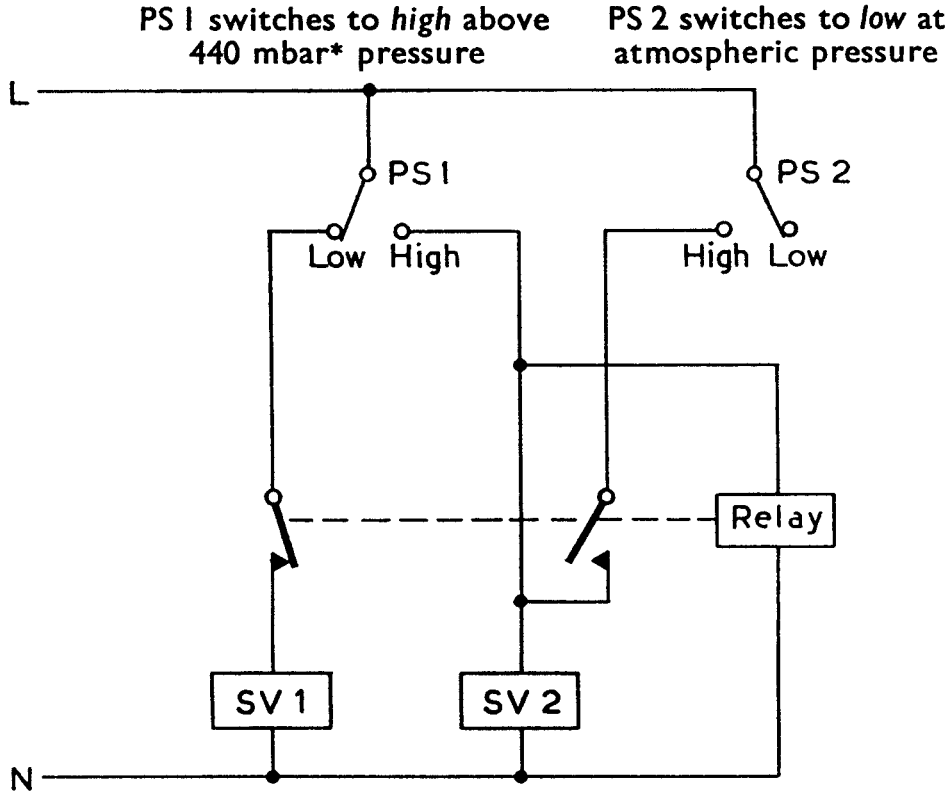


NOTE The test dial hand may rotate in either clockwise or anti-clockwise direction. Its direction of rotation is required to be indicated on the test dial.

Figure 5 — Meter index, direct reading with test dial, over 3 000 ft³/h badged rating (see 5.3)



Flow diagram



Electrical circuit

* 1 mbar = 10^2 N/m^2.

Circuit shown with power and pressure off, both SV1 and SV2 are closed.

Figure 6 — Case durability test apparatus

Figure 7 — Escape badge

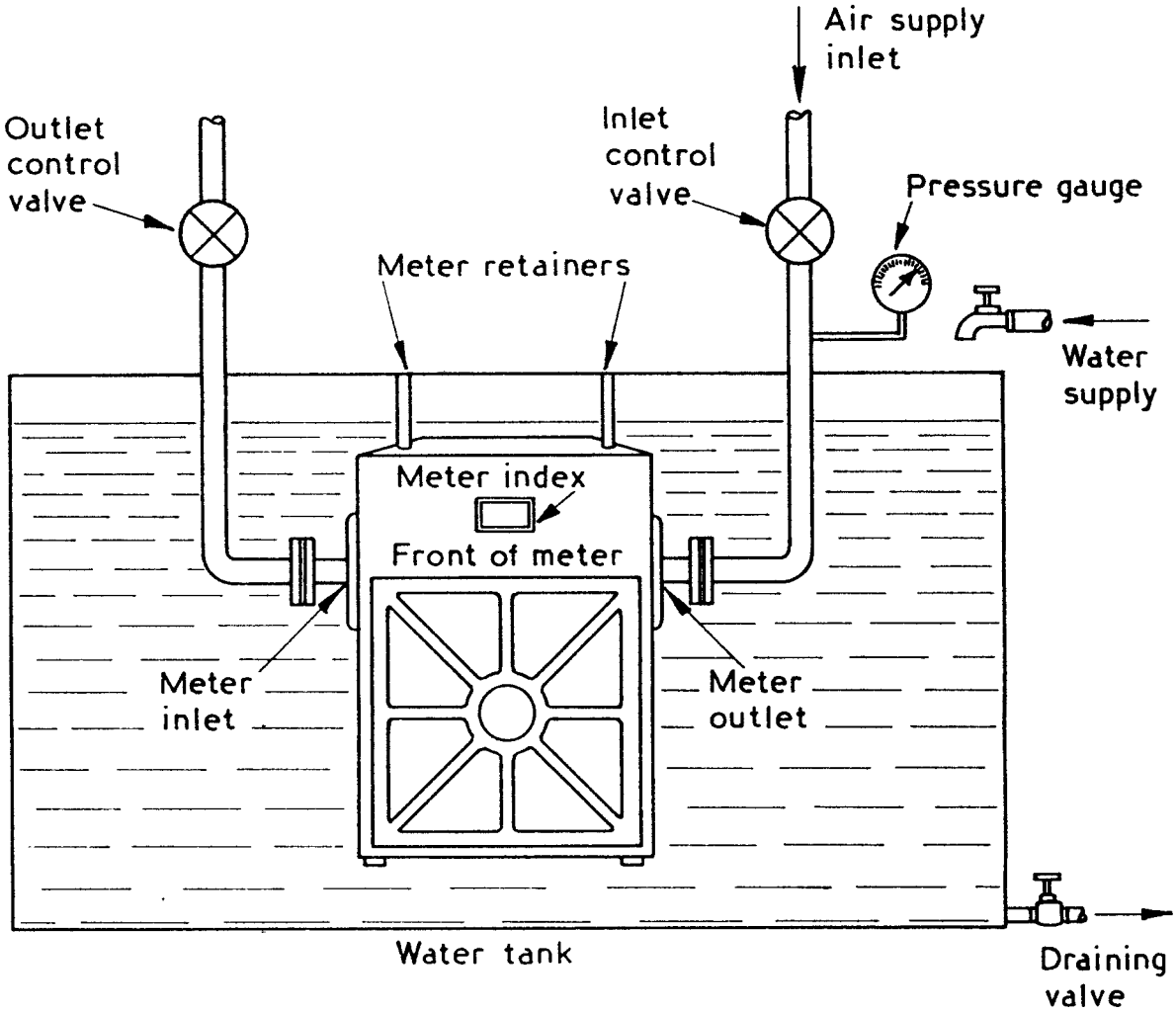


Figure 8 — External leakage test apparatus

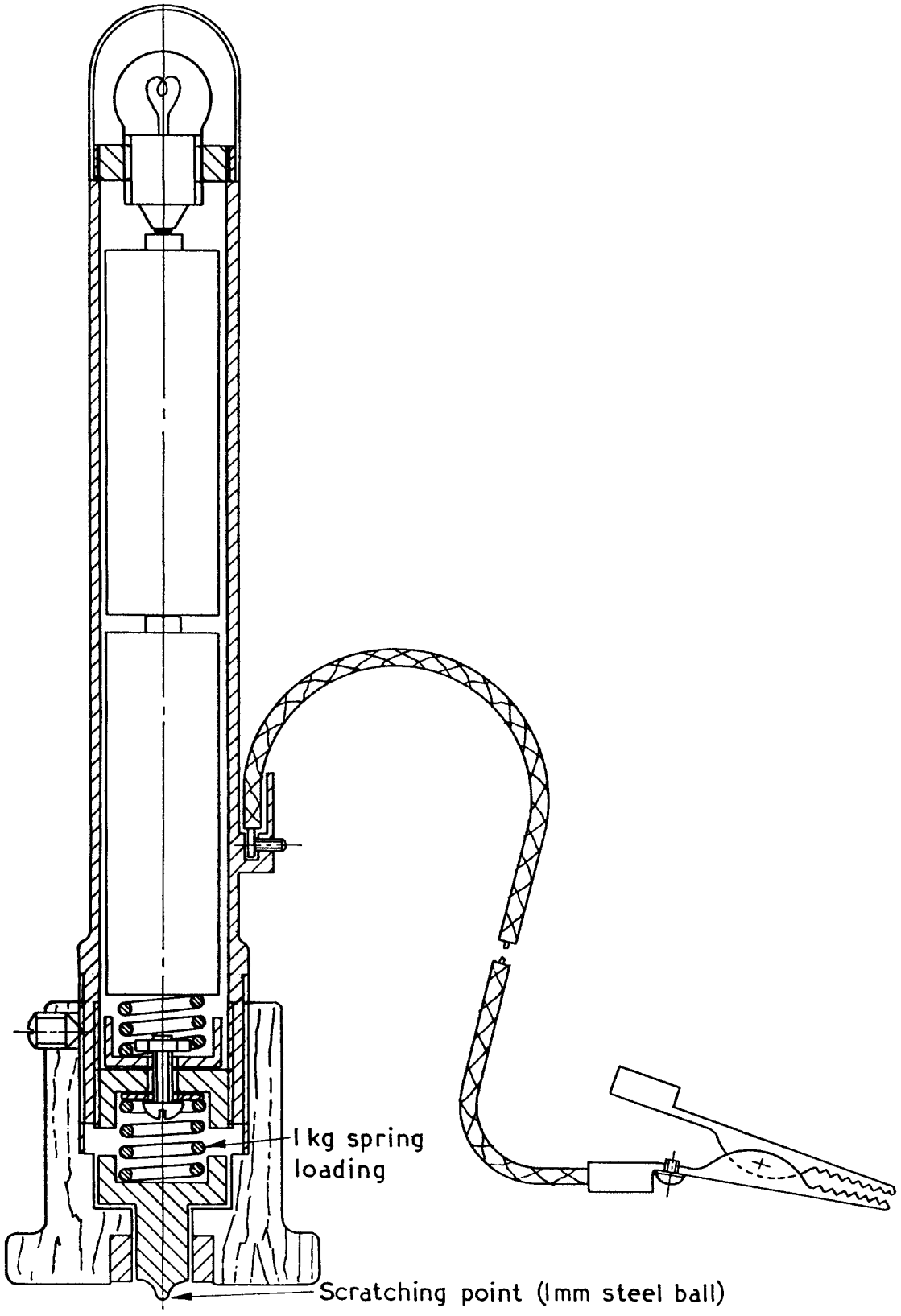
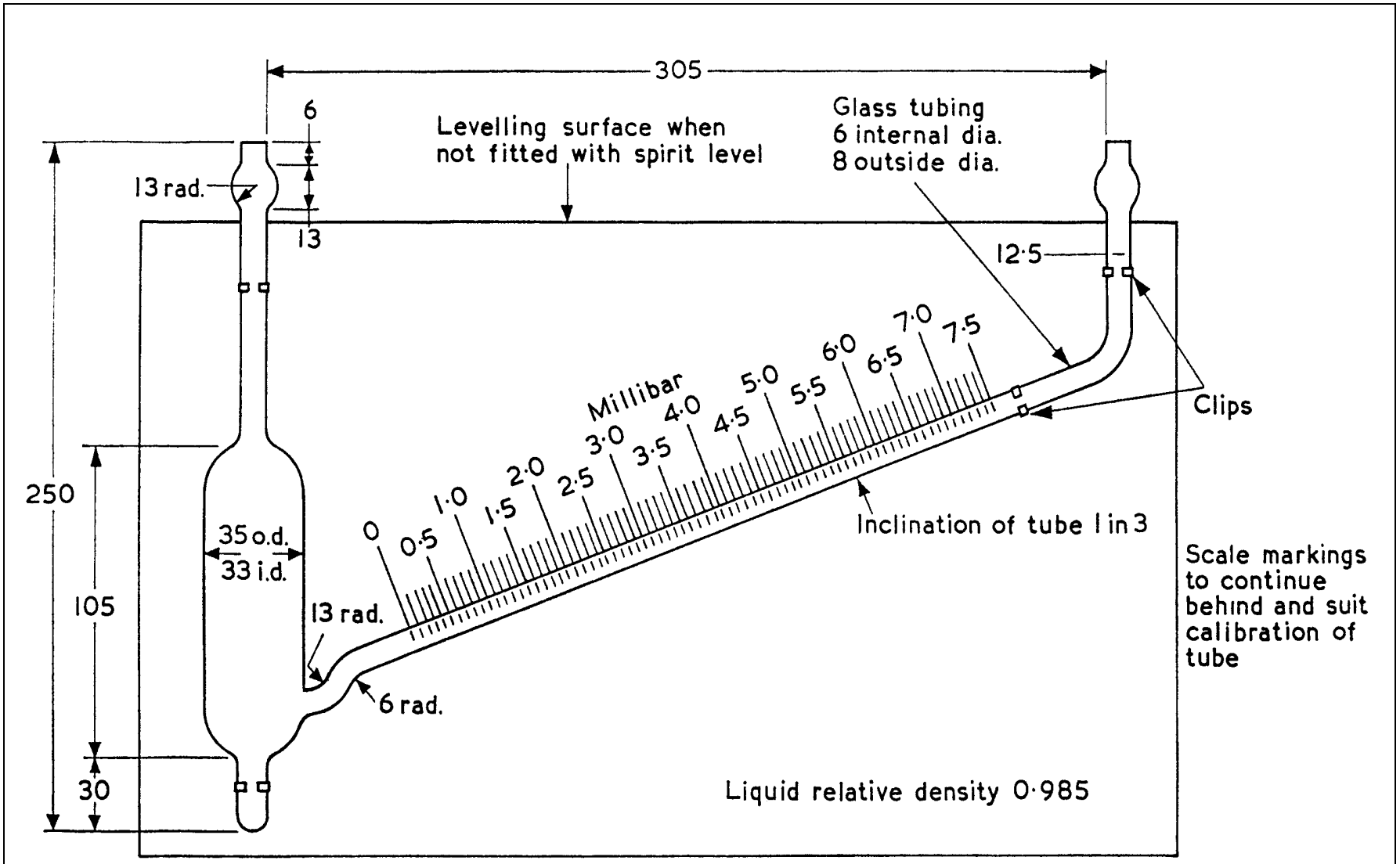


Figure 9 — Paint scratch test apparatus



Dimensions in millimetres

Figure 10 — Inclined pressure gauge — 7.5 mbar range (For 3 in range see BS 4161-1, Figure 17)

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