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R 1642

PLASTICS

BASIS FOR SPECIFICATION FOR INDUSTRIAL LAMINATED SHEETS BASED ON THERMOSETTING RESINS

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BRIEF HISTORY

The ISO Recommendation R 1642, *Plastics – Basis for specification for industrial laminated sheets based on thermosetting resins,* was drawn up by Technical Committee ISO/TC 61, *Plastics,* the Secretariat of which is held by the American National Standards Institute (ANSI).

Work on this question led to the adoption of Draft ISO Recommendation No. 1642, which was circulated to all the ISO Member Bodies for enquiry in August 1968. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies :

Belgium	Israel	Spain
Brazil	Italy	Sweden
Canada	Japan	Switzerland
Czechoslovakia	Korea, Rep. of	Turkey
France	Netherlands	U.A.R.
Germany	New Zealand	United Kingdom
Greece	Poland	U.S.A.
Hungary	Portugal	U.S.S.R.
India	Romania	
Iran	South Africa, Rep. of	

No Member Body opposed the approval of the Draft.

This Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided to accept it as an ISO RECOMMENDATION.

FOREWORD

This ISO Recommendation does not contain limits for properties. These will be inserted as soon as the necessary methods of test have been given in ISO and IEC Recommendations and data arising from experience of these methods become available.

ISO Recommendation R 1642 January 1971

PLASTICS

BASIS FOR SPECIFICATION FOR INDUSTRIAL LAMINATED SHEETS BASED ON THERMOSETTING RESINS

1. SCOPE

This ISO Recommendation gives a basis for specification covering industrial laminated sheets made with any one of the following resins as the binder : epoxy (epoxide), melamine, phenolic, (unsaturated) polyester and silicone. The sheets covered are flat and are those of the nominal thicknesses listed in Table 2.

2. CLASSIFICATION

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

2.1 Abbreviations

Resins	Abbreviation
Epoxy (epoxide)	EP
Melamine	MF
Phenolic	PF
Polyester	UP
Silicone	SI

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

2.2 Types

The following list shows the combinations of resins and reinforcements which constitute the types covered by the specification, together with applications and distinguishing properties.

Type			Applications and distinguishing properties
Resin	Reinforcement	Number	
EP	CP	1	Electronic application. Good stability of electrical properties under high humidity, flame resistant.
	GC	1	Mechanical and electrical 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, flame resistant.
	GC	3	Similar to Type EP GC 1, extremely high mechanical strength at elevated temperature.
	GC	4	Similar to Type EP GC 3, flame resistant.
MF	GC	1	Mechanical and electrical applications. High mechanical strength, flame, arc, and tracking resistant.
PF	CP	1	Mechanical application. Mechanical properties better than other PF CP types. Poor electrical properties under normal humidity.
	CP	2	High voltage application at power frequencies. High electric strength under oil. Good electric strength in air under normal humidity.
	CP	3	Electrical and mechanical applications, good electrical properties under normal humidity.
	CP	4	Electrical and electronic applications, good stability of electrical properties under high humidity.
	CC	1	Mechanical application (coarse weave*). Good mechanical properties.
	CC	2	Mechanical and electrical applications (coarse weave*).
	CC	3	Mechanical application (fine weave*), recommended for small parts.
	CC	4	Mechanical and electrical applications (fine weave*), recommended for small parts.
	WV	1	Mechanical application. Good mechanical properties.
	WV	2	High voltage applications at power frequencies. Properties and other applications under consideration.
	WV	3	Mechanical and electrical applications, good electrical properties under normal humidity.
	AP	1	Mechanical application, heat and flame resistant.

* Characteristics of the base material

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

These values are given for information only; they are not to be considered specification values.

Type			Applications and distinguishing properties
Resin	Reinforcement	Number	
PF	AC	1	Mechanical application. Mechanically better than PF AP 1, heat and flame resistant.
	AM	1	Mechanical application, heat and flame resistant.
	GC	1	Mechanical and electrical applications. High mechanical strength and good electrical properties under normal humidity, heat and flame resistant.
UP	GM	1	Mechanical, electrical and electronic applications. Good stability of electrical properties under high humidity.
	GM	2	Mechanical, electrical and electronic applications. Similar to UP GM 1, flame resistant.
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.

NOTE. – It must not be inferred from the above 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.

3. DEFINITIONS

For the purpose of this ISO Recommendation, the following definitions apply :

3.1 *Laminates.* Products made by bonding together two or more layers of material or materials. Industrial laminated sheets consist of superimposed layers of paper, fabric, veneer or felt (mat) that have been substantially impregnated with a thermosetting or curable resin and bonded together under pressure, with or without heat, to form a single piece. Other ingredients, for example, colouring matter, may be incorporated.

3.2 *Epoxy (Epoxide) resin.* Synthetic resin containing epoxide groups and capable of cross-linking.

3.3 *Melamine resin.* An amino resin made by polycondensation of melamine with formaldehyde or a compound that is capable of providing methylene bridges.

3.4 *Phenolic resin.* Generically a class of resins made by the polycondensation of phenol, its homologues and/or derivatives, with aldehydes or ketones.

3.5 *Polyester resin.* A polymer in which the repeated structural unit in the chain is of the ester type.

3.6 *Silicone resin.* Resin in which the main polymer chain consists of alternating silicon and oxygen atoms, with carbon-containing side groups.

4. APPEARANCE

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

5. 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 straight-edge laid in any direction upon it shall not exceed the appropriate value given in Table 1.

TABLE 1 – **Maximum permissible departure of surface of sheet from straight-edge**

Material	Thickness	Length of straight-edge	
		100 cm	50 cm
Values for various materials and thicknesses are to be inserted later.			

6. TOLERANCES IN THICKNESS

The deviation from nominal thickness of a sheet at any point shall not exceed the value shown in Table 2 for the appropriate type and thickness. The diameter of the anvil of the measuring device shall be 6 to 8 mm.

TABLE 2 – **Tolerances in thickness (± mm)**

Nominal thickness (mm)	EP		MF	PF						UP	SI
	CP	GC	GC	CP	CC	WV	AP	AC	AM	GC	GM	GC
	1	1 – 2 – 3 – 4	1	1 – 2 – 3 – 4	1 – 2 – 3 – 4	1 – 2 – 3	1	1	1	1	1 – 2	1 – 2
Values for various materials and thicknesses are to be inserted later.												

7. PHYSICAL PROPERTIES

When determined by the appropriate test methods, the physical properties shall be as given in Table 3.

TABLE 3 – Physical properties

A. Epoxy resin EP										
Property	Method of test	Unit	Maximum or minimum	Maximum or minimum 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
Flexural stress at rupture, perpendicular to laminations	Annex A	N/mm^2	minimum	1.5 mm minimum	n	n	n	n[1]	n[1]
Impact strength (notched test piece tested parallel to laminations)									
(*a*) Charpy[2]	Annex B	kJ/m^2	minimum	5 mm minimum	n	n	n	n	n
(*b*) Izod[2]	Annex C	J per mm of notch	minimum	5 mm minimum	n	n	n	n	n
Electric strength at 90 °C in oil, perpendicular to laminations	Annex D	kV/mm	minimum	3 mm maximum[4]	See Tables 5A and 5B				
Electric strength at 90 °C in oil, parallel to laminations[3]									
(*a*) 20 s step-by-step test	Annex D	kV	minimum	3 mm minimum[5]	n	n	n	n	n
(*b*) 1 minute proof test	Annex D	kV	minimum	3 mm minimum[5]	n	n	n	n	n
Insulation resistance after immersion in water	Annex E	MΩ	minimum	3 mm maximum	n	n	n	n	n
Dissipation factor at 1 MHz after immersion in water	Annex F		maximum	3 mm maximum	n	n	n	n	n
Permittivity at 1 MHz after immersion in water	Annex F		maximum	3 mm maximum	n	n	n	n	n
Flammability	ISO/TC 61 method	s	maximum	0.8 mm minimum	n	–	n	–	n
Temperature of deflection under load[6]	Under consideration								
Water absorption	ISO/R 62[11] Procedure A	mg	maximum		See Table 4				

NOTES : see page 14.

TABLE 3 (*continued*)

B. Melamine resin MF					
Property	**Method of test**	**Unit**	**Maximum or minimum**	**Maximum or minimum nominal thickness of sheet to which test is applied**	**Type MF GC 1**
Flexural stress at rupture, perpendicular to laminations	Annex A	N/mm^2	minimum	1.5 mm minimum	n
Impact strength (notched test piece tested parallel to laminations) (*a*) Charpy[2] (*b*) Izod[2]	 Annex B Annex C	 kJ/m^2 J per mm of notch	 minimum minimum	 5 mm minimum 5 mm minimum	 n n
Electric strength at 90 °C in oil, perpendicular to laminations	Annex D	kV/mm	minimum	3 mm maximum[4]	See Tables 5A and 5B
Electric strength at 90 °C in oil, parallel to laminations[3] (*a*) 20 s step-by-step test (*b*) 1 minute proof test	 Annex D Annex D	 kV kV	 minimum minimum	 3 mm minimum[5] 3 mm minimum[5]	 n n
Insulation resistance after immersion in water	Annex E	MΩ	minimum	3 mm maximum	n
Comparative tracking index	IEC Publication 112[12]	V	minimum		n
Flammability	ISO/TC 61 method	s	maximum	0.8 mm minimum	n
Temperature of deflection under load[6]	Under consideration				
Water absorption	ISO/R 62[11] Procedure A	mg	maximum		See Table 4

NOTES : see page 14.

TABLE 3 – (*continued*)

C. Phenolic resin PF																	
Property	**Method of test**	**Unit**	**Maximum or minimum**	**Maximum or minimum nominal thickness of sheet to which test is applied**	**Types**														
					PF CP 1	PF CP 2	PF CP 3	PF CP 4	PF CC 1	PF CC 2	PF CC 3	PF CC 4	PF WV 1	PF WV 2	PF WV 3	PF AP 1	PF AC 1	PF AM 1	PF GC 1
Flexural stress at rupture, perpendicular to laminations	Annex A	N/mm^2	minimum	1.5 mm minimum	n	n	n[8]	n[8]	n	n	n	n	n[7]	n[7]	n[7]	n	n	n	n
Impact strength (notched test piece tested parallel to laminations)																			
(*a*) Charpy[2]	Annex B	kJ/m^2	minimum	5 mm minimum	n	n	n	n	n	n	n	n	n[7]	n[7]	n[7]	n	n	n	n
(*b*) Izod[2]	Annex C	J per mm of notch	minimum	5 mm minimum	n	n	n	n	n	n	n	n	n[7]	n[7]	n[7]	n	n	n	n
Electric strength at 90 °C in oil, perpendicular to laminations	Annex D	kV/mm	minimum	3 mm maximum[4]	See Tables 5A and 5B														
Electric strength at 90 °C in oil, parallel to laminations[3]																			
(*a*) 20 s step-by-step test	Annex D	kV	minimum	3 mm minimum[5]	–	n[9]	n	n	–	n	–	n	–	n[9]	n	–	–	–	n
(*b*) 1 minute proof test	Annex D	kV	minimum	3 mm minimum[5]		n[9]	n	n	–	n	–	n	–	n[9]	n	–	–	–	n
Insulation resistance after immersion in water	Annex E	MΩ	minimum	3 mm maximum	–		n	n	–	n	–	n	–	n	n	–	–	–	n
Dissipation factor at 1 MHz after immersion in water	Annex F		maximum	3 mm maximum	–	–		n	–	–	–	–	–	–	–	–	–	–	–
Permittivity at 1 MHz after immersion in water	Annex F		maximum	3 mm maximum	–	–	–	n	–	–	–	–	–	–	–	–	–	–	–
Dissipation factor at 50 Hz after heating	Annex G		maximum	3 mm maximum	–	n	–	–	–	–	–	–	–	n	–	–	–	–	–
Permittivity at 50 Hz after heating	Annex G		maximum	3 mm maximum	–	n	–	–	–	–	–	–	–	n	–	–	–	–	–
Flammability	ISO/TC 61 method	s	maximum	0.8 mm minimum	–	–	–	–	–	–	–	–	–	–	–	n	n	n	–
Temperature of deflection under load[6]	Under consideration																		
Water absorption	ISO/R 62[11] Procedure A	mg	maximum		See Table 4														

NOTES : see page 14.

TABLE 3 (*continued*)

D. Polyester resin UP						
Property	**Method of test**	**Unit**	**Maximum or minimum**	**Maximum or minimum nominal thickness of sheet to which test is applied**	**Types** UP GM 1	UP GM 2
Flexural stress at rupture, perpendicular to laminations	Annex A	N/mm^2	minimum	1.5 mm minimum	n	n
Impact strength (notched test piece tested parallel to laminations) (*a*) Charpy[2] (*b*) Izod[2]	 Annex B Annex C	 kJ/m^2 J per mm of notch	 minimum minimum	 5 mm minimum 5 mm minimum	 n n	 n n
Electric strength at 90 °C in oil, perpendicular to laminations	Annex D	kV/mm	minimum	3 mm maximum[4]	See Tables 5A and 5B	
Electric strength at 90 °C in oil, parallel to laminations[3] (*a*) 20 s step-by-step test (*b*) 1 minute proof test	 Annex D Annex D	 kV kV	 minimum minimum	 3 mm minimum[5] 3 mm minimum[5]	 n n	 n n
Insulation resistance after immersion in water	Annex E	MΩ	minimum	3 mm maximum	n	n
Flammability	ISO/TC 61 method	s	maximum	0.8 mm minimum	–	n
Temperature of deflection under load[6]	Under consideration					
Water absorption	ISO/TC 62[11] Procedure A	mg	maximum		See Table 4	

NOTES : see page 14.

TABLE 3 (*concluded*)

E. Silicone resin SI						
Property	**Method of test**	**Unit**	**Maximum or minimum**	**Maximum or minimum 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	N/mm^2	minimum	1.5 mm minimum	n	n(10)
Impact strength (notched test piece tested parallel to laminations)						
(*a*) Charpy(2)	Annex B	kJ/m^2	minimum	5 mm minimum	n	n
(*b*) Izod(2)	Annex C	J per mm of notch	minimum	5 mm minimum	n	n
Electric strength at 90 °C in oil, parallel to laminations(3)						
(*a*) 20 s step-by-step test	Annex D	kV	minimum	3 mm minimum(5)	n	n
(*b*) 1 minute proof test	Annex D	kV	minimum	3 mm minimum(5)	n	n
Insulation resistance after immersion in water	Annex E	MΩ	minimum	3 mm maximum	n	n
Dissipation factor at 1 MHz after immersion in water	Annex F		maximum	3 mm maximum	n	n
Permittivity at 1 MHz after immersion in water	Annex F		maximum	3 mm maximum	n	n
Flammability	ISO/TC 61 method	s	maximum	0.8 mm minimum	n	n
Water absorption	ISO/R 62(11) Procedure A	mg	maximum		See Table 4	

NOTES : see page 14.

NOTES CONCERNING TABLE 3

n. Limits to be inserted when data are available.

(1) For Types EP 3 and GC 4, the flexural strength measured at 150 ± 5 °C after conditioning for 1 hour at 150 ± 5 °C in air should not be less than *x* % of the value specified in the Table.

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

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

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

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

(6) The types to which this test is to be applied will be specified at a later date.

(7) The values in the Table 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 vendor and purchaser.

(8) Materials with improved punchability are available, but they will not necessarily comply with this specification in flexural strength.

(9) After heating at 105 ± 5 °C in air for 4 days (96 hours). These values should not be compared with those given for other types.

(10) For Type SI GC 2, the flexural strength measured at 180 ± 5 °C after conditioning for 1 hour at 180 ± 5 °C in air should not be less than *x* % of the value specified in the Table.

(11) ISO Recommendation R 62, *Plastics – Determination of water absorption.*

(12) IEC Publication 112, *Recommended method for determining the comparative tracking index of solid insulating materials under moist conditions.*

TABLE 4 – **Limits for water absorption in milligrammes**

Type	Mean measured thickness of test pieces (mm)																			
	0.4	0.7	1	1.5	2	3	4	5	6	7	8	10	12	14	16	18	20	22	25	22.5 : one face machined*
EP CP 1																				
EP GC 1																				
EP GC 2																				
EP GC 3																				
EP GC 4																				
MF GC 1																				
PF CP 1																				
PF CP 2																				
PF CP 3																				
PF CP 4																				
PF CC 1																				
PF CC 2																				
PF CC 3																				
PF CC 4																				
PF WV 1																				
PF WV 2																				
PF WV 3																				
PF AP 1																				
PF AC 1																				
PF AM 1																				
PF GC 1																				
UP GM 1																				
UP GM 2																				
SI GC 1																				
SI GC 2																				

* Sheets of nominal thicknesses greater than 25 mm should be machined to a relatively smooth surface on one face to a thickness of 22.5 mm, according to ISO Recommendation R 62, *Plastics – Determination of water absorption.*

NOTE. – If the mean of the measured values of thickness of the test pieces lies between two values of thickness shown in the above Table, the limit should 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 should apply. If the nominal thickness is 25 mm and the mean measured thickness exceeds 25 mm, the limit for 25 mm should apply.

TABLE 5A – Limits for electric strength at 90 °C in oil, perpendicular to laminations (20 s step-by-step test) in kV/mm*

Type	Mean measured thickness of test pieces (mm)																
	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	2.6	2.8	3.0
EP CP 1																	
EP GC 1																	
EP GC 2																	
EP GC 3																	
EP GC 4																	
MF GC 1																	
PF CP 2																	
PF CP 3																	
PF CP 4																	
PF GC 1																	
UP GM 1																	
UP GM 2																	

TABLE 5B – Proof values of electric stress at 90 °C in oil, perpendicular to laminations (1 minute proof test) in kV/mm*

Type	Mean measured thickness of test pieces (mm)																
	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	2.6	2.8	3.0
EP CP 1																	
EP GC 1																	
EP GC 2																	
EP GC 3																	
EP GC 4																	
MF GC 1																	
PF CP 2																	
PF CP 3																	
PF CP 4																	
PF GC 1																	
UP GM 1																	
UP GM 2																	

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

ANNEX A

DETERMINATION OF FLEXURAL STRESS AT RUPTURE PERPENDICULAR TO LAMINATIONS

Flexural stress at rupture shall be determined as specified in ISO Recommendation R 178, *Plastics – Determination of flexural properties of rigid plastics*.

The test pieces shall be cut from the sheet to be tested with their major axes in the directions indicated at A and B in Figure 1 of ISO Recommendation R 178, at least five test pieces being taken in each direction. If the sheet to be tested is more than 10 mm thick (20 mm in the case of Type WV), the thickness of the test pieces shall be reduced to 10 mm (20 mm in the case of Type WV), one face of the sheet being left intact.

The test pieces shall be loaded perpendicular to the laminations.

The average of the results for each direction shall be calculated and the lower of the two averages shall be taken 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, the higher of the two averages shall be taken. (See Note (7) concerning Table 3.)

ANNEX B

DETERMINATION OF IMPACT STRENGTH, CHARPY
(NOTCHED TEST PIECE)

Impact strength, Charpy, shall be determined with notched test pieces as specified in ISO Recommendation R 179, *Plastics – Determination of the Charpy impact resistance of rigid plastics (Charpy impact flexural test).*

The test pieces shall be cut from the sheet to be tested with their major axes in the directions indicated at A and B in Figure 1, five test pieces being taken in each direction.

The test pieces shall be struck parallel to the laminations.

The average of the results for each direction shall be calculated, and the lower of the two averages shall be taken 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, the higher of the two averages shall be taken. (See Note (7) concerning Table 3.)

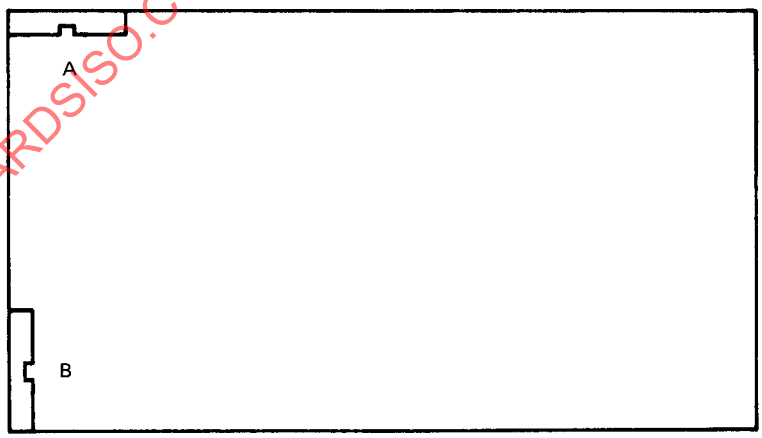

FIG. 1

ANNEX C

DETERMINATION OF IMPACT STRENGTH, IZOD
(NOTCHED TEST PIECE)

Impact strength, Izod, shall be determined by Method B of ISO Recommendation R 180, *Plastics – Determination of the Izod impact resistance of rigid plastics (Izod impact flexural tests).*

The test pieces shall be cut from the sheet to be tested with their major axes in the directions indicated at A and B in Figure 1, five test pieces being taken in each direction.

The test pieces shall be struck parallel to the laminations.

The average of the results for each direction shall be calculated and the lower of the two averages shall be taken 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, the higher of the two averages shall be taken. (See Note (7) concerning Table 3.)