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Plastics — Industrial laminated sheets based on thermosetting resins — Specification

Plastiques — Stratifiés industriels en planches à base de résines thermodurcissables — Spécification

Withdrawn

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 1642 was prepared by Technical Committee ISO/TC 61, *Plastics.*

This third edition cancels and replaces the second edition (ISO 1642 : 1979), of which it constitutes a minor revision.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

Printed in Switzerland

Plastics — Industrial laminated sheets based on thermosetting resins — Specification

1 Scope and field of application

This International Standard specifies the characteristics of industrial laminated sheets made with any one of the following resins as the binder : epoxide (epoxy), melamine, phenolic, polyester (unsaturated), and silicone. The sheets covered are flat and the preferred nominal thicknesses are listed in table 3.

NOTE — The scope of this International Standard may subsequently be extended to cover additional commercially established types of industrial laminated sheets of similar basic composition.

2 Refernces

ISO 62, *Plastics — Determination of water absorption.*

ISO 178, *Plastics — Determination of flexural properties of rigid plastics.*

ISO 179, *Plastics — Determination of the Charpy impact strength of rigid materials.*

ISO 180, *Plastics — Determination of the Izod impact strength of rigid materials.*

ISO 291, *Plastics — Standard atmospheres for conditioning and testing.*

ISO 472, *Plastics — Vocabulary.*

ISO 604, *Plastics — Determination of compressive properties.*

ISO 1043, *Plastics — Symbols.*

ISO 1183, *Plastics — Methods for determining the density and relative density (specific gravity) of plastics excluding cellular plastics.* [1)]

ISO 2578, *Plastics — Determination of time-temperature limits after exposure to prolonged action of heat.*

IEC Publication 112, *Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions.*

IEC Publication 167, *Methods of test for the determination of the insulation resistance of solid insulating materials.*

IEC Publication 243, *Recommended methods of test for electric strength of solid insulating materials at power frequencies.*

IEC Publication 249, *Metal-clad base materials for printed circuits.*

IEC Publication 250, *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.*

IEC Publication 587, *Test method for evaluating resistance to tracking and erosion of electrical insulating materials used under severe ambient conditions.*

IEC Publication 707, *Methods of test for the determination of the flammability of solid electrical insulating materials when exposed to an igniting source.*

3 Classification

3.1 Designation

The sheets covered by this specification are classified into types which differ in the resin and reinforcement employed and in the distinguishing properties.

Individual types are designated by

— a two-letter abbreviation denoting the resin;

— a second two-letter abbreviation, denoting the reinforcement;

— a serial number.

The abbreviations are given in 3.2.

Example : Type EP GC 3 is the third type in the group of types based on epoxide resin reinforced with woven glass cloth.

1) At present at the stage of draft. (Revision of ISO/R 1183 : 1970.)

3.2 Abbreviations

Resins	Abbreviation
Epoxide (epoxy)	EP
Melamine	MF
Phenolic	PF
Polyester (unsaturated)	UP
Silicone	SI

Reinforcement	Abbreviation
Cellulose paper	CP
Woven cotton cloth	CC
Wood veneer	WV
Asbestos paper	AP
Woven asbestos cloth	AC
Asbestos felt (mat)	AM
Woven glass cloth	GC
Glass mat	GM

3.3 Type

The combinations of resins and reinforcements that constitute the types covered by this International Standard, together with applications and distinguishing properties, are given in table 1.

Table 1 — Types

Type[1]			Applications and distinguishing properties
Resin	Reinforcement	Serial number	
EP	CP	1	Electronic applications. Good stability of electrical properties under high humidity. Of defined burning characteristics.
	GC	1	Mechanical, electrical, and electronic applications. Extremely high mechanical strength at moderate temperature. Very good stability of electrical properties under high humidity.
	GC	2	Similar to Type EP GC 1. of defined flammability.
	GC	3	Similar to Type EP GC 1. High mechanical strength at elevated temperature.
	GC	4	Similar to Type EP GC 3. Of defined flammability.
	GC	5	Similar to Type EP GC 3, but with roving cloth in very coarse weave.
	GM	1	Mechanical and electrical applications. Extremely high mechanical strength at ambient temperature. Very good electrical properties under high humidity.
	GM	2	Similar to EP GM 1. Of defined flammability.
	GM	3	Similar to EP GM 1. High mechanical strength at elevated temperature.
	GM	4	Similar to EP GM 3. Of defined flammability.
MF	CC	1	Mechanical and electrical applications (coarse weave[3]). Arc and tracking resistant.
	GC	1	Mechanical and electrical applications. High mechanical strength. Arc and tracking resistant. Of defined flammability.
PF	CP	1	Mechanical applications. Mechanical properties better than other PF CP types. Poor electrical properties under normal humidity. Also available in hot-punching versions.
	CP	2	High voltage applications at power frequencies. High electric strength under oil. Good electric strength in air under normal humidity.

Table 1 (*concluded*)

Type[1]			Applications and distinguishing properties
Resin	**Reinforcement**	**Serial number**	
PF	CP	3	Electrical and mechanical applications. Good electrical properties under normal humidity. Also available in hot-punching versions.
	CP	4	Electrical and electronic applications. Good stability of electrical properties under high humidity. Also available in cold- or hot-punching versions.
	CP	5	Similar to Type PF CP 4, but of defined flammability.
	CP	6	Electrical and mechanical applications. Good electrical properties under high humidity. Also available in hot-punching versions.
	CP	7	Similar to Type PF CP 1, but with improved punching characteristics at lower temperatures.
	CC	1	Mechanical applications (coarse weave[3]). Good mechanical properties.
	CC	2	Mechanical and electrical applications (coarse weave[3]).
	CC	3	Mechanical applications (fine weave[3]). Recommended for small parts.
	CC	4	Mechanical and electrical applications (fine weave[3]). Recommended for small parts.
	WV	1	Mechanical applications. Good mechanical properties.
	WV	2	Mechanical and electrical applications. Good electrical properties under normal humidity.
	AP[2]	1	Mechanical applications. Heat resistant.
	AC[2]	1	Mechanical applications. Mechanically better than Type PF AP 1. Heat resistant.
	AM[2]	1	Mechanical applications. Heat resistant.
	GC	1	Mechanical and electrical applications. High mechanical strength and good electrical properties under normal humidity. Heat resistant.
UP	GM	1	Mechanical and electrical applications. Good stability of electrical properties under high humidity.
	GM	2	Mechanical and electrical applications. Similar to Type UP GM 1. Of defined flammability.
	GM	3	Mechanical and electrical applications. Similar to Type UP GM 2, but with improved resistance to arcing and tracking.
	GM	4	Mechanical and electrical applications. Very high mechanical properties at ambient temperature. Good mechanical properties at elevated temperature.
	GM	5	Mechanical and electrical applications. Similar to Type UP GM 4 of defined flammability.
SI	GC	1	Electronic and other electrical applications. Extremely good dielectric properties under dry conditions; still good properties under humidity.
	GC	2	Mechanical and electrical applications at elevated temperature. Good heat resistance.

1) 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.

2) In some countries, the use of asbestos products is regulated by legislation. In such cases, national regulations must be observed.

3) Characteristics of the base material

Mass per unit area, g/m^2	**Thread count per cm**
Coarse weave > 130	< 30
Fine weave < 130	> 30

These values are given for information only; they are not to be considered specification values. In general, the finer weave materials give the better machining characteristics.

4 Definitions

Definitions of terms used in this International Standard are given in ISO 472.

5 Appearance

Sheets shall be free from blisters, wrinkles and cracks and reasonably free from other defects, for example scratches, dents and discoloration. A small amount of mottle is permissible.

6 Flatness

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

7 Tolerances on thickness and width

7.1 The deviation from nominal thickness of a sheet at any point shall not exceed the value shown in table 3 for the appropriate type and thickness. The diameter of the anvil of the measuring device shall be 6 to 8 mm.

7.2 When material is supplied in the form of cut strips, the deviation from the nominal width at any point shall not exceed the appropriate values shown in table 4.

8 Physical properties

When determined by the appropriate test methods, the physical properties shall be as given in table 5. In all cases, test results shall be rounded to the same degree of precision as the limiting values.

Annex K gives tables of typical values for other properties. These typical values are intended to give only general guidance and are not to be considered as requirements of this International Standard.

Table 2 — Maximum permissible departure of surface of sheet from straightedge

Values in millimetres

Material	Thickness d	Length of straightedge	
		1 000	500
PF AG 1 SI GC 1 SI GC 2	$1{,}6 < d < 3$	See note	
	$3 < d < 6$	15	4
	$6 < d < 8$	12	3
	$8 < d$	10	2,5
PF WV 1 PF WV 2	$12 < d$	9	2
All other types	$1{,}6 < d < 3$	See note	
	$3 < d < 6$	10	2,5
	$6 < d < 8$	8	2,0
	$8 < d$	6	1,5

NOTE — Limiting values for sheets of nominal thickness fron 1,6 mm up to but excluding 3 mm are under consideration and will be included in the next revision of this International Standard.

Table 3 — Tolerances on thickness (± mm)[1]

Nominal thickness[2] mm	EP				MF		PF											UP	SI
	CP	GC		GM	CC	GC	CP		CC				WV	AP	AC	AM	GC	GM	GC
	1	1, 2, 3, 4	5	1, 2, 3, 4	1	1	1, 2, 3, 4, 6	5, 7	1	2	3	4	1, 2	1	1	1	1	1, 2, 3, 4	1, 2
0,4	0,07	0,10	—	—	—	0,10	0,07	0,07	—	—	0,12	—	—	—	—	—	0,10	—	0,10
0,5	0,08	0,12	—	—	—	0,12	0,08	0,08	—	—	0,13	0,13	—	—	—	—	0,12	—	0,12
0,6	0,09	0,13	—	—	—	0,13	0,09	0,09	—	—	0,14	0,14	—	0,19	—	—	0,13	—	0,13
0,8	0,10	0,16	—	—	—	0,16	0,10	0,10	0,19	0,19	0,15	0,15	—	0,19	—	—	0,16	—	0,16
1,0	0,12	0,18	—	—	—	0,18	0,12	0,12	0,20	0,20	0,16	0,16	—	0,20	—	—	0,18	—	0,18
1,2	0,14	0,20	—	—	—	0,21	0,14	0,14	0,22	0,22	0,17	0,17	—	0,22	—	—	0,21	—	0,21
1,6	0,16	0,24	—	0,23	0,24	0,24	0,16	0,16	0,24	0,24	0,19	0,19	—	0,24	0,63	0,63	0,24	0,23	0,24
2,0	0,19	0,28	—	0,25	0,26	0,28	0,19	0,19	0,26	0,26	0,21	0,21	—	0,26	0,65	0,65	0,28	0,25	0,28
2,5	0,22	0,33	—	0,30	0,29	0,33	0,22	0,22	0,29	0,29	0,24	0,24	—	0,29	0,68	0,68	0,33	0,30	0,33
3,0	0,25	0,37	0,50	0,35	0,31	0,37	0,25	0,25	0,31	0,31	0,26	0,26	—	0,31	0,70	0,70	0,37	0,35	0,37
4,0	0,30	0,45	0,60	0,40	0,36	0,45	0,30	—	0,36	0,36	0,32	0,32	—	0,36	0,75	0,75	0,45	0,40	0,45
5,0	0,34	0,52	0,70	0,55	0,42	0,52	0,34	—	0,42	0,42	0,36	0,36	—	0,42	0,79	0,79	0,52	0,55	0,52
			Plus only						Plus only		Plus only								
6,0	0,37	0,60	1,60	0,60	0,46	0,60	0,37	—	0,92	0,46	0,80	0,40	—	0,46	0,85	0,85	0,60	0,60	0,60
8,0	0,47	0,72	1,90	0,70	0,55	0,72	0,47	—	1,10	0,55	0,98	0,49	—	0,55	1,00	1,00	0,72	0,70	0,72
10,0	—	0,82	2,20	0,80	0,63	0,82	0,55	—	1,26	0,63	1,12	0,56	—	0,63	1,14	1,14	0,82	0,80	0,82
12,0	—	0,94	2,40	0,90	0,70	0,94	0,62	—	1,40	0,70	1,28	0,64	1,25	0,70	1,28	1,28	0,94	0,90	0,94
14,0	—	1,02	2,60	1,00	0,78	1,02	0,69	—	1,56	0,78	1,40	0,70	1,35	0,78	1,42	1,42	1,02	1,00	1,02
16,0	—	1,12	2,80	1,10	0,85	1,12	0,75	—	1,70	0,85	1,52	0,76	1,45	0,85	1,57	1,57	1,12	1,10	1,12
20,0	—	1,30	3,00	1,30	0,95	1,30	0,86	—	1,90	0,95	1,74	0,87	1,60	0,95	1,85	1,85	1,30	1,30	1,30
25,0	—	1,50	3,50	1,40	1,10	1,50	1,00	—	2,20	1,10	2,04	1,02	1,80	1,10	2,18	2,18	1,50	1,40	1,50
30,0	—	1,70	4,00	—	1,22	1,70	1,15	—	2,44	1,22	2,24	1,12	2,00	1,22	2,54	2,54	1,70	—	1,70
35,0	—	1,95	4,40	—	1,43	1,95	1,25	—	2,68	1,34	2,48	1,24	2,10	1,34	2,89	2,89	1,95	—	1,95
40,0	—	2,10	4,80	—	1,45	2,10	1,35	—	2,90	1,45	2,70	1,35	2,25	1,45	3,24	3,24	2,10	—	2,10
45,0	—	2,30	5,10	—	1,55	2,30	1,45	—	3,10	1,55	2,90	1,45	2,40	1,55	3,59	3,59	2,30	—	1,17
50,0	—	2,45	5,40	—	1,65	2,45	1,55	—	3,30	1,65	3,10	1,55	2,50	1,65	3,91	3,91	2,45	—	2,45
60,0	—	—	5,80	—	—	—	—	—	3,70	—	3,50	—	2,80	—	—	—	—	—	—
70,0	—	—	6,20	—	—	—	—	—	4,00	—	3,80	—	3,00	—	—	—	—	—	—
80,0	—	—	6,60	—	—	—	—	—	4,40	—	4,20	—	3,25	—	—	—	—	—	—
90,0	—	—	6,80	—	—	—	—	—	4,70	—	4,50	—	3,50	—	—	—	—	—	—
100,0	—	—	7,00	—	—	—	—	—	5,00	—	4,80	—	3,75	—	—	—	—	—	—

1) Other tolerances may be agreed between the vendor and the purchaser (for example, those given in IEC 249).

2) Where the nominal thickness is not one of the preferred thicknesses listed, then the tolerance for the next higher preferred nominal thickness shall apply.

Table 4 — Tolerances on width of cut strips (mm; minus only)

Nominal thickness	Nominal width (mm); all types					
	Above 3 up to 50	Above 50 up to 100	Above 100 up to 160	Above 160 up to 300	Above 300 up to 500	Above 500 up to 600
0,4	0,5	0,5	0,5	0,6	1,0	1,5
0,5	0,5	0,5	0,5	0,6	1,0	1,5
0,6	0,5	0,5	0,5	0,6	1,0	1,5
0,8	0,5	0,5	0,5	0,6	1,0	1,0
1,0	0,5	0,5	0,5	0,6	1,0	1,0
1,2	0,5	0,5	0,5	1,0	1,2	1,2
1,6	0,5	0,5	0,5	1,0	1,2	1,2
2,0	0,5	0,5	0,5	1,0	1,2	1,5
2,5	0,5	1,0	1,0	1,5	2,0	2,5
3,0	0,5	1,0	1,0	1,5	2,0	2,5
4,0	0,5	2,0	2,0	3,0	4,0	5,0
5,0	0,5	2,0	2,0	3,0	4,0	5,0

NOTE — In all cases, the measured width of the strip shall not be more than the specified nominal width. The values given in table 4 are unilateral, all-negative tolerances.

Table 5 — Physical properties

A. Epoxide resin EP													
Property	Method of test	Unit	Max. or min.	Max. or min. nominal thickness of sheet to which test is applied	Types									
					EP CP 1	EP GC 1	EP GC 2	EP GC 3	EP GC 4	EP GC 5	EP GM 1	EP GM 2	EP GM 3	EP GM 4
Flexural stress at rupture, perpendicular to laminations	Annex A	MPa	min.	1,5 mm min.	110	340	340	340[1]	340[1]	340[1]	320	320	320[1]	320[1]
Impact strength (notched specimen tested parallel to laminations)														
a) Charpy[2]	Annex B	kJ/m^2	min.	5 mm min.	—	33	33	33	33	50	50	50	50	50
b) Izod[2]	Annex C	J per mm of notch	min.	5 mm min.	—	0,35	0,35	0,35	0,35	0,55	0,55	0,55	0,55	0,55
Electric strength at 90 °C in oil, perpendicular to laminations	Annex D	MV/m	min.	3 mm max.[3]	See table 7.									
Electric strength at 90 °C in oil, parallel to laminations[4]														
a) 20 s step-by-step test	Annex D	kV	min.	3 mm min.[5]	20	35	35	35	35	35	35	35	35	35
b) 1 min proof test	Annex D	kV	min.	3 mm min.[5]	20	35	35	35	35	35	35	35	35	35
Insulation resistance after immersion in water	Annex E	MΩ	min.	25 mm max.	1×10^4	5×10^4	5×10^4	5×10^4	5×10^4	1×10^4	5×10^3	5×10^3	5×10^3	5×10^3
Dissipation factor at 1 MHz	Annex F	—	max.	3 mm max.	0,05	0,04	0,04	0,04	0,04	0,04	—	—	—	—
Permittivity at 1 MHz	Annex F	—	max.	3 mm max.	5,0	5,5	5,5	5,5	5,5	5,5	—	—	—	—
Flammability	Annex J	—	max.	1,6 mm min.	FVO	—	FVO	—	FVO	—	—	FVO	—	FVO
Water absorption	Annex H	mg	max.	All thickness	See table 6.									

See notes at the end of the table (page 11).

Table 5 (*continued*)

B. Melamine resin MF						
Property	**Method of test**	**Unit**	**Max. or min.**	**Max. or min. nominal thickness of sheet to which test is applied**	**Types**	
					MF GC 1	**MF CC 1**
Flexural stress at rupture, perpendicular to laminations	Annex A	MPa	min.	1,5 mm min.	240	70
Impact strength (notched specimen tested parallel to laminations)						
a) Charpy[2]	Annex B	kJ/m^2	min.	5 mm min.	30	3,0
b) Izod[2]	Annex C	J per mm of notch	min.	5 mm min.	0,32	0,025
Electric strength at 90 °C in oil, perpendicular to laminations	Annex D	MV/m	min.	3 mm max.[3]	See table 7.	
Electric strength at 90 °C in oil, parallel to laminations[4]						
a) 20 s step-by-step test	Annex D	kV	min.	3 mm min.[5]	15	15
b) 1 min proof test	Annex D	kV	min.	3 mm min.[5]	15	15
Insulation resistance after immersion in water	Annex E	MΩ	min.	25 mm max.	1×10^1	1×10^1
Proof tracking index	IEC Publication 112	—	proof	All thicknesses	PTI 500	PTI 500
Flammability	Annex J	—	min.	1,6 mm min.	FVO	—
Water absorption	Annex H	mg	max.	All thicknesses	See table 6.	

See notes at the end of the table (page 11).

Table 5 (*continued*)

C. Phenolic resin PF														
Property	**Method of test**	**Unit**	**Max. or min.**	**Max. or min. nominal thickness of sheet to which test is applied**	**Types**										
					PF CP 1	**PF CP 2**	**PF CP 3**	**PF CP 4**	**PF CP 5**	**PF CP 6**	**PF CP 7**	**PF CC 1**	**PF CC 2**	**PF CC 3**	**PF CC 4**
Flexural stress at rupture, perpendicular to laminations	Annex A	MPa	min.	1,5 mm min.	135	120	120	75	75	85	80	100	90	110	100
Impact strength (notched specimen tested parallel to laminations)															
a) Charpy[2]	Annex B	kJ/m^2	min.	5 mm min.	—	—	—	—	—	—	—	8,8	7,8	7,0	6,0
b) Izod[2]	Annex C	J per mm of notch	min.	5 mm min.	—	—	—	—	—	—	—	0,075	0,060	0,060	0,050
Electric strength at 90 °C in oil, perpendicular to laminations	Annex D	MV/m	min.	3 mm max.[3]	—	See table 7.					—	—	See table 7	—	See table 7
Electric strength at 90 °C in oil, parallel to laminations[4]															
a) 20 s step-by-step test	Annex D	kV	min.	3 mm min.[5]	—	60[9]	20	25	—	25	—	—	15	—	15
b) 1 min proof test	Annex D	kV	min.	3 mm min.[5]	—	60[9]	20	25	—	25	—	—	15	—	15
Insulation resistance after immersion in water	Annex E	MΩ	min.	25 mm max.	—	—	5×10^1	1×10^4	1×10^3	1×10^3	—	—	5×10^1	—	5×10^1
Dissipation factor at 1 MHz	Annex F	—	max.	3 mm max.	—	—	—	0,05	0,05	0,055	—	—	—	—	—
Permittivity at 1 MHz	Annex F	—	max.	3 mm max.	—	—	—	5,5	5,5	6,0	—	—	—	—	—
Dissipation factor at 50 Hz after heating	Annex G	—	max.	3 mm max.	—	0,05	—	—	—	—	—	—	—	—	—
Permittivity at 50 Hz after heating	Annex G	—	max.	3 mm max.	—	5,5	—	—	—	—	—	—	—	—	—
Flammability	Annex J	—	min.	1,6 mm min.	—	—	—	—	FVI	—	—	—	—	—	—
Water absorption	Annex H	mg	max.	All thicknesses	See table 6.										

See notes at the end of the table (page 11).

Table 5 (*continued*)

C. Phenolic resin PF										
Property	**Method of test**	**Unit**	**Max. or min.**	**Max. or min. nominal thickness of sheet to which test is applied**	**Types**					
					PF WV 1	**PF WV 2**	**PF AP 1**	**PF AC 1**	**PF AM 1**	**PF GC 1**
Flexural stress at rupture perpendicular to laminations	Annex A	MPa	min.	1,5 mm min.	90[6]	75[6]	70	70	135	140
Impact strength (notched specimen tested parallel to laminations)										
a) Charpy[2]	Annex B	kJ/m^2	min.	5 mm min.	6,9[6]	4,9[6]	2,9	6,9	9,8	25
b) Izod[2]	Annex C	J per mm of notch	min.	5 mm min.	0,060[6]	0,050[6]	0,020	0,10	0,080	0,30
Electric strength at 90 °C in oil, perpendicular to laminations	Annex D	MV/m	min.	3 mm max.[3]	—	—	—	—	—	See table 7
Electric strength at 90 °C in oil, parallel to laminations[4]										
a) 20 s step-by-step test	Annex D	kV	min.	3 mm min.[5]	—	24[6]	—	—	—	20
b) 1 min proof test	Annex D	kV	min.	3 mm min.[5]	—	24[6]	—	—	—	20
Insulation resistance after immersion in water	Annex E	MΩ	min.	25 mm max.	—	1×10^1	—	—	—	1×10^2
Dissipation factor at 1 MHz	Annex F	—	max.	3 mm max.	—	—	—	—	—	—
Permittivity at 1 MHz	Annex F	—	max.	3 mm max.	—	—	—	—	—	—
Dissipation factor at 50 Hz after heating	Annex G	—	max.	3 mm max.	—	—	—	—	—	—
Permittivity at 50 Hz after heating	Annex G	—	max.	3 mm max.	—	—	—	—	—	—
Flammability	Annex J	—	min.	1,6 mm min.	—	—	—	—	—	—
Water absorption	Annex H	mg	max.	All thicknesses	See table 6.					

See notes at the end of the table (page 11).

Table 5 (*continued*)

D. Polyester resin (unsaturated) UP									
Property	**Method of test**	**Unit**	**Max. or min.**	**Max. or min. nominal thickness of sheet to which test is applied**	**Types**				
					UP GM 1	**UP GM 2**	**UP GM 3**	**UP GM 4**	**UP GM 5**
Flexural stress at rupture, perpendicular to laminations	Annex A	MPa	min.	1,5 mm min.	130[7]	130[7]	130[7]	250[10]	250[10]
Impact strength (notched specimen tested parallel to laminations)									
a) Charpy[2]	Annex B	kJ/m^2	min.	5 mm min.	40	40	40	50	50
b) Izod[2]	Annex C	J per mm of notch	min.	5 mm min.	0,36	0,36	0,36	0,45	0,45
Electric strength at 90 °C in oil, perpendicular to laminations	Annex D	MV/m	min.	3 mm max.[3]	See table 7.				
Electric strength at 90 °C in oil, parallel to laminations[4]									
a) 20 s step-by-step test	Annex D	kV	min.	3 mm min.[5]	35	35	35	35	35
b) 1 min proof test	Annex D	kV	min.	3 mm min.[5]	35	35	35	35	35
Insulation resistance after immersion in water	Annex E	MΩ	min.	All thicknesses	5×10^2	5×10^2	5×10^2	5×10^2	5×10^2
Tracking resistance									
a) Proof tracking index	IEC Publication 112	—	proof	All thicknesses	PTI 500	PTI 500		—	—
b) Inclined plane test Method 2 : Stepwise tracking voltage	IEC Publication 587	KV	min.	3 mm min.			Class 2A 2,0	—	—
Flammability	Annex J	—	min.	1,6 mm min.	—	FVO	FVO	—	FVO
Water absorption	Annex H	mg	max.	All thicknesses	See table 6.				

See notes at the end of the table (page 11).

Table 5 (*concluded*)

E. Silicone resin SI						
Property	**Method of test**	**Unit**	**Max. or min.**	**Max. or min. nominal thickness of sheet to which test is applied**	**Types**	
					SI GC 1	**SI GC 2**
Flexural stress at rupture, perpendicular to laminations	Annex A	MPa	min.	1,5 mm min.	90	120[8]
Impact strength (notched specimen tested parallel to laminations)						
a) Charpy[2]	Annex B	kJ/m^2	min.	5 mm min.	20	25
b) Izod[2]	Annex C	J per mm of notch	min.	5 mm min.	0,21	0,27
Electric strength at 90 °C in oil, parallel to laminations[4]						
a) 20 s step-by-step test	Annex D	kV	min.	3 mm min.[5]	30	25
b) 1 min proof test	Annex D	kV	min.	3 mm min.[5]	30	25
Insulation resistance after immersion in water	Annex E	MΩ	min.	25 mm max.	1×10^3	1×10^2
Dissipation factor at 1 MHz	Annex F	—	max.	3 mm max.	0,02	0,07
Permittivity at 1 MHz	Annex F	—	max.	3 mm max.	4,5	6,0
Flammability	Annex J	—	min.	1,6 mm min.	FVO	FVO
Water absorption	Annex H	mg	max.	All thicknesses	See table 6.	

NOTES CONCERNING TABLE 5

1) For Types EP GC 3, EP GC 4, EP GC 5, EP GM 3 and EP GM 4, the flexural strength measured at 150 ± 5 °C after conditioning for 1 h at 150 ± 5 °C in air shall not be less than 50 % of the value specified in the table. (The temperature of test and conditioning has been chosen for uniformity of quality control testing and is not necessarily an indication of the maximum service temperature of the material.)

2) The requirements for impact strength, Charpy, and impact strength, Izod, are alternatives. A material meeting either requirements shall be deemed to comply with the specification with respect to impact strength.

3) Requirements for sheets of nominal thickness greater than 3 mm may be applied only by agreement between the vendor and the purchaser.

4) The requirments for the 20 s step-by-step and the 1 min proof test for electric strength at 90 °C in oil, parallel to laminations, are alternatives. A material meeting either requirement shall be deemed to comply with the specification with respect to electric strength at 90 °C in oil, parallel to laminations.

5) Requirements for sheets of nominal thickness not greater than, or equal to, 3 mm may be applied only by agreement between the vendor and the purchaser.

6) Values apply to thicknesses of 12 mm and over. The values in the table for mechanical strength properties are primarily intended for cross-laminated sheet; for other arrangements of the layers the values will be higher in one direction (see annexes A, B and C) and should be agreed upon between the vendor and the purchaser.

7) For Types UP GM 1, UP GM 2 and UP GM 3, the flexural strength measured at 130 ± 2 °C after conditioning for 1 h at 130 ± 2°C in air shall not be less than 50 % of the value specified in the table. (The temperature of test and conditioning has been chosen for uniformity of quality control testing and is not necessarily an indication of the maximum service temperature of the material.)

8) For Type SI GC 2, the flexural strength measured at 180 ± 5 °C after conditioning for 1 h at 180 ± 5 °C in oil shall not be less than 40 % of the value specified in the table. (The temperature of test and conditioning has been chosen for uniformity of quality control testing and is not necessarily an indication of the maximum service temperature of the material.)

9) Type PF CP 2 shall be preconditioned in air at 105 ± 5 °C for 96 h immediately before this test.

10) For Types UP GM 4 and UP GM 5 the flexural strength measured at 155 ± 5 °C after conditioning for 1 h at 155 ± 5 °C in air shall be not less than 50 % of the value specified in the table.

Table 6 — Limits for water absorption, mg

Types	Mean measured thickness of test specimens, mm[1]																			
	0,4	0,5	0,6	0,8	1,0	1,2	1,6	2,0	2,5	3	4	5	6	8	10	12	14	16	20	25	22,5 with one face machined[2]
EP CP 1	30	31	31	33	35	37	41	45	50	55	60	68	76	90	—	—	—	—	—	—	—
EP GC 1	17	17	17	18	18	18	19	20	21	22	23	25	27	31	34	38	41	46	52	61	73
EP GC 2	17	17	17	18	18	18	19	20	21	22	23	25	27	31	34	38	41	46	52	61	73
EP GC 3	17	17	17	18	18	18	19	20	21	22	23	25	27	31	34	38	41	46	52	61	73
EP GC 4	17	17	17	18	18	18	19	20	21	22	23	25	27	31	34	38	41	46	52	61	73
EP GC 5	—	—	—	—	—	—	—	—	—	22	23	25	27	31	34	38	41	46	52	61	73
EP GM 1	—	—	—	—	—	—	25	26	27	28	29	31	33	35	40	44	48	55	60	70	90
EP GM 2	—	—	—	—	—	—	25	26	27	28	29	31	33	35	40	44	48	55	60	70	90
EP GM 3	—	—	—	—	—	—	25	26	27	28	29	31	33	35	40	44	48	55	60	70	90
EP GM 4	—	—	—	—	—	—	25	26	27	28	29	31	33	35	40	44	48	55	60	70	90
MF CC 1	—	—	—	133	136	139	145	151	157	162	169	190	210	260	305	350	400	450	550	660	1 080
MF GC 1	103	107	110	116	123	129	142	155	172	188	220	252	285	350	414	479	544	609	738	900	1 080
PF CP 1	410	417	423	437	450	460	480	500	525	550	600	650	700	810	920	1 020	1 130	1 230	1 440	1 700	2 040
PF CP 2	165	167	168	173	180	188	204	220	240	260	300	342	382	470	550	630	720	800	970	1 150	1 380
PF CP 3	160	162	163	167	170	174	182	190	195	200	220	235	250	285	320	350	390	420	490	570	684
PF CP 4	44	45	45	47	48	50	53	56	59	63	70	77	84	99	113	128	142	157	186	222	266
PF CP 5	44	45	45	47	48	50	53	56	59	63	—	—	—	—	—	—	—	—	—	—	—
PF CP 6	62	63	65	67	69	71	76	80	85	90	100	110	118	135	149	162	175	186	202	219	263
PF CP 7	410	417	423	437	450	460	480	500	525	550	—	—	—	—	—	—	—	—	—	—	—
PF CC 1	—	—	—	201	206	211	220	229	239	249	262	275	284	301	319	336	354	371	406	450	540
PF CC 2	—	—	—	133	136	139	145	151	157	162	169	175	182	195	209	223	236	250	277	311	373
PF CC 3	186	190	194	201	206	211	220	229	239	249	262	275	284	301	319	336	354	371	406	450	540
PF CC 4	125	127	129	133	136	139	145	151	157	162	169	175	182	195	209	223	236	250	277	311	373
PF WV 1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2 500	2 650	2 810	3 110	3 500	4 200
PF WV 2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	600	630	660	720	800	960
PF AP 1	—	231	232	234	236	238	242	246	252	257	268	278	289	310	332	353	374	395	437	490	588
PF AC 1	—	—	—	—	—	305	318	331	347	363	396	428	461	526	590	655	720	784	913	1 075	1 290
PF AM 1	—	—	—	—	—	430	460	490	530	575	660	750	840	1 010	1 190	1 360	1 540	1 710	2 060	2 500	3 000
PF GC 1	80	85	89	95	100	105	116	127	140	153	178	202	226	270	310	347	380	410	465	525	630
UP GM 1	—	—	—	—	—	—	43	47	51	55	63	69	76	89	101	112	124	135	157	185	—
UP GM 2	—	—	—	—	—	—	43	47	51	55	63	69	76	89	101	112	124	135	157	185	—
UP GM 3	—	—	—	—	—	—	43	47	51	55	63	69	76	89	101	112	124	135	157	185	—
UP GM 4	—	—	—	—	—	—	43	47	51	55	63	69	76	89	101	112	124	135	157	185	—
UP GM 5	—	—	—	—	—	—	43	47	51	55	63	69	76	89	101	112	124	135	157	185	—
SI GC 1	7	7	8	8	9	9	10	11	12	13	15	17	19	23	27	31	35	39	47	57	68
SI GC 2	28	29	29	31	32	33	35	36	38	40	45	50	55	65	75	85	95	105	125	150	180

1) If the mean of the measured values of thickness of the test specimens lies between two values of thickness shown in the above table, the limit shall be obtained by interpolation. If the mean of the measured values of thickness is below the minimum thickness for which a limit is given, the water absorption limit appropriate to the minimum thickness shall apply. If the nominal thickness is 25 mm and the mean measured thickness exceeds 25 mm, the limit for 25 mm shall apply.

2) Sheets of nominal thicknesses greater than 25 mm shall be machined to a relatively smooth surface on one face to a thickness of 22,5 mm.

Table 7 — Proof values of electric strength at 90 °C in oil, perpendicular to laminations (1 min proof test), MV/m[1)]
Limits for electric strength at 90 °C in oil, perpendicular to laminations (20 s step-by-step test), MV/m[1)]

Types	Mean measured thickness of test specimens, mm[2)]																	
	0,4	0,5	0,6	0,7	0,8	0,9	1,0	1,2	1,4	1,6	1,8	2,0	2,2	2,4	2,5	2,6	2,8	3,0
EP CP 1	19,0	18,2	17,6	17,1	16,6	16,2	15,8	15,2	14,7	14,3	13,9	13,6	13,4	13,3	13,3	13,2	13,0	13,0
EP GC 1	16,9	16,1	15,6	15,2	14,8	14,5	14,2	13,7	13,2	12,7	12,2	11,8	11,4	11,1	10,9	10,8	10,5	10,2
EP GC 2	16,9	16,1	15,6	15,2	14,8	14,5	14,2	13,7	13,2	12,7	12,2	11,8	11,4	11,1	10,9	10,8	10,5	10,2
EP GC 3	16,9	16,1	15,6	15,2	14,8	14,5	14,2	13,7	13,2	12,7	12,2	11,8	11,4	11,1	10,9	10,8	10,5	10,2
EP GC 4	16,9	16,1	15,6	15,2	14,8	14,5	14,2	13,7	13,2	12,7	12,2	11,8	11,4	11,1	10,9	10,8	10,5	10,2
EP GC 5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	9,0
EP GM 1	—	—	—	—	—	—	—	—	12,3	11,6	11,0	10,5	10,0	9,8	9,6	9,4	9,2	9,0
EP GM 2	—	—	—	—	—	—	—	—	12,3	11,6	11,0	10,5	10,0	9,8	9,6	9,4	9,2	9,0
EP GM 3	—	—	—	—	—	—	—	—	12,3	11,6	11,0	10,5	10,0	9,8	9,6	9,4	9,2	9,0
EP GM 4	—	—	—	—	—	—	—	—	12,3	11,6	11,0	10,5	10,0	9,8	9,6	9,4	9,2	9,0
MF CC 1	—	—	6,6	6,3	6,1	5,8	5,6	5,3	5,0	4,7	4,5	4,3	4,2	4,1	4,1	4,1	4,0	4,0
MF GC 1	9,1	8,6	8,2	7,9	7,6	7,3	7,0	6,6	6,2	5,9	5,6	5,4	5,3	5,2	5,2	5,2	5,1	5,0
PF CP 2[3)]	19,0	18,2	17,6	17,1	16,6	16,2	15,8	15,2	14,7	14,3	13,9	13,6	13,4	13,3	13,3	13,2	13,0	13,0
PF CP 3	15,7	14,7	14,0	13,4	12,9	12,5	12,1	11,4	10,7	10,1	9,6	9,3	9,0	8,8	8,7	8,6	8,5	8,4
PF CP 4	15,7	14,7	14,0	13,4	12,9	12,5	12,1	11,4	10,7	10,1	9,6	9,3	9,0	8,8	8,7	8,6	8,5	8,4
PF CP 5	15,7	14,7	14,0	13,4	12,9	12,5	12,1	11,4	10,7	10,1	9,6	9,3	9,0	8,8	8,7	8,6	8,5	8,4
PF CP 6	17,5	16,0	15,0	14,1	13,4	12,8	12,3	11,4	10,6	10,0	9,5	9,1	8,7	8,4	8,3	8,2	7,9	7,7
PF CC 2	—	—	—	—	5,6	5,3	5,1	4, 6	4,2	3,8	3,6	3,4	3,3	3,2	3,2	3,1	3,0	3,0
PF CC 4	—	8,1	7,7	7,3	7,0	6,6	6,3	5,8	5,4	5,1	4,8	4,6	4,4	4,2	4,2	4,1	4,1	4,0
PF GC 1	10,8	10,2	9,7	9,3	9,0	8,7	8,4	8,0	7,6	7,3	7,0	6,8	6,5	6,3	6,2	6,1	5,9	5,7
UP GM 1	—	—	—	—	—	—	—	—	12,3	11,6	11,0	10,5	10,0	9,6	9,4	9,2	9,0	9,0
UP GM 2	—	—	—	—	—	—	—	—	12,3	11,6	11,0	10,5	10,0	9,6	9,4	9,2	9,0	9,0
UP GM 3	—	—	—	—	—	—	—	—	12,3	11,6	11,0	10,5	10,0	9,6	9,4	9,2	9,0	9,0
UP GM 4	—	—	—	—	—	—	—	—	12,3	11,6	11,0	10,5	10,0	9,6	9,4	9,2	9,0	9,0
UP GM 5	—	—	—	—	—	—	—	—	12,3	11,6	11,0	10,5	10,0	9,6	9,4	9,2	9,0	9,0

1) The requirements for the 20 s step-by-step and the 1 min proof test for electric strength at 90 °C in oil, perpendicular to laminations, are alternatives. A material meeting either requirement shall be deemed to comply with the specification with respect to electric strength at 90 °C in oil, perpendicular to laminations.

2) If the mean of the measured values of thickness of the test specimen lies between two values of thickness shown in the above table, the limit shall be obtained by interpolation. If the mean of the measured values of thickness is below the minimum thickness for which a limit is given, the electric strength limit appropriate to the minimum thickness shall apply. If the nominal thickness is 3 mm and the mean measured thickness exceeds 3 mm, the limit for 3 mm shall apply.

3) Type PF CP 2 shall be preconditioned in air for 96 h at 105 ± 5 °C before this test.

Annex A

Determination of flexural stress at rupture, perpendicular to laminations

(This annex forms an integral part of the Standard.)

Flexural stress at rupture shall be determined by the method specified in ISO 178, using a strain rate of 0,035/min.

Cut the test specimens from the sheet to be tested with their major axes in the directions indicated at A and B in figure 1 of ISO 178. Take at least five specimens in each direction. If the sheet to be tested is more than 10 mm thick (20 mm in the case of Type WV), reduce the thickness of the test specimens to 10 mm (20 mm in the case of Type WV), leaving one face of the sheet intact. In such cases, the test specimen shall be tested with the original surface of the sheet in tension.

Condition the test specimens for at least 24 h in a controlled atmosphere of (50 ± 5) % relative humidity at a temperature of 23 ± 2 °C. Commence the test within 3 min of removal of each test specimen from the controlled atmosphere. Load the specimens perpendicular to the laminations.

Calculate the average of the results for each direction and take the lower of the two averages as the flexural stress at rupture of the sheet under test. However, for Type WV sheets with the veneers arranged with their grain mainly in the same direction, take the higher of the two averages. [See note 6) to table 5.]

NOTE — In tropical countries, the alternative standard conditioning atmosphere given in ISO 291 [27 ± 2 °C, (65 ± 5) % relative humidity] may be used, by agreement.

Annex B

Determination of impact strength, Charpy (notched specimen)

(This annex forms an integral part of the Standard.)

Impact strength, Charpy, shall be determined in the edgewise direction by the method designated as Method ISO 179/3C in ISO 179.

Cut the test specimens from the sheet to be tested with their major axes in the directions indicated at A and B in figure 1. Take five specimens in each direction.

Condition the test specimens for at least 24 h in a controlled atmosphere of (50 ± 5) % relative humidity at a temperature of 23 ± 2 °C. Commence the test within 3 min of removal of each test specimen from the controlled atmosphere. Strike the specimens parallel to the laminations.

Calculate the average of the results for each direction and take the lower of the two averages as the impact strength, Charpy, of the sheet under test. However, for Type WV sheets with the veneers arranged with their grain mainly in the same direction, take the higher of the two averages. [See note 6) to table 5.]

NOTE — In tropical countries, the alternative standard conditioning atmosphere given in ISO 291 [27 ± 2 °C, (65 ± 5) % relative humidity] may be used, by agreement.

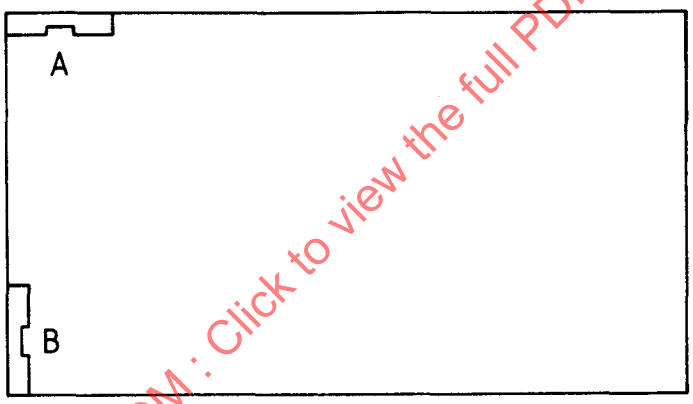

Figure 1 — Determination of impact strength — Direction of test specimens

Annex C

Determination of impact strength, Izod (notched specimen)

(This annex forms an integral part of the Standard.)

Impact strength, Izod, shall be determined in the edgewise direction by the method specified in ISO 180, using Type 2 specimens with Type A notches.

Cut the test specimens from the sheet to be tested with their major axes in the directions indicated at A and B in figure 1. Take five specimens in each direction.

Condition the test specimens for at least 24 h in a controlled atmosphere of (50 ± 5) % relative humidity at a temperature of 23 ± 2 °C. Commence the test within 3 min of removal of each test specimen from the controlled atmosphere. Strike the specimens parallel to the laminations.

Calculate the average of the results for each direction and take the lower of the two averages as the impact strength, Izod, of the sheet under test. However, for Type WV sheets with the veneers arranged with their grain mainly in the same direction, take the higher of the two averages. [See note 6) to table 5.]

NOTE — In tropical countries, the alternative standard conditioning atmosphere given in ISO 291 [27 ± 2 °C, (65 ± 5) % relative humidity] may be used, by agreement.

Annex D

Determination of electric strength

(This annex forms an integral part of the Standard.)

Electric strength shall be determined by the method specified in IEC Publication 243. The test shall be carried out in mineral oil at 90 ± 2 °C.

To ensure that the test specimen has reached the test temperature, immerse it in oil maintained at that temperature for not less than 0,5 h and not more than 1 h immediately before test. Use either the 20 s step-by-step test or the 1 min proof test. In both cases test three specimens.

In the cases of the 20 s step-by-step test, the average of the individual test results shall be taken as the electric strength of the sheet under test. In the case of the 1 min proof test the sheet under test shall be deemed to comply with this requirement only if all three specimens withstand the specified proof voltage for one minute.

Express the result in megavolts per metre for the test perpendicular to the laminations and in kilovolts for the test parallel to the laminations.

NOTE — A temperature of 90 °C has been chosen for uniform testing of all materials and not with respect to the allowable temperature of application.

Annex E

Determination of insulation resistance after immersion in water

(This annex forms an integral part of the Standard.)

Insulation resistance after immersion in water shall be determined by the method specified in IEC Publication 167.

The test specimen shall be 76^{+2}_{0} mm long and 50^{+2}_{0} mm wide and shall be of the thickness of the sheet under test. Four specimens shall be used, two with their major axes parallel with direction A and two with their major axes parallel with direction B, as indicated in figure 2.

Heat the specimen for 24 ± 1 h in an oven at 50 ± 2 °C, cool to room temperature and then immerse for 24 ± 1 h in distilled water of equivalent purity, at a temperature of 23 ± 2 °C.

Remove the specimen from the water and wipe dry with a clean cloth or filter paper. Insert the electrodes and measure the insulation resistance at 15 to 35 °C in an atmosphere of not more than 75 % relative humidity. Complete the measurement between 1,5 and 2 min after the removal of the specimen from the water.

Calculate the average of the individual results for each direction and take the lower of two averages as the insulation resistance after immersion in water of the sheet under test.

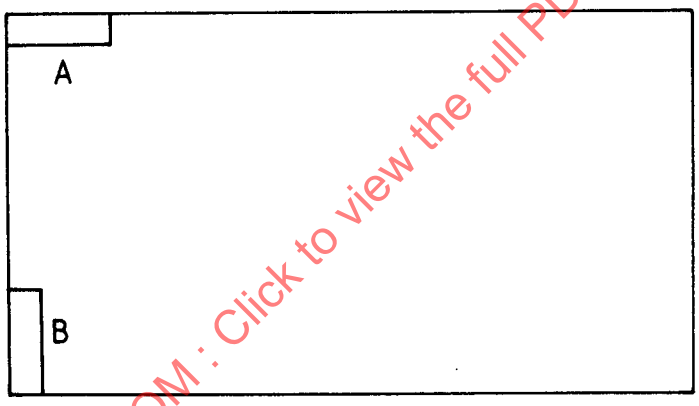

Figure 2 — Determination of insulation resistance after immersion in water — Direction of test specimens