IS 2036 (1995): Phenolic Laminated Sheets [PCD 12: Plastics]

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फिनॉलिक परतदार चादरें – विशिष्टि

(दूसरा पुनरीक्षण)

Indian Standard

PHENOLIC LAMINATED SHEETS — SPECIFICATION

(Second Revision)

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BUREAU OF INDIAN STANDARDS
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Price Group 8

FOREWORD

This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Plastics Sectional Committee had been approved by the Petroleum, Coal and Related Products Division Council.

Phenolic laminated sheets have, in general, good machining properties, mechanical strength and electrical insulation properties. They are suitable for a wide range of mechanical and electrical applications. Reinforcement in phenolic resin bonded laminates consists usually of asbestos felt, asbestos paper, asbestos cloth, cotton or cotton/synthetic fibre mixture fabric, cellulose paper or wood veneer.

Phenolic laminated sheets may be classed into:

- sheets in which the mechanical properties in direction A and B are of the same order and for which any assessment of the mechanical strength of a sheet is based upon the lower of the values corresponding to these two directions. Such sheets are intended to be used without consideration of directions A and B;
- materials in which the mechanical properties in directions A and B are markedly different and for which any assessment of the mechanical strength of a sheet is based upon the higher of the values corresponding to these two directions. Such materials are intended to be used with due regard to the difference in the mechanical strengths associated with directions A and B.

Sheets of these classes may be further divided in accordance with their composition (reinforcements).

This standard was first issued in 1962 and was subsequently revised in 1974 to meet the general demand for a standard to cover requirements and methods of tests for paper and fabric based synthetic resin bonded laminated sheets. The paper based grades were prescribed in the order of increasing electrical properties and resistance to water absorption, while the fabric based laminated sheets were sought after because of their impact strength although they possess decreasing tensile strength. The fabric based laminated sheets could be used with discretion for usage requiring low tension electrical applications. Laminated sheets based on asbestos paper and woven asbestos fabric were kept in abeyance. The punching test and the requirements were left to the agreements between the purchaser and the supplier, pending development of a suitable and satisfactory method for carrying out the test. The first revision of this standard was based largely on the relevant British Standard BS 2572 : 1955 'Phenolic laminated sheets', which has since been revised as BS 2572 : 1990 aligning with IS 1642 : 1987 issued by the International Organization for Standardization (ISO). In this revision phenolic resin bonded laminates in which the reinforcement consisting of asbestos felt, asbestos paper, asbestos cloth, cotton or cotton/synthetic fibre mixture fabric, cellulose paper have been dealt with. Laminated sheets of only one class, namely, in which the mechanical properties in directions A and B are of the same order, have been covered. Such sheets are intended to be used without consideration of directions A and B. The sheets of this class are further divided in accordance with their composition into four groups namely, A (asbestos reinforcement); F (fabric reinforcement); P (cellulose paper reinforcement); and W (wood veneer reinforcement) comprising of various types. Phenolic resin bonded paper laminates that are specifically used in the electrical industry are represented by type A5 in this standard. Laminated sheets with wood veneer reinforcement have however, not been included in this revision. Requirements for sanded sheets produced by sanding one or both sides have also been included.

Impact strength (charpy) requirements have not been specified for P types, in line with the decision of ISO Technical Committee, TC 61 'Plastic', that impact strength requirements should not be applied to paper based industrial laminated sheets. It was agreed that for such brittle materials impact strength measurement are of little practical significance and the variability of results makes it difficult to set meaningful limiting values.

If using an asbestos material attention is drawn to the need to take account of the precautions to minimize health hazards by controlling exposure at work to asbestos fibre which may be released from electrical insulating materials.

Considerable assistance have been derived from BS 2572 : 1990 'Phenolic laminated sheet and epoxy cotton fabric laminated sheet', issued by the British Standards Institution, while preparing this revision.

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 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

PHENOLIC LAMINATED SHEETS — SPECIFICATION

(Second Revision)

1 SCOPE

1.1 This standard prescribes the requirements and methods of sampling and test for phenolic resin bonded laminated sheets of one class in which the mechanical properties in directions A and B are of the same order, with asbestos, woven cotton fabric and cellulose paper reinforcements and covers seventeen types.

1.2 This standard covers only sheets of a nominal thickness from 0·4 to 50 mm for cellulose paper based types and nominal thickness from 0·4 to 100 mm for woven cotton fabric and asbestos reinforced types.

1.3 This standard prescribes requirements for phenolic resin bonded paper laminated sheet sanded on one side, of nominal thickness in the range 0·4 mm to 3 mm inclusive.

NOTE — It is permissible for sheet complying with this standard to contain additives, for example colouring matter.

2 REFERENCES

The following standards contain provisions which through reference in this text, constitute provision of the standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard over encouraged to investigate the possibility of applying the most recent edition of the standard indicated below:

IS No.	*Title*
1998 : 1962	Methods of test for thermosetting synthetic resin bonded laminated sheets (Amendment 1)
2259 : 1963	Methods of test for determination of insulation resistance of solid insulating materials (Amendment 1)
2584 : 1963	Methods of test for electric strength of solid insulating materials at power frequencies (Amendment 1)
4486 : 1967	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
13360 (Part 1) : 1992	Plastics – Methods of testing : Part 1 Introduction
13360 (Part 2/Sec 4) : 1992	Plastics – Methods of testing : Part 2 Sampling and preparation of test specimens, Section 4 Preparation of test specimens by machining
13411 : 1992	Glass reinforced polyester dough moulding compounds (DMC)

3 DEFINITIONS

For the purpose of this standard the definition given in IS 1998 : 1962 and the following shall apply.

3.1 Phenolic Laminated Sheet

Sheet consisting of superimposed layers of paper, felt, fabric or veneer which have been coated or impregnated with a thermosetting phenolic resin and bonded together under heat and pressure.

3.2 Flatwise

Perpendicular to the plane of lamination.

3.3 Edgewise

Parallel to the plane of lamination.

3.4 Direction A and B

Two directions in the plane of a sheet which are at right angles to each other. For fabric and wood based laminates these directions are related to the surface layer of fabric or wood veneer. One of these directions is parallel either to the warp threads of a fabric or to the grain of a wood veneer. For paper or felt reinforced sheet, one of these directions is parallel to the edge of the sheet.

4 CLASSIFICATION

4.1 General

The sheets covered by this specification are classified in accordance with their composition into groups A, F and P, with subdivision into types, as described in 4.2.

4.1.1 *Group A*

Sheets with asbestos reinforcement comprising the following types:

Type	*Reinforcement*
A1	Asbestos felt
A2 and A5	Asbestos paper
A3 and A4	Woven asbestos cloth

NOTES

1 With a woven asbestos cloth reinforcement the numbers of threads per unit length of warp and weft fall usually, but not necessarily into following ranges:

Type	*Threads*/cm
A3	7 to 20
A4	3 to 7

2 All types of asbestos reinforcement used in the manufacture of Group A sheets contain up to 15 percent of organic fibre, which is essential for the manufacture of these reinforcements.

4.1.2 *Group F*

Sheets with fabric reinforcement made from cotton, or cotton/synthetic fibre mixture comprising Types F1, F2, F2/1, F3, F4 or F5.

NOTE — The numbers of the threads per unit length of warp and weft of the fabric reinforcement fall usually, but not necessarily, into the following ranges:

Type	*Threads*/cm
F1	37 to 43
F2, F2/1, F4 and F5	18 to 39
F3	12 to 20

4.1.3 *Group P*

Sheets with cellulose paper reinforcement comprising types P1, P2, P2/1, P3, P3/1 and P4.

4.2 The types covered by this standard together with applications and distinguishing properties are given in Table 1.

Table 1 Types

Types	Reinforcement	Applications and Distinguishing Properties
A1	Asbestos felt	Mechanical applications. Heat resistant.
A2	Asbestos paper	Mechanical applications. Heat resistant.
A3	Woven asbestos cloth	Mechanical applications. Mechanically better than A2. Heat resistant.
A4	do	do
A5	Asbestos paper	Mechanical applications. Heat resistant.
F1	Fine weave, bleached cotton fabric	Mechanical applications. Recommended for small parts, requiring extremely fine machining.
F2	Fine weave, cotton fabric	do
F2/1	Medium weave, scoured cotton fabric	Mechanical applications. Recommended for small parts, requiring fine machining superior machining and punching properties and better resistance to chemicals compared to the materials of F3.
F3	Coarse-weave, grey cotton fabric	Mechanical applications. Good mechanical properties, strong and tough with good machining properties. Suitable for applications requiring high impact strength.
F4	Coarse-weave, cotton fabric	Mechanical and electrical applications.
F5	Fine weave, cotton fabric	Mechanical and electrical applications.
P1	Cellulose paper	Mechanical applications. Mechanical properties better than other P types. Poor electrical properties under normal humidity. Also available in hot punching versions.
P2	do	High voltage applications at power frequencies. High electric strength under oil. Good electric strength in air under normal humidity.
P2/1	do	Electrical and mechanical applications. Good electrical properties under normal humidity. Also available in hot punching versions.
P3	do	Good electrical properties even under humid conditions. Good machining and hot punching properties. Suitable for high tension electrical applications at power frequencies.
P3/1	do	Similar properties to these of P3 but has better punching properties.
P4	do	Electrical and electronic applications. Good stability of electrical properties under high humidity. Also available in cold or hot punching versions.

NOTE — It should not be inferred from Table 1 that laminates of any particular type are necessarily unsuitable for applications other than those listed for them, or that specific laminates will be suitable for all applications within the wide descriptions given.

5 REQUIREMENTS

5.1 Appearance and Workmanship

5.1.1 Sheets shall be free from blisters, wrinkles and cracks and from other visible defects. Sheets shall be of uniform appearance and be free from other small defects, for example, scratches, dents inclusions, excessive mottling and discolouration. Sheets shall be supplied with trimmed edges.

NOTE — Untrimmed edges may be supplied if specified by the purchaser.

5.1.2 The types of surface finish shall be as agreed to between the purchaser and the supplier.

5.2 Flatness

When any sheet of nominal thickness 3 mm or more is placed without restraint, concave side up, on a flat horizontal surface, the departure at any part of the upper surface of the sheet from a light straightedge laid in any direction upon it shall not exceed the values given in Table 2.

Table 2 Departure from Straightedge

All dimensions in millimetres.

Thickness	Departure from Straightedge	
	1 000 mm Straightedge	500 mm Straightedge
3 to 8 inclusive	8	2
Over 8	6	1·5

5.3 Nominal Thickness and Permissible Deviations

The thickness of a sheet at any point shall not deviate from the nominal thickness by more than the values given in Table 3. If the nominal thickness is not one of the preferred values, the permissible deviation for the next higher preferred nominal thickness shall apply.

Thickness shall be measured using an external micrometer having measuring faces not greater than 8 mm diameter.

NOTES

1 The preferred nominal thicknesses are given in Table 3.

2 The permissible deviations from nominal thickness given in Table 3 define upper and lower limits of thickness which are symmetrically disposed about the nominal thickness. By agreement between the purchaser and the supplier, limits disposed asymmetrically about the nominal thickness may be applied. In such cases, the maximum range of tolerance should not exceed twice the value given in Table 3.

5.4 Machinability

When sawn, drilled turned, routed, milled or punched in accordance with the manufacturer's recommendations the sheet shall not show any sign of splitting, cracking or delamination.

NOTES

1 Chipping can occur with certain materials and in such instances an agreement between the purchaser and the supplier would be required.

2 For materials designated cold-punching, (for example, Type P3/1), with good punching practice sheets up to and including 1·6 mm in thickness may be punched at a temperature not less than 27°C, and in thickness over 1·5 mm up to and including 3 mm when heated to a temperature up to 60°C.

5.5 Resistance to Hot Oil

Sheets when tested in accordance with 11 of IS 1998 : 1962 shall not show any sign of splitting, blistering, disintegration, appreciable warping or delamination.

NOTES

1 This requirement does not apply to sheet of Types P3/1, A1, A2, A3, A4 or A5.

2 Types A1, A2, A3, A4 and A5 are subject to the alternative test requirement for crushing strength after heating (*see* Table 4).

5.6 Physical and Electrical Properties

When determined by appropriate test methods, various types of the material shall further comply with the requirements in Tables 4 to 6.

6 OPTIONAL REQUIREMENTS

The requirements given in Table 7 are optional. The material shall also comply with any one or all the optional requirements given in Table 7 as may be agreed to between the purchaser and the supplier.

7 SANDED SHEETS

7.1 General Quality

Sanded sheets of types P2/1, P3, P3/1 and P4 of any nominal thickness in the range 0·4 mm to 3 mm shall be produced by sanding one or both sides. Before sanding, the sheets shall comply with the basic requirements given in 5 except those in 5.3, and also with any of the optional requirements given in 6 that are specified by the purchaser. After sanding, the sheets shall comply with 7.2 to 7.4

7.2 Deviations of Thickness of Sanded Sheets

The thickness of a sanded sheet at any point shall not deviate from the nominal sanded thickness by more than ± 0·050 mm for thickness up to and including 1·6 mm and by not more than ± 0·1 mm at higher values up to and including 3 mm.

Table 3 Nominal Thickness and Permissible Deviation

(*Clause* 5.3)

All dimensions in millimetres.

Preferred Nominal Thickness	Permissible Deviation from Nominal Thickness (Plus or Minus)				
	Type A2, F2, F2/1 F3, F4 and F5	Type A1, A3 and A4	Type A5	Type F1	Type P1, P2, P2/1, P3, P3/1 and F4
0·4	[1]	—	0·10	0·09	0·06
0·5	[1]	—	0·11	0·10	0·07
0·6	[1]	—	0·12	0·11	0·08
0·8	0·19	—	0·13	0·13	0·09
1·0	0·20	—	0·14	0·15	0·11
1·2	0·21	—	0·15	0·16	0·12
1·6	0·24	0·63	0·18	0·19	0·14
2·0	0·27	0·65	0·20	0·21	0·16
2·5	0·31	0·68	0·23	0·23	0·18
3·0	0·34	0·70	0·26	0·25	0·20
4·0	0·40	0·75	0·30	0·29	0·24
5·0	0·45	0·79	0·33	0·33	0·28
6·0	0·50	0·83	0·37	0·37	0·32
8·0	0·59	0·92	0·41	0 46	0·39
10·0	0·68	1·01	0·46	0·53	0·45
12·0	0·76	1·10	0·48	0·60	0·50
14·0	0·84	1·19	0·51	0·65	0·56
16·0	0·91	1·28	0·54	0·70	0·61
20·0	1·06	1·46	0·59	0·80	0·72
25·0	1·24	1·68	0·66	0·92	0·85
30·0	1·41	1·91	—	1·03	0·98
35·0	1·56	2·13	—	1·13	1·10
40·0	1·71	2·35	—	1·23	1·23
45·0	1·87	2·57	—	1·33	1·33
50·0	2·05	2·79	—	1·43	1·43
60·0	2·42	3·23	—	1·63	—
70·0	2·80	3·68	—	1·83	—
80·0	3·20	4·12	—	2·03	—
90·0	3·60	4·56	—	2·23	—
100·0	4·00	5·01	—	2·43	—

[1] The thickness tolerance for this nominal thickness should be agreed between the purchaser and the supplier.

Table 4 Requirements for Physical Characteristics

(*Clause* 5.6)

Sl No.	Characteristics	Unit	Nominal Thickness to which Requirement Applies	Requirements for Types																Method of Test Ref to Annex of This Standard
				A1	A2	A3	A4	A5	F1	F2	F2/1	F3	F4	F5	P1	P2	P2/1	P3	P3/1	P4	
i)	Cross breaking strength, (average of direction A and direction B)	MPa	Not less than 1·6 mm	135	90	105	70	125	135	110	85	100	100	100	130	130	130	85	70	70	A
ii)	Impact strength edgewise (charpy method), (average of direction A and direction B), *Min*	kJ/m²	Not less than 5 mm	9·8	2·9	15	10	6·0	6·0	7·0	6·0	8·8	7·0	6·0	—	—	—	—	—	—	B
iii)	Shear strength, flatwise, *Min*	MPa	Less than 1.6 mm	—	55	—	—	55	65	65	65	65	60	65	75	70	70	60	50	60[1)]	C
iv)	Water absorption, *Max*	mg	All thickness	As shown in Table 5																	D
v)	Electric strength, flatwise, in oil at 90°C, *Min*	MV/m	Not greater than 3 mm	—	—	—	—	As shown in Table 6													E
vi)	Electric strength, edgewise in oil at 90°C, *Min*	kV	Greater than 3 mm	—	—	—	—	3	2	1	7	1	15	20	—	20	20	25	25	30	F
vii)	Dissipation factor (Loss tangent) at 1 MHZ, *Max*	—	Not greater than 3 mm	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0·045	0·045	0·038	G
viii)	Permittivity at 1 MHZ, *Max*	—	do	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5·7	5·2	5·0	G
ix)	Insulation resistance after immersion in water, *Min*	MΩ	Not greater than 25 mm	—	0·5	—	—	20	1·0	0·5	50	0·5	50	150	1·0	10	100	1×10^3	1×10^3	3×10^4	H
x)	Crushing strength after heating, *Min*	kN	Not less than 10mm	13·5	13·5	13·5	13·5	—	—	—	—	—	—	—	—	—	—	—	—	—	J

1)For thickness of 0·8 mm and less than limit is 40.

Table 5 Limits for Water Absorption

(*Clause* 5.6)

Mean Measured Thickness[1] mm	Maximum Water Absorption, mg for Types																
	A1	A2	A3	A4	A5	F1	F2	F2/1	F3	F4	F5	P1	P2	P2/1	P3	P3/1	P4
0·4	—	—	—	—	66	186	186	—	—	—	—	413	330	111	62	62	35
0·5	—	—	—	—	68	191	191	—	—	—	—	419	343	115	63	63	36
0·6	—	—	—	—	70	195	195	—	—	—	—	424	354	119	65	65	37
0·8	—	234	—	—	72	201	201	133	201	133	133	435	374	125	67	67	39
1·0	—	236	—	—	76	206	206	136	206	136	136	446	393	129	69	69	40
1·2	—	238	—	—	80	211	211	139	211	139	139	457	403	134	71	71	41
1·6	460	242	357	318	84	220	220	145	220	145	145	478	426	142	76	76	43
2·0	490	246	372	331	90	229	229	151	229	151	151	500	440	150	80	80	46
2·5	530	252	389	347	98	238	238	157	238	157	157	521	465	160	85	85	48
3·0	575	257	407	363	104	245	245	162	245	162	162	550	482	169	90	90	50
4·0	660	268	444	396	116	256	256	169	256	169	169	587	509	186	100	100	54
5·0	750	278	480	428	128	267	267	176	267	176	176	620	527	200	110	—	57
6·0	840	289	517	461	140	277	277	183	277	183	183	645	545	216	118	—	60
8·0	1 010	310	588	526	156	294	294	194	294	194	194	689	579	242	135	—	63
10	1 190	332	661	590	168	309	309	204	309	204	204	721	601	268	149	—	65
12	1 360	353	733	655	180	324	324	214	324	214	214	747	621	292	162	—	66
14	1 540	374	807	720	192	339	339	224	339	224	224	772	642	315	175	—	68
16	1 710	395	878	784	204	354	354	234	354	234	234	794	852	332	186	—	69
20	2 060	437	1 020	913	228	384	384	253	384	253	253	830	692	364	202	—	71
25	2 500	488	1 210	1 070	260	420	420	277	420	277	277	862	718	397	219	—	74
22·5	3 000	—	1 450	1 290	—	504	504	333	504	—	—	1 030	860	476	263	—	89

One face machined[2]

[1] If the mean measured thickness of the test specimens is intermediate between two consecutive thickness given the limit is determined to the nearest mg, by straightline interpolation. If the mean measured thickness is less than the minimum thickness for which a limit is given for a type, the limit for that minimum thickness applies. For example, for type A1, if the mean measured thickness is 1·5 mm the limit is 460 mg. If the mean measured thickness is greater than the maximum thickness for which a limit is given for the type, the limit for that maximum thickness applies. For example, for type P 3/1, if the mean measured thickness is 4·1 mm, the limit is 100 mg.

[2] If the nominal thickness of the sheet exceeds 25 mm the test specimen is reduced to 2·5 ± 0·2 mm, one face being left intact (*see* Annex D), and the limits given apply.

Table 6 Requirements for Electric Strength, Flatwise, in Oil

(*Clause* 5.6)

Mean Measured Thickness[1] mm	Minimum Electric Strength[2], MV/m							
	A5	F1	F2	F2/1	F3	F4	F5	P2, P2/1 P3, P3/1 and P4
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
0·4	6·0	2·72	1·01	—	—	—	—	16·2
0·5	5·9	2·50	0·98	—	—	—	—	15·0
0·6	5·8	2·30	0 95	—	—	—	—	14·1
0 8	5·5	1·97	0 89	1·97	0·89	7 0	9·6	13·1
1·0	5·1	1·72	0 84	1·72	0·84	6·3	8·7	11·8
1·2	4 8	1·50	0 80	1·50	0·80	5 8	8·1	10 8
1·6	4·4	1·21	0·72	1·21	0·72	5·1	7·3	9·4
2·0	4·0	1·03	0·65	1·03	0·65	4 6	6·6	8·3
2·5	3·5	0·94	0·57	0 94	0·57	4·2	6·0	7·4
3·0	3·0	0·94	0·50	0 94	0·50	4·0	5·5	6·4
4·0	—	—	—	—	—	—	—	7·2[3]
5·0	—	—	—	—	—	—	—	6·3[3]
6·0	—	—	—	—	—	—	—	5·5[3]
8·0	—	—	—	—	—	—	—	4·7[3]
10 0	—	—	—	—	—	—	—	4·1[3]
12 0	—	—	—	—	—	—	—	3·7[3]
14·0	—	—	—	—	—	—	—	3·4[3]

[1] If the mean measured thicknesses of the test specimens is intermediate between two consecutive thickness, the limit is determined by straightline interpolation. If the mean measured thickness is less than the minimum for which a limit is given for a type, the limit for that minimum thickness applies. For example, for type F2/1, if the mean measured thickness is 0·79 mm the limit is 1·97 MV/m. If the mean measured thickness is greater than the maximum thickness for which a limit is given for a type, the limit for that maximum thickness applies. For example, for type F1, if the mean measured thickness is 3·1 mm, the limit is 0·94 MV/m.

[2] All values are given as r.m.s.

[3] These are optional requirements (*see* Table 7).

Table 7 Optional Requirements

(*Clause* 6)

Types	Resistant to Flatwise Compression %, *Max*	Electric Strength Flatwise, in Oil at 90°C. MV/m *Min*	Shear Strength Flatwise MPa, *Min*	Temperature at Deflection Under Load, °C, *Min*	Flammability
(1)	(2)	(3)	(4)	(5)	(6)
A1	3·0	—	—	—	Values and the test method to be agreed between the purchaser and the supplier
A2	2·5	—	—	—	
A3	—	—	—	—	
A4	—	—	—	—	
A5	2·5	—	—	—	
F1	—	—	—	—	
F2	—	—	—	—	
F2/1	—	—	—	—	
F3	—	—	—	—	
F4	—	—	—	—	
F5	—	—	—	—	
P1	3 0	—	—	—	
P2	3·0	As	70	Values to be agreed	
P2/1	3 ·0	given	70	between the pur-	
P3	3·0	in	60	chaser and the supplier	
P3/1	3·5	Table	50		
P4	2·5	6	60		
Test Method	Annex K of this standard	Annex E of this standard	Annex C of this standard	Annex H of IS 13411 : 1992	

7.3 Insulation Resistance of Sanded Sheets

The insulation resistance of sanded sheets shall be determined in accordance with Annex H. The test results shall not be less than the following:

Types	*Values*, mΩ
P2/1	30
P3	500
P3/1	100
P4	1 000

7.4 Water Absorption of Sanded Sheets

The water absorption of sanded sheets shall be determined in accordance with Annex D. The test results shall not exceed the limits obtained by adding the following increments to the limits given in Table 5 or to the limits derived from Table 5 by straightline interpolation.

Types	*Values*, mg
P2/1	35
P3	20
P3/1	20
P4	15

8 PACKING AND MARKING

8.1 Packing

The material shall be supplied in packages as agreed to between the purchaser and the supplier.

8.2 Marking

The consignment shall be marked suitably with the following:

a) Indication of the source of manufacture and trade-mark, if any;

b) Name and type of the material;

c) Nominal thickness of the sheet; and

d) Batch No. or Code No.

8.3 BIS Certification Marking

8.3.1 The sheets may also be marked with the Standard Mark.

8.3.2 The use of the Standard Mark is governed by the provisions of 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.

9 SAMPLING AND CRITERIA FOR CONFORMITY

9.1 Lot

All the packages of phenolic laminated sheets of the same group and type, produced under uniform conditions of manufacture shall constitute a lot.

9.1.1 *Number of Samples*

For ascertaining the conformity of the material in a lot to the requirements of the specification, tests shall be carried out on each lot separately. The number of packages to be selected from the lot shall depend upon the size of the lot and shall be in accordance with Table 8.

Table 8 Scale of Sampling

Lot Size (No. of Packages)	No. of Packages to be Selected in a Sample
(1)	(2)
Up to 150	3
151 to 500	4
501 and above	5

9.1.2 Each package in the sample shall be selected at random from each lot. For this purpose reference may be made to IS 4905 : 1968 'Methods of random sampling, (Amendment No. 1)'.

10 NUMBER OF TESTS

10.1 From each package selected in the sample, the sheets shall be tested for appearance and workmanship (**5.1**), flatness (**5.2**), and nominal thickness and permissible deviations (**5.3**).

10.2 The sheets having been found satisfactory as per **10.1**, shall then be further tested for the various requirements given in Tables 4, 5 and 6. The sheets shall also be tested for machinability (**5.4**) and resistance to hot oil (**5.5**). For this purpose the requisite number of sheets shall be selected at random, approximately equal in number, from each package selected as per col 2 of Table 8. The number of test specimens shall be cut from different portions of the sheets, which shall be sufficient for carrying out all the above tests.

11 CRITERIA FOR CONFORMITY

11.1 Any sample sheet failing in one or more requirements of the specification shall be termed as defective.

11.1.1 No defective sheet shall be found in the sample for the lot to be considered as conforming to the specification.

ANNEX A

[*Table* 4, *Sl No.* (i)]

DETERMINATION OF CROSS BREAKING STRENGTH

A-1 GENERAL

Carry out the test as described for flexural stress at rupture in Annex F of IS 13411 : 1992 and as modified by A-2 to A-6.

A-2 FORM OF TEST SPECIMEN

For sheet of thickness greater than 10 mm reduce the thickness to 10 mm, one face being left intact.

The length and thickness of the test piece shall be

$$l, Min = 20\ h,$$

where

l = length, and

h = thickness.

The width of the test piece may be any value between 10 and 25 mm except for materials with very coarse fillers for which the width shall be 20 to 50 mm.

A-3 NUMBER AND DIRECTION OF TEST SPECIMEN

Test five specimens with their lengths in direction A and five with their lengths in direction B.

A-4 CONDITIONING

Condition the test specimens in accordance with IS 13360 (Part 1) : 1992 (27 ± 2°C, 65 ± 5 percent RH for at least 16 h).

A-5 PROCEDURE

Perform the test at a temperature of 27 ± 2°C. Carry out the test flatwise, with the original surface of the sheet against the supports. Use a rate of relative movement of the loading member and the supports such that fracture occurs in 15s to 45s.

A-6 EXPRESSION OF RESULTS

Calculate the arithmetic means of the cross-breaking strengths of the direction A test specimens and the arithmetic mean of the cross-breaking strengths of direction B test specimens. Record the average of the two means as the test result.

ANNEX B

[*Table* 4, *Sl No.* (ii)]

DETERMINATION OF IMPACT STRENGTH, EDGEWISE (CHARPY METHOD)

B-1 GENERAL

The test specimen, supported as a horizontal beam, is broken by a single swing of a pendulum, with the line of impact midway between the supports and, in the case of notched specimens, directly opposite the notch.

B-2 APPARATUS

B-2.1 Testing Machine

B-2.1.1 The testing machine shall be of the pendulum type and shall be of rigid construction. It shall be capable of measuring the impact energy required in breaking a test specimen, the value of which shall be taken as equal to the difference between the initial potential energy in the pendulum and the energy remaining in the pendulum after breaking the test specimen. The energy scale shall be accurately corrected for friction and air resistance losses and scale errors.

B-2.1.2 The machine shall have the following characteristics which shall be periodically checked:

Impact Energy, J	*Velocity at Impact*, m/s	*Maximum Permissible Frictional Loss*, percent	*Permissible Error After Correction*, J
0·5	2·9 (± 10 %)	4	0·01
1·0	do	2	0·01
2·0	do	1	0·01
4·0	do	0·5	0·02
5·0	do	0·5	0·02
2·7	3·8 (± 10 %)	0·5	0·02
7 5	do	do	0·05
15·0	do	do	0·05
25·0	do	do	0·10
50·0	do	do	0·10

B-2.1.3 The machine shall be securely fixed to a foundation having a mass of at least 40 times that of the heaviest pendulum in use. It shall be adjusted so that the orientations of the striker and supports are as specified in **B-2.1.4** and **B-2.1.6**.

B-2.1.4 The striking edge of the pendulum shall be tappered to an included angle of $30 \pm 1°$ and shall be rounded to a radius of $2 \pm 0{\cdot}5$ mm. It shall pass midway, to within $\pm 0{\cdot}2$ mm, between the test specimen supports, and shall be aligned so that it makes contact across the full width of rectangular test specimens. The line of contact shall be within $\pm 2°$ of perpendicular to the longitudinal axis of test specimen.

B-2.1.5 The distance between the axis of rotation and the centre of percussion of the pendulum shall be within ± 1 percent of the distance from the axis of rotation to the centre of the test specimen.

B-2.1.6 The test specimen support shall comprise two rigidly mounted smooth blocks so arranged that the longitudinal axis of a perfectly rectangular test specimen is horizontal to within 1 in 200, and the striking face of such a test specimen is parallel to the striking edge of the pendulum to within 1 in 200 at the moment of impact.

The shape of the blocks shall be as shown in Fig. 1 and the separation of the blocks (distance between lines of supports) shall be 70 mm (d). Means shall be provided to centre test specimens, in relation to the striker, to within $\pm 0{\cdot}5$ mm. Separate support blocks may be required for each test specimen type.

B-2.2 Micrometers and Gauges

Micrometers and gauges suitable for measuring the essential dimensions of test specimens to an accuracy of 0·02 mm are required.

B-3 FORM OF TEST SPECIMEN

The dimensions of the test specimens shall be as follows:

Length, $l = 120 \pm 2$ mm

Dimension, $y = 15 \pm 0{\cdot}5$ mm

Preferred value of dimensions, $x = 10 \pm 0{\cdot}5$ mm

For test specimens cut from sheet of nominal thickness from 5 mm to 10 mm, inclusive, the thickness of the test specimen shall be that of the sheet. Test specimen, from sheets of nominal thickness greater than 10 mm shall be machined uniformly on both sides to achieve a thickness of $10 \pm 0{\cdot}5$ mm.

The shape and dimensions of the notch shall be as shown in Fig. 2, $y_k = 6{\cdot}7 \pm 0{\cdot}3$; $n = 2 \pm 0{\cdot}2$.

B-4 CONDITIONING

Condition the test specimen in accordance with IS 13360 (Part 1) : 1992. ($27 \pm 2°C$, 65 ± 5 percent RH for at least 16 h).

B-5 NUMBER OF DIRECTION OF TEST SPECIMENS

Test five test specimens with their lengths in direction A and five with their lengths in direction B.

B-6 PROCEDURE

B-6.1 Check that the pendulum machine is of the correct energy range and that it has the specified striking velocity (**B-2.1.2**).

The selected pendulum shall consume at least 10 percent, but not more than 80 percent, of its stored energy in breaking the test specimen. If more than one of the pendulums described in **B-2.1.2** meet these requirements, the pendulum having the highest energy shall be used.

B-6.2 Adjust the pointer on the energy scale so that it touches the driving pin when the pendulum is in the starting position. Carry out a blank test, that is, without a specimen in place and ensure that the total frictional losses do not exceed the values given in **B-2.1.2**.

B-6.3 Measure the dimensions x and y of the test specimens, in the centre, to the nearest 0·02 mm. In the case of notched specimen, carefully measure the dimension Y_k using, for example, a micrometer fitted with an anvil of width 2 to 3 mm and of suitable profile to fit the shape of the notch. Carry out two measurements one at each end of the notch, and calculate the mean value.

B-6.4 Lift and arrest the pendulum, and adjust the pointer in accordance with **B-6.2**. Place the specimen on the supports of the machine in such a manner that the striking edge will hit the centre of the specimen. Carefully align notched specimens so that the centre of the notch is located directly in the plane of the impact, with the notch in the face of the specimen opposite the impact face (*see* Fig. 1).

B-6.5 Carefully release the pendulum. Read from the scale the impact energy absorbed by the specimen and apply such corrections for frictional losses, etc, as may be necessary. Perform the test at a temperature of $27 \pm 2°C$.

B-6.6 For calculation of test results, only completely broken specimens shall be taken into consideration. Hinged breaks where the specimen remains joined by a very thin

moulding skin may be exhibited; such breaks are acceptable.

B-7 CALCULATION AND EXPRESSION OF RESULTS

B-7.1 The charpy impact strength, of notched specimens tested edgewise, a_k in kJ/m² is given by the formula :

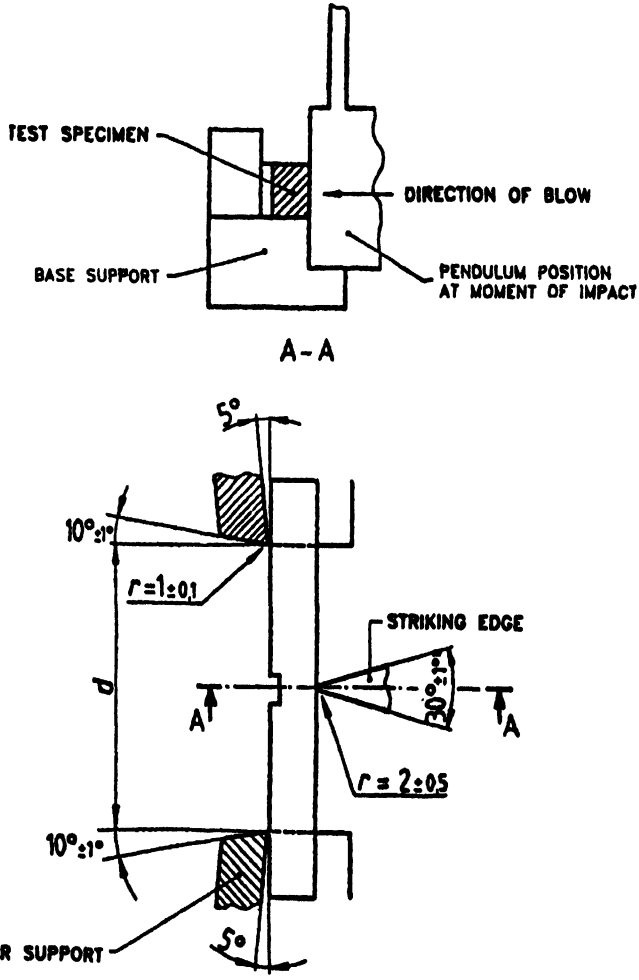
$$a_k = \frac{A_k}{x.y_k} \times 10^3$$

where

A_k is the impact energy, in joules absorbed by the notched specimen;

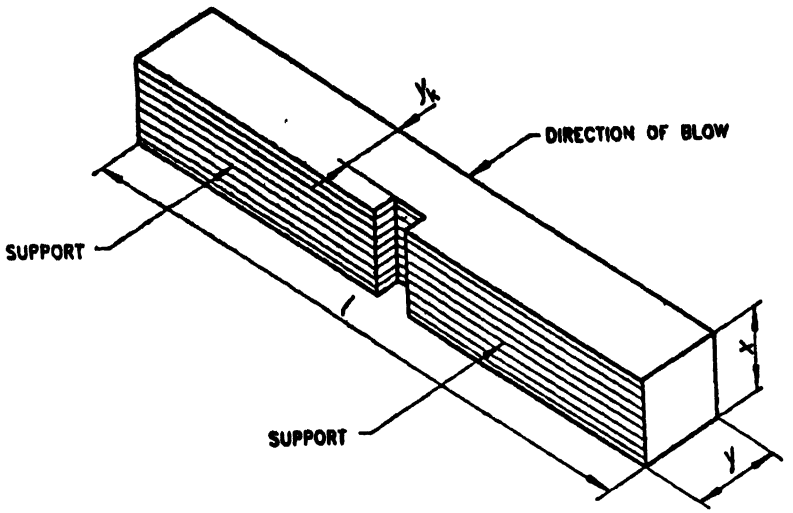
x is the dimension x, in millimetres, of the test specimens; Y_k is the dimension Y_k in millimetre of the test specimen.

B-7.2 Calculate the arithmetic mean of the impact strengths of the direction A test specimens and the arithmetic mean of the impact strength of the direction B test specimens. Record the average of the two means as the test results.



All dimensions in millimetres.

FIG. 1 STRIKING EDGE AND SUPPORT BLOCKS FOR STANDARD TEST SPECIMENS



NOTE — A U-notch is shown but the figure is equally applicable to a V-notch

FIG. 2 NOTCHED TEST SPECIMEN FOR LAMINATED SHEET TESTED IN THE EDGEWISE DIRECTION

ANNEX C

[*Table* 4, *Sl No.* (iii) and *Table* 7]

DETERMINATION OF SHEAR STRENGTH, FLATWISE

C-1 GENERAL

A test piece in the form of a 6·4 mm wide rectangular bar is tested so that both ends of the bar are simultaneously sheared using a specified punching tool assembly. A factor K is used in calculation to allow for the cylindrical curvature of the sheared surfaces.

C-2 APPARATUS

C-2.1 Compression Testing Machine

Which shall be power-driven and capable of maintaining a constant rate of movement such that the test piece fractures within 15s to 45s. A continuous indication of the force applied to the test piece, preferably recorded autographically, with a permanent indication of the maximum force, shall be provided. The force scale shall be calibrated by a suitable method to ensure that error does not exceed ±0·2 percent.

C-2.2 Punching Tool (*See* Fig. 3)

Which shall consist of a bolster, into one end of which is screwed a die, and a cylindrical punch which is a close sliding fit in the other end of the bolster. The cutting edges of the punch and die shall be re-ground as necessary to maintain maximum sharpness.

The bolster shall be provided with rectangular slots to accept the rectangular bar test piece.

C-3 TEST PIECE

Each test piece shall be a rectangular bar, 6·4 ± 0·2 mm and not less than 32 mm long. The thickness of the test piece shall be the thickness of the sheet under test, except that where this exceeds 6·35 mm the thickness of the test piece shall be reduced to 6·10 ± 0·25 mm, one original surface of the sheet being left intact.

C-4 NUMBER AND DIRECTION OF TEST SPECIMENS

Test three test specimens with their lengths in direction A and three with their lengths in direction B.

C-5 CONDITIONING OF TEST SPECIMEN

Condition the test specimens in accordance with IS 13360 (Part 1) : 1992 (27° ± 2°C, 65 ± 5 percent RH for at least 16h).

C-6 PROCEDURE

Perform the test at a temperature of 27 ± 2°C. Measure the thickness and width of the test piece at several points along the excepted lines of shear and determine the mean value of these measurements to the nearest 0·01 mm.

Immediately following conditioning and measurement, position the test piece symmetrically in the punching tool and screw the die home against the test piece in the bolster. Use only sufficient force to ensure that there is no clearance between the test piece and adjacent die and bolster surfaces.

Mount the punching tool assembly between the anvils of the testing machine and apply a steadily increasing force to the test piece by means of the punch so that the test piece fractures within 15s to 45s. Record the maximum force (F) sustained by the test piece.

Repeat the test with the remaining test pieces.

C-7 CALCULATION AND EXPRESSION OF RESULTS

C-7.1 Calculate the shear strength of each test piece using the following equation:

$$S = \frac{F}{2\,BTK} + \frac{F}{2{\cdot}096\,BT}$$

where

S is the shear strength (in MPa) of the test piece;

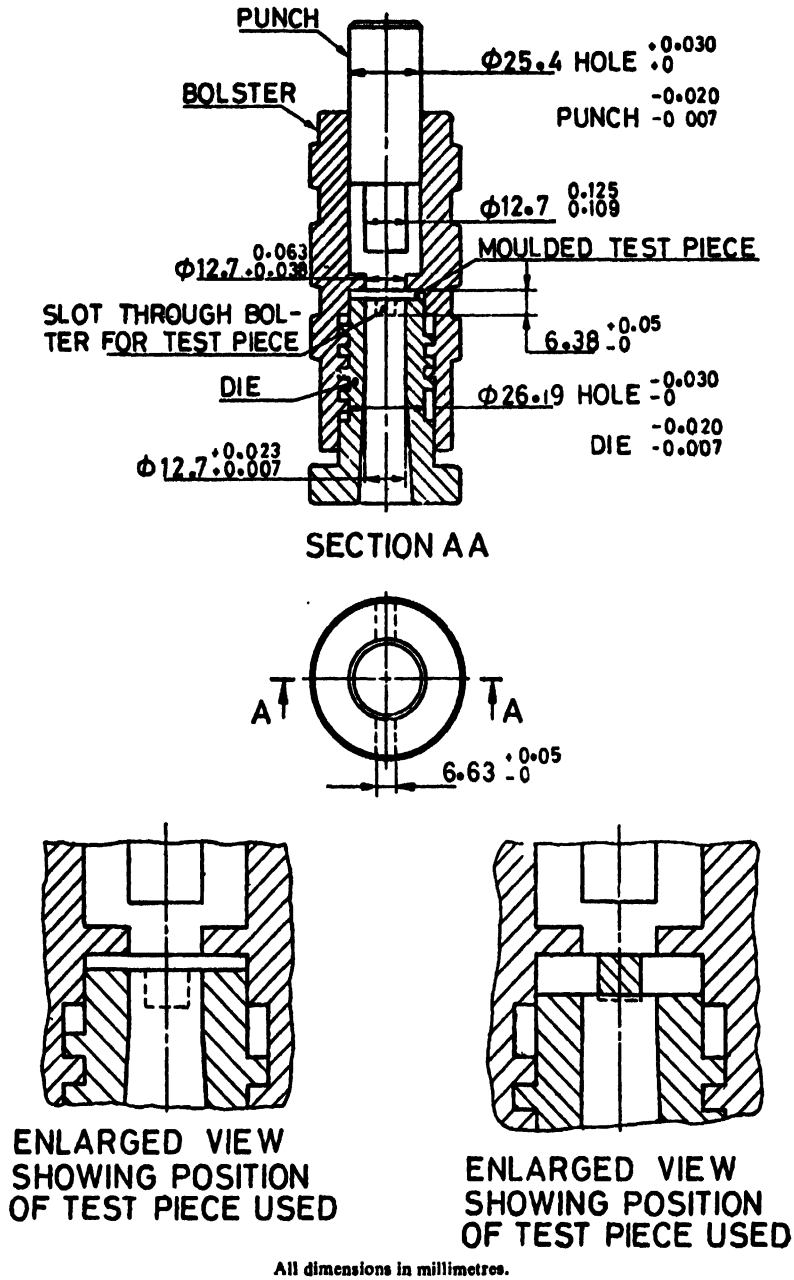
F is the force (in N) at fracture;

B is the mean width (in mm) of the test piece;

T is the mean thickness (in mm) of the test piece; and

K is the factor of constant value 1·048, introduced to allow for the cylindrical curvature of the sheared surfaces.

C-7.2 Calculate the arithmetic mean of the shear strength of the direction A test specimens and the arithmetic mean of the shear strength of direction B test specimens. Record the lower of the two means as the test result.



All dimensions in millimetres.

FIG. 3 PUNCHING TOOL ASSEMBLY

ANNEX D

[*Clause* 7.4, *Table* 4, *Sl No.* (iv) and *Table* 5]

DETERMINATION OF WATER ABSORPTION

D-1 GENERAL

Carry out the test as described in Annex D of IS 13411 : 1992 and modified by D-2 to D-4.

D-2 FORM OF TEST SPECIMEN

The specimen shall be 50 ± 1 mm square and shall be machined from the sheet under test [*see* IS 13360 (Part 2/Sec 4) : 1992].

The thickness of the test specimen shall be the same as that of the sheet under test if the nominal thickness of the sheet is equal to or less than 25 mm.

If the nominal thickness of the sheet exceeds 25 mm, reduce the thickness of the test specimen to 22·5 ± 0·2 mm, leaving one face of the sheet intact.

D-3 NUMBER OF TEST SPECIMENS

Test three test specimens.

D-4 EXPRESSION OF RESULTS

Record the arithmetic mean of the water absorptions of the three test specimens as the test results.

ANNEX E

[*Table* 4, *Sl No.* (v) and *Table* 7]

DETERMINATION OF ELECTRIC STRENGTH, FLATWISE

E-1 GENERAL

Carry out the test as described in IS 2584 : 1963 and as modified by E-2 to E-4.

E-2 NUMBER OF TEST SPECIMENS

Test at least three test specimens.

E-3 PROCEDURE

Perform the test in oil at 90±2°C. Immerse the test specimens in oil at this temperature for not less than 30 min and not more than 1 h before the test.

E-4 EXPRESSION OF RESULTS

Record the arithmetic mean of two valid electric strength measurements in megavolts per metre as the test result. Express all voltages as root mean square (rms).

ANNEX F

[*Table* 4, *Sl No.* (vi)]

DETERMINATION OF ELECTRIC STRENGTH, EDGEWISE

F-1 GENERAL

Carry out the test as described in IS 2584 : 1963 and as modified by F-2 to F-4.

F-2 NUMBER OF TEST SPECIMENS

Test at least three test specimens.

F-3 PROCEDURE

Perform the test in oil at 90±2°C. Immerse the test specimens in oil at this temperature for less than 30 min and not more than 1h before the test.

F-4 EXPRESSION OF RESULTS

Record the arithmetic mean of two valid electric strength measurements as the test results expressed in Kilovolts. Express all voltages as root mean square (rms).

ANNEX G

[*Table* 4, *Sl No.* (vii) and (viii)]

DETERMINATION OF DISSIPATION FACTOR AND PERMITTIVITY AT 1 MHz

G-1 GENERAL

Carry out the test as described IS 4486 : 1967 and as modified by G-2 and G-3.

G-2 PROCEDURE

Perform the test at 27 ± 2°C. Determine for each test specimen the power factor and permittivity at 1 MHz as described in IS 4486 : 1967.

G-3 EXPRESSION OF RESULTS

Record the arithmetic mean of the two measurements of power factor and arithmetic mean of the two measurements of permittivity as the test results.

ANNEX H

[*Table* 4, *Sl No.* (ix)]

DETERMINATION OF INSULATION RESISTANCE AFTER IMMERSION IN WATER

H-1 GENERAL

Carry out the test as described in IS 2259 : 1963 and as modified by H-2 to H-4.

H-2 NUMBER AND DIRECTION OF TEST SPECIMENS

Test two test specimens with their lengths in direction A and two with their lengths in direction B.

H-3 PROCEDURE

Maintain the distilled water at a temperature of 27 ± 2°C. Complete the electrical resistance measurement between 1·5 min and 2 min after the removal of each test specimen from the water.

H-4 EXPRESSION OF RESULTS

Calculate the arithmetic mean of the insulation resistance of the two direction A test specimens and the arithmetic mean of the insulation resistance of the two direction B test specimens. Record the lower of these two mean values in megohms as the test results.

ANNEX J

[*Table* 4, *Sl No.* (x)]

DETERMINATION OF CRUSHING STRENGTH AFTER HEATING

J-1 APPARATUS

J-1.1 Compression Testing, as described in C-2.1.

J-1.2 Parallel Flat Anvils, for insertion in each jaw of the testing machine.

J-1.3 Drying Oven Range, 0·200°C.

J-1.4 Bath, of fusible metal, capable of being maintained at a temperature of 400 ± 10°C.

J-1.5 Desiccator, containing dry calcium chloride or similar desiccant.

J-2 TEST PIECES AND NUMBER OF TEST SPECIMENS

J-2.1 Cut cubes of sides 10 ± 0·2 mm from the sheet. Alternatively, composite test pieces may be prepared from a sheet of thickness less than 10 mm, provided that the test pieces remain reasonable flat after heating.

J-2.2 Test two test specimens.

J-3 PROCEDURE

Heat two test pieces in the oven at 135 ± 5°C for 17 ± 1h and then at 170 ± 5°C for 6h ± 15 min. Then immerse the test pieces in the bath of fusible metal at a temperature of 400 ± 10°C for 30 ± 2 min, remove the test pieces from the bath of metal and allow them to cool to room temperature in the desiccator. Then place each test pieces in turn between the parallel flat anvils of the test machine and apply a steadily increasing compressive force, so that the test piece fails in 30 ± 15s. The maximum force shall be noted. Apply the force in a direction normal to the plane of the laminate (flatwise direction).

J-4 EXPRESSION OF RESULTS

Record the arithmetic mean of the two crushing forces in kilonewtons as the test results.

ANNEX K

[*Table* 7, *Sl No.* (i)]

DETERMINATION OF RESISTANCE TO FLATWISE COMPRESSION

K-1 TEST SPECIMEN

Use a test specimen 25 ± 0·25 mm square. For material less than 17 mm thick, build the test specimen up from a number of thicknesses, each with its original surfaces intact, so that the built-up test specimen has an overall thickness as near as possible to 25 mm. Remove any burrs from all edges of the test specimen.

K-2 CONDITIONING

Condition the test specimen in accordance with IS 13360 (Part 1) : 1992, (27 ± 2°C and 65 ± 5 percent RH for at least 16 h).

K-3 PROCEDURE

Test at a temperature of 27 ± 2°C.

Put the test specimen between parallel plates and apply the force in the flatwise direction uniformly over the whole area of the test specimen. Apply a force of 9 kN and, after 1 min, make the first measurement of thickness of the test specimen (whether single or composite).

Increase the force steadily at such a rate that a proof force of 53 kN, including the 9 kN initial force, is reached in approximately a further 2 min, Maintain the force of 53 kN for 1 min and determine the final thickness of the test specimen with the force on. After removal of the force, examine each component of the test specimen for sign of failure, that is, significant cracking or fracture.

K-4 EXPRESSION OF RESULTS

Calculate the reduction in thickness as a percentage of the initial thickness of the test specimen under the 9 kN force. Report any sign of failure.

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(Second Revision)

[*Page* 5, *Table* 4, *Sl No.* (i)] — Insert '*Min*' after 'Cross breaking strength'.

(PCD 12)

Reprography Unit, BIS, New Delhi, India