(*Continued from page* 1)

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Indian Standard
METHODS OF TEST FOR FLEXIBLE POLYURETHANE FOAM

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 29 July 1976, after the draft finalized by the Plastics Sectional Committee had been approved by the Chemical Division Council.

0.2 In the preparation of this standard, assistance has been derived from the following publications:

DIN 53420-1958 Prüfung von Schaumstoffen; Bestimmung der Rohdichte (Testing of cellular materials; Determination of gross density). Deutscher Normenausschuss, Berlin

DIN 53574-1967 Prüfung Weich— Elastischer Schaumstoffe; Dauerschwingversuch, im Eindruck-Schwellbereich mit Konstanter Belastungsamplitude (Testing of flexible cellular materials; Dynamic flexing test in the indentation/pulsation range with constant load amplitude). Deutscher Normenausschuss, Berlin

DIN 53576-1976 Prüfung von Weich-elastischen Schaumstoffen; Bestimmung von Eindrückhärten Eindrückhärte A, Eindrückhärtecharakteristik, Eindrückhärte C (Testing of flexible cellular materials; Hardness testing by indentation techniques). Deutscher Normenausschuss, Berlin

BS 3667 : Part 1 and 2: 1963 Methods of testing flexible polyurethane foam: Part 1 Indentation hardness; and Part 2 Indentation hardness characteristics. British Standards Institution.

BS 3667 : Part 3 to 10 : 1966 Methods of testing flexible polyurethane foam: Part 3 Dimensions of test pieces; Part 4 Apparent density of thin sheet; Part 5 Cell count; Part 6 Tensile strength and elongation at break of thin sheets; Part 7 Compression set of thin sheet; Part 8 Solvent swelling; Part 9 Humidity ageing; and Part 10 Heat ageing. British Standards Institution

ASTM D 1565-71 Flexible urethane foam, including test for. American Society for Testing and Materials

0.3 In reporting the result of a test made in accordance with this standard if the final value, observed or calculated, is to be rounded off, it shall be done in accordance with IS : 2-1960*.

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

1. SCOPE

1.1 This standard prescribes the methods of sampling and test for flexible polyurethane foam known as cellular foam.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Urethane Foam — An expanded cellular product produced by interaction of polyhydroxy compounds, water and *iso*cyanate.

2.2 Linear Dimensions — Linear measurements of a specimen in different directions expressed in millimetres.

2.3 Density — The mass per unit volume of the foam specimen at 27 ± 2°C expressed in kg/m³.

2.4 Tensile Strength — The stress at the breaking point of a specimen expressed in kgf/cm².

2.5 Tensile Stress — The stress at predetermined elongation of a specimen expressed in kgf/cm².

2.6 Ultimate Elongation (Elongation at Break) — The percentage strain produced in a specimen stretched to its breaking point.

2.7 Hardness Number — It is stated in the form of grading and is numerically equal to the compressive stress which is necessary to penetrate the specimen without puncture to a specified depth or deflection expressed as the load (kgf) per unit area of compression (cm²). Hardness number at 40 or 50 percent deflection on a specific thickness of sample is also referred to as hardness index.

2.8 Load Quotient — It is the ratio of hardness number at two specified deflections, namely, 65 percent and 25 percent.

3. DETERMINATION OF LINEAR DIMENSIONS

3.1 Apparatus

3.1.1 Linear dimensions below 100 mm are measured by using soft material thickness gauge. The apparatus consists of the following:

a) A graduated dial,
b) Flat circular foot of 6·5 cm² surface area with the foot operating load of 1 g/cm² attached to the moving shaft, and
c) Metallic spacers of 50, 20 and 10 mm sizes if the graduated dial does not cover the range 0 to 100 mm.

The instrument should be capable of being operated within an accuracy of ±1 percent of the dimension to be measured.

3.1.2 For dimensions greater than 100 mm vernier calipers or steel tape should be used so as to permit measurements with an accuracy of ±1 percent of the dimension to be measured.

3.2 Test Specimen — Cut the specimen from the foam slab cured for 48 hours at room temperature and condition for 6 hours at 27 ± 2°C and at 65 ± 5 percent relative humidity before testing. The specimen shall be free from skin and other surface defects.

3.3 Procedure

3.3.1 *Measurement Below 100 mm Linear Dimension* — Set the dial at zero. Place the specimen centrally below the foot. Lower the foot with the application of the specified load. Note the reading taking into account the metallic spacers used, if any. Repeat this thrice in each direction for every specimen.

3.3.2 *Measurement Above 100 mm Linear Dimension* — Place the specimen on a plane table and measure the dimension with vernier caliper or steel tape accurately. Repeat this thrice for every specimen.

3.4 Report the average of the measurements in each direction.

4. DETERMINATION OF DENSITY

4.1 Apparatus

4.1.1 Soft material thickness gauge for measurement of linear dimension up to 100 mm with an accuracy of one percent.

4.1.2 *Balance* — Capable of weighing the test specimen to an accuracy of one percent of the total mass.

4.2 Test Specimen — Obtain test specimens, of regular shape not less than 100 × 100 × 50 mm, one each from top, middle and bottom portions of the foam slab with respect to direction of rise of foam, cured for 48 hours at room temperature. Condition the specimens for 6 hours at 27 ± 2°C and at 65 ± 5 percent relative humidity before testing.

4.3 Number of Specimens — Unless otherwise specified three specimens shall be tested.

4.4 Procedure — Determine the linear dimensions as described in **3.3**. Weigh the specimens on a balance with an accuracy of one percent of the total mass.

4.5 Calculation

$$\text{Density } (\rho_d), \text{kg/m}^3 = \frac{m}{v} \times 1000$$

where

m = mass of specimen in g, and

v = volume of the specimen in cm³.

4.6 Report the mean density of the three specimens tested.

5. TENSION TEST

5.1 Apparatus — The apparatus consists of a power driven machine (medium load tensile tester) with the following provisions:

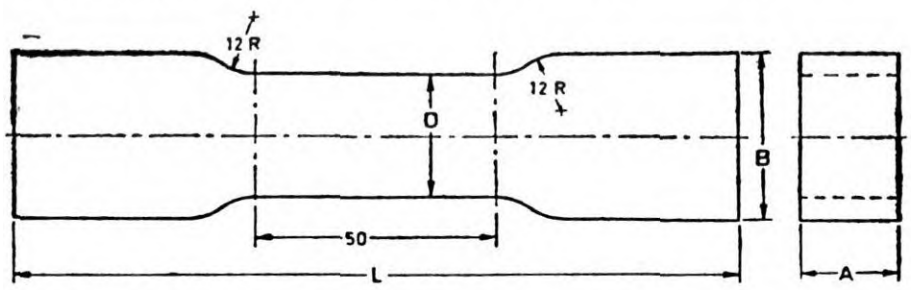
a) Sensitive dial indicator which remains at the point of maximum load after rupture of the specimen and measures the tension at the point,

b) Suitable grips for holding the specimen,

c) Rate of travel of power actuated grip shall be 500 ± 50 mm per minute and uniform at all times, and

d) The total capacity of the tester be such that the ultimate load is at least one-fifth of the total capacity of the machine.

5.2 Test Specimen — Punch the specimen in the shape of a dumb-bell shown in Fig. 1 by means of a sharp die out of a foam sheet of 10 or 20 mm thickness. The foam sheet shall be cut vertically in the direction of the rise of the foam with the help of a splitting machine, from the foam slab cured at room temperature for 48 hours. Condition the test specimen at 27 ± 2°C and 65 ± 5 percent relative humidity for 6 hours before testing.



	A	*B*	*D*	*L*
Small	10	25	13	152
Large	20	38	26	152

All dimensions in millimetres.

FIG. 1 DUMB-BELL TEST PIECE

5.3 Number of Specimens — Three specimens shall be tested.

5.4 Procedure

5.4.1 *Determine the thickness and width of the specimen accurately by*

means of a vernier caliper or soft material thickness gauge as described in **3**. Make two gauge marks 50 mm apart as shown in Fig. 1.

5.4.2 Clamp the specimen in the grips. The minimum separation between the grips shall be 65 mm. Adjust the specimen symmetrically between the grips for uniform distribution of the tension applied over the cross-section.

5.4.3 Start the machine and note continuously the distance between the two gauge marks and record the distance at rupture. Note the load indicated on the dial.

5.5 Calculation and Reporting

5.5.1 Tensile strength (B), kgf/cm^2 $= \frac{\sigma_{F max}}{A}$

where

$\sigma_{F max}$ = force at failure of the specimen in kgf, and

A = original cross-sectional area in cm^2.

5.5.2 *Tensile Stress*

$$\text{Tensile stress } (\sigma_t), \text{ kgf/cm}^2 = \frac{F_t}{A}$$

where

F_t = force at specified elongation in kgf, and

A = original cross-sectional area in cm^2.

5.5.3 *Ultimate Elongation* (*Elongation at Break*)

$$\text{Ultimate elongation } \epsilon_b, \text{ percent} = \frac{L_b - L}{L_o} \times 100$$

where

L_b = length between the gauge marks in mm at the time of failure, and

L_o = original length between the gauge marks in mm.

5.5.4 Report the averages of the three specimen tested.

6. INDENTATION LOAD DEFLECTION TEST

6.1 Apparatus — Apparatus consists of a flat circular indentor foot of 323 cm^2 surface area, connected by means of a swivel joint to a load measuring device and mounted in such a manner that specimen can be deflected at a fixed speed of 2 to 3 mm per second. The indentor is moved up and down pneumatically. The load measuring device shall have ve accuracy of ± 1 percent or $\pm 0{\cdot}1$ kg whichever is greater. The apparatus shall be capable of measuring the sample thickness with an accuracy of $\pm 0{\cdot}25$ mm. The base of the apparatus shall be a horizontal plate with perforations for a rapid escape of air during the test.

6.2 Test Specimen — Cut the specimen from the slab which has been cured at room temperature for 48 hours. The dimensions of specimen shall be not less than $380 \times 380 \times 50$ mm with thickness in the direction of the rise of foam so that the stress placed is parallel to the direction of rise of foam. Condition the test specimen for 6 hours at $27 \pm 2°C$ and 65 ± 5 percent relative humidity before testing. Samples of less than this standard thickness shall be plied together to reach as near the standard thickness as possible.

6.3 Procedure

6.3.1 *Preflexing of Test Specimen* — Carry out preflexing of test specimen as prescribed in **6.3.2**.

6.3.2 Place the specimen centrally under the indentor foot. Apply 1 kg load on the test area and measure the thickness (t_1). Compress the test piece by means of the indentor foot at the specified rate of 2 to 3 mm per second to produce an indentation of 70 percent of the thickness t_1. Hold the deflection for 1 minute and raise the indentor rapidly until clear of the test piece. Apply 1 kg load again after an interval of 45 seconds to the test area and maintain for 15 seconds. Measure the thickness (t_2) and apply the indentor immediately at the specified rate to produce an indentation of 25 percent of the thickness t_2. Measure the load after the deflection has been maintained for 30 seconds. Increase the deflection to 65 percent of thickness t_2 and maintain for 30 seconds. Measure the load and then remove the load clear of the test piece.

6.3.3 When hardness number is to be determined at 40 or 50 percent, the following procedure shall be followed:

Apply a load of 1 kg on the selected area and measure the exact thickness (t_1). Compress the test piece by means of the indentor at specified rate to produce indentation of 70 percent of the thickness t_1. Hold the indentor at this deflection for a period of one minute and raise the indentor rapidly until clear of the test piece. Again apply 1-kg load after an interval of 45 seconds and maintain for 15 seconds and measure the thickness (t_2). Then compress again at the specified rate under load to produce 40 or 50 percent deflection. Note the load after maintaining at 40 or 50 percent deflection for 30 seconds. Raise the indentor clear of the test piece.

6.4 Calculation and Reporting

$$\text{Hardness number, 25 percent} = \text{Compressive stress at 25 percent deflection}$$

$$= \frac{\text{Load at 25 percent deflection}}{323 \text{ cm}^2}$$

$$\text{Hardness number, 65 percent} = \text{Compressive stress at 65 percent deflection} = \frac{\text{Load at 65 percent deflection}}{323\ \text{cm}^2}$$

$$\text{Hardness number, 40 percent} = \text{Compressive stress at 40 percent deflection} = \frac{\text{Load at 40 percent deflection}}{323\ \text{cm}^2}$$

$$\text{Hardness number, 50 percent} = \text{Compressive stress at 50 percent deflection} = \frac{\text{Load at 50 percent deflection}}{323\ \text{cm}^2}$$

$$\text{Load quotient} = \frac{\text{Hardness No., 65 percent}}{\text{Hardness No., 25 percent}}$$

NOTE — Hardness number 25 percent, 40 percent, 50 percent and 65 percent are also known as 25 percent, 40 percent, 50 percent and 65 percent indentation load deflection values, respectively.

7. SHEAR FATIGUE TEST

7.1 Apparatus — The apparatus consists of the following:

a) A perforated moving platform (perforated base platen) with 6 *mm* diameter holes at 19 mm centre distance;

b) Provision for movement of the above platform at the rate of 28 cycles per minute and stroke length of 330 *mm*;

c) A stationary roller 460 mm long and 75 mm in diameter mounted in an off-set position (15°) with suitable means for adjustment for:

1) loading the test piece so that a specified deflection is maintained, and

2) deflecting the test specimen so that a specified load is maintained.

7.2 Test Specimen — Cut a test specimen of 380 × 380 mm and of desired thickness (preferably 50 mm) from a foam slab with thickness in the direction of rise of foam so that the stress applied is parallel to the direction of rise of foam. Condition the test specimen at 27 ± 2°C and 65 ± 5 percent relative humidity for 6 hours before testing.

7.3 Procedure

7.3.1 *Test Under Constant Deflection Condition* — Subject the specimen to indentation load deflection test as described in **6.3** and note the reading. Place the specimen centrally on the perforated base platen and secure it by means of double sided adhesive tape. Bring down the roller on to the

cimen and then adjust for a constant deflection of 65 percent of its original ckness. Switch on the machine and keep the specimen under the above nditions for 20 000 cycles (40 000 flex) at the specified frequency of the vement of the table and stroke length.

7.3.2 *Test Under Constant Load Condition* — Subject the specimen to inden- ion load deflection test as described in **6.3** and note the readings. Then ce the specimen centrally on the perforated base platen and secure it means of double sided adhesive tape. Bring down the roller on the cimen by the application of necessary load so as to achieve test under nstant load condition. Switch on the machine and keep the specimen der above conditions for 20 000 cycles (40 000 flex) at the specified fre- ency of the movement of the table and stroke length.

7.3.3 In both the above conditions of test, allow a recovery period of ± 10 minutes after 20 000 cycles and perform the indentation load deflec- n test as described in **6.3** and note the readings.

Calculation and Reporting

7.4.1 Percentage loss in load deflection $(F_1) = \frac{L_o - L_t}{L_o} \times 100$

where

L_o = original load deflection value, and

L_t = final load deflection value.

7.4.2 Percentage loss in thickness $(F_t) = \frac{t_o - t_t}{t_o} \times 100$

where

t_o = original specimen thickness in mm, and

t_t = final specimen thickness in mm.

7.4.3 Check the specimen for physical breakdown of cellular structure visual examination and compare with the unflexed specimen.

NOTE — Percentage loss of load deflection is to be reported only if the percentage loss in thickness is less than 10 percent.

COMPRESSION SET TEST

0 **General** — The test consists of maintaining the foam specimen under ecified conditions of temperature and observing the degree of recovery ithin a specified time after release.

1 **Apparatus** — The apparatus consists of two flat plates of 200 × 200 mm, ith appropriate spacers and clamps to keep the plates parallel to each other hen clamped with specimen between the plates.

2 **Test Specimen** — Cut the test specimen from a foam slab which

has been cured for 48 hours at room temperature in such a way that the load is applied in the direction of the rise of the foam to get specimen of $50 \times 50 \times 25$ mm. Test specimens shall be free from any contamination and skin on the vertical sides. When thin materials are to be tested, sufficient specimens of 50×50 mm shall be taken so that the sum of their thickness before compression is at least 25 mm. The specimens shall be plied together and interleaved with photographic glass-mounting slides where the number of plies is greater than two, and the complete assembly shall be treated during the test as a single thick specimen.

8.2.1 Condition the test specimens at 27 ± 2°C and 65 ± 5 percent relative humidity for 6 hours before testing. A minimum of 3 specimens shall be tested for 50 or 75 percent compression of its thickness. In special cases a compression of 90 percent may be agreed upon.

8.3 Procedure — A soft material dial thickness gauge is used for measuring the thickness of the specimen. In case of thin material calculate the thickness of the foam by deducting the aggregate thickness of the glass slides from the measured total thickness of the assembly. The specimen shall then be put between the plates and with the help of spacers subjected to 50 percent deflection. The whole assembly is then stored under standard atmospheric conditions for 70 hours or at 70 ± 2°C for 22 hours. After this duration, the plates are removed and the specimen is allowed to recover for at least 30 minutes under standard testing conditions. The thickness is measured again with the soft material dial thickness gauge. The same procedure is followed for 75 or 90 percent deflection.

8.4 Calculation and Reporting

$$\text{Compression set at the rate of 50 percent deflection} = \frac{h_o - h_{50}}{h_o} \times 100$$

$$\text{Compression set at the rate of 75 percent deflection} = \frac{h_o - h_{75}}{h_o}$$

$$\text{Compression set at the rate of 90 percent deflection} = \frac{h_o - h_{90}}{h_o} \times 100$$

where

h_o = original height of the specimen in mm,

h_{50} = final height of the specimen in mm after 50 percent deflection test,

h_{75} = final height of the specimen in mm after 75 percent deflection test, and

h_{90} = final height of the specimen in mm after 90 percent deflection test.

8.4.1 Average of the values obtained from the three samples tested shall be reported.

9. HUMIDITY AGEING TEST

9.0 General — The test specimen is subjected to low pressure steam and the effect on the physical properties observed.

9.1 Test Specimen — *The number, size and shape of test specimens shall* be appropriate to the property being examined and shall be prepared before the test.

9.2 Procedure — *The specimens shall be tested not less than 48 hours* after manufacture. They shall be conditioned immediately before testing for not less than 6 hours at 27 ± 2°C and 65 ± 5 percent relative humidity. Place the specimen in a steam pressure vessel and add just sufficient distilled water avoiding wetting the specimen. Heat the vessel to 105±1°C. Expel the air from inside by leaving the safety valve open until the steam blows out of the opening. Close the valve and maintain the tempereture for 3 hours. *After the expiry of the test period, open the pressure vessel and* remove the specimen. Dry at 70 ± 1°C in an air-circulating oven at the rate of 3 hours per 25 mm of thickness, subject to a minimum of 3 hours. Condition the specimen after removal from oven for at least 2 hours and not more than 24 hours at room temperature and 65 ± 5 percent relative humidity. Test the conditioned specimen for the particular physical property and express the result as the change from those of unaged specimen.

10. HEAT AGEING TEST

10.0 General — The test consists of subjecting the test specimen to dry heat *and observing the effect on its physical properties.*

10.1 Test Specimens — same as in **9.1**.

10.2 Procedure — The test specimens shall be tested not less than 48 hours after manufacture. Condition the specimen immediately before testing for a period of not less than 6 hours at 27 ± 2°C and 65 ± 5 percent relative humidity. Place the specimen in a thermostatically controlled oven with *air circulation and maintain the temperature at 140 ± 1°C for 16 hours.* After the expiry of the test period remove the specimen from the oven and condition it at room temperature for at least 2 hours but not more than 24 hours at 65 ± 5 percent relative humidity. Test the conditioned specimen for the particular property and express the result as the change from those of unaged specimens.

11. TEST FOR FLAMMABILITY

11.1 Apparatus

11.1.1 The general arrangement of the apparatus is as shown in Fig. 2.

11.1.2 The apparatus consists of a metal frame as shown in Fig. 3, constructed from brass strip 12·5 to 13 mm wide and 3 to 3·5 mm thick. The frame

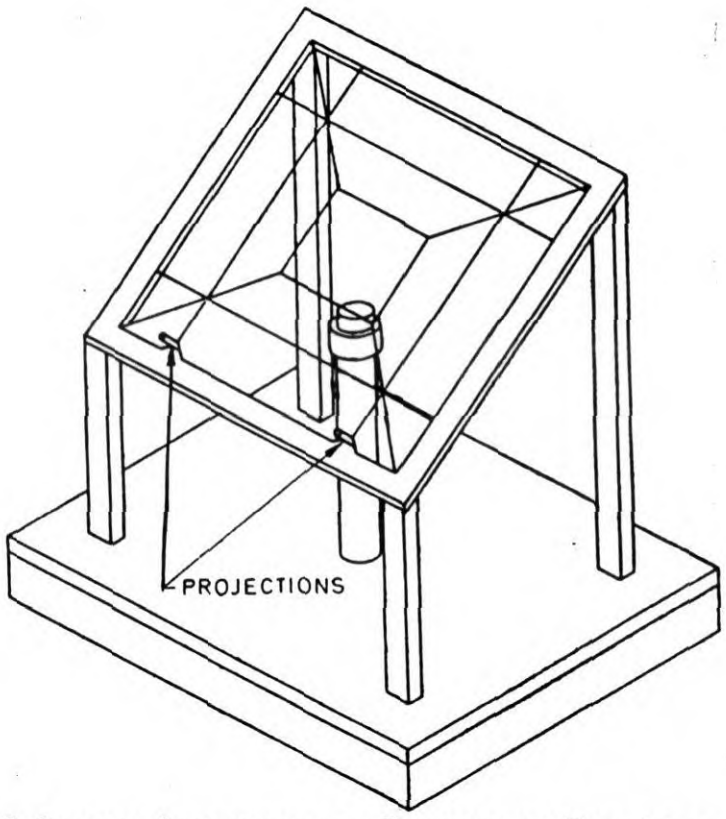
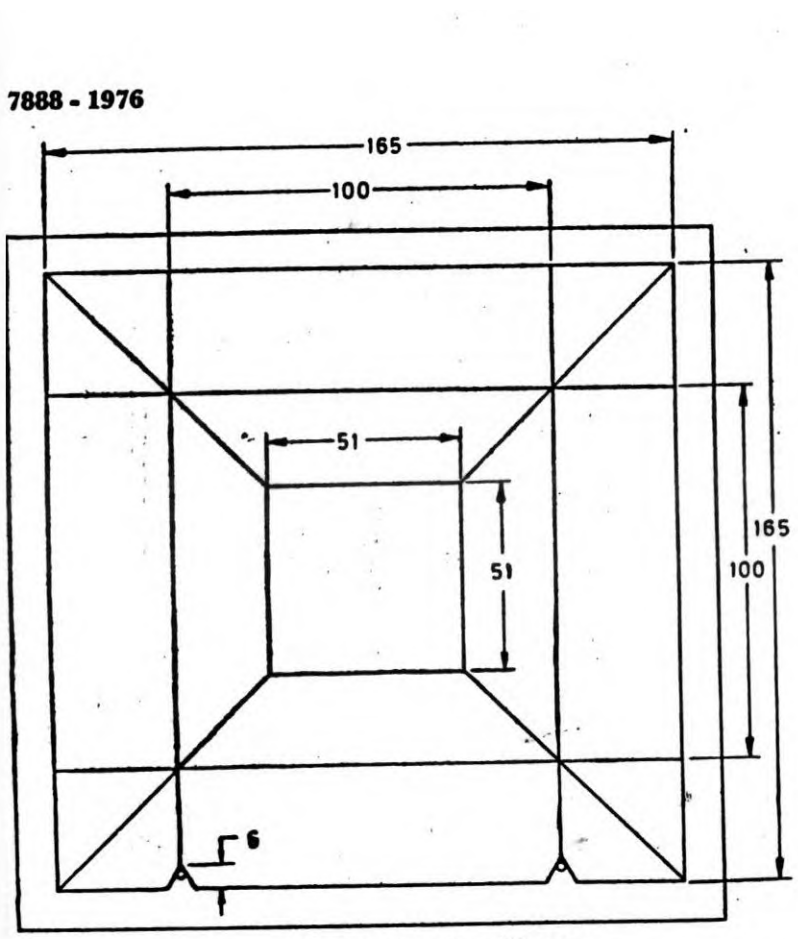


FIG. 2 GENERAL ARRANGEMENT OF FLAMMABILITY TEST APPARATUS

shall be supported at its corners so that its major plane is at an angle of 45° with the horizontal. The supports shall consist of four legs without any under-frame or other attachments to the legs that might modify the flow of air under the test specimen. The centre of the underside of the frame shall be 152 mm above the surface of the base of the apparatus which shall be covered with asbestos millboard not less than 3 mm thick. A wire grid of the form shown in Fig. 3 and made of nickel-chrome resistance wire about 0·15 mm in diameter shall be stretched across the underside of the metal frame to support the sample, the lower edge of which shall rest against the two projections so that the sample is central within the frame.

11.1.3 A flat-bottomed metal cup 17·5 mm in external diameter, 7·3 mm high and about 1 mm thick, shall rest in a shallow depression on a piece of asbestos board (or other material of low thermal conductivity). The base



All dimensions in millimetres.

FIG. 3 METAL FRAME AND WIRE GRID FOR FLAMMABILITY TEST APPARATUS

the cup shall be 25 mm below the centre of the lower surface of the sample 127 mm above the surface of the asbestos covering the base of the apparatus). The side elevation of the apparatus is shown in Fig. 4.

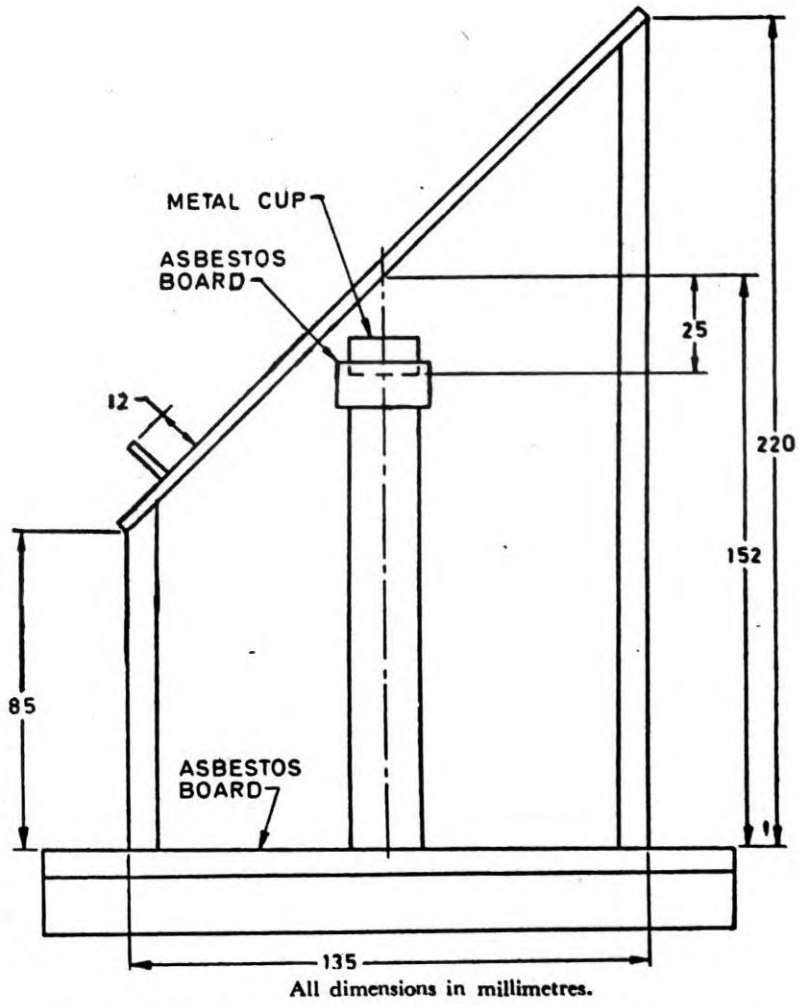
11.1.4 The apparatus shall be used in a room or enclosure free from draughts and such that the progress of the test may be observed.

11.2 Reagent

11.2.1 *Absolute Alcohol* — conforming to IS : 321-1964*.

11.3 Test Specimen — The specimens shall be 150 mm square, cut from

*Specification for absolute alcohol (*revised*).



All dimensions in millimetres.

FIG. 4 SIDE ELEVATION OF FLAMMABILITY TEST APPARATUS

the foam under test. The thickness of the specimen shall not exceed 50 mm. Three specimens shall be used for this test.

11.4 Procedure

11.4.1 Before the test is started, the cup shall be warmed by pouring 0·3 ml of absolute alcohol in the cup from a suitable pipette and ignited with a very small gas flame or other suitable small source of heat, which shall be

removed as soon as the alcohol is alight (*see* Note). When the alcohol has burnt out, a second quantity of 0·3 ml of alcohol shall be placed in the cup and the test specimen shall be placed on the support(s). The second quantity of alcohol shall be ignited, as before, 90±15 seconds after the instant of ignition of the first quantity of alcohol. When the alcohol has burnt out note the length of time that the specimen glows or flames.

When the specimen has ceased to glow or flame, note (a) whether any material that may have dropped from the specimen continued to burn after reaching the base of the apparatus; (b) the percentage of the area of the underside of the specimen that is charred or scorched; (c) the length of that part of the edge that is scorched. A charred area does not include an area that is covered with soot but is not burnt. If the length of the scorched part of the edge of the underside of any of three specimens exceeds 50 mm the material shall be described as flammable. If the length of the scorched part of the edge of the underside of each of three specimens does not exceed 50 mm, the material shall be described as having low flammability. If the material complies with the requirement for low flammability and if, in addition, each of the three specimens or 5 out of 6 specimens, meet the requirements that:

a) glowing does not continue for more than 5 seconds after the alcohol has burnt out;

b) any material that may have dropped from the specimen does not continue to burn after reaching the base of the apparatus; and

c) charring or scorching does not extend over an area exceeding 20 percent of the underside of the specimen, it shall be described as having very low flammability.

NOTE — The amount of alcohol used will burn, under normal conditions, for about 45 seconds. The burning of alcohol during each test will suffice to warm the cup in preparation for the next test provided that the time that elapses between the successive ignitions is 90 ± 15 seconds.

12. SCALE OF SAMPLING

12.1 Lot — Polyurethane foam products like cushions and matresses, of the same type, same grade and produced from similar type of material in a single consignment shall be grouped together to constitute a lot.

12.2 For ascertaining the conformity of the material for the requirements of the specification, samples shall be tested from each lot separately. The number of foam products to be sampled from a lot shall depend on the size of the lot and shall be in accordance with col 1 and 2 of Table 1.

12.2.1 These foam products shall be selected at random and in order to ensure the randomness of selection, procedures given in IS : 4905-1969* may be followed.

*Methods for random sampling.

TABLE 1 SCALE OF SAMPLING

(*Clause* 12.2)

FOAM PRODUCTS IN THE LOT (*N*)	FOAM PRODUCTS TO BE SELECTED (*n*)
(1)	(2)
Up to 25	2
26 to 50	3
51 ,, 100	4
101 ,, 200	5
201 and above	6

12.3 Number of Tests and Criteria for Conformity

12.3.1 The foam products selected according to **12.2** shall be examined for linear dimensions, density, tension, load deflection, compression set, humidity heat ageing, heat ageing and shear fatigue tests. Required number of test specimens as prescribed in various test methods shall be cut from the foam products selected under **12.2**.

12.3.2 The lot shall be declared as conforming to the requirements of the specification if no failure occurs under **12.3.1**.