

INTERNATIONAL STANDARD



1642

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Plastics — Industrial laminated sheets based on thermosetting resins — Basis for specification

*Matières plastiques — Stratifiés industriels en planches à base de résines thermodurcissables —
Bases de spécification*

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up 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.

Prior to 1972, the results of the work of the Technical Committees were published as ISO Recommendations; these documents are now in the process of being transformed into International Standards. As part of this process, Technical Committee ISO/TC 61 has reviewed ISO Recommendation R 1642 and found it technically suitable for transformation. International Standard ISO 1642 therefore replaces ISO Recommendation R 1642:1971 to which it is technically identical.

ISO Recommendation R 1642 was approved by the Member Bodies of the following countries :

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

No Member Body expressed disapproval of the Recommendation.

The Member Bodies of the following countries disapproved the transformation of ISO/R 1642 into an International Standard :

Canada
United Kingdom

Plastics — Industrial laminated sheets based on thermosetting resins — Basis for specification

1 SCOPE AND FIELD OF APPLICATION

This International Standard 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 3.

2 REFERENCES

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

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

ISO/R 179, *Plastics — Determination of the Charpy impact resistance of rigid plastics (Charpy impact flexural test).*

ISO/R 180, *Plastics — Determination of the Izod impact resistance of rigid plastics (Izod impact flexural tests).*

IEC Publication 112, *Recommended method for determining the comparative tracking index 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 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.*

3 CLASSIFICATION

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

3.1 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

3.2 Types

Table 1 shows the combinations of resins and reinforcements which constitute the types covered by the specification, together with applications and distinguishing properties.

4 DEFINITIONS

For the purpose of this International Standard, the following definitions apply:

4.1 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.

4.2 epoxy (epoxide) resin: Synthetic resin containing epoxide groups and capable of cross-linking.

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

4.4 phenolic resin: Generically a class of resins made by the polycondensation of phenol, its homologues and/or derivatives, with aldehydes or ketones.

4.5 polyester resin: A polymer in which the repeated structural unit in the chain is of the ester type.

4.6 silicone resin: Resin in which the main polymer chain consists of alternating silicon and oxygen atoms, with carbon-containing side groups.

TABLE 1 – Types

Type			Applications and distinguishing properties
Resin	Reinforcement	Number	
EP	CP	1	Electronic applications. 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 applications. Mechanical properties better than other PF CP types. Poor electrical properties under normal humidity.
	CP	2	High voltage applications 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 applications (coarse weave ¹⁾). Good mechanical properties.
	CC	2	Mechanical and electrical applications (coarse weave ¹⁾).
	CC	3	Mechanical applications (fine weave ¹⁾). Recommended for small parts.
	CC	4	Mechanical and electrical applications (fine weave ¹⁾). Recommended for small parts.
	WV	1	Mechanical applications. 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 applications. Heat and flame resistant.
	AC	1	Mechanical applications. Mechanically better than PF AP 1. Heat and flame resistant.
	AM	1	Mechanical applications. 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.

1) Characteristics of the base material (These values are given for information only; they are not to be considered specification values.)

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

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.

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

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

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 the appropriate value given in table 2.

7 TOLERANCES ON THICKNESS

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.

8 PHYSICAL PROPERTIES

When determined by the appropriate test methods, the physical properties shall be as given in table 4.

TABLE 3 — Tolerances in thickness ($\pm$ 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.												

TABLE 4 — Physical properties

A. Epoxy resin EP									
Property	Method of test	Unit	Max. or min.	Max. or min. nominal thickness of sheet to which test is applied	EP CP	EP GC	EP GC	EP GC	EP GC
Flexural stress at rupture, perpendicular to laminations	Annex A	N/mm ²	min.	1,5 mm min.	n	n	n	n ¹⁾	n ¹⁾
Impact strength (notched test piece tested parallel to laminations)	Annex B Annex C	kJ/m ² J per mm of notch	min.	5 mm min.	n	n	n	n	n
a) Charpy ²⁾ b) Izod ²⁾			min.	5 mm min.	n	n	n	n	n
Electric strength at 90 °C in oil, perpendicular to laminations	Annex D	kV/mm	min.	3 mm max. 4)	See tables 6A and 6B				
Electric strength at 90 °C in oil, parallel to laminations ³⁾	Annex D Annex D	kV kV	min.	3 mm min. 5)	n	n	n	n	n
a) 20 s step-by-step test b) 1 min proof test			min.	3 mm min. 5)	n	n	n	n	n
Insulation resistance after immersion in water	Annex E	MΩ	min.	3 mm max.	n	n	n	n	n
Dissipation factor at 1 MHz after immersion in water	Annex F		max.	3 mm max.	n	n	n	n	n
Permittivity at 1 MHz after immersion in water	Annex F		max.	3 mm max.	n	n	n	n	n
Flammability	ISO/TC 61 method	s	max.	0,8 mm min.	n	—	n	—	n
Temperature of deflection under load ⁶⁾	Under consideration				See table 5				
Water absorption	ISO/R 6211) Procedure A	mg	max.						

Notes : See page 9

TABLE 4 (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	Type MF GC 1
Flexural stress at rupture, perpendicular to laminations	Annex A	N/mm ²	min.	1,5 mm min.	n
Impact strength (notched test piece tested parallel to laminations)					
a) Charpy ²⁾	Annex B	kJ/m ²	min.	5 mm min.	n
b) Izod ²⁾	Annex C	J per mm of notch	min.	5 mm min.	n
Electric strength at 90 °C in oil, perpendicular to laminations	Annex D	kV/mm	min.	3 mm max. ⁴⁾	See tables 6A and 6B
Electric strength at 90 °C in oil, parallel to laminations ³⁾					
a) 20 s step-by-step test	Annex D	kV	min.	3 mm min. ⁵⁾	n
b) 1 min proof test	Annex D	kV	min.	3 mm min. ⁵⁾	n
Insulation resistance after immersion in water	Annex E	MΩ	min.	3 mm max.	n
Comparative tracking index	IEC 112	V	min.		n
Flammability	ISO/TC 61 method	s	max.	0,8 mm min.	n
Temperature of deflection under load ⁶⁾	Under consideration				
Water absorption	ISO/R 62 ¹⁾ Procedure A	mg	max.		See table 5

Notes : See page 9

TABLE 4 (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	PF	CP	PF	CP	PF	CP	PF	CP	PF	CP	PF	CP	PF	CP	PF	CP
Flexural stress at rupture, perpendicular to laminations	Annex A	N/mm ²	min.	1,5 mm min.	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
Impact strength (notched test piece tested parallel to laminations) a) Charpy ²⁾ b) Izod ²⁾	Annex B	kJ/m ²	min.	5 mm min.	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	Annex C	J per mm of notch	min.	5 mm min.	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
Electric strength at 90 °C in oil, perpendicular to laminations	Annex D	kV/mm	min.	3 mm max. ⁴⁾	See tables 6A and 6B																	
Electric strength at 90 °C in oil, parallel to laminations ³⁾ a) 20 s step-by-step test b) 1 min proof test	Annex D	kV	min.	3 mm min. ⁵⁾	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
	Annex D	kV	min.	3 mm min. ⁵⁾	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
Insulation resistance after immersion in water	Annex E	MΩ	min.	3 mm max.	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
Dissipation factor at 1 MHz after immersion in water	Annex F		max.	3 mm max.	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
Permittivity at 1 MHz after immersion in water	Annex F		max.	3 mm max.	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
Dissipation factor at 50 Hz after heating	Annex G		max.	3 mm max.	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
Permittivity at 50 Hz after heating	Annex G		max.	3 mm max.	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
Flammability	ISO/TC 61 method	s	max.	0,8 mm min.	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
Temperature of deflection under load ⁶⁾	Under consideration																					
Water absorption	ISO/R 62 ¹⁾ Procedure A	mg	max.		See table 5																	

Notes : See page 9

TABLE 4 (continued)

D. Polyester resin UP						
Property	Method of test	Unit	Max. or min.	Max. or min. nominal thickness of sheet to which test is applied	UP GM 1	UP GM 2
Flexural stress at rupture, perpendicular to laminations	Annex A	N/mm ²	min.	1,5 mm min.	n	n
Impact strength (notched test piece tested parallel to laminations)						
a) Charpy ²⁾	Annex B	kJ/m ²	min.	5 mm min.	n	n
b) Izod ²⁾	Annex C	J per mm of notch	min.	5 mm min.	n	n
Electric strength at 90 °C in oil, perpendicular to laminations	Annex D	kV/mm	min.	3 mm min. ⁴⁾	See tables 6A and 6B	
Electric strength at 90 °C in oil, parallel to laminations ³⁾						
a) 20 s step-by-step test	Annex D	kV	min.	3 mm min. ⁵⁾	n	n
b) 1 min proof test	Annex D	kV	min.	3 mm min. ⁵⁾	n	n
Insulation resistance after immersion in water	Annex E	MΩ	min.	3 mm max.	n	n
Flammability	ISO/TC 61 method	s	max.	0,8 mm min	—	n
Temperature of deflection under load ⁶⁾	Under consideration					
Water absorption	ISO/R 62 ¹¹⁾ Procedure A	mg	max.		See table 5	

Notes : See page 9

TABLE 4 (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	SI GC 1	SI GC 2	Types
Flexural stress at rupture, perpendicular to laminations	Annex A	N/mm ²	min.	1,5 mm min.	n	n ¹⁰⁾	
Impact strength (notched test piece tested parallel to laminations)							
a) Charpy ²⁾	Annex B	kJ/m ²	min.	5 mm min.	n	n	
b) Izod ²⁾	Annex C	J per mm of notch	min.	5 mm min.	n	n	
Electric strength at 90 °C in oil, parallel to laminations ³⁾							
a) 20 s step-by-step test	Annex D	kV	min.	3 mm min. 5)	n	n	
b) 1 min proof test	Annex D	kV	min.	3 mm min. 5)	n	n	
Insulation resistance after immersion in water	Annex E	MΩ	min.	3 mm max.	n	n	
Dissipation factor at 1 MHz after immersion in water	Annex F		max.	3 mm max.	n	n	
Permittivity at 1 MHz after immersion in water	Annex F		max.	3 mm max.	n	n	
Flammability	ISO/TC 61 method	s	max.	0,8 mm min.	n	n	
Water absorption	ISO/R 62 ¹¹⁾ Procedure A	mg	max.		See table 5		

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NOTES CONCERNING TABLE 4

n Limits to be inserted when data are available.

- 1) For types EP GC 3 and 4, the flexural strength measured at $150 \pm 5^\circ\text{C}$ after conditioning for 1 h at $150 \pm 5^\circ\text{C}$ in air shall 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 shall 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 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 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 shall 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 $105 \pm 5^\circ\text{C}$ in air for 4 days (96 h). These values shall not be compared with those given for other types.
- 10) For Type SI GC 2, the flexural strength measured at $180 \pm 5^\circ\text{C}$ after conditioning for 1 h at $180 \pm 5^\circ\text{C}$ in air shall not be less than $x\%$ of the value specified in the table.
- 11) See clause 2.

TABLE 5 — Limits for water absorption in milligrams

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 ¹⁾
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																				

1) 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, according to ISO/R 62.

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 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.

TABLE 6A — Limits for electric strength at 90 °C in oil, perpendicular to laminations
(20 s step-by-step test) in kV/mm¹⁾

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
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 6B — Proof values of electric strength at 90 °C in oil, perpendicular to laminations
(1 min proof test) in kV/mm¹⁾

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
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																

1) The requirements for the 20 s step-by-step test 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 in respect of electric strength at 90 °C in oil, perpendicular to laminations.