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SPECIFICATION FOR CONSTANT FLOW TYPE AIR-PERMEABILITY APPARATUS (LEA AND NURSE TYPE)

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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Indian Standard

SPECIFICATION FOR CONSTANT FLOW TYPE AIR-PERMEABILITY APPARATUS (LEA AND NURSE TYPE)

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Indian Standard

SPECIFICATION FOR CONSTANT FLOW TYPE AIR-PERMEABILITY APPARATUS (LEA AND NURSE TYPE)

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 22 December 1969, after the draft finalized by the Cement and Concrete Sectional Committee had been approved by the Civil Engineering Division Council.

0.2 The Indian Standards Institution has already published a series of standards on different types of cements and on their methods of chemical and physical tests. It has been recognized that reliable and intercomparable test results could be obtained only with standard types of testing equipment which are capable of giving the desired level of accuracy. The Sectional Committee has proposed to bring out a series of specifications covering the requirements of testing equipments to encourage the development and manufacture of the above types of standard testing equipment for cement testing in the country.

0.3 IS : 4031-1968* specifies the use of Blaine air-permeability apparatus for determination of fineness of cement as represented by specific surface, which involves the use of Standard cement sample. In order to cater to certain special needs, the use of air-permeability apparatus (Lea and Nurse Type) is frequently resorted to. The equipment is also used for determination of specific surface of other powdery materials.

0.4 The dimensions specified in this standard are in rationalized metric units. The Sectional Committee responsible for the preparation of this standard recommends that all laboratories in the country should switch over to the metric unit as early as possible, preferably within the course of next three years.

0.5 In the formulation of this standard due weightage has been given to international co-ordination among the standards and practices prevailing in different countries in addition to relating it to the practices in the field in this country.

*Methods of physical tests for hydraulic cement.

0.6 This standard is one of a series of Indian Standards on instruments for cement and concrete testing. Other standards published so far in the series are:

IS : 5512-1969	Flow table for use in tests of hydraulic cements and pozzolanic materials
IS : 5513-1969	Vicat apparatus
IS : 5514-1969	Apparatus used in Le-Chatelier's test
IS : 5515-1969	Compaction factor apparatus
IS : 5516-1969	Variable flow type air-permeability apparatus (Blain Type)

0.7 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers the requirements of air-permeability apparatus (Lea and Nurse Type) for measuring the specific surface of powdery materials expressed as total surface area in square centimetre per gram of material.

1.1.1 The method of determination of specific surface using the above apparatus is also covered in this standard†.

2. ASSEMBLY, DIMENSIONS AND MATERIALS FOR CONSTRUCTION OF DIFFERENT PARTS

2.1 The assembly and dimensions of different parts of the apparatus are shown in Fig. 1 and 2.

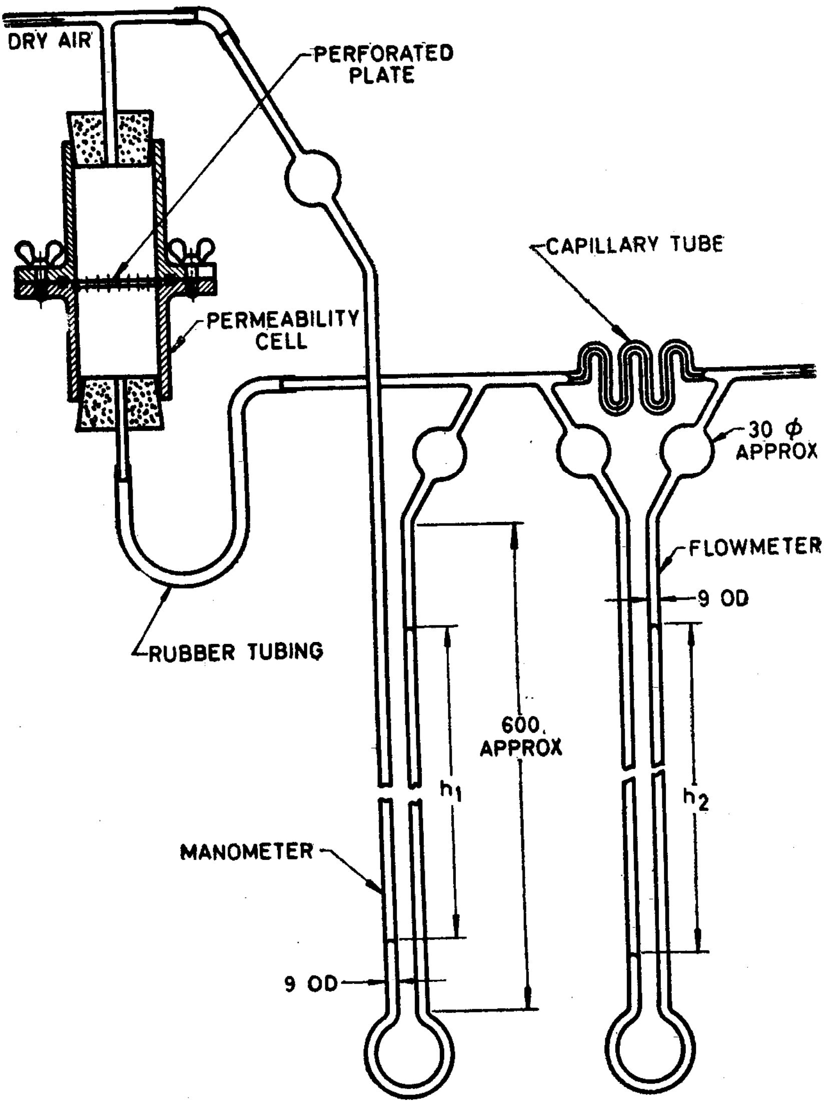
2.2 The materials for construction of the different parts shall be a indicated in Table 1.

3. WORKING PRINCIPLE OF THE APPARATUS

3.1 The apparatus consists of means to draw a stream of dry air at a constant velocity through a bed of powder contained in the permeability cell and the resulting pressure drop is measured by a manometer

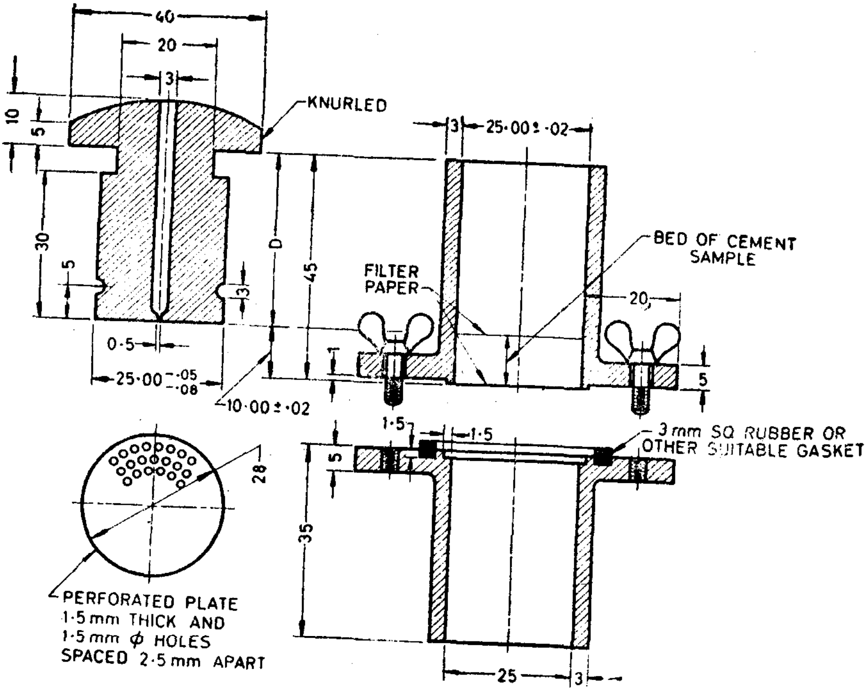
*Rules for rounding off numerical values (*revised*).

†This method is not covered in IS : 4031-1968 'Methods of physical tests for hydraulic cement'.



All dimensions in millimetres.

FIG. 1 PERMEABILITY APPARATUS WITH MANOMETER AND FLOWMETER



All dimensions in millimetres.

FIG. 2 DETAILS OF PERMEABILITY CELL

connected to the top and bottom of the bed. The rate of air flow is measured by a flowmeter consisting of a capillary placed in the circuit and a manometer across its ends.

4. PARTS AND ACCESSORIES

4.1 Permeability Cell — The permeability cell shall consist of two flanged cylindrical units of brass or stainless steel which can be bolted together. A rubber or other suitable gasket shall be used between the flanges to render the joint air tight. The bottom half of the cell shall have a suitable recess for supporting the perforated plate and the gasket. Dimensions and tolerances shall be as detailed in Fig. 2.

4.2 Plunger — The plunger, of brass or stainless steel, shall have a knurled head, air event and circular recess as detailed in Fig. 2. The

TABLE 1 MATERIALS FOR CONSTRUCTION OF DIFFERENT PARTS OF CONSTANT FLOW TYPE AIR-PERMEABILITY APPARATUS (LEA AND NURSE TYPE)

(*Clause* 2.2)

SL No.	PART	MATERIAL	SPECIAL REQUIREMENT, IF ANY
(1)	(2)	(3)	(4)
i)	Permeability cell	Brass or stainless steel	Non-corroding metal
ii)	Plunger	Brass or stainless steel	Non-corroding metal
iii)	Perforated plate	Brass or stainless steel	Non-corroding metal
iv)	Manometers	Borosilicate glass or equivalent	Clear or transparent glass
v)	Flowmeter	Borosilicate glass or equivalent	Clear or transparent glass
vi)	Manometer stand	Well seasoned wood (teak or pressed steel sheets)	—
vii)	Filter Paper	—	Medium retentatively corresponding to No. 40 Whatman
viii)	Tubings and corks	Rubber	—
ix)	Liquid in manometer and flowmeter	Kerosene (paraffin oil)	—

bottom of the plunger shall have sharp square edges and shall be at right angles to the principal axis. The dimension *D* of the plunger in Fig. 2 shall be so adjusted that when the plunger is placed in the cell and the knurled head brought in contact with the top of the cell, a bed of cement sample of thickness 10 ± 0·05 mm is formed over the filter paper kept on top of the perforated plate. The plunger shall also fit snugly into the cell (clearance between the plunger and the cell should not be more than 0·1 mm).

4.3 Perforated Plates — The plate shall be of brass or stainless steel, with a number of circular perforations as shown in Fig. 1. The plate shall be plane and shall fit snugly in the recess in the permeability cell.

4.4 Manometer and Flow meter — Both the manometer and the flow-meter, shall be constructed of clear borosilicate glass or equivalent material. The dimensions shall generally be as shown in Fig. 2. The arms of the manometers should be about 60 cm long. The bends and bulbs of the manometer of the flowmeter shall be symmetrical. The manometer shall be of standard-wall glass tubing with an outer diameter of 9 mm.

4.5 Flowmeter — The flowmeter shall be connected by a capillary placed in circuit. The capillary shall have a minimum diameter of 0·5 mm through out its length and shall have a flowmeter constant between 2×10^{-6} and 4×10^{-6} cgs units (*see also* **5.2**).

4.6 Manometer Stand — The entire apparatus shall be mounted on a stand of well seasoned teak or suitable hard wood or pressed steel sheets. For convenience in handling, the monometer or flowmeter shall be mounted in the front panel, with the cell assembly in the centre. The capillary shall be mounted at the back. All the mountings shall be secured by clamps. The rubber tubings and rubber corks used for linking the cell and manometers shall be of good quality to resist frequent reconnections. The manometer and flowmeter shall be fixed at the same levels.

4.6.1 A measuring scale be fixed along each limb of the manometers to record the levels conveniently. All connections be air-tight. To facilitate taking connections through the panel flanged nipples of brass shall be fixed above and below the position of the cell assembly.

4.7 Filter Paper — The filter paper shall be medium retentive (corresponding to No. 40 Whatman). The filter paper discs shall be circular, with smooth edges, and shall have the same diameter as the inside of the cell.

NOTE — Filter paper discs that are too small may leave part of the sample adhering to the inner wall of the cell above the top disc. When too large in diameter, the discs have tendency to buckle and cause erratic results.

4.8 Accessories — Filter paper disc cutter.

5. METHOD OF TEST

5.1 Connect the permeability cell by rubber bungs to the manometer and flowmeter as shown in Fig. 2. The necessary air flow may be produced by any convenient process, but the air entering the apparatus shall be dried by passing it through a tower packed with anhydrous calcium chloride or other suitable desiccant. The liquid in both manometer and flowmeter shall be kerosene or paraffin oil.

5.2 Calibration of the Flowmeter — Pass dry air at a constant rate through the flowmeter for a measured period of time. Collect the issuing air over water, and measure its volume. Repeat this measurement for a number of flowmeter readings over the range 25 to 55 cm difference in level. Calculate the value of the constant C from the formula:

$$C = \frac{Q\eta}{h_2 \, d_L}$$

where

Q = volume of dry air passed, in cubic centimetres per second corrected to atmospheric pressure,

η = the viscosity of air at the given temperature in cgs unit,

h_2 = flowmeter readings in cm, and

d_L = density of the kerosene in the flowmeter.

5.2.1 Calculate the volume of dry air passed per second by the formula:

$$Q = \frac{V}{t}\left(\frac{P - p}{P}\right)$$

where

V = measured volume of air in cc collected over water at atmospheric pressure P,

p = vapour pressure of water at the room temperature, and

t = time in seconds during which the air was collected.

5.2.2 The flowmeter constant C shall have a value within the range of $2{\cdot}0\text{-}4{\cdot}0 \times 10^{-6}$ cgs units and should be checked every three months.

5.2.3 The viscosity of air in cgs units multiplied by 10^{-4} at temperatures from 25° to 35°C is given below:

Temperature	°C	25	26	27	28	29	30
Viscosity		1·84	1·84	1·85	1·85	1·86	1·86
Temperature	C°	31	32	33	34	35	
Viscosity		1·87	1·87	1·88	1·88	1·89	

5.3 Assembling and Testing — The gasket and perforated plate are placed in their respective recesses on the lower half of the cell. A 25 mm dia filter paper disc is then placed concentrically on the perforated disc and the upper half of the cell carefully replaced and theflanges bolted firmly together. Test the apparatus for leakage from time to time. This is best done by disconnecting the rubber tube which leads from the lower bung of the cell to the manometer, sealing the end with a screw clip, applying air pressure to the cell and then sealing off the air inlet. With the cell thus sealed, the readings of the manometer shall not change by more than 0·5 mm in a period of one minute.

5.4 Determination of Density — Determine the density of the cement in accordance with the method specified in **13** of IS : 4031-1968*.

5.5 Determination of Specific Surface

5.5.1 From Table 2 select the weight of material which, when compacted gives a porosity of 0·475 at the given density of the material. The porosity is defined as the ratio of the volume of pore space to the total volume of the bed. A filter paper (25 mm dia) shall be placed on the perforated plate and the edges pressed down with a pencil or thin rod. Brush the material from the weighing bottle into the permeability cell, and gently shake the cell from side to side level off the surface. A filter paper disc (25 mm dia) shall be placed on top of the material.

NOTE — Filter paper discs that are too small may leave part of the sample adhering to the inner wall of the cell above the top disc. When too large in diameter, the discs have a tendency to buckle and cause erratic results.

TABLE 2 WEIGHT OF POWDERY MATERIALS (GRAMS) REQUIRED TO FORM A BED 10 mm HIGH × 25 mm DIAMETER WITH A POROSITY OF 0·475

DENSITY	0·00	0·01	0·02	0·03	0·04	0·05	0·06	0·07	0·08	0·09
2·8	7·216	7·242	7·267	7·293	7·319	7·345	7·371	7·396	7·422	7·448
2·9	7·474	7·499	7·525	7·551	7·577	7·602	7·628	7·654	7·680	7·706
3·0	7·731	7·757	7·783	7·809	7·834	7·860	7·886	7·912	7·937	7·963
3·1	·989	8·015	8·041	8·066	8·092	8·118	8·144	8·169	8·195	8·221
3·2	247	8·272	8·298	8·324	8·350	8·376	8·401	8·427	8·453	8·479

5.5.2 Tap the cell four times by allowing it to fall from a height of about ten millimetres on to a wooden bench. Then slowly insert the plunger and push it in until the collar of the plunger comes into contact with the top of the permeability cell. Slowly withdraw the plunger with a twisting motion, taking care that the plunger is not twisted while in contact with the cement surface.

5.5.3 Inspect the cement bed and, if it is distrubed, knock out the cement and repeat the operation with a freshly weighed sample. Occasionally, a cement is encountered which springs up slightly

*Methods of physical tests for hydraulic cement.

on withdrawing the plunger. The increase in the depth of bed so caused may be up to 0·1 mm. The resulting error in specific surface will be less than two percent, but if desired, the true height of the bed may be measured and the result corrected.

5.5.4 Insert the upper bung of the permeability cell and slowly turn on the air. Then slowly put on the lower bung also, taking care to avoid forcing air through the cement in the wrong direction. Adjust the rate of air flow until the flowmeter shows a difference in level of 30 to 50 cm. Read the difference in level (h_1) of the manometer and the difference in level (h_2) of the flowmeter. Repeat these observations to ensure that steady conditions have been obtained as shown by a constant value of h_1/h_2.

5.5.5 Change the filter paper after every 6 determinations.

5.6 Calculation of Results — Calculate the specific surface Sw from the ormula:

$$Sw = K\sqrt{h_1/h_2}$$

$$\text{and } K = \frac{14}{d\,(1\text{-}\Sigma)}\sqrt{\frac{\Sigma^3 A}{CL}}$$

where

d = density of the cement;

Σ = porosity, that is 0·475;

A = area of the cement bed;

C = flowmeter constant; and

L = length of the cement bed in cm.

5.6.1 Values of K for densities made between 2·8 and 3·2 should be tabulated for each apperatus. For apparatus made to the specified dimensions:

$$K = \frac{19\cdot 35}{d}\sqrt{\frac{1}{C}}$$

5.7 Routine Checking of K Values

5.7.1 When made to the specified dimensions, the values of A and L to be used in calculating K will be 4·906 cm² and 10 mm respectively. The dimension D (*see* Fig. 2) of the plunger shall be such as to get a cement sample bed of 10 ± 0·02 mm in the cell.

5.7.2 Check these dimensions when the apparatus is received either by means of a travelling microscope or by using a test piece to simulate the thickness of the cement bed. The test piece shall be made up of a hardened steel, 24·8 mm in diameter and 10·15 mm high. Place the steel test piece on the filter paper and insert the plunger. Check the depth of the bed by measuring the gap between the shoulder of the plunger and the top of the permeability cell with filter gauges.

5.7.3 Check the dimensions of the permeability cell after every 100 determinations.

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