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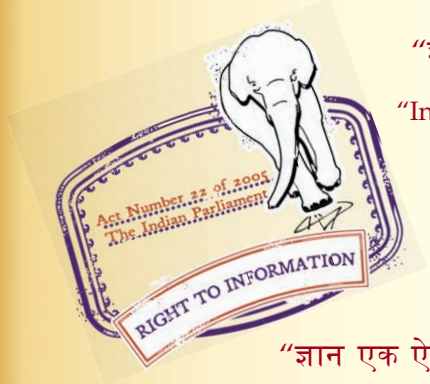

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SPECIFICATION FOR SYNTHETIC RESIN BONDED GLASS FIBRE (SRBGF) FOR ELECTRICAL PURPOSES

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NEW DELHI 110002

Gr 6 *January* 1983

Indian Standard

SPECIFICATION FOR SYNTHETIC RESIN BONDED GLASS FIBRE (SRBGF) SHEETS FOR ELECTRICAL PURPOSES

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Indian Standard

SPECIFICATION FOR SYNTHETIC RESIN BONDED GLASS FIBRE (SRBGF) SHEETS FOR ELECTRICAL PURPOSES

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 15 February 1982, after the draft finalized by the Solid Electrical Insulating Materials Sectional Committee had been approved by the Electrical Division Council.

0.2 This standard covers the general requirements and methods of test for physical, electrical, mechanical and thermal properties of synthetic resin bonded glass fibre (SRBGF) sheets.

0.3 Thermosetting synthetic resin bonded sheets made from glass-fibre reinforcements are superior to those made from cellulosic reinforcements, such as paper, wood veneer and cotton fabric, in that they have generally better combination of electrical, mechanical and physical properties, and superior thermal characteristics. Glass fibre reinforced materials are more difficult to machine and require special technique. It is advisable to follow the recommendations of the manufacturers for this, as well as, employ efficient dust extraction/collection system at the time of machining for human safety.

0.4 This standard is a representative document of the practical needs of the user industry, rather than an analysis of the various available materials. It emphasises the importance of having a wide range of levels of properties with different combinations in order to meet the generally expected levels of performance in electrical equipment. It also provides better guidance to users of such materials by incorporating such features and suggesting possibilities that do not restrict the scope for the designer of electrical equipment for the selection of a suitable material.

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

ISO/R 179-1961 Plastics — Determination of the Charpy impact resistance of rigid plastics (Charpy impact flexural test). International Organization for Standardization.

ASTM D532-1968 Polyester glass mat sheet laminate. American Society for Testing Materials.

ASTM D709-1971 Testing of rigid sheet and plate materials used for electrical insulation. American Society for Testing Materials.

IEC 216-1 (1974) Part 1: Guide for determination of thermal endurance properties of electrical insulating materials — General procedures for the determination of thermal endurance properties, temperature indices and thermal endurance profiles. International Electrotechnical Commission.

IEC 216-2 (1974) Part 2: Guide for determination of thermal endurance properties of electrical insulating materials — List of materials and available tests. International Electrotechnical Commission.

BS 2782-1970 Methods of testing plastic. British Standards Institution.

BS 3953-1965 Synthetic resin bonded woven glass fabric laminated sheets. British Standards Institution.

DIN 7707 Plastics — Thermosetting plastic materials hot-moulded laminated plastics compregnated laminated wood. Deutsches Normenausschuss.

DIN 53458 — Method of test for determination of temperature of deflection under load (Martens method). Deutsches Normenausschuss.

DIN 53462 — Test apparatus for determination of temperature of deflection under load (Martens method). Deutsches Normenausschuss.

GOST 2910-1951 Sheet textolite for electrical purposes. Gosudarstvennyi Komitet Standartov, Meri Izmeritel 'nyh Priborov SSR (USSR).

NF C26.151 Solid insulating material. Glass and epoxy — resin bonded laminated sheets. Association Francaise de Normalization.

NEMA Publication No. L1 1-1971 Industrial laminated thermosetting products. National Electrical Manufacturers' Association.

0.6 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 prescribes general requirements and methods of test (specimen details, etc) for a number of types of synthetic resin bonded glass fibre (SRBGF) sheets. The nominal thicknesses covered range from 0·5 to 70·0 mm.

2. TERMINOLOGY

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

2.1 **Flatwise** — It is the direction perpendicular to the plane of lamination.

2.2 **Edgewise** — It is the direction parallel to the plane of the lamination.

3. CLASSIFICATION

3.1 SRBGF sheets are broadly classified according to types of resins used as follows:

a) UP, based on unsaturated polyester resin system;

b) PF, based on phenolic resin system; and

c) EP, based on epoxide resin system.

NOTE — Melamine (MF) based SRBGF sheets would be considered for inclusion in the specification at a later date.

3.2 **Thermal Classification (Temperature Index)** — For a general guidance the following resin systems are recommended:

a) Phthalic acid based polyester for temperature index 120,

b) Isophthalic acid based polyester for temperature index 130,

c) Phenolic based for temperature index 140,

d) Modified phenolic based for temperature index 155,

e) Bisphenol A epoxy with appropriate hardner for temperature index 130,

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

f) Bisphenol A epoxy with appropriate hardner for temperature index 155, and

g) Epoxy novolac with appropriate hardner for temperature index 155.

3.3 Type of glass fibre reinforcements are:

a) woven,

b) non-woven, and

c) random mat.

NOTE – The glassfibre reinforcements shall be made from Type E glass containing not more than 1 percent of alkali metal oxide expressed as Na_2O.

3.4 SRBGF sheets are further classified for different combinations of properties by means of numerical suffixes.

Example: UP 1, UP 2, PF 1, PF 2, ...etc.

Details of classification, resin and reinforcement are given in Table 1 for guidance only.

4. GENERAL REQUIREMENTS

4.1 Appearance — SRBGF sheets shall be reasonably smooth and free from visible defects like loose fibres, resin concentration, discolouration, deep scratches and inclusion of foreign matter. A slight amount of black lines, spots, and wrinkles are permissible in so far as they do not affect the properties and/or performance.

4.2 Flatness

4.2.1 The test shall be conducted on sheets as manufactured or as received and not on cut panels.

4.2.2 The flatness of sheets of nominal thickness 3 mm and above shall be such that when a sheet is placed without restraint on a flat surface and a light straight edge laid in any direction upon it shall not exceed the following:

Length of Straight Edge (*in mm*)	*Maximum Departure* (*in mm*)
Up to and including 300	0·5
Over 300 and up to and including 600	3·0
Over 600 and up to and including 1 000	6·0

No limits are specified for sheets having a nominal thickness of less than 3 mm.

TABLE 1 GRADES OF SRBGF SHEETS

(*Clause* 3.4)

Sl No.	Grade	Reinforcement	Resin	Remarks
(1)	(2)	(3)	(4)	(5)
i)	UP 1	Random mat	Polyester — phthalic acid based polyester for temperature index 120	—
ii)	UP 2	Random mat	Polyester — isophthalic acid based polyester for temperature index 130	Higher electrical and mechanical properties than those of UP 1
iii)	PF 1	Woven fabric	Phenolic for temperature index 140	—
iv)	PF 2	Woven fabric	Modified phenolic for temperature index 155	Higher electrical and mechanical properties than those of PF 1
v)	EP 1	Random mat or Woven fabric	Bisphenol A epoxy with appropriate hardner for temperature index 130	—
vi)	EP 2	Random mat or Woven fabrici	Bisphenol A epoxy with appropriate hardner for temperature index 155	Higher electrical and mechanical properties than those of EP 1
vii)	EP 3	Woven fabric	Bisphenol A epoxy with appropriate hardner for temperature index 155 or Epoxy novolac with appropriate hardner for temperature index 155	Higher electrical and mechanical properties than those of EP 2

Note 1 — Wherever options of reinforcement and resin systems are indicated those will be subjected to agreement between the supplier and the buyer.

Note 2 — The non-woven reinforcements will be added later.

4.3 Dimensions and Tolerances

4.3.1 The dimensions (length and width) shall be the standard sized sheets or as agreed to between the supplier and the buyer.

Tolerance on length and width:

Up to 1 000 mm	± 35 mm
Over 1 000 mm	± 50 mm

4.3.2 The thickness of the sheet shall not depart at any point from the nominal thickness by more than the appropriate value as shown in Table 2.

TABLE 2 TOLERANCE ON THICKNESS OF SHEET

All dimensions in millimetres.

Nominal Thickness		Tolerance (±)	
Over	Up to and including	Grade EP/PF	Grade UP
(1)	(2)	(3)	(4)
—	0·5	0·10	—
0·5	1·0	0·20	0·30
1·0	2·0	0·20	0·35
2·0	3·0	0·25	0·40
3·0	5·0	0·50	0·70
5·0	7·0	0·75	0·90
7·0	10·0	0·90	1·20
10·0	15·0	1·10	1·50
15·0	20·0	1·25	1·75
20·0	25·0	1·40	2·00
25·0	30·0	1·50	—
30·0	40·0	1·75	—
40·0	50·0	2·00	—
50·0	60·0	2·50	—
60·0	70·0	3·00	—

4.4 Characteristics — The characteristics of the SRBGF sheets when tested in accordance with the methods specified in Table 3 shall comply with the requirements specified therein.

4.4.1 All the tests, unless otherwise specified, shall be carried out under standard atmospheric conditions as specified in IS : 2260-1973*.

5. PACKING AND MARKING

5.1 Packing — The sheets shall be supplied in packages as agreed to between the supplier and the buyer.

5.2 Marking — The consignment shall be marked suitably with the name of manufacturer or his trade-mark, if any, the grade, nominal thickness and batch number of the sheet.

5.2.1 The product may also be marked with Standard mark.

5.3 The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

6. SAMPLING AND ACCEPTANCE

6.1 Routine and Acceptance Tests

6.1.1 One sheet chosen at random out of every 20 sheets subject to a maximum of 2 percent of a supply batch shall be subjected to routine tests.

6.1.2 The number of samples for individual tests shall be in accordance with the test methods specified in Table 3, unless otherwise stated.

6.1.3 *Criteria for Acceptance*

a) The arithmetic mean of the test results for an individual test shall be the value specified in Table 3, and

b) The lowest value obtained for any test shall not be less than 90 percent of the specified value. This is to allow for variations arising out of human error, sample cutting, etc.

6.2 Type Tests — Unless otherwise agreed to between the supplier and the buyer these tests shall be carried out once in two years.

*Specifications for preconditioning, conditioning and testing of solid electrical insulating materials (*first revision*).

TABLE 3 SCHEDULE OF CHARACTERISTICS

[*Clauses* 4.4, 6.1.2 *and* 6.1.3 (a)]

Sl No.	Characteristic	Unit	Grades							Method of Test	Type of Test
			UP 1	UP 2	PF 1	PF 2	EP 1	EP 2	EP 3		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	PHYSICAL										
i)	Specific gravity, *Min*	—	1·6	1·6	1·7	1·7	1·7	1·7	1·8	Appendix A	Routine
ii)	Water absorption, *Max*	Percent	———			*See* Appendix B			———	12 of IS : 1998-1962*	Routine
	MECHANICAL										
iii)	Tensile strength, *Min*	N/mm²	120	180	160	180	200	230	250	5 of IS : 1998-1962*	Type
iv)	Cross breaking strength, *Min*	N/mm²	160	200	180	200	300	320	350	6 of IS : 1998-1962*	Routine
v)	Compressive strength, *Min*	N/mm²									
	Thickness: 5-12 mm		200	200	280	300	300	350	400	8 of IS : 1998-1962*	Routine
	More than 12 mm		230	250	300	350	350	400	450		
vi)	Impact strength edgewise, *Min*	KJ/m²	30	40	50	60	75	75	75	Appendix C	Type
vii)	Shear strength, *Min*	N/mm²	50	60	90	100	100	100	100	7 of IS : 1998-1962*	Type
viii)	Splitting resistance, *Min*	kN	0.75	0·90	1·30	1·50	2·50	2·50	2·50	Appendix D	Type

Sl No.	Characteristic	Unit	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Method of Test	Type or Routine Test
	ELECTRICAL										
ix)	Electrical strength, *Min* (proof voltage at 90°C in oil conforming to IS : 335-1972†)										
	a) Flatwise up to 5 mm thickness	kV/mm	6	8	6	8	10	12	14	13 of IS : 1998-1962*	Routine
	more than 5 mm	kV/mm	5	6	5	6	8	10	12		
	b) Edgewise—5 mm and above thickness	kV	30	40	20	30	40	40	40	14 of IS : 1998-1962*	Routine
x)	Insulation resistance, *Min*	Megohms	500	500	500	500	1 000	2 000	1 0000	15 of IS : 1998-1962*	Routine
xi)	Dissipation factor, *Max* at 50 Hz	—	0·06	0·04	0·20	0·1	0·03	0·02	0·02	IS : 4486-1967‡	Type
xii)	Permittivity at 50 Hz	—	4 to 6								
xiii)	Comparative tracking, *Min* index	Volts	300	300	100	100	200	200	250	IS : 2824-1975§	Type
	THERMAL										
xiv)	Martens heat distortion temperature, *Min*	°C	100	120	180	180	150	160	160	Appendix E	Routine

NOTE 1 — Sheets of more than 5 mm thickness shall be machined on one face to 5 mm thickness, for electrical strength test given at Sl No. 9(ii).

NOTE 2 — Martens heat distortion temperature is not applicable for sheets for thickness less than 4 mm.

*Methods of test for thermosetting synthetic resin bonded laminated sheets.

†New insulating oils for transformers and switchgear (*second revision*).

‡Recommended methods for the determination of the permittivity and dielectric dissipation factor of electrical insulating materials at power, audio and radio frequencies including metre wavelengths.

§Method for determining comparative tracking index of solid insulating materials under moist conditions (*first revision*)

APPENDIX A

[*Table* 3, *Sl No.* (i)]

METHOD OF TESTING SPECIFIC GRAVITY

A-1. TEST SPECIMEN

A-1.1 The specimen used for the determination of water absorption may be used. Dimensions of the specimen shall be a square piece of dimension 40 ± 1 mm and of thickness *t*, when the thickness of the specimen is less than 25 mm. In the case of thicker specimen, one of the faces shall be machined to bring the sample thickness to 25 mm. Tolerances in the thickness shall be as specified in Table 2. The faces as well as the edges shall be smooth.

A-1.2 Procedure — The specimen shall be weighed in air by suspending it with a thread to the hook of a balance. It shall then be weighed under fresh distilled water, case being taken to remove any air bubbles from sticking to the specimen. Before taking the weight in water, sufficient time should be allowed for the specimen to attain the temperature of water.

A-1.3 Calculations — The specific gravity of the specimen is calculated using the equation:

$$\text{Specific gravity} = \frac{W_1}{W_1 - W_2}$$

where

W_1 = weight of the specimen in air, and

W_2 = weight of the specimen under water.

A-1.4 The arithmetics mean of the results of at least three specimens shall be taken as the specific gravity of the material under test.

APPENDIX B

[*Table* 3, *Sl No.* (ii)]

LIMITS OF WATER ABSORPTION (PERCENT)

Thickness in mm								
Above	Up to and Including	UP 1	UP 2	PF 1	PF 2	EP 1	EP 2	EP 3
—	1	2·00	1·60	5·00	3·50	0·50	0·50	0·40
1	1·5	1·70	1·40	3·70	1·70	0·40	0·40	0·30
1·5	3	1·40	1·10	2·50	1·30	0·30	0·30	0·20
3	5	0·80	0·70	2·20	1·10	0·30	0·30	0·15
5	10	0·75	0·60	2·00	0·80	0·20	0·20	0·15
10	15	0·70	0·55	1·80	0·60	0.20	0·20	0·10
15	20	0·55	0·45	1·40	0·50	0·15	0·15	0·10
20	25	0·50	0·40	1·20	0·40	0·15	0·15	0·10
More than 25		—	—	—	—	0·15	0·15	0·10

APPENDIX C

[*Table* 3, *Sl No.* (vi)]

METHOD FOR TESTING IMPACT STRENGTH (EDGEWISE) CHARPY IMPACT TEST

C-1. GENERAL

C-1.1 This method prescribes the procedure for conducting the Charpy impact test on notched specimen for SRBGF sheets.

C-1.2 The test consists of breaking by one blow from a swinging hammer, under prescribed conditions, a test specimen notched in the middle and supported at each end. The energy absorbed by a given cross sectional area to failure shall be calculated as under:

$$\frac{\text{Energy absorbed in } N/\text{mm}}{\text{Cross-sectional area in mm}^2}$$

C-1.3 The testing machine shall be of pendulum type and comply with the following requirements:

Distance between supports (L) in mm	$= 70{\cdot}0 \begin{smallmatrix} +0{\cdot}5 \\ -0{\cdot}0 \end{smallmatrix}$
Radius of curvature of supports in mm	= 1
Taper of supports	= 1:5
Angle at the tip of hammer	$= 30° \pm 1°$
Radius of curvature of the top of hammer	= 2 to 2·5
Velocity of the centre of the striking edge at the instant of impact in m/s	= 3·8

C-1.4 For a standard test the striking energy of the testing machine shall be 400 ± 10 N/mm.

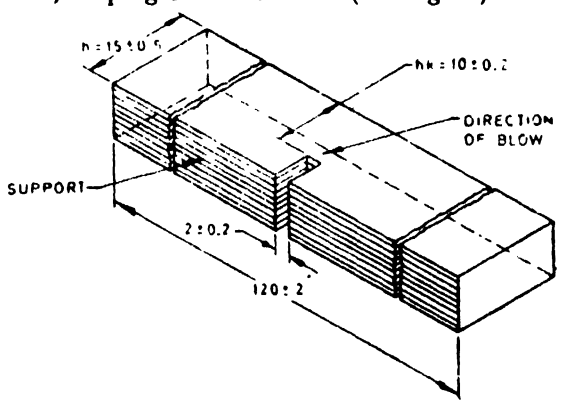
C-1.5 The accuracy of graduation of the scale of the machine shall be 0·5 percent of the maximum striking energy of the machine.

C-1.6 The testing machine shall be rigidly constructed and installed steadily. The machine shall be so constructed that the loss of energy (such as from translation, rotation or vibration) in the machine framework during a test is negligible. The plane of swing of the hammer shall be vertical and so aligned that it will make contact across the full width of the specimen.

C-1.7 The test specimen shall be supported against two rigid blocks in such a position that its centre of gravity shall be on a tangent to the arc of travel of the centre of percussion of the pendulum drawn at the position of impact.

C-2. TEST SPECIMEN

C-2.1 The specimen shall be a rectangular bar of length 120 ± 2 mm and breadth 15 ± 0·5 mm cut from a sheet of thickness not less than nominal thickness of 5·0 mm. The thickness of the test specimen shall be the thickness of the sheet except that where this exceeds nominal thickness of 10·0 mm, the thickness shall be reduced to 10 ± 1·0 mm by machining down the surface, keeping one face intact (*see* Fig. 1).



All dimensions in millimetres.

FIG. 1 TEST SPECIMEN FOR IMPACT STRENGTH

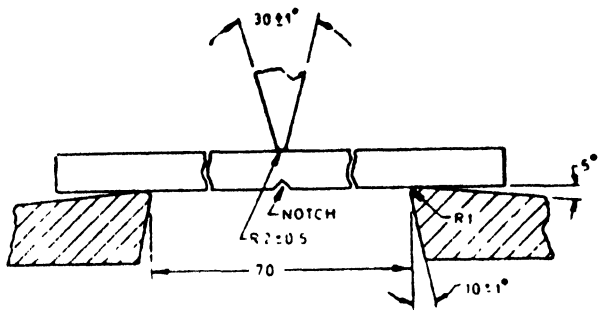
C-2.2 The test shall be carried out on ten specimens, five in direction *A* and five in direction *B*.

C-2.3 Test shall be conducted on specimen in as received condition.

C-3. TEST PROCEDURE

C-3.1 The test specimen shall be supported against the steel blocks, so that the blow will strike at the centre of the specimen. The specimen shall be so placed that edge of the test specimen receives the blow (*see* Fig. 2).

C-3.2 The test shall be conducted at the specified temperature and should not depart from the same by ± 2°C. If the temperature of testing is not specified, it shall be taken as 27°C subject to the above tolerance.



All dimensions in millimetres.

FIG. 2 ARRANGEMENT FOR IMPACT STRENGTH TEST

C-4. REPORT

C-4.1 The arithmetic mean of the five values of impact strength obtained in the direction *A* or the direction *B* of the test specimen whichever is lower, shall be reported as the impact strength of the material under test in KJ/m^2.

APPENDIX D

[*Table* 3, *Sl No.* (viii)]

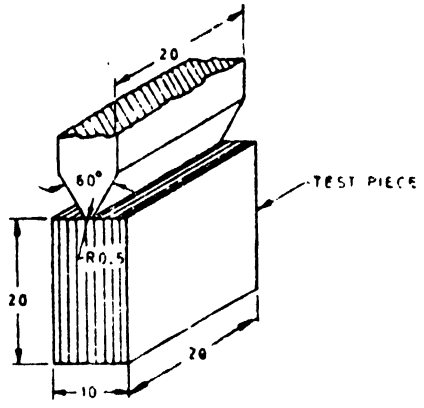
METHOD OF TESTING SPLITTING RESISTANCE

D-1. GENERAL

D-1.1 This test precribes the method of conducting splitting test to check the bond strength of thermosetting synthetic resin bonded laminated sheets. This test is applicable to sheets of nominal thickness of 10·0 mm and above.

D-1.2 Number of Tests — The test shall be carried out on four specimens.

D-1.3 Test Specimen — Each specimen shall be a rectangular bar of 20 × 20 × 10 mm. The thickness of the test specimen shall be the thickness of the sheet under test except that where this exceeds 10·0 mm, the thickness of the specimen shall be reduced by machining down to 10·0 mm uniformly on both sides (*see* Fig. 3).



All dimensions in millimetres.

FIG. 3 SPLITTING RESISTANCE TEST

D-1.4 Apparatus — A suitable compression testing machine, capable of developing a load of about 20 kN shall be used.

D-1.5 Procedure — The test shall be carried out on the test piece in as received condition. The test specimen is gripped between a flat surface and a wedge is placed on the centre of the test piece in the direction parallel to its laminations. The force on the wedge shall be increased at a rate of 40-60 N/S, to split the test piece.

D-1.6 Report — The arithmetic mean of the four values of force shall be reported as the splitting resistance of the material under test.

APPENDIX E

[*Table* 3, *Sl No.* (xiv)]

METHODS OF TEST OF MARTENS HEAT DISTORTION TEMPERATURE

E-1. OUTLINE OF THE METHOD

E-1.1 — 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 up to a certain temperature. It is characterized by the temperature at which the increasingly heated specimen is deflected by a given amount under load.

E-2. TEST BAR

E-2.1 For the purpose of this test, the test specimen of the following dimensions shall be prepared:

Thickness of the Sheet	*Specimen Dimension in mm*			*Specimen Thickness (Height)*
	Specimen Form	Specimen Length *a*	Specimen Width *b*	
10 mm and above	1	120 ± 2	15 ± 0·5	10 ± 0·5
4 mm and up to 10 mm	2	60 ± 1	15 ± 0·2	4 ± 0·2

NOTE — If the sheet to be tested is thicker than one of the specimen from mentioned above, it shall be machined down evenly from both sides to the thickness of the next thinner specimen form.

E-3. TEST APPARATUS

a) Length measuring scale and calipers;

b) Calibrated fine-reading thermometers from 0 to 250°C graduated at intervals of 1°C;

c) Gripping and indicating device – To permit the test specimen clamped in a position in the manner shown in Fig. 4. An indicating device shall show when the end of the lever arm has sunk to the prescribed extent as a result of deflection of the loaded specimen;

NOTE 1 — For convenience, calculations involved in designing the test apparatus are given in **E-4.**

NOTE 2 — Details of upper clamping head for gripping device are shown in Fig. 5 The lower clampping head is designed accordingly.

d) Heating oven with temperature regulating device to raise the temperature at the rate of 50 ± 1°C per hour from 27 ± 2°C to 250°C. The oven shall provide an even temperature of ± 1°C everywhere in the vicinity of test specimen. It shall be possible to measure the temperature at the side on the upper end of the first specimen and at the side in the lower end of the third specimen; and

e) Light and sound signalling device wherever necessary. It shall be an electrical signalling appliance which indicates when a lever arm has sunk to the prescribed extent, one light signal for each test specimen and joint sound signal for all test specimens.

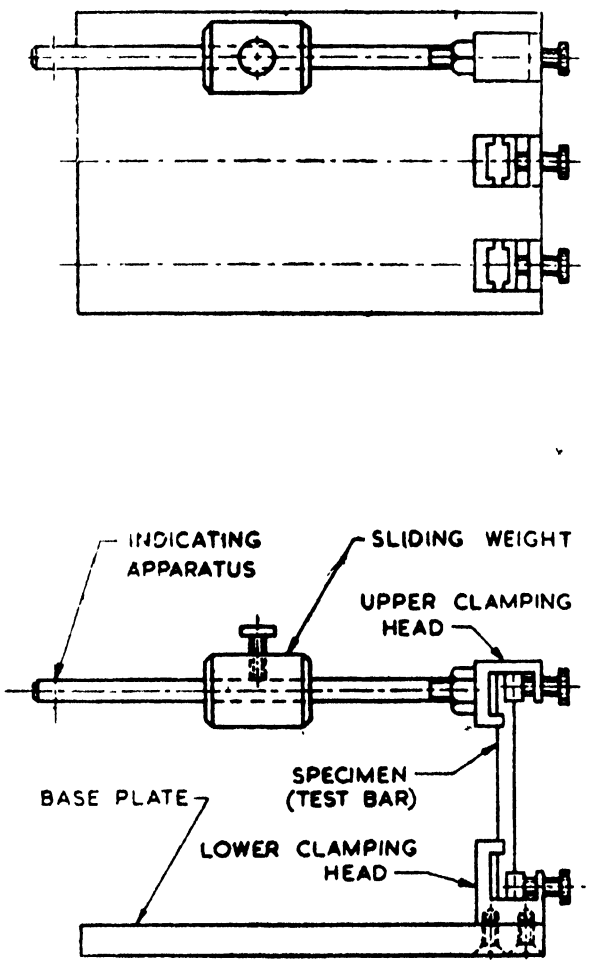
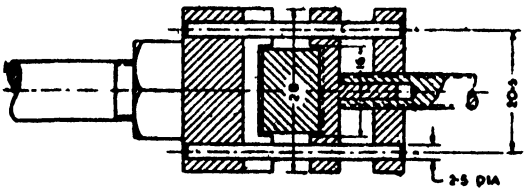
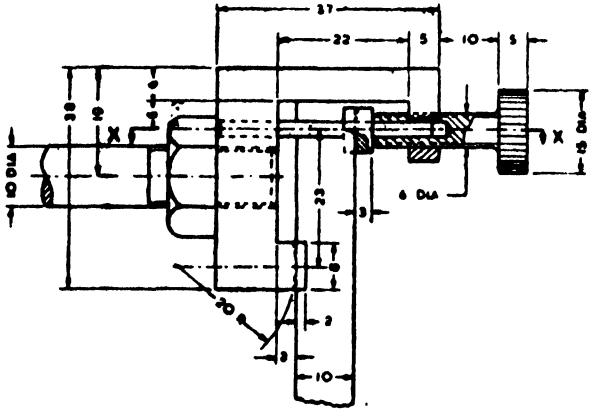


FIG. 4 APPARATUS FOR SOFTENING POINT TEST





All dimensions in millimetres.

FIG. 5 CLAMPING ARRANGEMENT

E-4. CALCULATIONS RELATING TO MARTENS TEST

E-4.1 Let the specimen be held in a vertical position by means of two clamping heads, the upper clamping head carrying a lever arm with sliding weight, as in the actual apparatus.

E-4.1.1 The bending moment to which the specimen is subjected is given by the equation:

$$M = W_s L_s + W_1 L_1 + W_p L_p$$

where

M = bending moment in N.m,

W_s = load in N of the sliding weight,

L_s = distance in m of the centre of gravity of the sliding weight from the longitudinal axis of the sample,

W_1 = load in N of the lever arm and of the upper clamping head together with its support,

L_1 = distance in m of the centre of gravity of the lever arm including the upper clamping head from the longitudinal axis of the sample,

W_p = load in N of the indicating pointer, and

L_p = distance in m of the longitudinal axis of the indicator pointer from the specimen.

E-4.2 Representation of bending moments is shown in Fig. 6. The bending moment over the length B corresponds to the moment P_{xa} (that is $M = P_{xa}$) and within certain limits of the length of specimen, the bending moment is independent of the length B. With too large a value of B, significant errors may arise during the lowering of the lever arm together with the weight through the lateral deflection of the specimen.

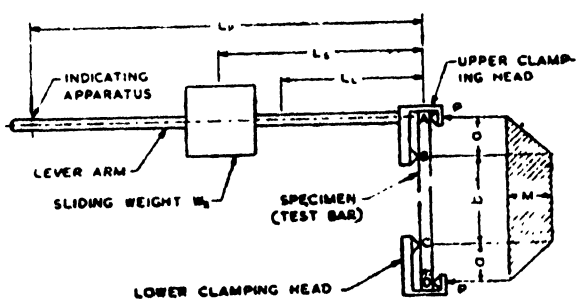


FIG. 6 DIAGRAM SHOWING CALCULATIONS OF BENDING MOMENT

E-4.3 The length L_s shall also be sufficiently large for a relatively small weight W_s so that the compressive force which W_s produces on the clamped specimen is negligible. A mass of 650 g is found to be suitable. If the length L_s is desired, it can be calculated from the following:

$$\frac{\text{Bending moment } (M)}{\text{Modulus of section } (z)} = \text{Bending stress} \qquad \ldots(1)$$

A bending stress of 5 MPa is prescribed for plastic materials for this test, that is

$$\frac{M}{z} = 5 \text{ MPa} \quad \ldots \quad (2)$$

The modulus of section of the specimen $z = \frac{bh^2}{6} m^3$ ... (3)

where

b is the width of the specimen and h its thickness in metres.

From equations (2) and (3)

$$M = \frac{5\ bh^2}{6} \times 10^6 \text{ N.m} \quad \ldots \quad (4)$$

and from (1) and (4)

$$W_s L_s + W_1 L_1 + W_p L_p = \frac{5\ bh^2}{6} \times 10^6 \quad \ldots \quad (5)$$

$$L_s = \frac{5\ bh^2}{6\ W_s} \times 10^6 \quad \frac{(W_1 L_1 + W_p L_p)}{W_s} \quad \ldots \quad (6)$$

E-5. PROCEDURE

E-5.1 Measure the cross section dimensions of the test specimen to an accuracy of 0·1 mm in the middle of the test specimen. The test bar shall be held in a clamp in a vertical position in the apparatus. It shall be subjected to constant bending stress of 5 MPa by means of the loaded arm and the load shall be calculated as given in **E-4**. The lever arm shall be horizontal. Set the indicating appliance in such a way that it is possible to record the sinking of the loading lever by 6 ± 0·1 mm.

The apparatus shall be placed in the heating oven and the temperature raised at a constant rate of 50 ± 1°C per hour.

The temperature at which the lever falls through a height of 6 ± 0·1 mm or at which the specimen breaks shall be noted.

During the test, the temperature shall be measured at the side on the upper end of the first specimen and at the side on the lower end of the last specimen. The mean temperature from the readings of the two temperature measuring points at which the lever falls through a height

of 6 ± 0·1 mm or at which the specimen breaks shall be the dimensional stability under heat by Martens method.

If the readings of the two thermometers deviate from each other during the test by more than 2°C or if there is external evidence of damage on the test specimens, the test results shall be discarded and the test shall be repeated.

In the case of tests carried out in succession the heating oven shall be cooled down to 27 ± 2°C before introducing new test specimen.

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