BRITISH STANDARD

BS 2572:1990

Reprinted, incorporating Amendment Nos. 1 and 2

Specification for

Phenolic laminated sheet and epoxy cotton fabric laminated sheet

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Plastics Standards Policy Committee (PLM/-) to Technical Committee PLM/43, upon which the following bodies were represented:

British Paper and Board Industry Federation
ERA Technology Ltd.
EEA (The Electronics and Business Equipment Association)
Electrical and Electronic Insulation Association (BEAMA Ltd.)
Ministry of Defence
Rotating Electrical Machines Association (BEAMA Ltd.)
Society of British Aerospace Companies Ltd.

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Contents

Foreword

This British Standard has been prepared under the direction of the Plastics Standards Policy Committee and is based on data provided by the British Plastics Federation. It supersedes BS 5102:1974 and BS 2572:1976 which are withdrawn.

Since the publication of BS 2572 in 1955 some of the types of phenolic laminated sheet covered in that standard have become obsolete and new types of laminate have been introduced. In drafting this standard consideration has been given to alignment with the work of the International Organization for Standardization (ISO), particularly with ISO 1642.

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.

Epoxy cotton fabric laminated sheets are similar to the corresponding phenolic cotton fabric type except that they have considerably lower water absorption, improved electrical properties and high resistance to electrical tracking.

This standard deals with phenolic resin bonded laminates in which the reinforcement consists of one of the following: asbestos felt, asbestos paper, asbestos cloth, cotton or cotton/synthetic fibre mixture fabric, cellulose paper or wood veneer. It also deals with one type of epoxy resin bonded laminate in which the reinforcement is a fine weave cotton fabric.

Phenolic resin bonded asbestos paper laminated sheets for electrical applications at power frequencies, formerly covered by BS 3253 (which has been withdrawn), are represented by type A5 in this standard.

Phenolic resin bonded paper laminates that are used specifically in the electrical industry were formerly covered by BS 5102. Phenolic resin bonded woven glass fabric laminated sheets are covered by BS 3953 and have not therefore been included in this standard.

The correspondence between the type designations in this edition and those in the 1976 edition and other standards dealing with laminated sheet is given in Table 1.

Table 1 — Relationship between types of laminated sheet specified in this standard and BS 2572:1976, BS 5102:1974 and ISO 1642

Types in this edition	Types in BS 2572:1976 (withdrawn)	Types in BS 5102:1974 (withdrawn)	Types in ISO 1642
A1	A1	—	PF AM 1
A2	A2	—	PF AP 1
A3	A3	—	—
A4	A4	—	PF AC 1
A5	A5	—	—
F1	F1	—	—
F2/1	F2/1	—	—
F6	F6	—	—
—	—	—	PF CP 2
P2	P2	3	—
P3/1	P3/1	5	—
W1	W1	—	PF WV 2
—	—	—	PF WV 1

Table 1 is only a general guide to the relationships between the types of laminated sheets in the various standards. In view of differences in limiting values, in test methods and in the ranges of properties covered, it should not be assumed that corresponding types are exact equivalents.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 14, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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1 Scope

This British Standard specifies requirements for 20 types of phenolic laminated sheet and for one type of epoxy laminated sheet as classified in clause **3**.

The ranges of thicknesses covered are as follows.

Types	Range of nominal thickness
	mm
A2, F2/1, F6	0.8 to 100
A1, A3, A4, W1, BW1, UW1	1.6 to 100
A5	0.4 to 25
F1	0.4 to 100
P2, P3/1	0.4 to 50

Requirements are included 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 1 It is permissible for sheet complying with this standard to contain additives, e.g. colouring matter.
NOTE 2 The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this British Standard the following definitions apply.

2.1
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

2.2
flatwise

perpendicular to the plane of lamination

2.3
edgewise

parallel to the plane of lamination

2.4
directions 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

2.5
epoxy bonded cotton fabric laminated sheet

sheet consisting of layers of cotton fabric which have been impregnated with a thermosetting epoxy resin and bonded together under heat and pressure

3 Classification

3.1 General

For the purposes of this British Standard laminated sheets are classified as described in **3.2** and **3.3**.

3.2 Class 1

3.2.1 *General*

Sheets in which the mechanical properties in directions A and B are of the same order. Any assessment of the mechanical strength of a sheet of this class 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.

The sheets of this class are divided in accordance with their composition into four groups A, F, P and W, with subdivision into types, as described in **3.2.2** to **3.2.5**.

3.2.2 *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

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

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

NOTE 2 All the types of asbestos reinforcement used in the manufacture of group A sheets contain up to 15 % of organic fibre, which is essential for the manufacture of these reinforcements.
NOTE 3 If using an asbestos material attention is drawn to the need to take account of the provisions of the Asbestos Regulations 1988. BS 7018 provides guidance on recommended procedures to minimize health hazards by controlling exposure at work to asbestos fibre which may be released from electrical insulating materials.

3.2.3 *Group F*

Sheets with fabric reinforcement made from cotton, or cotton/synthetic fibre mixture, comprising phenolic types F1, F2/1, and epoxy type F6.

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

Type	Threads/cm
F1 and F6	37 to 43
F2/1	18 to 39

3.2.4 *Group P*

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

3.2.5 *Group W*

Sheets with wood veneer reinforcement comprising type W1.

NOTE Special consideration should be given to the difference in mechanical properties between directions A and B in the case of type W1 sheets of nominal thicknesses near the lower end of the thickness range covered in this British Standard. Due to the use of comparatively thick veneers in the manufacture of this type of material, a thin sheet may contain a significant majority of layers with the one grain direction. Therefore, the user of thin type W1 sheets is recommended to take due note of the predominant direction of grain when cutting components from the sheet, to obtain the maximum strength in the required direction.

3.3 Class 2

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.

4 Properties

4.1 Appearance and workmanship

Sheets shall be free from visible defects.

NOTE 1 Sheets are normally supplied with trimmed edges. Untrimmed edges may be supplied if specified by the purchaser.

NOTE 2 If the purchaser requires a particular type of surface or edge finish, this should be stated in the enquiry and/or order,

In the case of type W1, all joints between veneers shall be closely butted and free from gaps or overlaps.

NOTE 3 Sheets should be of uniform appearance and are normally available free from other small defects, e.g. scratches, dents, inclusions, excessive mottling and discoloration.

4.2 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

Thickness	Departure from straightedge	
	1 m straightedge	0.5 m straightedge
mm	mm	mm
3 to 8 inclusive	8	2
over 8	6	1.5

4.3 Nominal thickness and permissible deviations

Thickness shall be measured using an external micrometer complying with BS 870 and having measuring faces not greater than 8 mm diameter.

The thickness of a sheet at any point shall not deviate from the nominal thickness by more than the value 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.

NOTE 1 The preferred nominal thicknesses are given in Table 3.

NOTE 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.

4.4 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.

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

NOTE 2 For materials designated cold-punching (e.g. 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 23 °C, and in thicknesses over 1.5 mm up to and including 3 mm when heated to a temperature up to 60 °C.

4.5 Resistance to hot oil

Sheets when tested in accordance with Appendix M shall not show any sign of splitting, blistering or delamination.

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

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

4.6 Physical and electrical properties

4.6.1 *Basic requirements*

The limiting values for any single sheet shall be as given in Table 4 to Table 7.

NOTE Impact strength (Charpy) requirements have not been given for group P types, in line with the decision of ISO Technical Committee 61, Plastics, that impact strength requirements should not be applied to paper based industrial laminated sheets. During the relevant international discussions it was agreed that for such brittle materials impact strength measurements were of little practical significance and the variability of the results made it difficult to set meaningful limiting values.

4.6.2 *Optional requirements*

NOTE The requirements given in Table 8 and Table 9 are optional and if required these should be specified by the purchaser.

The limiting values for any single sheet shall be as given in Table 8 and Table 9.

Table 3 — Nominal thickness and permissible deviations

Preferred nominal thickness[a]	Permissible deviation from nominal thickness (plus or minus)					
	Type A2, and F2/1	Type A1, A3, A4, and W1	Type A5	Type F1	Type F6	Type P2 and P3/1
mm	mm	mm	mm	mm	mm	mm
0.4	[b]	—	0.10	0.09	—	0.06
0.5	[b]	—	0.11	0.10	—	0.07
0.6	[b]	—	0.12	0.11	—	0.08
0.8	0.19	—	0.13	0.13	0.16	0.09
1	0.20	—	0.14	0.15	0.18	0.11
1.2	0.21	—	0.15	0.16	0.19	0.12
1.6	0.24	0.63	0.18	0.19	0.22	0.14
2	0.27	0.65	0.20	0.21	0.24	0.16
2.5	0.31	0.68	0.23	0.23	0.27	0.18
3	0.34	0.70	0.26	0.25	0.30	0.20
4	0.40	0.75	0.30	0.29	0.34	0.24
5	0.45	0.79	0.33	0.33	0.39	0.28
6	0.50	0.83	0.37	0.37	0.44	0.32
8	0.59	0.92	0.41	0.46	0.52	0.39
10	0.68	1.01	0.46	0.53	0.60	0.45
12	0.76	1.10	0.48	0.60	0.68	0.50
14	0.84	1.19	0.51	0.65	0.74	0.56
16	0.91	1.28	0.54	0.70	0.80	0.61
20	1.06	1.46	0.59	0.80	0.93	0.72
25	1.24	1.68	0.66	0.92	1.08	0.85
30	1.41	1.91	—	1.03	1.22	0.98
35	1.56	2.13	—	1.13	1.34	1.10
40	1.71	2.35	—	1.23	1.47	1.23
45	1.87	2.57	—	1.33	1.60	1.33
50	2.05	2.79	—	1.43	1.74	1.43
60	2.42	3.23	—	1.63	2.02	—
70	2.80	3.68	—	1.83	2.32	—
80	3.20	4.12	—	2.03	2.62	—
90	3.60	4.56	—	2.23	2.92	—
100	4.00	5.01	—	2.43	3.22	—

[a] See clause **1** and **4.3**.

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

Table 4 — Basic requirements for Class 1 materials

Property	Unit	Nominal thickness to which the requirement applies[a]	Test method appendix	Max. or min.	Type										
					A1	A2	A3	A4	A5	F1	F2/1	F6	P2	P3/1	W1
Cross-breaking strength	MPa	Not less than 1.6 mm	A	Min.	135	90	105	70	125	135	85	135	130	70	75
Impact strength, edgewise (Charpy method)[b]	kJ/m^2	Not less than 5 mm	B	Min.	9.8	2.9	15	10	6.0	6.0	6.0	3.5	—	—	6.0
Shear strength, flatwise	MPa	Less than 1.6 mm	C	Min.	—	55	—	—	55	65	65	70	70	50	—
Water absorption	mg	All thicknesses	D	Max.	As shown in Table 6										
Electric strength, flatwise, in oil at 90 °C	MV/m	Not greater than 3 mm	E	Min.	—	—	—	—	As shown in Table 7						
Electric strength, edgewise, in oil at 90 °C	kV	Greater than 3 mm	F	Min.	—	—	—	—	3	2	7	55	20	25	24

Table 4 — Basic requirements for Class 1 materials

Property	Unit	Nominal thickness to which the requirement applies[a]	Test method appendix	Max. or min.	Type										
					A1	A2	A3	A4	A5	F1	F2/1	F6	P2	P3/1	W1
Loss tangent at 1 Mhz	—	Not greater than 3 mm	G	Max.	—	—	—	—	—	—	—	0.060	—	0.045	—
Permittivity at 1 Mhz	—	Not greater than 3 mm	G	Max.	—	—	—	—	—	—	—	5.3	—	5.2	—
Insulation resistance after immersion in water	MΩ	Not greater than 25 mm	H	Min.	—	0.5	—	—	20	1.0	50	1 000	10	1 000	3.0
Crushing strength, after heating	kN	Not less than 10 mm	J	Min.	13.5	13.5	13.5	13.5	—	—	—	—	—	—	—
Proof tracking tracing index (PTI)	—	All thicknesses	N	Min.	—	—	—	—	—	—	—	500	—	—	—

[a] See clause **1** and **4.3**.
[b] See note to **4.6.1**.
[c] For thicknesses of 0.8 mm and less the limit is 40.

5 Sanded sheets

5.1 General quality

Sanded sheets of type P3/1, 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 clause **4** except those in **4.3**, and also with any of the optional requirements given in **4.6.2** that are specified by the purchaser. After sanding, the sheets shall comply with **5.2** to **5.4**.

5.2 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 thicknesses up to and including 1.6 mm and by not more than ± 0.1 mm at higher values up to and including 3 mm.

5.3 Insulation resistance of sanded sheets

The insulation resistance of sanded sheets after water immersion shall be determined in accordance with Appendix H. The test results shall be not less than the following.

Type P3/1
MΩ
100

5.4 Water absorption of sanded sheets

The water absorption of sanded sheets shall be determined in accordance with Appendix D. The test results shall not exceed the limits obtained by adding the following increments to the limits given in Table 6 or to the limits derived from Table 6 by straight-line interpolation.

Type P3/1
Mg
20

Table 6 — Basic requirements for water absorption

Mean measured thickness[a]	Maximum water absorption										
	A1	A2	A3	A4	A5	F1	F2/1	F6	P2	P3/1	W1
mm	mg	mg	mg	mg	mg	mg	mg	mg	mg	mg	mg
0.4	—	—	—	—	66	186	—	—	330	62	—
0.5	—	—	—	—	68	191	—	—	343	63	—
0.6	—	—	—	—	70	195	—	—	354	65	—
0.8	—	234	—	—	72	201	133	67	374	67	—
1.0	—	236	—	—	76	206	136	69	393	69	—
1.2	—	238	—	—	80	211	139	71	403	71	—
1.6	460	242	357	318	84	220	145	76	426	76	—
2.0	490	246	372	331	90	229	151	80	448	80	—
2.5	530	252	389	347	98	238	157	85	465	85	—
3.0	575	257	407	363	104	245	162	90	482	90	—
4.0	660	268	444	396	116	256	169	100	509	100	—
5.0	750	278	480	428	128	267	176	110	527	—	490
6.0	840	289	517	461	140	277	183	118	545	—	510
8.0	1 010	310	588	526	156	294	194	135	579	—	540
10	1 190	332	661	590	168	309	204	149	601	—	570
12	1 360	353	733	655	180	324	214	162	621	—	600
14	1 540	374	807	720	192	339	224	175	642	—	630
16	1 710	395	878	784	204	354	234	186	662	—	660
20	2 060	437	1 020	913	228	384	253	202	692	—	720
25	2 500	488	1 210	1 070	260	420	277	219	718	—	800
22.5 one face machined[b]	3 000	—	1 450	1 290	—	504	333	263	860	—	850

[a] If the mean measured thickness of the test specimens is intermediate between two consecutive thicknesses given, the limit is determined to the nearest milligram by straight line 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 P3/1, if the mean measured thickness is 4.1 mm, the limit is 100 mg.

[b] If the nominal thickness of the sheet exceeds 25 mm the test specimen is reduced to 22.5 ± 0.2 mm, one face being left intact (see Appendix D), and the limits given apply.

Table 7 — Basic requirements for electric strength, flatwise, in oil

Mean measured thickness[a]	Minimum electric strength[b]				
	A5	F1	F2/1	F6	P2 and P3/1
mm	MV/m	MV/m	MV/m	MV/m	MV/m
0.4	6.0	2.72	—	—	17.5
0.5	5.9	2.50	—	—	16.0
0.6	5.8	2.30	—	—	15.1
0.8	5.5	1.97	1.97	10.0	13.6
1.0	5.1	1.72	1.72	9.2	12.7
1.2	4.8	1.50	1.50	8.6	11.9
1.6	4.4	1.21	1.21	7.7	10.8
2.0	4.0	1.03	1.03	7.1	10.0
2.5	3.5	0.94	0.94	6.4	9.2
3.0	3.0	0.94	0.94	5.9	8.4
4.0	—	—	—	—	7.2[c]
5.0	—	—	—	—	6.3[c]
6.0	—	—	—	—	5.5[c]
8.0	—	—	—	—	4.7[c]
10.0	—	—	—	—	4.1[c]
12.0	—	—	—	—	3.7[c]
14.0	—	—	—	—	3.4[c]

[a] If the mean measured thicknesses of the test specimens is intermediate between two consecutive thicknesses, the limit is determined by straight-line 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.

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

[c] These are optional requirements (see Table 8).

Table 8 — Optional requirements for Class 1 materials

Property	Unit	Nominal thickness to which the requirement applies[a]	Test method appendix	Max. or min.	Type										
					A1	A2	A3	A4	A5	F1	F2/1	F6	P2	P3/1	W1
Resistance to flatwise compression	%	All thicknesses	K	Max.	3.0	2.5	—	—	2.5	—	—	—	3.0	3.5	3.0
					In addition, test specimens are to show no sign of failure										
Loss tangent at 50 Hz or 0.8 kHz to 1.6 kHz	—	All thicknesses	L	Max.	—	—	—	—	—	—	—	—	—	—	[b]
Electric strength, flatwise, in oil at 90 °C	MV/m	Greater than 3 mm up to 14 mm	E	Min.	—	—	—	—	—	—	—	—	As given in Table 7		—
Shear strength, flatwise	MPa	1.6 mm to 6 mm	C	Min.	—	—	—	—	—	—	—	—	70	50	—
Temperature of deflection under load	°C	Not less than 3 mm	P	Min.	—	—	—	—	—	—	—	—	[b]	[b]	[b]
Flammability	—	Not greater than 5 mm	Q	—	—	—	—	—	—	—	—	—	—	—	—

[a] See clause **1** and **4.3**.
[b] Limiting value to be agreed between the purchaser and the supplier.

Appendix A Determination of cross-breaking strength

A.1 General

Carry out the test as described for flexural stress at rupture in BS 2782:Method 335A, and as modified by **A.2** to **A.6**.

A.2 Form of test specimens

For sheet of thickness greater than 10 mm (greater than 20 mm for group W of class 1 or for class 2) reduce the thickness to 10 mm (20 mm for group W of class 1 or for class 2), one face being left intact.

The dimensions of the test specimens shall be as described in **5.2** a) and **5.2** b) of BS 2782:Method 335A:1978.

A.3 Number and direction of test specimens

Test five test 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 Appendix R before testing.

A.5 Procedure

Perform the test at a temperature of 23 ± 5 °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 15 s to 45 s.

A.6 Expression of results

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

Appendix B Determination of impact strength, edgewise (Charpy method)

B.1 General

Carry out the test in the edgewise direction, by the method described in BS 2782:Method 359, and as modified by **B.2** to **B.6**.

B.2 Form of test specimens

The dimensions of the test specimens shall be as given for test specimen size no. 3 in Table 2 of BS 2782:Method 359:1984.

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 specimens from sheets of nominal thickness greater than 10 mm shall be machined uniformly on both sides to achieve a thickness of 10 ± 0.5 mm.

The shape and dimensions of the notch shall be those given for type C notches in **6.1.4** and Figure 6 of BS 2782:Method 359:1984.

B.3 Number and direction of test specimens

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

B.4 Conditioning

Condition the test specimens in accordance with Appendix R before testing.

B.5 Procedure

Perform the test at a temperature of 23 ± 5 °C.

B.6 Expression of results

Calculate the arithmetic mean of the impact strengths of the direction A test specimens and the arithmetic mean of the impact strengths of the direction B test specimens. Record the lower of the two means as the test result.

Appendix C Determination of shear strength, flatwise

C.1 General

Carry out the test as described in BS 2782:Method 340B, and as modified by **C.2** to **C.5**.

C.2 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.3 Conditioning of test specimens

Condition the test specimens in accordance with Appendix R before testing.

C.4 Procedure

Perform the test at a temperature of 23 ± 5 °C.

C.5 Expression of results

Calculate the arithmetic mean of the shear strengths of the direction A test specimens and the arithmetic mean of the shear strengths of the direction B test specimens. Record the lower of the two means as the test result.

Appendix D Determination of water absorption

D.1 General

Carry out the test as described in BS 2782:Method 430A, and as modified by **D.2** to **D.4**.

D.2 Form of test specimens

Prepare test specimens as described in BS 2782:Method 430A, except that if the nominal thickness of the sheet exceeds 25 mm, reduce the thickness of the test specimens 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 result.

Appendix E Determination of electric strength, flatwise

E. 1 General

Carry out the test as described in method 221A of BS 2782:Method 220 and BS 2782:Method 221:1983, 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 (r.m.s.).

Appendix F Determination of electric strength, edgewise

F.1 General

Carry out the test as described in method 221G of BS 2782:Method 220 and BS 2782:Method 221:1983, and as modified by **F.2** to **F.4**.

F.2 Number and direction 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 not less than 30 min and not more than 1 h before the test.

F.4 Expression of results

Record the arithmetic mean of two valid electric strength measurements as the test result, expressed in kilovolts. Express all voltages as root mean square (r.m.s.).

Appendix G Determination of loss tangent and permittivity at 1 MHz

G.1 General

Carry out the test either as described in method 207B of BS 2782:1970 and as modified by **G.2** and **G.3** or by any other method that gives the same results.

NOTE In case of dispute the procedure described in method 207B of BS 2782:1970 should be used.

G.2 Procedure

Perform the test at 23 ± 5 °C. Determine for each test specimen the loss tangent (power factor) and permittivity at 1 MHz, as described in method 207B of BS 2782:1970.

G.3 Expression of results

Record the arithmetic mean of the two measurements of loss tangent and the arithmetic mean of the two measurements of permittivity as the test results.

Appendix H Determination of insulation resistance after immersion in water

H.1 General

Carry out the test as described in BS 2782:Method 232C, 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 23 ± 0.5 °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 resistances of the two direction A test specimens and the arithmetic mean of the insulation resistances of the two direction B test specimens. Record the lower of these two mean values in megohms as the test result.

Appendix J Determination of crushing strength after heating

J.1 General

Perform the test as described in BS 2782: Method 131D, and as modified by **J.2** and **J.3**.

J.2 Number of test specimens

Test two test specimens.

J.3 Expression of results

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

Appendix K 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 the edges of the test specimens.

K.2 Conditioning

Condition the test specimen in accordance with Appendix R before testing.

K.3 Procedure

Test at a temperature of 23 ± 5 °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 signs of failure, i.e. significant cracking or fracture.

K.4 Expression of result

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.

Appendix L Determination of loss tangent at 50 Hz or 0.8 kHz to 1.6 kHz

L.1 General

Carry out the test either as described in BS 2782:Method 240A, and as modified by **L.2** to **L.4** or by any other method that gives the same results.

NOTE In case of dispute the procedure described in BS 2782:Method 240A should be used.

L.2 Number of test specimens

Test two test specimens.

L.3 Procedure

Perform the test at 23 ± 5 °C. Determine for each test specimen the loss tangent (power factor) at 50 Hz or 0.8 kHz to 1.6 kHz as described in BS 2782:Method 240A.

L.4 Expression of results

Record the arithmetic mean of the two measurements of loss tangent as the test result.

Appendix M Determination of resistance to hot oil

M.1 Form and number of test specimens

Test one test specimen, approximately 75 mm square, of the thickness of the sheet under test.

M.2 Procedure

Immerse the unheated test specimen in oil that complies with BS 148, at a temperature of 105 ± 2 °C. Maintain this temperature for 24 h, remove the test specimen and allow it to cool to room temperature. Examine the test specimen for splitting, blistering or delamination.

Appendix N Proof tracking index test

N.1 General

Perform a proof tracking index test as described in BS 5901 and **N.2** to **N.6**.

N.2 Form of test specimens

Use test specimens as described in BS 5901. If the thickness of the test specimen needs to be reduced by machining to suit a standard test fixture, leave one face intact and take care to protect it from abrasion or other damage during the machining operation.

N.3 Number of test specimens

Test five test specimens.

N.4 Conditioning

Test the material in the as-received condition, except that a cleaning procedure may be performed in accordance with clause **4** of BS 5901:1980.

N.5 Procedure

Perform the proof tracking index test as described in BS 5901 on one original face of each of the five test specimens. Use test solution A and a test voltage of 500 V.

N.6 Expression of results

Report compliance with the proof tracking test if all five of the test specimens withstand 50 drops without tracking.

Appendix P Determination of temperature of deflection under load

P.1 General

Carry out the test as described in BS 2782:Method 121C and as modified by **P.2**.

P.2 Number of test specimens

Test two test specimens.

Appendix Q Determination of flammability

Q.1 General

Carry out the test as described in method FV of BS 6334:1983[1)], and as modified by **Q.2** to **Q.4**.

Q.2 Number and form of test specimens

Test a set of five test specimens, each of length 125 ± 5 mm and of width 13 ± 0.3 mm. The thickness of the test specimens shall be the same as that of the sheet under test, if the nominal thickness of the sheet is not greater than 6 mm. If the nominal thickness of the sheet is greater than 6 mm, reduce the thickness of the test specimens to 5.0 ± 0.2 mm by machining one face only. All machined edges and faces shall have a smooth finish.

Q.3 Conditioning of test specimens

Condition the test specimens in accordance with Appendix R before testing.

Q.4 Expression of results

The category assigned to the set of five results in accordance with **9.4** of BS 6334:1983 shall be taken as the flammability of the sheet under test.

NOTE This test method is used solely for monitoring the consistency of production of laminated sheet. Under no circumstances should it be considered to give results relating to the fire hazards presented by these materials under actual conditions of use.

Appendix R Conditioning of test specimens

Where conditioning is specified in the test method, condition the test specimens for not less than 18 h in a controlled atmosphere of 50 ± 5 % r.h. at a temperature of 23 ± 2 °C. Fan circulate the air inside the conditioning chamber to maintain uniform conditions and ensure that all the test specimens have free access to the conditioning atmosphere. Start the relevant test within 3 min of removal of each test specimen from this controlled atmosphere.

NOTE An atmosphere of 50 % r.h. can be obtained conveniently in an enclosed chamber in which a saturated solution of sodium dichromate or magnesium nitrate is exposed to the atmosphere in the chamber. BS 3718 gives details of a suitable chamber. The saturated solution should be prepared from distilled water and sodium dichromate or magnesium nitrate of a recognized analytical quality.

The saturated solution is exposed so that the maximum surface is in contact with the air in the chamber, e.g. by covering the floor of the chamber with a tray containing the saturated solution. It is important that an ample excess of solid sodium dichromate or magnesium nitrate be used in contact with the saturated solution. If desired, a mobile slurry of the salt and saturated solution may be used, this being prepared by an addition to the solid salt, of suitable particle size, of a previously prepared saturated solution of sodium dichromate or magnesium nitrate until the desired fluid consistency is obtained. The air in the chamber is fan circulated over the surface of the saturated solution or slurry and around the test specimens. From time to time, the humidity of the air in the chamber should be checked. The saturated salt solution or slurry will become contaminated in the course of time. The salt tray should therefore be emptied, cleaned and refilled with fresh saturated solution or slurry at intervals of not more than 2 months. More frequent changes may be necessary where severe contamination is experienced.

[1)] Identical with IEC 707 (published by the International Electrotechnical Commission) and Annex J of ISO 1642:1987.

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Publication(s) referred to

BS 148, *Specification for unused mineral insulating oils for transformers and switchgear.*

BS 870, *Specification for external micrometers.*

BS 2782:1970, *Methods of testing plastics.*

BS 2782, *Methods of testing plastics.*

BS 2782-1, *Thermal properties.*

BS 2782:Method 121A to Method 121C, *Determination of temperature of deflection under a bending stress of 1.8 MPa, of plastics and ebonite. Determination of temperature of deflection under a bending stress of 0.45 MPa, of plastics and ebonite. Determination of temperature of deflection under a bending stress, of rigid thermosetting resin bonded laminated sheet Method 131C and Method 131D Crushing strength after heating (heat resistance) of thermosetting moulding material. Crushing strength after heating (heat resistance) of thermosetting laminated sheet or mouldings.*

BS 2782-2, *Electrical properties.*

BS 2782:Method 220 and Method 221, *Determination of electric strength: rapidly applied voltage method.*

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