# IEC 61249-2-35

Edition 1.0 2008-11

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

## Materials for printed boards and other interconnecting structures – Part 2-35: Reinforced base materials, clad and unclad – Modified epoxide woven E-glass laminate sheets of defined flammability (vertical burning test), copper-clad for lead-free assembly

## Matériaux pour circuits imprimés et autres structures d'interconnexion – Partie 2-35: Matériaux de base renforcés, plaqués et non plaqués – Feuilles stratifiées en tissu de verre de type E époxyde modifié, plaquées cuivre, d'inflammabilité définie (essai de combustion verticale) pour les assemblages sans plomb

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## Part 2-35: Reinforced base materials, clad and unclad – Modified epoxide woven E-glass laminate sheets of defined flammability (vertical burning test), copper-clad for lead-free assembly

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The text of this standard is based on the following documents:

| FDIS | Report on voting |
|---|---|
| 91/810/FDIS | 91/832/RVD |

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

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

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# MATERIALS FOR PRINTED BOARDS AND OTHER INTERCONNECTING STRUCTURES –

## Part 2-35: Reinforced base materials, clad and unclad – Modified epoxide woven E-glass laminate sheets of defined flammability (vertical burning test), copper-clad for lead-free assembly

## 1 Scope

This part of IEC 61249 gives requirements for properties of modified brominated epoxide woven E-glass laminate sheet 0,05 mm up to 3,2 mm, of defined flammability (vertical burning test), copper-clad. The glass transition temperature is defined to be 150 °C to 200 °C.

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

Some property requirements may have several classes of performance. The class desired should be specified on the purchase order; otherwise, the default class of material will be supplied.

## 2 Normative references

The following referenced documents are indispensable for the application 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 method for interconnection structures*

IEC 61249-5-1:1995, *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)*

ISO 9000, *Quality management systems – Fundamentals and vocabulary*

ISO 11014-1, *Safety data sheet for chemical products – Part 1: Content and order of sections*

ISO 14001, *Environmental management systems – Requirements with guidance for use*

## 3 Materials and construction

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

### 3.1 Resin system

Majority di-functional epoxide, modified epoxide, woven E-glass laminate with a glass transition temperature of 150 °C to 200 °C. The flammability rating is achieved through the use of bromine reacted into the polymer. Inorganic fillers may be used. 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.

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### 3.2 Metal foil

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

### 3.3 Reinforcement

Woven E-glass as specified in the future IEC 61249-6-3, woven E-glass fabric (for the manufacture of prepreg and copper clad materials).

## 4 Internal marking

Not specified.

## 5 Electrical properties

The electrical property requirements are shown in Table 1.

**Table 1 – Electrical properties**

| Property | Test method (IEC 61189-2) | Requirements |
|---|---|---|
| Resistance of foil | 2E12 | As specified in IEC 61249-5-1 |
| Surface resistance after damp heat while in the humidity chamber (optional) | 2E03 | ≥10 000 MΩ |
| Surface resistance after damp heat and recovery | 2E03 | ≥50 000 MΩ |
| Volume resistivity after damp heat while in the humidity chamber (optional) | 2E04 | ≥5 000 MΩm |
| Volume resistivity after damp heat and recovery | 2E04 | ≥10 000 MΩm |
| Relative permittivity after damp heat and recovery (1 MHz) | 2E10 | ≤5,4 |
| Dissipation factor after damp heat and recovery (1 MHz) | 2E10 | ≤0,035 |
| Electric strength (only for material thickness less than 0,5 mm) | 2E11 | ≥30 kV/mm |
| Arc resistance | 2E14 | ≥60 s |
| Dielectric breakdown (only for material thicknesses ≥0,5 mm) | 2E15 | ≥40 kV |
| Surface resistance at 125 °C | 2E07 | ≥1 000 MΩ |
| Volume resistivity at 125 °C | 2E07 | ≥1 000 MΩm |

## 6 Non-electrical properties of the copper-clad laminate

### 6.1 Appearance of the copper-clad sheet

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

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

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### 6.1.1 Indentations (pits and dents)

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

| **Size** mm | **Point value for each indentation** |
|---|---|
| 0,13 – 0,25 | 1 |
| 0,26 – 0,50 | 2 |
| 0,51 – 0,75 | 4 |
| 0,76 – 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.

### 6.1.2 Wrinkles

There shall be no wrinkles in the copper surface.

### 6.1.3 Scratches

Scratches deeper than 20 % of the nominal thickness of the foil thickness are not permitted.

Scratches with a depth 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 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.

### 6.1.4 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.

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### 6.1.5 Surface waviness

When examined in accordance with test method 2M12 of IEC 61189-2, the surface waviness in both the machine and cross machine direction shall not exceed 7 µm.

## 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 or release foil used. Variations of gloss due to the impact of pressure of gases released during the curing are permitted.

## 6.3 Laminate thickness

The laminate thickness may be ordered to include or exclude the copper foil contribution as specified in the purchase order. As a general rule, laminates less than 0,8 mm are measured excluding copper and laminates greater or equal to 0,8 mm are measured including copper. 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 2. The fine tolerances shall apply unless the other tolerances are ordered.

**Table 2 – Nominal thickness and tolerance of metal-clad laminate**

| Nominal thickness excluding metal foil (material intended for multilayer boards) mm | Nominal thickness including metal foil (material intended for single or double sided boards) mm | Tolerance requirement ±mm | | |
|---|---|---|---|---|
| | | Coarse | Fine | Extra fine |
| ≥0,05 ≤0,10 | | 0,03 | 0,02 | 0,01 |
| >0,10 ≤0,15 | | 0,04 | 0,03 | 0,02 |
| >0,15 ≤0,30 | | 0,05 | 0,04 | 0,03 |
| >0,30 ≤0,50 | | 0,08 | 0,05 | 0,04 |
| >0,50 ≤0,80 | | 0,09 | 0,06 | 0,05 |
| >0,80 ≤1,00 | ≥0,80 ≤1,00 | 0,13 | 0,09 | 0,07 |
| >1,00 ≤1,30 | >1,00 ≤1,30 | 0,17 | 0,11 | 0,08 |
| | >1,30 ≤1,70 | 0,20 | 0,13 | 0,10 |
| | >1,70 ≤2,10 | 0,23 | 0,15 | 0,12 |
| | >2,10 ≤2,60 | 0,25 | 0,18 | 0,15 |
| | >2,60 ≤3,20 | 0,30 | 0,20 | 0,15 |

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 3.

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**Table 3 – Bow and twist**

| 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 | ≥0,8 ≤ 1,3 | ≤350 | ≤2,0 | ≤1,5 |
| | | | >350 ≤ 500 | ≤1,8 | ≤1,3 |
| | | | >500 | ≤1,5 | ≤1,0 |
| | | >1,3 < 1,7 | ≤350 | ≤1,5 | ≤1,0 |
| | | | >350 ≤ 500 | ≤1,3 | ≤0,8 |
| | | | >500 | ≤1,0 | ≤0,5 |
| | | ≥1,7 ≤ 3,2 | ≤350 | ≤1,0 | ≤0,5 |
| | | | >350 ≤ 500 | ≤0,8 | ≤0,4 |
| | | | >500 | ≤0,5 | ≤0,3 |

NOTE 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 are 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 4. These requirements apply to copper foil with a normal profile depth. In the case of low or very low profile copper foil, the requirements shall be at least 50 % of that shown in Table 4 as a minimum.

**Table 4 – Pull-off and peel strength**

| Property | Test method (IEC 61189-2) | Requirements | | | |
|---|---|---|---|---|---|
| Pull-off strength | 2M05 | ≥25 N | | | |
| | | Thickness of the copper foil | | | |
| | | ≤12 µm (≤101 g/m$^2$) | 18 µm (152 g/m$^2$) | 35 µm (305 g/m$^2$) | ≥70 µm (≥610 g/m$^2$) |
| Peel strength after heat shock of 20 s | 2M14 | ≥0,7 N/mm | ≥0,9 N/mm | ≥1,2 N/mm | ≥1,6 N/mm |
| | | No blistering nor delamination | | | |
| Peel strength after dry heat 125 °C | 2M15 | ≥0,7 N/mm | ≥0,9 N/mm | ≥1,2 N/mm | ≥1,6 N/mm |
| | | No blistering nor delamination | | | |
| Peel strength after exposure to solvent vapour. Solvents as agreed upon between purchaser and supplier | 2M06 | ≥0,7 N/mm | ≥0,9 N/mm | ≥1,2 N/mm | ≥1,6 N/mm |
| | | No blistering nor delamination | | | |
| Peel strength after simulated plating | 2M16 | ≥0,6 N/mm | ≥0,8 N/mm | ≥1,0 N/mm | ≥1,2 N/mm |
| | | No blistering nor delamination | | | |

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| Property | Test method (IEC 61189-2) | Requirements | | | |
|---|---|---|---|---|---|
| Peel strength at high temperature<br>Temperature 125 °C (optional) | 2M17 | Not specified | ≥0,7 N/mm | ≥0,9 N/mm | ≥1,1 N/mm |
| Blistering after 20 s heat shock | 2C05 | No blistering nor delamination | | | |
| NOTE 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

Punching is not applicable. The laminate shall, in accordance with the manufacturer's recommendations, be capable of being 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.

### 6.7 Dimensional stability

The dimensional stability requirements are shown in Table 5. When specimens are tested in accordance with IEC 61189-2, 2X02 the observed tolerance shall be as specified in Table 5. The nominal dimensional stability value shall be as agreed upon between user and vendor. The tolerance range around the agreed upon nominal thickness shall be range B unless otherwise specified on the purchase order.

The choice of the glass fabrics 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.

Class A performance shall apply unless otherwise noted on the purchase order.

**Table 5 – Dimensional stability**

| Property | Test method (IEC 61189-2) | Class | Requirements ppm |
|---|---|---|---|
| Dimensional stability | 2X02 | A | ±300 |
| | | B | ±200 |
| | | C | ±100 |
| | | X | As agreed upon between user and supplier |

### 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;
– 1 065 mm × 1 155 mm;
– 1 065 mm × 1 280 mm;
– 1 000 mm × 1 000 mm;
– 1 000 mm × 1 200 mm.

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### 6.8.2 Tolerances for sheet sizes

The size of sheet delivered by the supplier shall not deviate more than $^{+20}_{0}$ mm from the ordered size.

## 6.9 Cut panels

### 6.9.1 Cut panel sizes

Cut panel sizes, when delivered, shall be 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 following tolerances for length and width shall apply as shown in Table 6. Tolerances indicated as normal shall be in effect unless otherwise specified by in the purchasing specification.

**Table 6 – Size tolerances for cut panels**

| **Panel size** mm | **Tolerance** ± 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 following requirements for rectangularity shall apply as shown in Table 7. Tolerance indicated as normal shall be in effect unless otherwise specified in the purchasing specification.

**Table 7 – Rectangularity of cut panels**

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

# 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 4X.

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

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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;
- 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 one 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 8.

**Table 8 – Flexural strength**

| Property | Test method (IEC 61189-2) | Requirements |
|---|---|---|
| Flexural strength<br>Length direction<br>Cross direction<br>(applicable to sheets ≥1,0 mm in thickness) | 2M20 | <br>≥400 N/mm$^2$<br>≥300 N/mm$^2$ |
| Flexural strength<br>Length direction<br>Elevated temperature<br>(applicable to sheets ≥1,0 mm in thickness) | | Not specified |

### 7.3 Flammability

When the laminate is tested in accordance with test method 2C08 (thickness ≥0,05 mm ≤0,3 mm) or 2C06 (thickness >0,3 mm ≤ 3,2 mm) of IEC 61189-2, the flammability shall be as shown in Table 9.

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

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