IEC 61249-2-47

Edition 1.0 2018-01

INTERNATIONAL STANDARD

Materials for printed boards and other interconnecting structures – Part 2-47: Reinforced base materials clad and unclad – Non-halogenated epoxide non-woven/woven E-glass reinforced laminate sheets of thermal conductivity 2,0 W/(m•K) and defined flammability (vertical burning test), copper-clad for lead-free assembly

IEC 61249-2-47:2018-01(en)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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MATERIALS FOR PRINTED BOARDS AND OTHER INTERCONNECTING STRUCTURES –

Part 2-47: Reinforced base materials clad and unclad – Non-halogenated epoxide non-woven/woven E-glass reinforced laminate sheets of thermal conductivity 2,0 W/(m•K) and defined flammability (vertical burning test), copper-clad for lead-free assembly

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International Standard IEC 61249-2-45 has been prepared by IEC technical committee 91: Electronics assembly technology.

The text of this International Standard is based on the following documents:

CDV	Report on voting
91/1449/FDIS	91/1485/RVC

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 61249 series, under the general title *Materials for printed boards and other interconnecting structures*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

MATERIALS FOR PRINTED BOARDS AND OTHER INTERCONNECTING STRUCTURES –

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1 Scope

This part of IEC 61249 gives requirements for properties of non-halogenated epoxide non-woven reinforced core/woven E-glass reinforced surface laminate sheets of thermal conductivity and defined flammability (vertical burning test), copper-clad for lead-free assembly in thicknesses of 0,60 mm up to 1,70 mm. The flammability rating is achieved through the use of non-halogenated fire retardants reacted as part of the epoxide polymeric structure. The glass transition temperature is defined to be 105 °C minimum. Thermal conductivity is defined to be (2,0 ± 0,30) W/(m•K).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61189-2:2006, *Test methods for electrical materials, printed boards and other interconnection structures and assemblies – Part 2: Test methods for materials for interconnection structures*

IEC 61249-5-1, *Materials for interconnection structures – Part 5: Sectional specification set for conductive foils and films with and without coatings – Section 1: Copper foils (for the manufacture of copper-clad base materials)*

IEC/PAS 61249-6-3, *Specification for finished fabric woven from "E" glass for printed boards*

ISO 11014, *Safety data sheet for chemical products – Content and order of sections*

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

4 Materials and construction

4.1 General

The sheet consists of an insulating base with metal foil bonded to one side or both.

4.2 Resin system

Non-halogenated epoxide, filled, resulting in a laminate with a glass transition temperature of 105 °C minimum.

Contrast agents may be added to enhance processing such as automated optical inspection (AOI).

Its flame resistance is defined in terms of the flammability requirements of 7.3.

4.3 Metal foil

Copper as specified in IEC 61249-5-1, copper foil (for the manufacture of copper-clad materials). The preferred foils are electrodeposited of defined ductility.

4.4 Reinforcement

Woven E-glass as specified in IEC/PAS 61249-6-3, woven E-glass fabric (for the manufacture of prepreg and copper-clad material) as the surface sheet on each side of a core reinforcement comprised of non-woven E-glass mat.

5 Electrical properties

The electrical property requirements are shown in Table 1.

Table 1 – Electrical properties

Property	Test method IEC 61189-2	Requirements
Surface resistance after damp heat while in the humidity chamber	2E04	≥5 000 MΩ
Surface resistance after damp heat and recovery (optional)	2E04	≥40 000 MΩ
Volume resistivity after damp heat while in the humidity chamber	2E04	≥5 000 MΩm
Volume resistivity after damp heat and recovery (optional)	2E04	≥10 000 MΩm
Relative permittivity after damp heat and recovery (1 MHz)	2E10	≤6,6
Dissipation factor after damp heat and recovery (1 MHz)	2E10	≤0,040
Arc resistance	2E14	≥60 s
Dielectric breakdown	2E15	≥40 kV
Surface resistance at 125 °C	2E04	≥1 000 MΩ
Volume resistivity at 125 °C	2E04	≥1 00 MΩm

6 Non-electrical properties of the copper-clad laminate

6.1 Appearance of the copper-clad sheet

6.1.1 General

The copper-clad face shall be substantially free from defects that can have an impact on the material's fitness for use for the intended purpose.

For the defects given in 6.1.2 to 6.1.5, the requirements given shall apply when inspection is made in accordance with IEC 61189-2, method 2M18.

6.1.2 Indentations (pits and dents)

The size of an indentation, usually the length, shall be determined and given a point value to be used as a measure of the quality as indicated in Table 2.

Table 2 – Size of indentations

Size mm	Point value for each indentation
0,13 to 0,25	1
0,26 to 0,50	2
0,51 to 0,75	4
0,76 to 1,00	7
Over 1,00	30

The total point count for any 300 mm × 300 mm area shall be calculated to determine the class of the material.

- Class A 29 maximum
- Class B 17 maximum
- Class C 5 maximum
- Class D 0
- Class X To be agreed upon by user and supplier

The required class of material shall be specified in the purchase order. Class A applies unless otherwise specified.

6.1.3 Wrinkles

There shall be no wrinkles in the copper surface.

The inspection area shall exclude a 13 mm border from the edge of the panel or sheet.

6.1.4 Scratches

Scratches deeper than 10 µm or 20 % of the nominal thickness of the foil thickness, whichever is lower, are not permitted.

Scratches with a depth of less than 5 % of the nominal thickness of the foil shall not be counted unless this depth is 10 µm or more.

Scratches with a depth of between 5 % and 20 % of the nominal thickness of the foil are permitted to a total length of 100 mm for a 300 mm × 300 mm area.

The inspection area shall exclude a 13 mm border from the edge of the panel or sheet.

6.1.5 Raised areas

Raised areas are usually impressions in the press plates used during manufacture but may also be caused by blisters or inclusions of foreign particles under the foil.

Raised areas caused by blisters or inclusions are not permitted.

Raised areas being impressions of defects in press plates are permitted to the following extent:

– Class A and X material maximum height 15 µm and maximum length 15 mm;
– Class B and C material maximum height 8 µm and maximum length 15 mm;
– Class D material maximum height 5 µm and maximum length 15 mm.

6.2 Appearance of the unclad face

The unclad face of single side clad sheet shall have the natural appearance resulting from the curing process. Small irregularities in colour are permitted. The gloss of the unclad face shall be that given by the press plate, release film, or release foil used. Variations of gloss due to the impact of the pressure of gases released during the curing are permitted.

6.3 Laminate thickness

If the copper-clad laminate is tested in accordance with test method 2D01 of IEC 61189-2, the thickness shall not depart from the nominal thickness by more than the appropriate value shown in Table 3. The fine tolerances shall apply unless the other tolerances are ordered.

Table 3 – Nominal thickness and tolerance of metal-clad laminate

Property	Test method IEC 61189-2	Nominal thickness including metal foil mm	Tolerance requirement ± mm		
			Coarse	Fine	Extra fine
Thickness	2D01	≥0,60 <0,80	0,08	0,06	0,05
		≥0,80 <1,00	0,17	0,10	0,08
		≥1,00 ≤1,70	0,19	0,13	0,08

The thickness and tolerances do not apply to the outer 25 mm of the trimmed master sheet or the outer 13 mm of the cut-to-size panel as manufactured and delivered by the supplier. At no point shall the thickness vary from the nominal by a value greater than 125 % of the specified tolerance.

6.4 Bow and twist

When the copper-clad laminate is tested in accordance with test method 2M01 of IEC 61189-2, the bow and twist shall not exceed the values given in Table 4.

Table 4 – Bow and twist requirements

Property	Test method IEC 61189-2	Nominal thickness mm	Panel dimension longest side mm	Requirements %	
				Copper foil on one side	Copper foil on both sides
Bow and twist	2M01	≥0,6 ≤1,3	≤350	≤2,5	≤2,0
			>350 ≤500	≤2,3	≤1,8
			>500	≤2,0	≤1,5
		>1,3 ≤1,7	≤350	≤2,0	≤1,5
			>350 ≤500	≤1,8	≤1,3
			>500	≤1,5	≤1,0
The requirements for bow and twist apply only to one sided copper-clad laminates with maximum foil thickness of 105 µm (915 g/m^2) and double sided copper-clad laminates with maximum foil thickness difference of 70 µm (610 g/m^2). Requirements for laminates with copper foil configurations beyond these limits should be subject to agreement between purchaser and supplier.					

6.5 Properties related to the copper foil bond

Pull-off and peel strength requirements are shown in Table 5. These requirements apply to copper foil with a normal profile depth.

Table 5 – Pull-off and peel strength requirements

Property	Test method IEC 61189-2	Requirement		
Pull-off strength	2M05	≥25 N		
		Thickness of the copper foil		
		18 µm (152 g/m^2)	≥35 µm (305 g/m^2)	≥70 µm (610 g/m^2)
Peel strength after heat shock 288 °C, 20 s	2M14	≥0,8 N/mm	≥1,0 N/mm	≥1,2 N/mm
		No blistering or delamination		
Peel strength after dry heat 125 °C	2M15	Under consideration	Under consideration	Under consideration
		No blistering or delamination		
Peel strength after exposure to solvent vapour. Solvents as agreed upon between purchaser and supplier	2M06	≥0,8 N/mm	≥1,0 N/mm	≥1,2 N/mm
		No blistering or delamination		
Peel strength after simulated plating	2M16	Under consideration	Under consideration	Under consideration
		No blistering or delamination		
Peel strength at high temperature Temperature 125 °C (optional)	2M17	≥0,6 N/mm	≥0,7 N/mm	≥0,9 N/mm
Blistering after 288 °C, 20 s heat shock	2C05	No blistering or delamination		
In case of difficulty due to breakage of the foil or reading range of the force measuring device, the measurement of peel strength at high temperature may be carried out using conductor widths of more than 3 mm.				

6.6 Punching and machining

The laminate shall, in accordance with the manufacturer's recommendations, be capable of being punched, sheared or drilled. Delamination at the edges due to the shearing process is permissible, provided that the depth of delamination is not larger than the thickness of the base material. Delamination at the edges of drilled holes due to the drilling process is not permissible. Drilled holes shall be capable of being through-plated with no interference from any exudations into the hole.

A suitable test method for evaluating punching is 2M19 of IEC 61189-2. Requirements for punching force and pull-out force are matters for agreement between user and supplier.

6.7 Dimensional stability

When specimens are tested in accordance with IEC 61189-2, 2X02, the observed tolerance shall be as specified in Table 6. The nominal dimensional stability value shall be as agreed upon between user and vendor. The tolerance range around the agreed upon nominal range shall be range B unless otherwise specified on the purchase order.

Table 6 – Dimensional stability

Property	Test method IEC 61189-2	Class	Requirement µm/m
Dimensional stability	2X02	A	±600
		B	±400
		C	±200
		X	As agreed upon between user and supplier

The choice of the glass fabrics and cellulose papers in the construction of the laminate has a significant impact on dimensional stability. Examples of typical constructions used in printed board applications can be found in Annex B. Annex B is not a construction requirement table but is presented for engineering information only.

6.8 Sheet sizes

6.8.1 Typical sheet sizes

Sheet sizes are matters of agreement between purchaser and supplier. However, the recommended sizes are listed below:

– 915 mm × 1 220 mm;
– 1 020 mm × 1 220 mm;
– 1 070 mm × 1 220 mm;
– 1 065 mm × 1 155 mm;
– 1 065 mm × 1 280 mm;
– 1 000 mm × 1 000 mm;
– 1 000 mm × 1 200 mm.

6.8.2 Tolerances for sheet sizes

The size of the sheet delivered by the supplier shall not deviate by more than $^{+25}_{-0}$ mm from the ordered size.

6.9 Cut panels

6.9.1 Cut panel sizes

Cut panel sizes shall be, when delivered, in accordance with the purchaser's specification.

6.9.2 Size tolerances for cut panels

For panels cut to size according to the purchaser's specification, the tolerances for length and width shall apply as shown in Table 7. Tolerances indicated as "normal" shall be in effect unless otherwise specified by in the purchasing specification.

Table 7 – Size tolerances for cut panels

Panel size mm	Tolerance requirement ± mm	
	Normal	Close
≤300	2,0	0,5
>300 ≤600	2,0	0,8
>600	2,0	1,6
NOTE The specified tolerances include all deviations caused by cutting the panels.		

6.9.3 Rectangularity of cut panels

For panels cut to size according to the purchaser's specification, the requirements for rectangularity shall apply as shown in Table 8. Tolerance indicated as "normal" shall be in effect unless otherwise specified in the purchasing specification.

Table 8 – Rectangularity of cut panels

Property	Test method IEC 61189-2	Requirement mm/m	
		Normal	Close
Rectangularity of cut panels	2M23	≤3	≤2

6.10 Thermal conductivity

The thermal conductivity shall meet the requirement in Table 9.

Table 9 – Thermal conductivity

Property	Test method	Nominal Value W/(m•K)	Tolerance W/(m•K)
Thermal conductivity	2XXX[a]	2,0	±0,3
[a] Under consideration (steady-state heat flow method).			

7 Non-electrical properties of the base material after complete removal of the copper foil

7.1 Appearance of the dielectric base material

The etched specimens shall be inspected to verify that no surface or subsurface imperfections of the dielectric material exceed those shown below. The panels shall be inspected using an optical aid apparatus which provides a minimum magnification of 4×.

Referee inspection shall be conducted at 10× magnification. Lighting conditions of inspection shall be appropriate to the material under inspection or as agreed upon between user and supplier.

Surface and subsurface imperfections (such as weave texture, resin starvation, voids, foreign inclusions) shall be acceptable provided that the imperfections meet the following:

- the reinforcement fibres are not cut or exposed;
- the foreign inclusions are not conductive;
- metallic inclusions are not acceptable;
- the imperfections do not propagate as a result of thermal stress;
- the foreign inclusions are translucent;
- opaque foreign fibres are less than 15 mm in length and average no more than 1,0 per 300 mm × 300 mm area;
- opaque foreign inclusions other than fibres shall not exceed 0,50 mm. Opaque foreign inclusions less than 0,15 mm shall not be counted. Opaque foreign inclusions between 0,50 mm and 0,15 mm shall average no more than two spots per 300 mm × 300 mm area;
- voids (sealed voids or surface void) have a longest dimension less than 0,075 mm and there shall not be more than three voids in a 3,5-mm diameter circle.

7.2 Flexural strength

When the laminate is tested in accordance with test method 2M20 of IEC 61189-2, the flexural strength shall be as shown in Table 10.

Table 10 – Flexural strength requirements

Property	Test method IEC 61189-2	Requirements
Flexural strength Length direction Cross direction (applicable to sheets ≥0,80 mm – 1,70 mm in thickness)	2M20	 ≥250 N/mm^2 ≥150 N/mm^2
Flexural strength at elevated temperature Length direction (applicable to sheets ≥0,80 mm – 1,70 mm in thickness)		Not specified

7.3 Flammability

When the laminate is tested in accordance with test method 2C06 of IEC 61189-2, the flammability shall be as shown in Table 11.

The performance labelled FV-0 shall be in effect unless otherwise noted on the purchase order.

Table 11 – Flammability requirements

Property	Test method IEC 61189-2	Requirements	
		Designation	
		FV0	FV1
Flammability:	2C06		
Flaming combustion time after each application of the flame for each test specimen		≤10 s	≤30 s
Total flaming combustion time for the 10 flame applications for each set of five specimens		≤50 s	≤250 s
Glowing combustion time after the second removal of the test flame		≤30 s	≤60 s
Flaming or glowing combustion up to the holding clamp		None	None
Dripping flaming particles that ignite the tissue paper		None	None

7.4 Water absorption

When the laminate is tested in accordance with test method 2N02 of IEC 61189-2, the maximum water absorption shall be as shown in Table 12.

Table 12 – Water absorption requirements

Property	Test method IEC 61189-2	Thickness mm	Requirements %
Water absorption	2N02	≥0,60 <1,20	≤0,50
		≥1,20 <1,60	≤0,40
		≥1,60 ≤1,70	≤0,25

7.5 Measling

When the laminate is tested in accordance with test method 2N01 of IEC 61189-2, the measle requirements shall be as shown in Table 13.

Table 13 – Measling requirements

Property	Test method IEC 61189-2	Requirements
Measling	2N01[a]	No measling on three specimens. If one out of three specimens fails, the test has to be repeated. No measling on three specimens of the second test is permitted. No blistering or delamination on any of the three specimens is permitted.
[a] The following test conditions shall be demanded: the dwell time at 2 atmospheres in pressure vessel is 90 min and the condition of the heat shock after cooking is 288 °C, 20 s.		

7.6 Glass transition temperature and cure factor

The requirements for glass transition temperature and cure factor are found in Table 14.

Table 14 – Glass transition temperature and cure factor requirements

Property	Test method IEC 61189-2	Requirements
Glass transition temperature	2M10 or 2M11	≥105 °C
Cure factor	2M03	≥0,95

7.7 Decomposition temperature

The requirements for decomposition temperature are found in Table 15.

Table 15 – Decomposition temperature requirements

Property	Test method IEC 61189-2	Requirements
Decomposition temperature (5 % weight loss from 50 °C)	2MXX[a]	≥310 °C
[a] Under consideration..		

7.8 Time to delamination (TMA)

The requirements for time to delamination are found in Table 16. The specimen shall not have copper foil on any layer.

Table 16 – Time to delamination requirements

Property		Test method IEC 61189-2	Requirements
Time to delamination	T260 (at 260 °C)	2M25	≥30 min
	T288 (at 288 °C)		≥5 min

7.9 Halogen content

The requirements for halogen content are found in Table 17.

Table 17 – Halogen content

Property	Test method IEC 61189-2	Requirements
Halogen Content	2C12	
Chlorine		≤0,09%
Bromine		≤0,09%
Chlorine+ Bromine		≤0,15%

8 Quality assurance

8.1 Quality system

The supplier shall operate a quality system, ISO 9000 or similar, to support quality conformance inspection.

The supplier shall operate a management system for environmental control, ISO 14001 or similar, to support environmental considerations.

8.2 Responsibility for inspection

The supplier is responsible for all the inspections of the manufactured material. The purchaser or an appointed third party may audit this inspection.

8.3 Qualification inspection

Laminates furnished under this document shall be qualified. Qualification testing shall be performed to demonstrate the manufacturer's ability to meet the requirements of this specification sheet. Qualification testing shall be conducted at a laboratory in compliance with IEC laboratory requirements. A list of the normal qualification tests can be found in Annex C. The manufacturer shall retain on file the data that supports that the materials meet this document and shall be readily available for review upon request.

8.4 Quality conformance inspection

The supplier shall operate a quality plan to assure product conformance to this document. Such a quality plan, when appropriate, should use statistical methods rather than lot-by-lot inspection. It is the responsibility of the supplier based on the quality plan to determine the frequency of test to assure conforming products. In the absence of a quality plan or supporting data, the testing regime shall be as outlined in Annex C.

A combination of the following techniques may be used to show compliance with the requirements that can be used to reduce the frequency of testing. The data supporting the reduction of testing frequency shall be available for review upon request:

- in-process parameter control;
- in-process inspection;
- periodic final inspection;
- final lot inspection.

8.5 Certificate of conformance

The supplier shall, on request from the purchaser, issue a certificate of conformance to this document in electronic or paper format.

8.6 Safety data sheet

A safety data sheet in accordance with ISO 11014 shall be available for products manufactured and delivered in compliance with this document.

9 Packaging and marking

If not otherwise specified in the purchase order, laminate sheets shall be marked with the manufacturer's designation and lot number. Marking shall remain legible during normal handling but be readily removable prior to use of the material.

Cut-to-size panels shall be identified by marking on the package.

Laminates comprised of asymmetric copper configurations shall be marked on the side of the heaviest copper weight.

Sheets and panels shall be packaged in moisture protective bags and in a manner that will provide adequate protection against corrosion, deterioration and physical damage during shipment and storage.

Packages shall be marked in a manner to clearly identify the content.

10 Ordering information

Orders shall include the following details:

a) reference to this document;
b) type of material (see Clause 1 and 7.3);
c) size, thickness and copper cladding;
d) class of indentations (see 6.1.2);
e) class of raised areas (see 6.1.5);
f) class of thickness tolerance (see 6.3);
g) class of dimensional stability (see 6.7);
h) class of panel size tolerance (see 6.9.2);
i) class of flammability (see 7.3); and
j) request for certification, if applicable (see 8.5).

Annex A
(informative)

Engineering information

A.1 General

Information in this annex does not detail material property requirements. The information is intended as a guideline for design and engineering purposes. Users of this document are encouraged to supply information to be included in the annex.

Materials according to this document show the properties and data as listed in Clause A.2 to Clause A.7.

A.2 Chemical properties

- Resistance against chemicals

A.3 Electrical properties

- Comparative tracking index 400 V and greater

A.4 Flammability properties

- Needle flame test
- Oxygen index 45 %

A.5 Mechanical properties

- Compressive strength (flatwise) 400 N/mm^2
- Compressive strength (edgewise) 180 N/mm^2
- Hardness at room temperature 200 (Rockwell M)
- Modulus of elasticity, flexural (warp) 1,9 × 10^4 [N/mm^2]
- Modulus of elasticity, flexural (weft) 1,5 × 10^4 [N/mm^2]
- Modulus of elasticity, tensile (warp) 1,7 × 10^4 [N/mm^2]
- Modulus of elasticity, tensile (weft) 1,4 × 10^4 [N/mm^2]
- Poisson's ratio 0,12 to 0,16
- Shear strength 148 N/mm^2
- Young's modulus 22 Gpa

A.6 Physical properties

- Density 2,49 g/cm^3

A.7 Thermal properties

- Coefficient of thermal expansion (<Tg) 60 ×10^{-6}/ °C
- Coefficient of thermal expansion (>Tg) 300 ×10^{-6}/ °C
- Specific heat capacity 1,0 KJ/kg.°C
- Thermal conductivity 1,7 W/(m•K) to 2,3 W/(m•K)