AA 085 17 01 : METHODS OF TEST FOR LAMINATED SHEETS

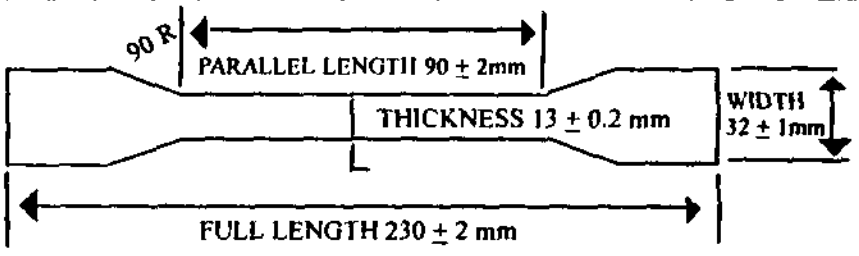

Fig.1 Specimen for Tensile strength test

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2.1 Cl:6.3 "Test specimens" 2nd sentence is modified as follows:
"The Thickness of the test piece shall be thickness of the sheet under test, except that where this exceeds 10 mm, the thickness of the test piece shall be

2.2 Cl 7.3 TEST SPECIMES : 2nd sentence is modified as follows :

"The thickness of the test speciemen shall be the thickness of the sheet under test except that where it exceeds 6.3 mm the thickness of the specimen shall be reduced by machining to 6.3 ± 0.2 mm leaving one face of the specimen intact (After machining)

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3.1 Cl 8.1 Test specimens : 1st sentence is modified as follows :

"prepare a rectangular block 15 ± 0.2 mm long, 15 ± 0.2 mm width and 25 ± 0.5 mm height.

The height being brilt up with several layers of the material when necessary

3.2 Cl 8.3 PROCEDURE. The 3rd sentence is modified as follows :

"Increase the load at a rate such that a final load to give the required proof stress in reached in 30 to 45 seconds from the commencement of application of load.

4.0 Page 7 of 30 Cl 9.3 : Test specimen: The 1st sentence is modified as follows:

"If the measured thickness of the sheet is less than 5 mm, cut a test specimen of length 55 $\pm$ 0.5 mm and width $6 \begin{matrix} + 0.0 \\ - 0.1 \end{matrix}$ mm

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Cl 11.3 Test specimen : Replace the existing matter with the following.

"cut 3 nos of samples to the size 20 $\pm$ 0.2 mm C X 20 $\pm$ 0.2 mm X 10 $\pm$ 0.1 mm sheets with above 10 mm thick shall be machined doun to 10 $\pm$ 0.1 mm uniformly on both sides.

AMENDMENT - NOTIFICATION

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Cl.9.1 General alongwith the matter is "deleted"

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Add the following new clause as Cl.25 at the end.

Cl.25 REFERRED STANDARDS (Latest publications incl. amndts.

1) ASTM D 495	2) IS:2824	3) IS:1070
4) IS:335	5) DIN 53462	6) DIN 50011

Please see instructions on the reverse.

Ref:	Amd. No.	Approved	Issued	Date	Cum. Sr. No.
Cl.31.6.3 of MOM of MRC(E)	01	MRC(E)	CORP. R&D	1-12-96	A 1999

METHODS OF TEST FOR LAMINATED SHEETS

1. GENERAL:

This standard prescribes the methods of test for thermosetting synthetic resin bonded laminated sheets of various types. The tests included in this standard are as given in Table 1.

TABLE 1 TESTS ON LAMINATED SHEETS

	TEST	CLAUSE NO
1.	Conditioning	3
2.	Thickness	4
3.	Tensile strength	5
4.	Cross-breaking strength	6
5.	Shearing strength	7
6.	Compression Strength	8
7.	Impact Strength	9
8.	Punching Test	10
9.	Splitting Load Test	11
10.	Arc Resistance Test	12
11.	Flammability Test	13
12.	Comparative Tracking Index	14
13.	Resistance to Hot Oil	15
14.	Accelerated Ageing	16
15.	Marten's Heat Stability Test	17
16.	Water Absorption	18
17.	Electric Strength,Flat-wise	19
18.	Electric Strength,Edgewise	20
19.	Insulation Resistance	21
20.	Loss Tangent & Permitivity	22
21.	Volume Resistivity	23
22.	Surface Resistivity	24

2. TERMINOLOGY:

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

2.1 Direction A and Direction B:

Two directions in the plane of a sheet which are mutually at right angles and are related to the surface layers of the sheet. One of these directions is parallel with the machine direction of paper or with either the warp or the weft threads of the fabrics.

2.2 Edgewise:

A direction parallel to the plane of lamination.

2.3 Flatwise:

A direction perpendicular to the plane of lamination.

2.4 Synthetic Thermosetting Resins:

Synthetic resins which on heating gradually pass from the fusible stage to one in which they are not only infusible but insoluble in the common solvents and in alkalis.

2.5 Phenolic Resin:

Resin produced by condensation of a phenol with aldehydes.

2.6 Synthetic Resin Bonded Laminated Sheet:

Laminated sheet in which the bonding medium is a synthetic thermosetting resin.

3. CONDITIONING OF SPECIMENS:

When specimens are required to be conditioned, they shall be subjected to an atomosphere of 65±5% R. H. at a temperature of 27°C for not less than 24 hours. Every specimen shall be tested as soon as possible after removal from the controlled atmosphere, and in any case, the test shall be started before three minutes have elapsed.

4. THICKNESS:

Measure the thickness of the sheets in the condition as received with a suitable micrometer at ten points equally spaced along the periphery of the sheet.

5. TENSILE STRENGTH:

5.1 General:

This test is applicable to sheets of more than 1.6 mm thickness.

5.2 Number of Tests:

Test shall be performed on four specimens, two cut in direction A and two in direction B.

5.3 Test Specimens:

The form and dimensions of test specimens shall be as shown in Fig. 1.

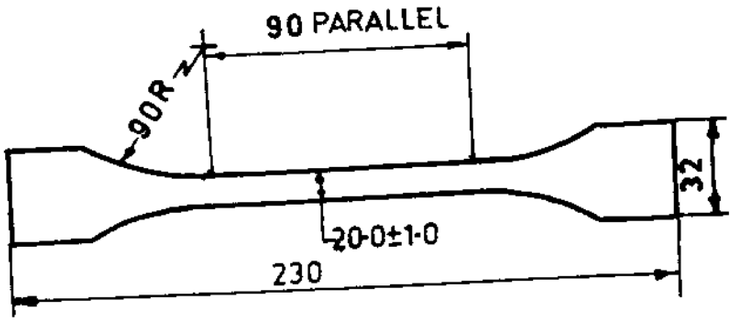


Fig. 1 Specimen for Tensile Strength Test.

Wedge grips shall be used in applying the load. Provision snall be made for self-alignment of the specimen under load by the use of suitable shakles. Measure the thickness of the test piece to the nearest 0.03 mm. The thickness of the test piece shall be the thickness of the sheet under test except that where this exceeds 13 mm, the thickness of the sheet shall be reduced to 13 mm leaving one face of the specimen intact.

5.4 Apparatus:

Standard tensile testing machine capable of measuring the load at the fracture to within 1 percent accuracy.

5.5 Procedure:

Condition the test specimens as in 3.1. Fix the specimen in the tensile testing machine, taking care to ensure correct alignment of the test piece. It may be of assistance to interpose an emery cloth between the test piece and the grips, the emery face being in contact with the test piece. Increase the load steadily at such a rate that the minimum specified breaking stress is reached in one and half to two minutes from the time of the initial application of load.

5.6 Report:

Report the arithemetic mean of the two test results in the direction A or in the direction B whichever is lower, as the tensile strength expressed in kg/cm^2 of the original cross sectional area calculated from the measured dimensions of the specimen.

6. CROSS BREAKING STRENGTH:

6.1 General:

This test is applicable to sheets of more than 1.6 mm thickness.

6.2 Number of Tests:

Test shall be performed on six specimens, three cut with their lengths in direction A and three with their lengths in direction B.

6.3 Test Specimens:

Each specimen shall consist of a rectangular bar of 15.0 ± 0.5 mm breadth and a length of 24 to 30 times the thickness of the sheet measured to the nearest 0.03 mm. The thickness of the test piece shall be thickness of the sheet under test except that where this exceeds 10 mm, the thickness of the test piece shall be reduced to 10 mm leaving one face of the specimen intact.

6.4 Procedure:

Condition the test specimens as in 3.1. Measure the breadth and thickness of the test piece to the nearest 0.03 mm. Lay the test piece symmetrically across two paralled V shaped supports with the original face of the sheet in contact with the supports keep the distance between the supports equal to 16 times the measured thickness of the test piece, adjusted to the nearest 1 mm. Apply a load squarely across the width of the test piece by means of a third V shaped block parallel to and midway between the supporting blocks. The contact edges of the blocks shall be not less than 25 mm long. Increase the load steadily at such a rate that the test piece fractures in 15 to 45 seconds. Note the load at fracture.

6.5 Calculation and Report:

Calculate the cross-breaking strength of each test piece as given below:

$$\text{Cross-breaking strength } kg/cm^2 = \frac{1.5\ WL}{BD^2}$$

Where

W = Load at fracture in kg
L = distance in cm between supports
B = Breadth in cm of test piece, and
D = thickness in cm of test piece

Report the arithmetic mean of the three values obtained in the direction A or of the three values in the direction B, whichever is lower, as the cross breaking strength.

7: SHEARING STRENGTH

7.1 General:

This test is applicable to sheets of more than 1.6 mm thickness.

7.2 Number of Tests:

Carryout the test on four specimens, two cut with their lengths in direction A and two with their lengths in direction B.

7.3 Test Specimens:

Each specimen shall be rectangular bar 6.5 ± 0.3 mm wide and not less than 30 mm long. The thickness of the test specimen shall be the thickness of the sheet under test except that where it exceeds 6.3 mm, the thickness of the specimen shall be reduced by machining to 6.10 ± 0.25 mm

leaving one face of the specimen intact.

7.4 Apparatus:

A Punch, Die and Bolster assembly conforming to the dimensions shown in Fig. 2 shall be used. The punch shall be a running fit in the die.

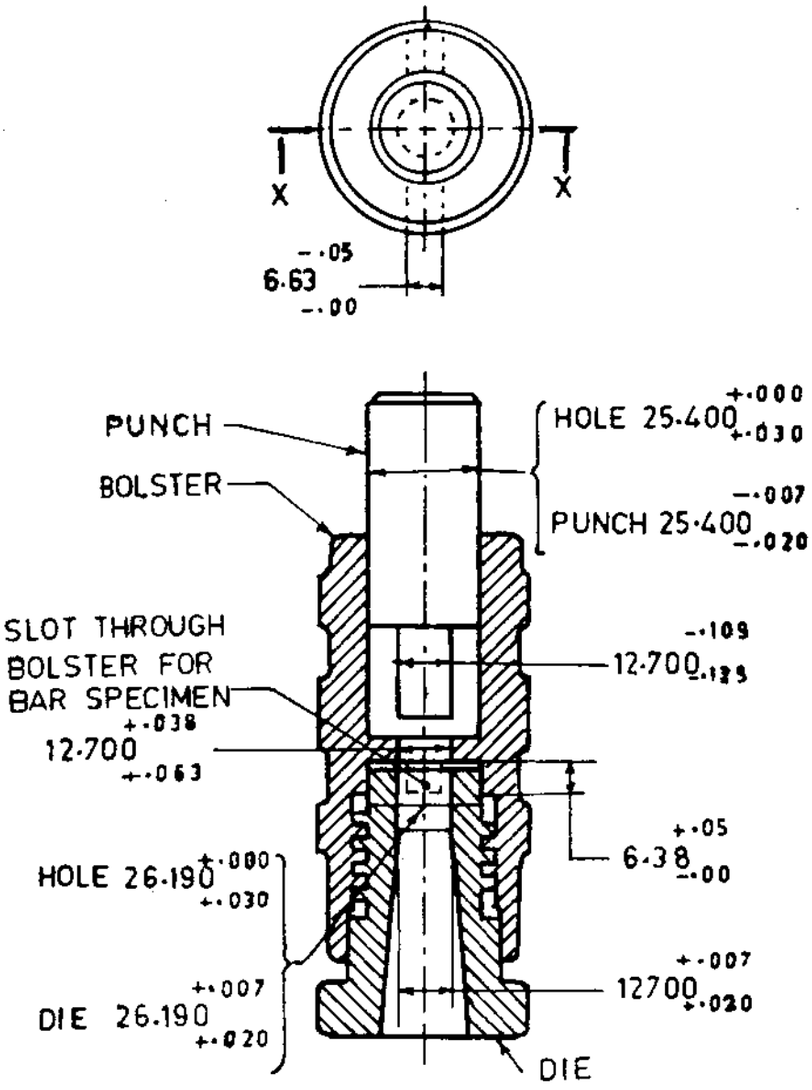


Fig. 2. Punch Die And Bolster Assembly.

A suitable compression testing machine, capable of developing a load of over 2 metric tonnes, shall be used.

7.5 Procedure:

Condition the test specimens as in cl. 3. Measure the thickness and the width of the specimen to the nearest 0.03 mm. Place the specimen with the unmachined face upwards, in the assembly, the die being screwed home against the specimen in the bolster. The load shall be applied

evenly to the specimen by means of the punch at such a rate that the final value at which the specimen shears is reached in 15 to 45 seconds from the time of initial application of the load.

7.6 Calculation and Report:

The shearing strength shall be calculated as follows:

$$\text{Shearing strength, } kg/cm^2 = \frac{W}{2\,BDK}$$

Where

W = load in kg at fracture
B = Width in cm of specimen
D = Thickness in cm of specimen
K = a factor with a value 1.048, introduced to allow for the curvature of the shear surface.

Calculate the arithmetic mean of the two values in direction A and two values in direction B, and report the lower of the two as the shearing strength of the sheet.

8. COMPRESSION STRENGTH:

8.1 Test Specimens:

Prepare a rectangular block 15 mm long, 15 mm wide and 25 mm high, the height being built up with several layers of the material when necessary. When it is necessary to machine a piece of sheet to obtain a specimen of 25 mm thickness, retain one original surface of the machined material. Remove the burs from the edges of the specimen including component layers, if any.

8.2 Apparatus:

A suitable compression testing machine capable of developing a load over two metric tonnes shall be used.

8.3 Procedure:

Condition the test specimen as in 3.1. Place it in the testing machine so that the load is applied perpendicular to the surface of the material. Increase the load at a rate such that a final load to give the required proof stress is reached within 4 to 5 seconds from the commencement of application of load. Maintain the final load for one minute, after which release the pressure.

Examine the specimen for cracks, splits or tendency to delaminate easily after the proof loading; the absence of all of these shall be considered as the material having passed the test.

9. IMPACT STRENGTH:

9.1 General:
This test is applicable to sheets with thickness more than 2.5 mm.

9.2 Number of Tests:

Carryout the test on 6 specimens, 3 cut with their lengths in direction A and three in direction B.

9.3 Test Specimen:

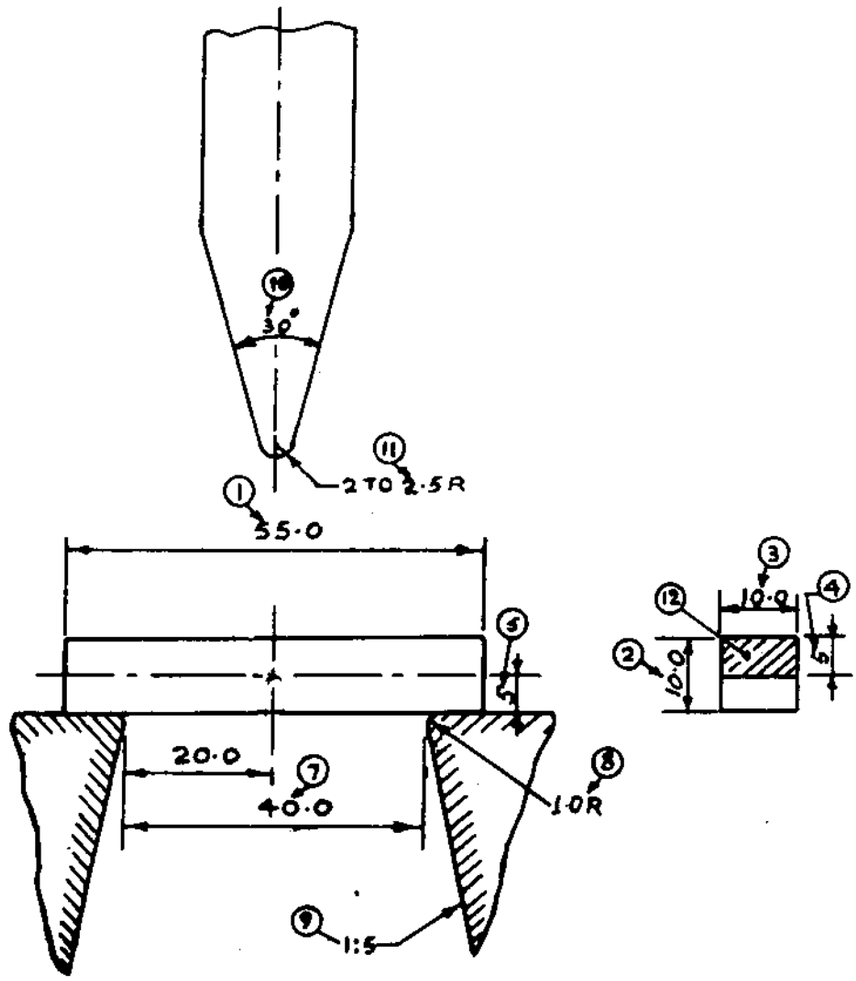
If the measured thickness of the sheet is less than 5 mm, cut a test specimen of length 50 $\pm$ 0.5 mm, and width $6^{+0.0}_{-0.1}$.

If the measured thickness of the sheet is 5 mm thick and above, cut a test specimen of length 120 mm $\pm$ 0.5 and width 15 mm $^{+0.0}_{-0.1}$.

The thickness of the test specimen shall be the thickness of the sheet under test except where it exceeds 10 mm, the thickness shall be reduced to $10^{+0.0}_{-0.1}$ by removal of one face, leaving the other face intact.

9.4 Apparatus:

Testing machine shall be in accordance with IS: 1499. (Fig. 3).



9.5 Procedure:

Condition the test specimen as in 3.1. The specimen shall be supported at a distance of 40 mm (below 5 mm thick) and 70 mm (above 5 mm thick. Spacers are to be provided to build up the thickness of samples as 10 mm at the support point for sheets of lower thickness. Release the impact load and note the energy of impact at fracture of the specimen.

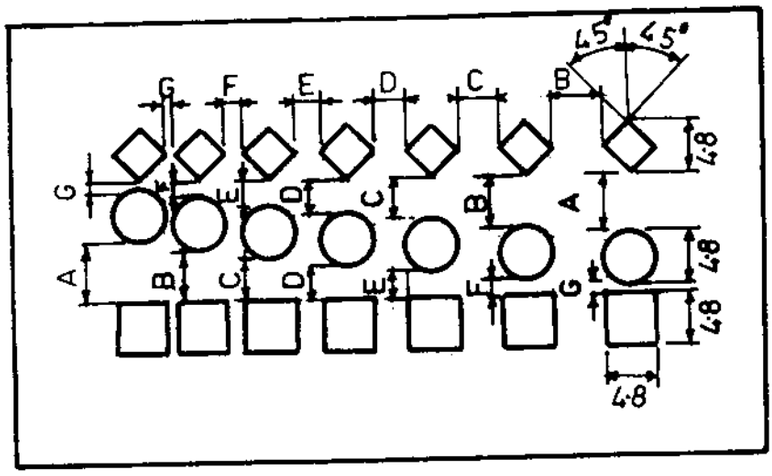
9.6 Report:

Report the arithmetic mean of the 3 values of the impact strength in kJ/m^2 ($kg\text{-}cm/cm^2$) obtained for test piece in the direction A and similarly for those of direction B, whichever is lower report it as the impact strength of the material under test.

10. PUNCHING TEST:

10.1 Procedure:

Pierce in a single operation in a sheet of nominal thickness not exceeding 2.5 mm as per the pattern shown in Fig. 4 and examine the pierced specimen for excessive lifting around the holes and excessive cracking between them.



A	B	C	D	E	F	G
5.6	4.8	4.0	3.2	2.4	1.6	0.8

Fig. 4 Pattern For Punching Test.

11. SPLITTING LOAD TEST:

11.1 General:

This test is applicable to sheets with thickness 10 mm and above.

11.2 Number of Tests:

Test shall be performed on six test specimens.

11.3 Test Specimen:

Cut the sample to the size 20 x 20 x 10 mm Sheets with above 10 mm thick shall be machined down to 10 mm uniformly on both sides.

11.4 Apparatus:

Any standard compression testing machine.

11.5 Procedure:

Condition the test specimen as in 3.1. A steel wedge with 60° included angle and 1 mm radius (See Fig. 5) is forced to delaminate the specimen. The pressure on the wedge shall be increased at a rate of 4-6 kg/sec until the sheet delaminates. Mean of 6 values shall be taken as splitting load expressed in Kg.

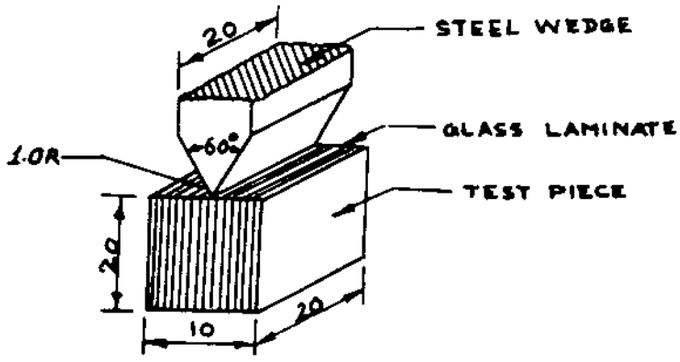


Fig. 5. Specimen and Steel Wedge for Splitting Load Test.

12. ARC RESISTANCE TEST:

12.1 Scope:

This test is intended to differentiate similar materials, with respect to their resistance to the action of a high-voltage low-current arc close to the surface of insulation, intending to form a conducting path therein.

This test is not applicable to materials that do not produce conductive paths under the action of an electric arc, or that melt or form fluid residues which float conductive residues out of the active test area thereby preventing formation of a conductive path.

12.2.1 Apparatus:

The test apparatus shall have an arc current rating of upto 40 m A and rated output secondary voltage upto 15000 volts on open circuit. It shall consist of 15 KV Transformer, variable auto transformer voltmeter (90-230 V), Milli Ammeter (10-40 mA), current control resistors, and a motor driven interruptor shall be capable of opening and closing the primary circuit according to schedule shown in the table 2 with an accuracy of ± 1/120

seconds or better. The scheme of connecting the various elements of the apparatus is shown in Fig. 6.

12.2.2 Electrodes:

Stainless steel strip electrodes shall be made from 0.15 mm stainless steel by cutting 12.7 by 25.4 mm rectangles as described in ASTMD495.

Tungsten rod electrodes shall be made from 2.4 mm diameter tungsten rod by sharpening one end as described in the same standard.

12.3 Test Specimens:

The test specimens shall 3.17 ± 0.25 mm in thickness, with a flat surface for testing such that no part of the arc is closer to the edge than 6.4 mm nor to a previously tested area than 12.7 mm. Thin materials shall be tested by first clamping them together, such as by screws, to form a specimen as close as possible to 3.2 mm in thickness.

For testing molded parts the arc may be applied to a location deemed most significant. All comparision tests of parts shall be performed similarly.

Dust, moisture, or finger marks can affect the time required to track. If thus affected, specimens or parts shall be cleaned with a cloth containing water or other suitable solvent before conditioning and shall be wiped with a dry cloth immediately before testing.

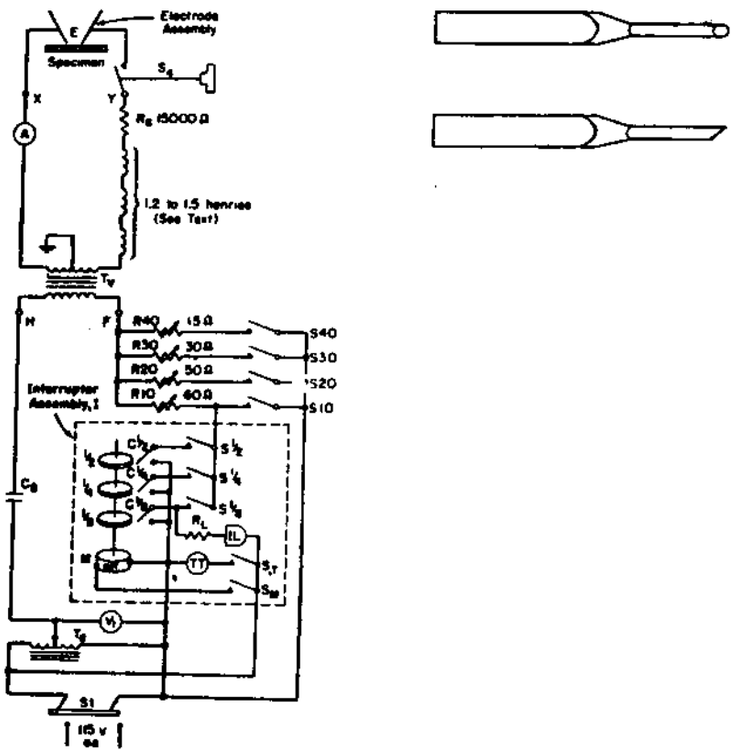


Fig. 6 Arc Resistance Test Circuit And Top & Side View of Tungsten Rod Electrode.

12.4 Conditioning:

Unless otherwise specified, the specimens shall be conditioned as per clause 3.

12.5 Procedure:

Place the specimen in a suitable holder to locate the test surface with the corners down and touching the surface. The corners shall be 6.35 $\pm$ 0.08 mm apart and the electrode edges shall make angles of 45 deg. to a line joining the corners. An electrode holder should be used. The tungsten Rod electrode Assembly, shall be as specified in ASTM D 495. Unless otherwise specified, only stainless steel strip electrodes shall be used.

The assembly shall be equipped with a transparent draft shield to prevent deflection of the arc by stray air currents. This shall completely surround the arc (not too closely) and shall be rented to permit convective flow to carry away combustion products. It shall not hinder the self alignment of the electrodes.

Lower the draft shield, close the line switch, and adjust the variable, auto transformer to obtain the open circuit secondary voltage of 12,500 V.

Begin the test sequence specified in Table 2 below and simultaneously start the interval times. At the end of each minute increase the severity in steps as shown below until a failure occurs forming a conducting path across the dielectric and the arc disappears into the material. Immediately interrupt the arc current and stop the interval timer. Record the seconds to failure.

12.6 Cleaning of Electrodes:

Two new corners of the stainless steel strip, electrodes shall be used for each test. In case of tungsten rod electrodes, after arc test, the tip of each electrode shall be freed from foreign matter.

12.7 Number of Tests:

At least five tests of a material for arc resistance time shall be made. Any larger number, as dictated by the behaviour of the material, may be made. The average and the lowest single value of time shall be noted.

12.8 Report:

The report shall include the following:

Thickness of specimen, if not a standard specimen, a description of the part.

Electrode system used and orientation whether normal or inverted.

Number of tests.

Special remarks, for instance burning, softening, and

Kind and amount of contaminant, if any.

Table 2 Sequence of 1-Min Current Steps

Step	Current mA	Time Cycle	Total Time S
1/8 - 10	10	0.25 s on, 1.75 s off	60
1/4 - 10	10	0.25 s on, 0.75 s off	120
1/2 - 10	10	0.25 s on, 0.25 s off	180
10	10	Continuous	240
20	20	Continuous	300
30	30	Continuous	360
40	40	Continuous	420

Note: A current of less than 10 mA produces an unsteady (flaring) arc.

13. FLAMMABILITY:

13.1 Test Specimen:

The specimen shall be 150 mm long, 13 mm wide and 1.5 $\pm$ 0.1 thick. Two lines shall be drawn across the specimen, one at 25 mm and the other at 127 mm from one end.

13.2 Number of Tests:

Test shall be carried out atleast on 3 specimens.

13.3 Procedure:

Condition the specimen as in clause 3.1. The specimen should be tested in a draught-free atmosphere. It shall be clamped in a rigid support at one end so that its longitudinal axis is horizontal and its transverse axis is at 45° to the horizontal and so that both lines on the specimen are clearly visible.

A piece of clean wire gauge 7 meshes per linear centimeter 130 mm square shall be clamped in a horizontal position 6 mm below specimen with 6 mm of the unsupported end of the specimen projecting beyond the edge of the gauge.

An alcohol lamp or Bunsen Burner with a non-luminous flame 13-19 mm in height shall be placed under the free end of the specimen so that the top of the flame just touches it. The flame shall be removed after 10 seconds and the specimen allowed to burn. The time taken for the edge of the flame to travel the distance of 100 mm between the two lines shall be measured with a stop watch and the rate of burning of the specimen in millimetres per minute is calculated therefrom.

The rate of burning of the material shall be the arithmetic mean of the results obtained on three specimens.

Any specimen which does not burn to the second mark shall be discarded and replaced. If three consecutive specimens do not burn to the second mark the material shall be reported as resistant to flame propagation.

If three consecutive specimens do not burn to the first work and show no flame or after glow 5 seconds after the burner has been removed the material shall be reported as self extinguishing.

13.4 Report:

The report shall state

a) The rate of burning of the material and the individual test results
or
b) that the material is resistant to flame propagation
or
c) that the material is self-extinguishing.

14. COMPARATIVE TRACKING INDEX:

14.1 General:

Comparative tracking index is the numerical value of the voltage, as determined under the conditions specified in this standard, which will cause tracking with the application of 50 drops of the electrolyte.

14.2 Tracking:

The progressive formation of a conductive path on the surface of the material between two points at different potential owing to the localized electric sparks which occur when the leakage path in surface contaminant is broken.

14.3 Test Specimen:

Any smooth flat surface may be used, provided that its area is sufficient to ensure that no liquid overflows the edges of the specimen during the test.

Convenient minimum dimensions for the test specimen are 15 x 15 mm.

Regions containing surface scratches should be avoided since these will increase the dispersion in the results.

No conditioning of the specimen is necessary. The test specimen should only be cleaned with a dry cloth, water or other solvents shall not be used.

14.4 Apparatus:

The Apparatus shall conform to IS: 2824.

14.4.1 Electrodes:

Two brass electrodes of rectangular cross section (5.0±0.1) x (2.0±0.1)mm

and approximately 20 mm long shall be used. The ends shall be bevelled to an angle of 30° and the sharpedge so formed shall be slightly rounded as shown in Fig. 7. When specially required, the electrodes may be of a different material and this fact shall then be reported.

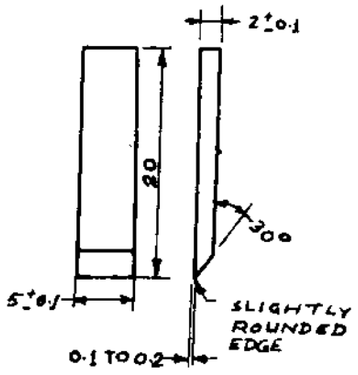


Fig. 7 (Fig 1 of IS 2824)

14. 4. 2 Supply to the electrodes:

The electrodes shall be supplied from a variable voltage alternating current source of 50 Hz, the current being limited on short-circuit to 1A at a power factor of 0. 9 to 1. 00. A manual or an automatic switch shall be included in the circuit to interrupt the supply when 0. 5 A flows between the electrodes for 2 seconds at test voltages upto and including 500 V and for 10 seconds at higher test voltages.

14. 4. 3 Circuit arrangement:

A typical circuit arrangement is shown in Fig. 8

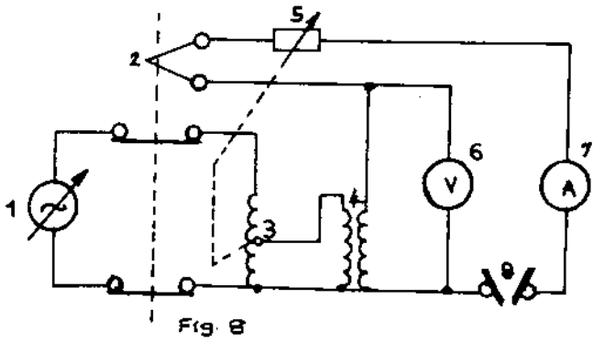


Fig. 8

1) Variable Voltage A. C. Supply
2) Over current Relay.
3) Auto transformer
4) Transformer.
5) Rheostat
6) Voltmeter
7) Ameter
8) Electrodes

14. 4. 4 Electrolyte:

The electrolyte shall be 0. 1±0. 002 percent solution of ammonium chloride (analytical Reagent grade) in distilled or deionized water conforming to IS 1070.

14.4.5 Electrolyte dropper:

The apparatus shall be capable of depositing electrolyte in drops of size 20^{+5}_{-0} mm^3 from a height of 30 ± 10 mm above the test piece at intervals of 30±5 seconds.

It has been found that an hypodermic needle having an outside diameter of 0.9 to 1.1 mm with the tip cut off square provides drops of the required size.

14.5 Procedure:

The test shall be carried out at an ambient temp. of 27°C. The test surface shall be horizontal and the electrodes shall rest on it.

Contact of the electrodes with the specimen shall be such that when light source is placed so that the light reaches the observer's eye along the surface of the specimen, no light is visible between the specimen and the electrodes. The electrodes shall be reground, if necessary, to achieve this.

The test voltage shall be applied to the electrodes and the series resistance adjusted so that a current of 1.0 ± 0.1A flows when the electrodes are short circuited.

Note: During this adjustment the over current switching device also should be short circuited.

Drops of electrolyte shall be allowed to fall on the test surface midway between the electrodes at a specified rate of until 50 or more drops have been deposited without giving rise to failure by tracking.

Test shall be made at several voltages on areas unaffected by previous test.

The voltages shall be so chosen as to enable a curve, showing the number of drops required to cause the failure by tracking as a function of voltage be drawn with sufficient accuracy to determine the comparative tracking index to with in 10%.

14.6 Test Report:

The following information shall be reported as well as other facts which may be relavent:

Quality of material tested including any surface treatment.
Thickness of test specimens.
The treatment, if any, given to produce a flat test area.
Each test voltage and the associated number of drops.
The comparative tracking index.
The maximum depth of erosion.

15. RESISTANCE TO HOT OIL:

15.1 Test Specimen:

Cut the sheet to size 75 x 75 mm square. The thickness of the test specimen shall be the thickness of the sheet except where this exceeds 25 mm, the thickness of specimen shall be reduced by machining to 25 mm leaving one face of the specimen intact.

15.2 Procedure:

Immerse the specimen in trasnformer oil of low viscosity (conforming to IS: 335) for 24 hours at a temperature between 110°C and 115°C. Examine the specimen for splitting, blistering, disintegration of appreciable working. Note: Hair line cracks do not constitute splitting.

16. ACCELERATED AGEING:

16.1 Procedure:

Keep the specimen of size 100 x 100 mm square in an electric oven at a specified temperature for 24 hours. The specimen after cooling is examined for any sign of disintegration splitting or blistering or appreciable warping. Hairline cracks on the surface are not considered as splitting.

17. MARTEN'S HEAT STABILITY TEST:
(Determination of Temperature of Deflection under Load).

Definition

Dimensional stability under heat by Martens method is the ability of a test specimen largely to preserve its shape under a given static bending stress upto a certain temperature. It is characterized by the temperature at which the increasingly heated test specimen is deflected by a given amount under load.

17.1 Apparatus:

The test apparatus shall be according to DIN 53462, viz 4-point loading apparatus as per Fig. 9.

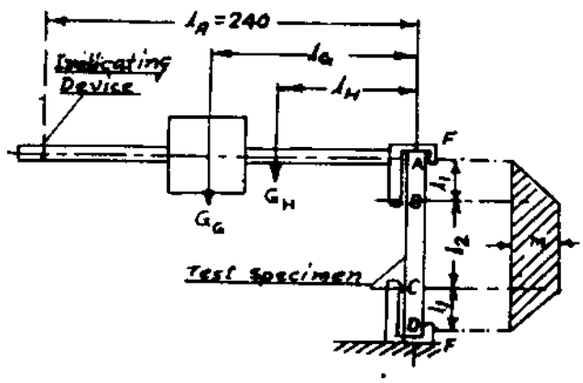


Fig. 9 Gripping Device-Schematic Arrangement.

The gripping device must allow the test specimen to be gripped in accordance with Fig 9 Each test specimen is held vertically in two clamping heads fitted with adapters, the upper head being arranged to carry a lever arm with sliding weight. An indicating device must show when the end of the lever arm has dropped by the specified amount as a result of the deflection of the test specimen.

The bending moment M exerted on the test specimen is given in kg-cm by-

$$M = G_G \cdot l_G + G_H \cdot l_H + G_A \cdot l_A \qquad (1)$$

Where

G_G is the weight force (in kg) of the sliding weight.

G_H is the weight force (in kg) of the lever arm and of the upper clamping head with adapters.

G_A is the weight force (in kg) of the indicating pin (assuming that an indicating pin is provided and the weight force G_A may be zero, for example when electrical indicating devices are used.

l_G is the distance (in cm) of the centre of gravity of the sliding weight (= centre of weight) from the longitudinal axis of the test specimen.

l_H is the distance (in cm) of the centre of gravity of the lever arm, including the upper clamping head, from the longitudinal axis of the test specimen.

l_A is the distance (in cm) of the longitudinal axis of the indicating device from the longitudinal axis of the test specimen.

17.2 Heating Chamber:

Air circulating type-hot cabinet according to DIN 50011 Sheet 1, The heating system and its control device must allow the temperature in the hot cabinet to be raised steadily from 20 to 250°C at a rate of 50°C ± 1°C per hour.

The temperature in the hot cabinet must be capable of being measured on the surface of each test specimen at mid length.

17.3 Signalling devices:

It is desirable that electrical signalling devices should be provided for the purpose of indicating when a lever arm has dropped by the amount specified one visible signal should be provided for each test specimen, and one audible signal common to all the test specimens in the same gripping device.

17.4 Measuring apparatus with a margin of error of ± 1 mm for measuring the length of the test specimen:

Measuring apparatus with a margin of error of ± 0.1 mm for measuring

the width and thickness of the test specimen. Temperature measuring apparatus with a margin of error of ± 0.5 deg.

Test Specimen: For dimensions of Test Specimen, See Table:

Table - Dimensions of Test Specimen

Test Specimen	Length Nominal Dimension mm	Length Tolerance mm	Width Nominal Dimension mm	Width Tolerance mm	Thickness Nominal Dimension mm	Thickness Tolerance mm	Gripping Appliance DIN 53462
1	120	± 2	15	±0.5	10	±0.5	3-120 or 6-120
2	60	± 1	15	±0.2	4	±0.2	3-60 or 6-60
3	50	± 1	6	±0.2	4	±0.2	3-50 or 6-50

Application of Test Specimens

Provided that no other agreement is reached, test specimens according to the type of products under testing.

Table 2 Test specimens to be used

Product to be tested	Production of test specimens	Test specimen No.
Moulding Materials	by compression moulding	1 or 2
	by injection moulding	1, 2 or 3

Mouldings of moulding materials — by machining (if the product to be tested is thicker than one of the test specimen forms mentioned down evenly from both sides to the thickness of the next thinner test specimen form)

Thickness of the product mm	Mouldings Compression moulding Test Specimen No.	Produced by Injection moulding Test specimen
≧ 10	1	1
≧4 < 10	2	2 or 3
< 4	-	-

Laminated Sheets

Thickness of the product mm	Test specimen No.
≧ 10	1
≧4 < 10	2
< 4	-

Number of Test Specimens

3 test specimen shall be tested simultaneously. When testing products with properties with a clear directional dependence (e.g. laminated sheets)

3 test specimens shall be tested in each main direction (e.g. in the longitudinal and transverse direction).

PROCEDURE:

Prior to testing the lengths of the test specimens shall be measured to an accuracy of 1 mm and the cross-sectional dimensions in the middle of the test specimen to an accuracy of 0.1 mm.

The section modulus W in cm^3 of the test specimen is

$$W = \frac{b\ h^2}{6} \qquad (2)$$

Where b is the width of the test specimen in cm, h is the thickness of the the test specimen in cm. The bending stress B of the test specimen shall be 50 kg/cm^2.

$$B = \frac{M}{W} = 50\ kg/cm^2 \qquad (3)$$

Equations (1), (2) and (3) yield the required distance l_G of the Centre of gravity of the weight from the longitudinal axis of the test specimen in cm:

$$l_G = \frac{50\ b.h^2}{6G_G} - \frac{G_H \cdot l_H + G_A \cdot l_A}{G_G}$$

According to the calculated moment of resistance W the effective bending moment M shall be set on the gripping appliance as per Table.

Table: Gripping device

Test Specimen Number	Length a mm	Width b mm	Thickness h mm	Clamping Head Fig	Gripping device	Adopter Fig	Mass of weight mG Kg
3	50	6	4	3	3-50	4	0.100
6	50	6	4		6-50		
3	60	15	4	3	3-60	5	0.200
6	60	15	4		6-60		
3	120	10	10	6	3-120	7	0.200
6	120	15	10		6-120		0.650

The test specimens are inserted the gripping appliance. The test specimens should be vertical, the lever arms of the gripping appliance horizontal (by sight).

Before placing the test apparatus in the hot cabinet, the indicating applicances are set in such a way that it is possible to record the sinking of the lever arms by 6 mm $\pm$ 0.1 mm.

During the test the temperature shall be measured close to each specimen. The dial gauge of a temperature measuring apparatus shall be placed in the middle of length of each test specimen in such a way that the difference between the surface of the dial gauge and the surface of the test specimen must be protected effeciently from the heat absorption.

The hot cabinet is heated in such a way that the temperature increases constantly every hour by 50 deg $\pm$ 1 deg.

The temperature measured after the lever arm has dropped by 6 mm $\pm$ 0.1 mm characterizes the dimensional stability under heat by Martens method.

Repeat testing:

If there is external evidence of damage on the test specimen (decomposition, formation of blisters, flaking etc) the testing shall be repeated with new test specimens. In such cases the result of the repeat testing shall be applicable.

In the case of testing carried out in succession the hot cabinet must be cooled down to 20°C $\pm$ 5 deg before introducing new test specimens.

REPORT

The test report shall make reference to this standard.

Form and dimensions of the test specimen.

In the case of test specimens, where applicable.

Particulars as to whether the test specimens has been machined in its thickness.

Dimensional stability under heat by Marten's method upto °C to the nearest 1 deg.

Individual values.

Mean value.

Where applicable, external changes in the test specimens due to the testing.

Date of Test.

18. WATER ABSORPTION

18.1 Number of Tests:

Carryout the test on three specimens.

18.2 Test Specimens:

Cut from the sheet test specimen $38.0^{+0.5}_{-0.0}$ mm. The thickness of the specimen shall be the thickness of the sheet under test except that where the nominal thickness exceeds 25 mm, the test piece shall be reduced to 25.0 ± 0.3 mm by machining, retaining one original face, smoothen the edges of the specimens with a No. 0 glass paper.

18.3 Procedure:

Condition the specimen as in 3.1. Measure the thickness to the nearest 0.03 mm, weigh to the nearest milligram and immerse for a period of 24 ± 1 hr in distilled water at a temperature between 20° and 30°C which shall not vary by more than $\pm$ 2°C. On removal from water, wipe dry the exposed surfaces with blotting paper or clean cloth. Reweigh the specimen to the nearest milligram and complete the weighing within two minutes of the removal of the specimen from water. Record the increase in weight in milligrams.

18.4 Calculation and Report:

Calculate the arithmetic mean of the three results obtained. Also calculate the mean value of the thickness of three specimens.

When the test has been carried out at an immersion temperature higher than 20°C, calculate the equivalent water absorption at 20°C by applying the correction factor given in Fig.10. Report this as the water absorption for the mean thickness of the specimen under test at 20°C.

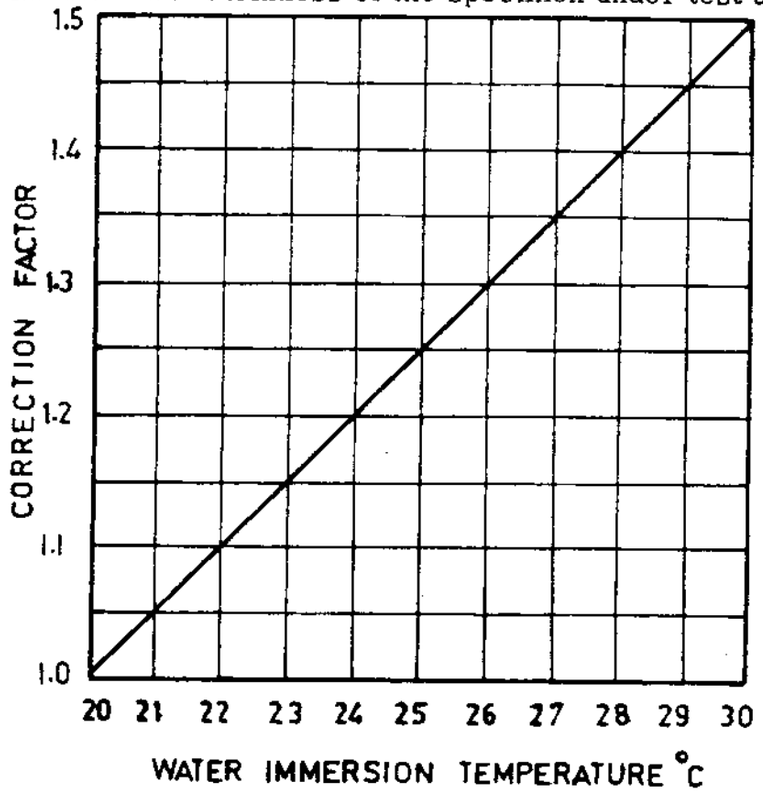


Fig. 10 Correction Factor For Interpretation of Values of Water Absorption.

19. ELECTRIC STRENGTH FLATWISE:

19.1 General:

This test is applicable for sheets upto and including 5 mm thickness.

19.2 Test Specimen:

Prepare atleast two specimens, each 150 x 150 mm square, out of the sheet under test.

19.3 Electrodes:

The upper electrode shall consist of a solid cylinder of brass 40 mm in diameter and approximately 40 mm in height.

The lower electrode shall be a brass block 80 mm in diameter and approximately 25 mm thick. The two electrodes shall be arranged as shown in Fig. 11. The sharp edge of the electrodes in contact with the specimen shall be rounded to a radius of not more than 1 mm.

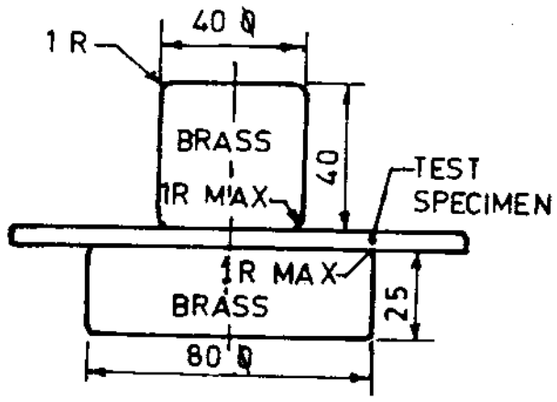


Fig. 11 Arrangement of Electrodes

19.4 Procedure:

Condition the test specimen as in 3. Place the specimen in between the electrodes as shown in Fig. 11 and immerse the whole assembly in low viscosity type insulating oil conforming to IS: 335. Maintain the temperature of oil at 90° ± 2°C with the specimen and electrodes immersed, for a period of half to one hour, after which apply an alternating voltage of frequency 50 ± 5 cycles per second between the electrodes. Start with a voltage one third of the specified proof stress and increase at the rate of approximately 1 kV per second to the specified proof stress. Maintain the proof stress for one minute.

The material shall be taken to have passed the test if there is no electrical breakdown with either of the test specimens at the specified voltage. In case the material fails, the breakdown voltage in kV/mm shall be reported for information.

20. ELECTRIC STRENGTH EDGEWISE:

20.1 General:

This test is applicable to sheets over 5 mm thick.

20.2 Test Specimens:

Prepare atleast two specimens each of 100 mm length and 25 mm width. The thickness of the specimen shall be that of the sheet under test. Finish the edges of the specimen that are in contact with the electrodes truly as parallel planes at right angles to the surface of the material, and remove any sharp corners.

20.3 Electrodes:

Two metal plates, preferably of brass, of sufficient size to cover the edges of the specimen.

20.4 Procedure:

Condition the test specimens as in clause 3. Place the specimens edgewise in between the electrodes and carry out the test as prescribed in 19.4.

The material shall be taken to have passed the test if no electrical breakdown occurs with either of the two specimens at the specified proof voltage.

21. INSULATION RESISTANCE:

21.1 General:

This test is applicable to sheets of nominal thickness upto and including 25 mm.

21.2 Number of Tests:

Carry out the test on two specimens.

21.3 Test Specimens:

Cut and drill from the sheet under test two specimens of the form and dimensions shown in Fig. 12, taking care that the three holes drilled are clean and the surfaces of the sheet are not damaged. The surfaces should be cleaned with petroleum solvent to remove dirt. Assemble the 4.5 mm brass screws, nuts and small plain washers to form the three electrodes as shown in Fig. 12.

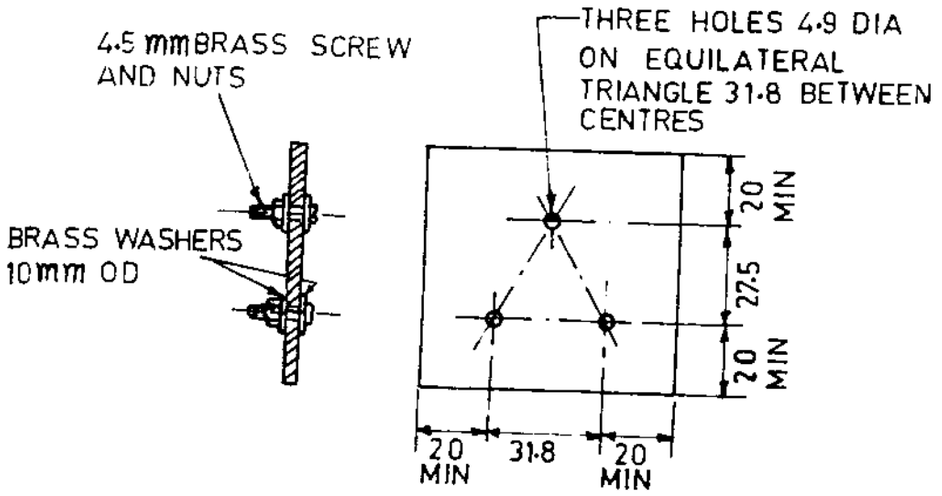


Fig. 12 Specimen And Electrodes

21.4 Procedure:

Heat the assembly for 24±1 hr at a temperature of 50°±2°C in a hot air oven. For routine test, pre-drying of the specimen may be dispensed with and the insulation resistance measured under prevailing conditions. However, to form the basis of rejection for non-compliance with the appropriate requirement testing shall be done after pre-drying as above. After allowing to cool to room temperature, immerse the assembly in distilled water for 24 ± 1 hr. at a temperature between 20° and 30°C which shall not vary by more than ± 2°C. On removal from water wipe dry the exposed surfaces with blotting paper or clean cloth.

Measure the insulation resistance between each pair of electrodes at a potential difference of 500 ± 50V dc after electrification for one minute, at a temperature of 27° ± 2°C in an atmosphere of not more than 75 per-cent relative humidity. All the readings shall be taken within five minutes of the removal of the assembly from the water.

21.5 Calculation and Report:

Calculate the arithmetic mean of the insulation resistance between the three pairs of electrodes and record it as the insulation resistance of the test specimen at the immersion temperature.

When the immersion temperature is higher than 20°C, calculate the equi-valent insulation resistance at 20°C by applying the correction factor given in Fig. 13 and report this as the insulation resistance at 20°C of the mate-rial under test. In case of dispute, the immersion should be in water at 20° ± 2°C for 24 ± 1 hr. and the insulation resistance should be mea-sured in an atmosphere of 20° ± 2°C at 65 ± 5 percent relative humidity.

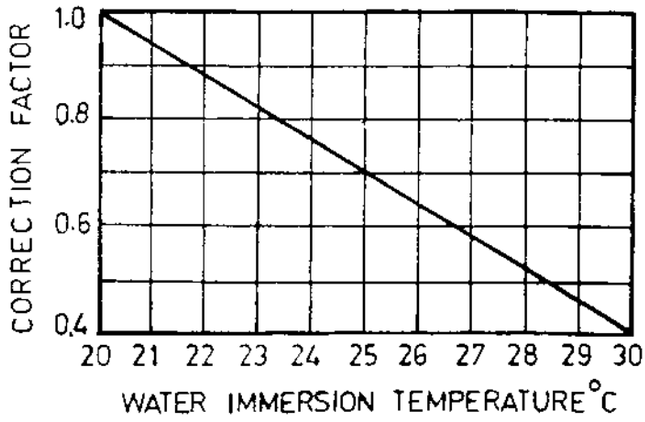


Fig. 13 Correction Factor For Interpretation of Values of Insulation Resistance.

22. LOSS TANGENT AND PERMITIVITY AT 50 Hz:

This test is in accordance with Method 205B of BS: 2782. This is applicable to Laminated sheets.

22.1 Scope:

The loss tangent of a material at 50 Hz often shows same correlation with its electric strength at power frequencies if the temperature of measurement is the same. Use may be made of this correlation, as the measurement of loss tangent can under certain circumstances be carried out on large sheets without damaging the material by cutting a special test specimen from it.

22.2 Test Specimen:

The thickness of the specimen shall be the thickness of the sheet under test The other dimensions shall be such that the specimen will accommodate the electrodes specified herein.

22.3 Electrodes:

The electrodes shall be circular and shall be applied to opposite faces of the specimen. They shall be:-

a) mercury (except that mercury is not suitable for use at 90°C), or
b) metal foil, 0.03-0.05 mm thick, applied with the thinnest possible film of petroleum jelly, or
c) brass discs applied with pressure and with their sharp edges removed. Brass discs may only be used, however, if they can be shown to give the same results as (a) or (b).

One electrode shall be surrounded by a guard ring 25 mm wide with a clearance of approximately 1.5 mm. The electrode on the opposite face

of the specimen shall have a diameter not less than that of the outer diameter of the guard ring.

The electrodes and guard ring shall be coaxial with one another. The diameter of the guarded electrodes shall be such that the capacitance can be determined to within 5% (See Note 2).

22.4 Procedure:

The temperature of test shall be 25 ± 5°C or 90 ± 1°C unless otherwise specified in the relevant material specification. The measurement of loss tangent and permitivity shall be made a schering Bridge provided with a Wanger earth. The low voltage lead shall be connected to the guarded electrode. It is recommended that the voltage applied to the specimen shall be 1000 V but it may be necessary to use a lower voltage for specimens of thickness less than 1 mm or for specimens of low electric strength.

The loss tangent of the specimen shall be expressed as Cos where $\emptyset$ is the phase angle (See Note 1).

The permitivity shall be calculated from the measured Capacitance of the specimen as follows:-

$$\text{Permitivity} = \frac{144\ Ct}{(d + W)}\ 2$$

Where

C = Capacitance of specimen in picofarads.
t = thickness of specimen in millimetres.
d = diameter of guarded electrode in millimetres.
W = width of gap between guarded electrode and guard ring in millimetres.

22.5 Report:

The report shall state:

1. The loss tangent and/or the permitivity of the material at 50 Hz.
2. The temperature at which the test was carried out.
3. The individual test results.
4. The conditioning if any, of the test specimen.

Note - 1

If tan δ, where δ is the loss angle ^{o} ($90^{o} - \emptyset$), is obtained from the bridge readings it can be converted to Cos $\emptyset$ by means of the formula:

$$\text{Cos } \emptyset = \frac{\tan\delta}{\sqrt{1 + \tan^2\delta}}$$

Cos Ø may be taken to be equal to tanδ for small values of tanδ , e.g. less than 0.2, for which value the difference is less than 2%.

Note - 2

Unless the capacitance of the specimen exceeds 200 pF, the leads connecting the specimen to the bridge network should be screened from each other and the switch used to connect the specimen should be such that the capacitance between its contacts when open does not exceed 2% of the capacitance of the specimen.

23. VOLUME RESISTIVITY:

23.1 General:

The definitions and terminology as given in IS: 3396 shall apply.

23.2 Test Specimens:

Test specimens shall be at least 120 x 120 mm for sheets. Thickness of the sheet shall be measured accurately as in Cl. 4.1.

23.3 Number of Specimens:

Two specimens shall be tested.

23.4 Electrodes:

The electrodes shall be of metal foil of 0.01 or 0.02 mm thick. A thin film of petroleum or silicone grease shall be used for keeping the electrodes in position. Electrodes shall comply with those described in Cl. 5 of IS: 3396, with the dimensions as given below: (See Fig. 14).

Recommended Dimensions of Electrodes

D1 mm	D2 mm	D3 mm
25	38	50
75	88	100

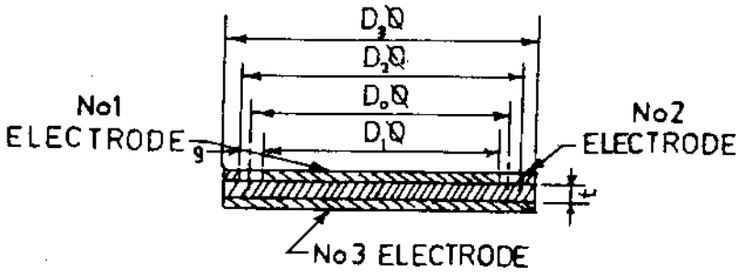


Fig. 14 Application And Arrangement of Electrodes for Plate Specimen.

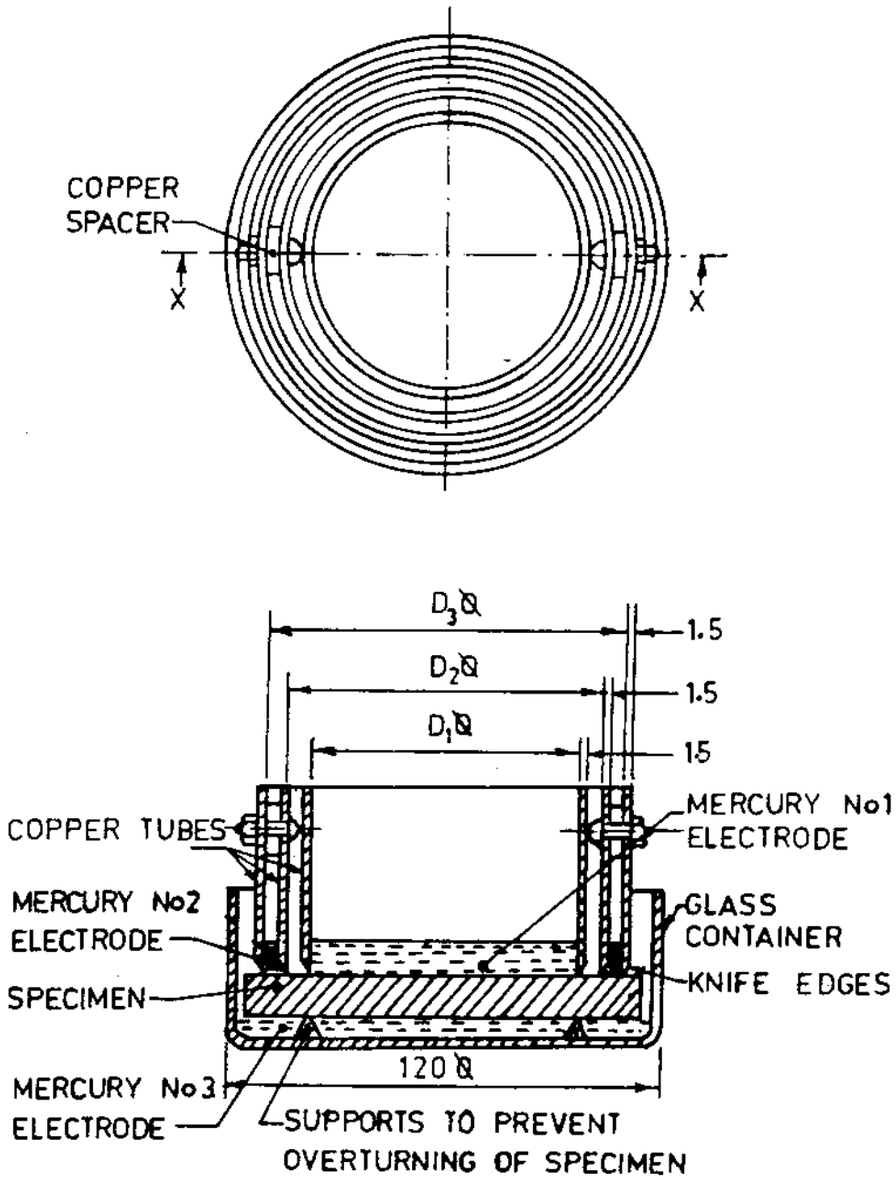


Fig. 15 Application of Mercury Electrodes to Plate Specimen

23.5 Apparatus:

A steady dc voltage source of 500 V shall be used along with a meter suitable to measure the resistance upto atleast 10^{13} Ohm with sufficient accuracy.

23.6 Conditioning:

Condition the test specimens as per Cl. 3.

23.7 Procedure:

Measure the volume resistance of the material one minute later, after applying 500 V d. c. between the upper and lower electrodes, maintaining the guard electrode at the earth potential.

23.8 Calculation:

Calculate the volume resistivity from the following formula:

$$P = \frac{A}{t} \times Rv$$

Where

P = Volume resistivity in Ohm-cm
A = effective area in cm^2 of the guarded electrodes.
t , = Average thickness of the specimen in cm.
Rv = Volume resistance in ohm.

23.9 Reporting:

Take the arithmetic mean of the logaritums i. e. geometric mean of the two values and report the volume resistivity.

24. SURFACE RESISTIVITY:

24.1 General:

The definitions and terminology as given in IS: 3396 shall apply.

24.2 Test Specimens:

Test specimens shall be at least 120 x 120 mm for sheets. Thickness of the sheet shall be measured accurately as in Cl. 4. 1.

24.3 Number of specimens:

Two specimens shall be tested.

24.4 Electrodes:

As described in Cl. 23.4

24.5 Apparatus:

As described in Cl. 23.5.

24.6 Conditions:

Condition the test specimens as per Cl. 3.

24.7 Procedure:

Measure the surface resistance one minute later after applying 500 V d.c. between the upper electrode and the guard, maintaining the bottom electrode at earth potential.

24.8 Calculation:

Calculate the surface resistivity from the following formula

$$\sigma = \frac{Pe}{g} \times Rs.$$

Where

σ = Surface resistivity in ohm.
Pe = effective perimeter of the guarded electrode
g = distance between electrodes.
Rs. = surface resistance in ohms.

24.9 Report:

Take the arithmetical mean of the logaritms of the two results, i.e., geometrical mean.