INTERNATIONAL STANDARD

IEC 61189-2

1997

AMENDMENT 1
2000-01

Amendment 1

Test methods for electrical materials, interconnection structures and assemblies –

Part 2: Test methods for materials for interconnection structures

Amendement 1

Méthodes d'essai pour les matériaux électriques, les structures d'interconnexion et les ensembles –

Partie 2: Méthodes d'essai des matériaux pour structures d'interconnexion

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FOREWORD

This amendment has been prepared by IEC technical committee 52: Printed circuits.

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

FDIS	RVD
52/832/FDIS	52/840/RVD

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

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

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Add the following table to the list of tables:

Add the following figures to the list of figures:

Add the following annexes to the list of annexes

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2 Normative references

Insert, in the existing list, the titles of the following standards:

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*

IEC 60249-1:1982, *Base materials for printed circuits – Part 1: Test methods*

IEC 60326-3:1991, *Printed boards – Part 3: Design and use of printed boards*

IEC 60707:1981, *Methods of test for the determination of the flammability of solid electrical insulating materials when exposed to an igniting source*

ISO 3274:1996, *Geometrical Products Specifications (GPS) – Surface texture: Profile method – Nominal characteristics of contact (stylus) instruments*

ANSI/UL-94:1996, *Standard for tests for flammability of plastic materials for parts in devices and appliances*

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7.1 Test 2D01: Thickness (under consideration)

Replace this subclause by the following subclause:

7.1 Test 2D01: Thickness of base materials and rigid boards

7.1.1 Object

This test method covers the procedure for the determination of the thickness of base materials, clad or unclad.

7.1.2 Test specimens

Standard sheet sizes of metal-clad or unclad base materials.

Standard panel sizes of metal-clad or unclad base materials.

7.1.3 Test apparatus and material

A suitable micrometer having a resolution of 0,01 mm or better shall be used.

7.1.4 Procedure

a) General conditions

- Test specimens shall be placed between the two faces of the micrometer, so that the whole face of the pressure-foot will fall within the area of the material. The pressure-foot shall be lowered gently, slowly and with great care onto the test specimen so that all punching effect is avoided.

– No stress shall be imposed by hand on the instrument or the material when a reading is being taken. The reading shall be taken as soon as the pointer has ceased to move. It is necessary to take care in avoiding parallax errors and vibrations which may significantly affect the results.

b) Method 1

– This procedure is intended for the thickness measurement of the sheets of metal-clad or unclad base materials.

– The specimen shall be held vertically or horizontally.

– Thickness to the nearest 0,01 mm at two points 25 mm or more inside each edge, at eight points, and additionally at two points in the middle parts, so that a total of 10 points, shall be measured as shown in figure 13.

– The measurement shall be made twice at each point and the mean value shall be determined as the thickness of each point.

– For automatic thickness inspection, continuous measuring shall be performed in three measuring tracks parallel to the longitudinal axis of the sheet, two at least 25 mm from the longitudinal edges and the third near the midline.

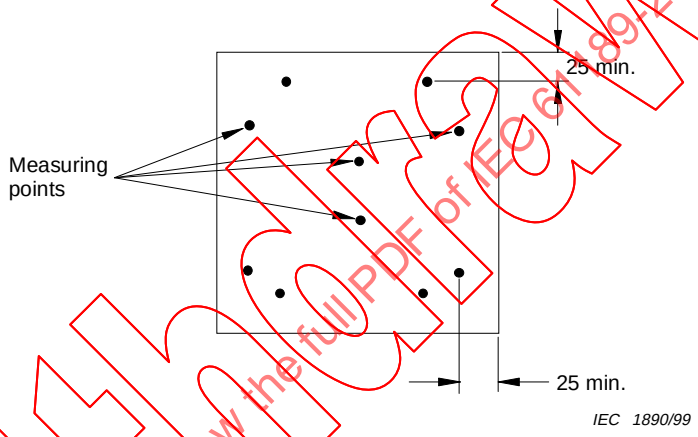

Figure 13 – Thickness measuring points

c) Method 2

– This procedure is intended for the thickness measurement of panels of metal-clad or unclad base materials. The thickness of the specimens held vertically or horizontally shall be measured at the places which are agreed between the interested parties.

7.1.5 Report

The report shall include

a) the test method number and revision;

b) the date of the test;

c) the identification of the material tested;

d) a statement certifying that the test was carried out for as-received metal-clad or unclad base materials;

e) the thicknesses measured and the nominal thickness with its tolerance;

f) any deviation from this test method;

g) the name of the person conducting the test.

7.1.6 Additional information

The use of a micrometer with a damping device, or controlled rate of movement of the pressure-foot, is advantageous.

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8.6 Test 2C06: Flammability, vertical (under consideration)

Replace this subclause by the following subclause:

8.6 Test 2C06: Flammability, vertical burning test for rigid materials

8.6.1 Object

This test method is intended as a laboratory quality control technique using a low energy source of ignition. Results from this test should not be used to attempt to predict the behaviour of materials in a large-scale fire.

This test should be used for materials having good resistance to ignition. The test is carried out using a small test flame having an intensity similar to that of an actual source of fire.

Timings measured by this test are an indication of the ability of the material(s) to self-extinguish. There is no correlation with other properties of the material(s), such as the oxygen index.

Materials suitable for testing in accordance with this technique include rigid substrates and rigid substrates in combination with any surface coating(s).

8.6.2 Test specimens

The test specimens shall be prepared from a sample of the metal-clad base material under test. The metal shall be completely removed using any etching method of commercial practice.

The specimen strip shall be (125 ± 5) mm long and (13 ± 0,3) mm wide. The edges shall be smooth. The corners of the specimens shall be rounded with a radius not exceeding 1,3 mm. The corners of the specimens shall be rounded with a radius not exceeding 1,33 mm. The thickness of the sample will prejudice the results obtained.

A minimum of 10 specimens shall be tested. However, it is usual to take a total of 20 specimens for conditioning and testing to cover the eventuality of a failure during the test of the first set of specimens.

8.6.3 Test apparatus and materials

The following test apparatus and materials shall be used.

a) A draught-free room, test chamber or enclosure which provides a means of venting the fumes from burning specimens. A hood may be used, but its exhaust fan shall be disabled during the tests and allowed to operate only between tests in order to clear fumes. Subdued light is advantageous.

b) The igniting source consisting of a blue flame, (20 ± 2) mm high, produced using a laboratory burner (Bunsen or Tirril burner) having a tube with a length of 100 mm and an inside diameter of (9,5 ± 0,5) mm. The tube shall not be equipped with end attachments such as stabilizers.

c) A supply of technical grade methane gas with a suitable regulator and meter to produce a uniform gas flow. If natural gas is used as an alternative to methane, it should have a heat content of approximately 37 MJ/m^3. This has been found to produce similar results.

The required flame shall be obtained by adjusting the gas supply and air inlets of the burner until a yellow-tipped blue flame of the specified height is produced, and then by increasing the air supply until the yellow tip has just disappeared. The height of the flame shall then be measured again and corrected if necessary.

d) A test fixture shall be comprised of a ring stand with two clamps or similar apparatus which is adjustable for vertical positioning of the specimen. Each specimen is to be held by clamping the upper 6 mm of the specimen with the long dimension oriented vertically, so that the lower end of the specimen is 10 mm above the top of the burner tube and 300 mm above a horizontal layer of dry tissue paper (50 mm × 50 mm swatch). An adjustable, movable holder maintains the burner tube centrally under the lower end of the specimen to an angle of 5° and the 10 mm distance between the lower end of the specimen and the top of the burner is to be maintained during the flame applications.

e) A hand-operated timing device with a resolution of 1 s or better.

8.6.4 Procedure

Ten specimens shall be preconditioned in accordance with the requirements of 5.3 of IEC 60068-1 for a period of 48 h as a referee and 24 h for normal quality conformance prior to testing. The detail requirements are

a) a temperature of 15 °C to 35 °C;

b) a humidity of 25 % RH to 75 % RH;

c) an air pressure of 86 kPa to 106 kPa.

Fluctuations shall be kept to a minimum.

The remaining 10 specimens shall be preconditioned in a circulating air oven for 24 h at (125 ± 2) °C. They shall then be allowed to cool in a desiccator until specimens reach room temperature prior to testing.

Each specimen shall be held in the test fixture by clamping the upper 6 mm of the specimen with the long direction oriented vertically so that the lower end of the specimen is 10 mm above the top of the burner tube and 300 mm above a horizontal layer of dry tissue papers (50 mm × 50 mm swatch).

The burner, in a remote position from the specimen, shall be adjusted by controlling the gas supply and air inlets of the burner until a yellow-tipped blue flame (20 ± 2) mm in height is produced. The air supply is then increased until the yellow tip has disappeared. The height of the flame shall then be measured again and corrected if necessary.

The burner shall be placed centrally beneath the lower end of the specimen and allowed to remain for 10 s. The burner shall then be moved at least 150 mm away from the specimen, and the time taken by the specimen to self-extinguish shall be measured. This shall be defined as the time from removal of the test flame from the specimen until the time when the specimen ceases to burn. Record the burn time on the laboratory pro forma in annex C.

When the specimen ceases to burn, the burner shall immediately be replaced in its original position beneath the specimen. After 10 s, the test flame shall again be withdrawn and the duration of flaming shall again be measured. Record the burn time on the laboratory pro forma in annex C.

If the test flame is extinguished during either application, it shall be reignited immediately and reapplied so that the total time of application is still 10 s. There shall be no more than three applications of the test flame during any 10 s ignition period, otherwise the material cannot be evaluated by this technique.

If the specimen drips molten or flaming material during either application of the test flame, the burner may be tilted to an angle of up to 45° and also slightly withdrawn from one of the 13 mm sides of the specimen during the flame application to avoid material dripping into the tube of the burner.

If the specimen drips molten or flaming material, or is consumed during the test, the burner shall be hand-held and the 10 mm distance between the bottom of the specimen and the top of the burner tube shall be maintained throughout the flame application. Any molten strings of material shall be ignored, and the flame shall be applied to the major part of the specimen. Record observed dripping or other significant observations on the laboratory pro forma in annex C.

If the total of the ten burn times meets the requirements of the relevant specification but individual burning times exceed the relevant requirements, a further set of five specimens shall be tested. If the second set meets all the requirements, these requirements shall be deemed to be satisfied.

If the total of ten burning times for any set of five specimens exceed the specified requirements by no more than 5 s, a second set of five specimens shall be tested, and if the requirements for total and individual burning times are met, these requirements shall be deemed to be satisfactory.

8.6.5 Report

In addition to the general requirements for reporting, the report shall include

a) test number and revision;
b) identification of the material tested;
c) testing date;
d) the thickness of the specimen;
e) the duration of flaming of each specimen after the first removal of the test flame;
f) the duration of flaming of each specimen after the second removal of the test flame;
g) whether the specimen burns up to the holding clamp;
h) whether the specimen drips flaming particles which ignite the tissue paper;
i) any deviation from this test method;
j) the name of the person performing the test;
k) the type of combustion. Flaming combustion is the combustion of the specimen in the gaseous phase with the emission of light. Glowing combustion of the specimen is the combustion without flame;
l) the evaluated results.

8.6.6 Additional information

Annex C shows a suggested pro forma for reporting.

There are obvious hazards associated with flammability testing. Training of test operators, and familiarity with laboratory safety procedures is of paramount importance.

All fire effluent should be considered to be toxic, for the purposes of safety if not in fact.

Uncertainty of measurement calculations for burn times, although a variable, prove to be impractical. The result of the test is an attribute; the FV-0, FV-1 rating etc.

This test method is based upon the method given in IEC 60707. Some minor technical differences do exist between this test method and that given in IEC 60707.

It is understood that a nominal substrate thickness of 1,6 mm will be used throughout the industry. IEC 60707 specifies a thickness of (3 ± 0,2) mm. Differences in thickness will prejudice test results.

IEC 60707 requires a specimen width of 13 mm with a tolerance of ±0,3 mm. The previous edition of this method as published in IEC 60249-1 required a tolerance of ±1,0 mm. American industry requirements (Underwriter's Laboratory Specification ANSI/UL-94) detail a specimen width of 12,7 mm to 13,2 mm.

The specimen width of (13 ± 0,3) mm has therefore been chosen since this will accommodate both IEC 60707 and ANSI/UL-94.

The smoothness of the specimen edges can be critical to the performance of the specimen. A polished finish is recommended. A rough finish (for example blanked) will significantly degrade performance due to the increase in surface area available to the flame.

Small-scale flammability tests, such as the one described herein, are an indicator of the behaviour of the material(s) tested. Fire integrity of equipments in which printed boards are used can only be assessed by equipment level testing.

Materials in combination may produce results that are different to those of the separate materials.

A material that is rated FV-1 or FV-2 when bonded to an inert substrate may produce an FV-0 performance (for example rigid polyimide/glass constrained with copper-invar). A FV-0 material in combination with a surface coating (for example solder resist) may be degraded to FV-1.

8.7 Test 2C07: Flammability, horizontal (under consideration)

Replace this subclause by the following subclause:

8.7 Test 2C07: Flammability; horizontal burning test for rigid materials

8.7.1 Object

This test method is intended as a laboratory quality control technique using a low energy source of ignition. Results from this test should not be used to attempt to predict the behaviour of materials in a large-scale fire.

This test is significantly less onerous than the similar vertical burn test and is intended to be used for materials having a limited resistance to ignition. The test is carried out using a small test flame having an intensity similar to that of an actual source of fire. This method does have an obvious application for printed board assemblies used in a horizontal configuration. Otherwise, due consideration should be given to its applicability.

Reference should be made to 8.3 of IEC 60326-3, with regard to the fire integrity of printed circuit boards and the suitability of test methods.

Timings measured by this test are an indication of the ability of the material(s) to self-extinguish. There is no correlation with other properties of the material(s), such as the oxygen index.

Materials suitable for testing in accordance with this technique include rigid substrates and rigid substrates in combination with any surface coating(s).

8.7.2 Test specimen

The test specimens shall be prepared from a sample of the metal-clad base material under test. The metal shall be completely removed using any etching method of commercial practice.

The specimen strip shall be (125 ± 5) mm long and (13 ± 0,3) mm wide. The edges shall be smooth. The corners of the specimens shall be rounded with a radius not exceeding 1,3 mm. The thickness of the sample will prejudice the results obtained.

The specimens shall be marked with an indelible line (for example by scribing) which is perpendicular to the longitudinal axis, and which is (25 ± 0,5) mm away from the end which is to be ignited.

A minimum of four specimens shall be tested.

8.7.3 Test apparatus and materials

The following test apparatus and materials shall be used.

a) A draught-free room, test chamber or enclosure which provides a means of venting the fumes from burning specimens. A hood may be used, but its exhaust fan shall be disabled during the tests and allowed to operate only between tests in order to clear fumes. Subdued light is advantageous.

b) The igniting source consisting of a blue flame, (25 ± 1) mm high, produced using a laboratory burner (Bunsen or Tirril burner) having a tube with a length of 100 mm and an inside diameter of (9,5 ± 0,5) mm. The tube shall not be equipped with end attachments such as stabilizers.

c) A supply of technical grade methane gas with a suitable regulator and meter to produce a uniform gas flow. If natural gas is used as an alternative to methane, it should have a heat content of approximately 37 MJ/m^3. This has been found to produce similar results.

   The required flame shall be obtained by adjusting the gas supply and air inlets of the burner until a yellow-tipped blue flame of the specified height is produced, and then by increasing the air supply until the yellow tip has just disappeared. The height of the flame shall then be measured again and corrected if necessary.

d) A test fixture comprised of a ring stand with two clamps, adjustable for horizontal positioning of the specimen, and of a wire gauze. This shall enable the test specimen to be fixed with its long dimension horizontally, and with its transverse axis inclined at 45° to the horizontal line.

e) A wire gauze (100 mm × 100 mm, 8 meshes per cm or 20 meshes per inch, 0,043 mm diameter steel wire) shall be clamped horizontally beneath the test specimen. An adjustable, movable holder maintains the burner tube in the same vertical plane as the lower longitudinal edge of the specimen and at an angle of approximately 45° to the horizontal line.

f) A hand-operated timing device with a resolution of ±1 s or better.

8.7.4 Test procedure

The specimens shall be preconditioned in accordance with the requirements of 5.3 of IEC 60068-1 for a period of 48 h as a referee or 24 h as normal quality conformance prior to testing. The detail requirements are

a) a temperature of 15 °C to 35 °C;

b) a humidity of 25 % RH to 75 % RH;

c) an air pressure of 86 kPa to 106 kPa.

Fluctuations shall be kept to a minimum.

The test specimen shall be mounted in the test fixture such that the distance between the lowest edge of the specimen and gauze shall be 10 mm, with (13 ± 2) mm of the unsupported end of the specimen projecting beyond the edge of the gauze as shown in figure 14.

The burner, in a remote position from the specimen, shall be adjusted by controlling the gas supply and air inlets of the burner until a yellow-tipped blue flame (20 ± 2) mm in height is produced. The air supply is then increased until the yellow tip has disappeared. The height of the flame shall be measured again and corrected if necessary.

The burner shall be placed beneath the free end of the specimen so that a length of approximately 6,5 mm is subjected to the flame. The centre axis of the burner shall be in the same vertical plane as the lower horizontal edge of the specimen and at an angle of (45 ± 10)° to the horizontal line. Its position shall remain unchanged whilst the flame is applied.

The flame shall be applied to the specimen for 30 s and then removed. The burn time, in seconds, shall be measured from the instant of removal of the burner flame until the specimen extinguishes. Observation shall be made as to whether the burning proceeds beyond the indelible line.

The burn times and other observations shall be recorded on the laboratory pro forma as shown in annex D.

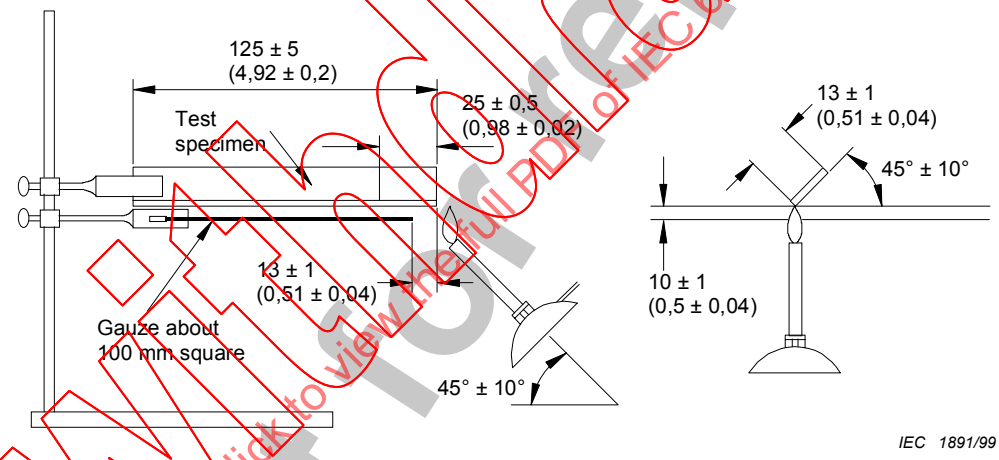

Figure 14 – Test fixture

8.7.5 Report

In addition to the general requirements for reporting, the report shall include

a) the test method;
b) the average of the four burning times;
c) the identification and description of the specimens;
d) the thickness of the specimen;
e) the average of the four burning times;
f) whether the burning of any of the specimens proceeds past the indelible line;
g) whether the specimen material melts or produces burning drips;
h) any deviation from this test method;
i) the name of the person performing this test.

8.7.6 Additional information

Annex D comprises a suggested pro forma for reporting.

There are obvious hazards associated with flammability testing. Training of test operators, and familiarity with laboratory safety procedures is of paramount importance.

All fire effluent should be considered to be toxic, for the purposes of safety, if not in fact.

Uncertainty of measurement for burn times, although a variable, prove to be impractical.

The result of the test is an attribute; the HB rating, etc.

This test method is based upon the method given in IEC 60707. Some minor technical differences do exist between this test method and that given in IEC 60707.

It is understood that a nominal substrate thickness of 1,6 mm will be used throughout the industry. IEC 60707 specifies a thickness of (3,0 ± 0,2) mm. Differences in thickness will prejudice test results.

IEC 60707 requires a specimen width of 13 mm with a tolerance of ±0,3 mm. The previous edition of this method as published in IEC 60249-1 required a tolerance of ±1,0 mm. American Industry requirements (Underwriter's Laboratory Specification ANSI/UL-94) detail a specimen width of 12,7 mm to 13,2 mm .

The specimen width of (13 ± 0,3) mm has therefore been chosen since this will accommodate both IEC 60707 and ANSI/UL-94.

The smoothness of the specimen edges can be critical to the performance of the specimen. A polished finish is recommended. A rough finish (for example, blanked) will significantly degrade performance due to the increase in surface area available to the flame.

Small-scale flammability tests, such as the one described, herein are an indicator of the behaviour of the material(s) tested. Fire integrity of equipment in which printed boards are used can only be assessed by equipment level testing.

8.9 Test 2C09: Melting viscosity of prepregnation materials (under consideration)

Replace this subclause by the following subclause:

8.9 Test 2C09: Melting viscosity of prepreg materials

8.9.1 Object

This test method covers the procedure for the determination of the isothermic melting viscosity of prepregs at elevated temperatures using a rotating cone-and-plate viscosimeter.

8.9.2 Test specimens

The test specimens shall be cut not less than 25 mm from the edge or selvedge of the prepreg.

The test specimens shall be prepared from a sample of the prepreg material under test by cutting rectangular pieces of approximately 200 mm × 300 mm, separating the resin from the reinforcement material by folding and crushing the prepreg and collecting it in a plastic bag.

Any glass fibres present shall be removed by sieving with a wire mesh of 0,5 mm mesh width. (200 ± 20) mg resin powder shall be taken with the measuring scoop.

A single specimen should suffice.

8.9.3 Test apparatus and materials

The following apparatus and test material shall be used.

a) A plate-and-cone rotating viscometer with a heatable plate and an adjustable revolution speed.

Cone material: Stainless steel type X12CrNiS18;

Cone diameter: (20 ± 0,5) mm;

Cone height: 2 mm;

Cone angle: 2°;

Cone surface: Roughness R = (6,3 ± 0,1) µm;

Distance between cone and plate:

– if spring-supported, the cone shall touch the surface of the plate; it can be lifted off with spring force (2 ± 1) mm;

– if fixed, the cone shall not touch the surface of the plate; the gap between cone and plate shall be constant during all measurements and is an item to be negotiated between customer and supplier.

b) An X/Y chart recorder adjusted to the viscometer.

The zero of the chart recorder shall coincide with the zero of the viscosimeter. The adjustment shall be made with the rotating cone not resting on the plate.

The revolution speed of the cone shall be selected suitable to the plot width. If the total width is 250 mm, the plot width measured shall be between 50 mm and 100 mm.

For the defined cones 1 mm plot width corresponds to the following viscosity values at different revolution speeds:

Revolution speed r/min	Viscosity factor Pa·s
6	2,048
12	1,024
24	0,512
48	0,256

c) A measuring scoop whose volume represents approximately 200 mg of resin powder.

d) A wire mesh screen of 0,5 mm mesh width.

e) A timer.

f) A ruler with a millimetre scale (overall length 30 cm).

g) Plastic bags large enough to hold prepreg sample.

8.9.4 Procedure

The surface temperature of the viscosimeter plate shall be adjusted and preheated to (140 ± 0,3) °C. The viscosimeter plate shall be preheated for a minimum of 30 min. The measuring cone, which is not heated, shall be lowered onto the preheated plate and shall be held in contact with it for 2 min ± 10 s. Then the cone shall be lifted, and the specimen of resin powder shall be placed on the heated plate concentric under the cone within 5 s.

As soon as the main amount of the specimen is placed on the plate and the revolution speed required is adjusted, the rotation of the viscosimeter and the timer shall be started. The recording head shall be lowered onto the recording paper and the paper transport shall be started with a speed of 20 mm/min.

(30 ± 3) s after placing the resin powder on the heated plate, the rotating cone shall be lowered onto the molten resin.

The graph of viscosity versus time is recorded automatically. The measurement is completed, when a point of greatest inflection of the curve has been observed (see figure 15) after the curve has been stabilized.

Then the cone is lifted from the plate, and the rotation is stopped.

In order to evaluate the graph the chart recording paper shall be taken from the X/Y chart recorder, the distance between the time base line and the minimum of the curve measured with the ruler, and this value multiplied with the viscosity factor for the selected revolution speed (see 5.9.3). The resulting product is the melting viscosity in pascal seconds.

8.9.5 Report

The report shall include

a) the test number and revision;
b) the identification of the sample prepreg tested;
c) the date of the test;
d) identification and description of the specimens of resin powder;
e) the distance between cone and plate, if fixed;
f) the revolution rate of the cone;
g) the melting viscosity;
h) any deviations form the parameters defined (for example plate temperature or cone type).

8.9.6 Additional information

As several cones may exhibit small differences of their geometry, it is necessary to calibrate each cone to be used with the viscosimeter. This can be carried out:

– either by the manufacturer, who gives the corresponding calibration factors;
– or by the user with a qualified calibration oil.

Cleaning of the cone and the heating plate. The following steps are recommended:

– rough cleaning with a bronze scraper;
– afterwards fine cleaning with an appropriate solvent.

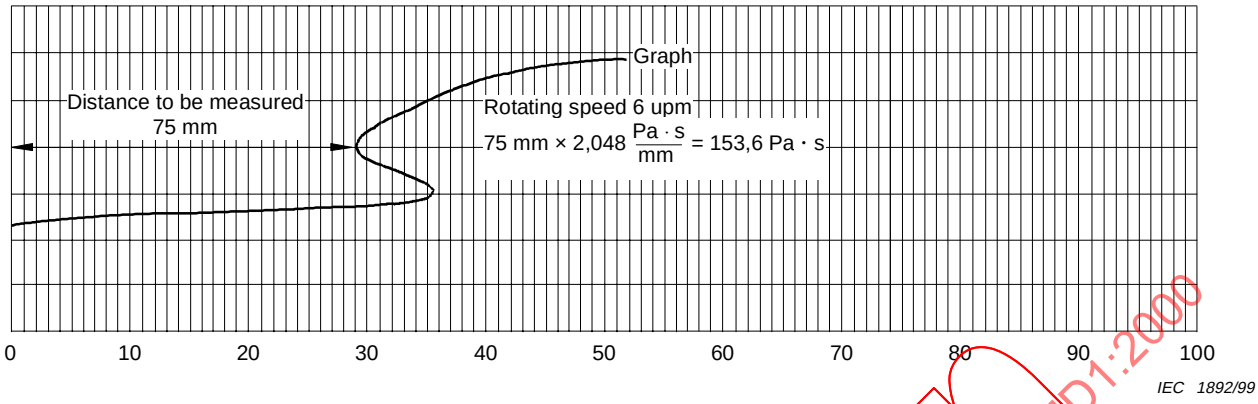

Figure 15 – Example of prepreg melting viscosity

8.10 Test 2C10: Resin content of prepregnation by sublimation (under consideration)

Replace this subclause by the following subclause:

8.10 Test 2C10: Resin content of prepreg materials by sublimation

8.10.1 Object

The purpose of this test method is to provide a means for measuring the resin content of resin impregnated B-stage glass fabric for use as bonding sheet material for base materials and printed boards using the resin sublimation method.

8.10.2 Test specimens

Each specimen shall be comprised of three squares (100 ± 10) mm by (100 ± 10) mm as taken from positions along a line normal to the warp of the fabric with the diagonals of the squares parallel to the warp and weft threads. One square shall be taken from the position equidistant from the edges, and the other two squares from positions on opposite sides of the first with their outer extremities (50 ± 25) mm from each edge or selvedge (see figure 16).

All loose particles and projecting fibres shall be removed from the squares.

8.10.3 Test apparatus and materials

The following test apparatus and material shall be used.

a) An analytical balance with an accuracy of 0,001 g.

b) A muffle furnace capable of maintaining a temperature between 550 °C and 800 °C. The muffle furnace must be placed in a ventilation hood.

c) A ceramic crucible of sufficient size to hold the specimen.

d) A stabilization chamber (drying cabinet desiccator) capable of maintaining less than 20 % RH at room temperature.

8.10.4 Procedure

For a referee, the crucible shall be heated in a muffle furnace between 550 °C and 800 °C for 15 min, and allowed to cool to room temperature in a desiccator and weighed to the nearest 0,001 g (M_1). For normal conformance testing, the crucible may simply be weighed to the nearest 0,001 g.

The test specimen shall be placed in the crucible. It is permissible to cut the 100 mm × 100 mm square into pieces to allow it to fit into the crucible.

The specimen and crucible shall then be weighed to the nearest 0,001 g (M_2).

The specimen and crucible shall be heated in the muffle furnace at a temperature of between 550 °C and 800 °C for 1 h and placed in the desiccator and allowed to cool to room temperature.

The specimen and crucible shall again be weighed to the nearest 0,001 g (M_3).

The heating, cooling, and weighing shall be repeated until two consecutive weighings (M_3) agree within 0,002 g.

The per cent resin content shall be calculated as follows:

$$C_r = \frac{100\ (M_2 - M_3)}{M_2 - M_1} - C_v$$

where

C_r is the percentage resin content (%);

M_1 is the weight of crucible (g);

M_2 is the initial weight of crucible and specimen (g);

M_3 is the final weight of crucible and specimen (g);

C_v is the percentage volatile content (%).

8.10.5 Report

The report shall include

a) the test number and revision;

b) the date of the test;

c) the identification of the material tested;

d) the resin content for each of the three specimens;

e) any deviation from this test method;

f) the name of the person conducting the list.

8.10.6 Additional information

The resin content of prepreg may also be determined by the treated weight method as described in test 2C03.

The fumes from burning resin are toxic, so the muffle furnace shall be placed in a ventilation hood.

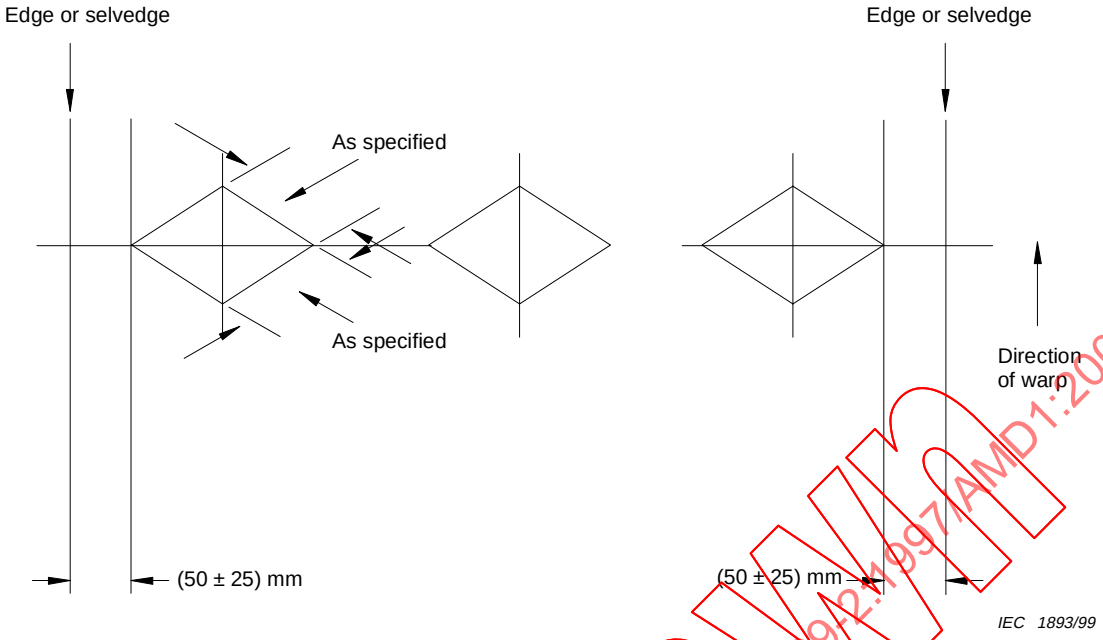

Figure 16 – Position of specimens for resin content

9.1 Test 2M01: Bow/twist (under consideration)

Replace this subclause by the following subclause:

9.1 Test 2M01: Test method for bow and twist

9.1.1 Object

This test method covers the procedure for determination of the deviation from flatness of the metal-clad sheet in a direction parallel to its edges or diagonal.

This test is not applicable to sheets thinner than 0,8 mm or with copper thickness differences side to side of more than 70 µm (610 g/m^2).

9.1.2 Test specimens

Test specimens shall be taken from the panel or sheet in such a manner that they are at least 25 mm from the edge.

Specimens shall be prepared from a sample of the metal-clad base material under test.

Specimen size shall be (300 ± 5) mm in both length and width. Other specific panel sizes may be tested upon agreement between customer and supplier.

For referee, the specimen will be conditioned at (23 ± 2) °C and (50 ± 5) % RH for a minimum of 18 h prior to measurement of bow or twist.

A minimum of three specimens shall be tested.

9.1.3 Test apparatus and materials

A taper gauge or feeler gauge shall be used.

9.1.4 Procedure

a) Bow measurement
   - Bow shall be measured by placing the specimen unrestrained on a flat horizontal surface with its predominantly convex surface upward. The maximum vertical distance from the flat surface to the bottom side of the laminate shall be determined using a taper gauge or a feeler gauge.
   - The result shall be expressed as a percentage of the length of the side where the vertical displacement was measured.

b) Twist measurement
   - Twist shall be measured by placing the specimen unrestrained on a flat horizontal surface with its predominantly convex surface upward and with three corners in contact with the flat surface. The maximum vertical distance from the flat surface to the bottom side of the remaining corner of the laminate shall be determined using a taper gauge or a feeler gauge.
   - The result shall be expressed as a percentage of the diagonal length of the specimen.
   - The bow and twist shall be reported as the average of the three specimens tested and the highest measurement for both bow and twist.

9.1.5 Report

The report shall include

a) the test number and revision;
b) the testing date;
c) the identification of the material tested;
d) the average and highest measurement of bow;
e) the average and highest measurement of twist;
f) any deviation from the test method, including panel size if not 300 mm × 300 mm;
g) the name of the person conducting the test.

9.1.6 Additional information

None

9.2 Test 2M02: Bow/twist after etching and heating (under consideration)

Replace this subclause by the following subclause:

9.2 Test 2M02: Bow/twist after etching and heating

9.2.1 Object

This test method covers the procedure for the determination of the deviation from flatness of the metal-clad sheet in a direction parallel to its edges, or diagonal after etching and heating, simulating two process steps of printed board fabrication.

This test is not applicable to sheets thinner than 0,8 mm or with copper thickness differences side to side of more than 70 µm (610 g/m^2).

9.2.2 Test specimens

Specimens shall be taken from the panel or sheet in such a manner that they are at least 25 mm from the edge.

Specimens shall be prepared from a sample of the metal-clad base material under test.

Specimen size shall be (300 ± 5) mm in both length and width. Other specific panel sizes may be tested upon agreement between user and supplier.

The specimens shall be maintained at standard laboratory conditions of (23 ± 2) °C and (50 ± 2) % RH during the test. As a referee the specimen will be conditioned for a minimum of 18 h prior to measurement of bow or twist.

A minimum of three specimens shall be tested.

9.2.3 Test apparatus and materials

The following test apparatus and materials shall be used.

a) Any etching method of commercial practice shall be used. In case of dispute between customer and supplier, the etching shall be carried out with a spray, or equivalent method with an aqueous solution of ferric chloride of density 1,32 g/cm^3 to 1,41 g/cm^3, as measured at room temperature. The temperature of the etching solution shall not exceed 37 °C.

b) A suitable chamber (air-circulating oven) capable of maintaining the temperature as called for in the relevant material specification with a tolerance of ±2 °C.

c) A taper gauge or feeler gauge.

9.2.4 Procedure

9.2.4.1 Etching

The metal of the specimen shall be completely removed by etching. Immediately after it is etched, the specimens shall be washed with cold running water of resistivity of not less than 10 Ω for as long as necessary to remove surface contamination (normally 15 min to 30 min).

9.2.4.2 Heating

The etched specimen shall be placed unrestrained on a flat horizontal surface and shall be subjected to dry heat as specified in 3.1 of IEC 60068-2-2 in a test chamber with the temperature indicated in the relevant material specification, a temperature tolerance of ±2 °C and for a duration of (30 ± 5) min.

9.2.4.3 Conditioning

After the process steps of etching and heating, for referee purposes the specimens shall be preconditioned at (23 ± 2) °C and (50 ± 5) % RH for 18 h as the conditioning step. As a quality conformance procedure, at least 2 h of conditioning shall be used.

9.2.4.4 Bow measurement

Bow shall be measured by placing the specimen unrestrained on a flat horizontal surface with its predominately convex surface upward. The maximum vertical distance from the flat surface to the bottom side of the laminate shall be determined using a taper gauge or feeler gauge.

The result shall be expressed as a percentage of the length of the side where the vertical distance was measured.

The bow value after etching and heating reported shall be the average of the percentages of the three test specimens as well as the highest measurement.

9.2.4.5 Twist measurement

Twist shall be measured by placing the specimen unrestrained on a flat horizontal surface with its predominantly convex surface upward and with three corners on the bottom side of the specimens in contact with the flat surface. The maximum vertical distance from the flat surface to the bottom side of the remaining corner of the laminate shall be determined using a taper gauge or feeler gauge.

The result shall be expressed as a percentage of the diagonal of the specimen.

The twist value after etching and heating reported shall be the average of the percentages of the three test specimens as well as the highest measurement.

9.2.5 Report

The report shall include

a) the test number and revision;
b) the date of the test;
c) the identification of the material tested;
d) the average and highest measurement of bow;
e) the average and highest measurement of twist;
f) any deviation from this test method;
g) the name of the person conducting the test.

9.2.6 Additional information

The etching solution described in 8.2.3 of this test method is a powerful acid chemical. It shall be handled with care preventing eye and skin contact by wearing protective glasses and chemically resistant gloves respectively.

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9.10 Test 2M10: Delta glass transition (DSC) (under consideration)

Replace this subclause by the following subclause:

9.10 Test 2M10: Glass transition temperature of base materials by differential scanning calorimetry (DSC)

9.10.1 Object

This test method covers the procedure for the determination of the glass transition temperature of base materials by differential scanning calorimetry. The glass transition temperature is indicated by an endothermic shift in the differential heat flow resulting from a change in the heat capacity of the material at that temperature.

9.10.2 Test specimens

The specimen shall be taken from the sheet in such a manner that it is not less than 25 mm from the edge.

The test specimens shall be of suitable size and shape for the specimen holder of the measuring system and weigh (0,010 + 0,030) g. The specimens may be prepared by sawing or punching.

For referee testing, a minimum of three specimens shall be tested.

9.10.3 Test apparatus and materials

The following test apparatus and materials shall be used.

a) Differential scanning calorimeter or differential thermal analyser capable of heating (cooling) at rates up to at least (20 ± 1) °C/min, and of automatically recording differential heat flow or differential temperature between the specimen and a reference, to the required sensitivity and precision.

b) Aluminum or other metal pans of high thermal conductivity specimen holders.

c) An empty specimen pan or a reference pan filled with an inert reference material with a heat capacity approximately equivalent to the specimen (for example aluminum oxide).

d) Recording charts for temperature-recording apparatus, with suitable graduations for recording of differential heat flow or differential temperature as a function of temperature. Instruments with digital data processing require an appropriate plotter or printer plotter.

e) Nitrogen of 99,9 % purity or other inert gas supply, for blanketing specimen oxidation. If oxidative reactions are excluded, inert gas supply is not necessary. The dew point of the selected gas must be below the lowest operating temperature.

9.10.4 Procedure

Use a specimen mass appropriate to the material to be tested. In most cases, a specimen mass of 0,010 g to 0,030 g specimen is satisfactory. As a reference, material with a heat capacity closely matched to that of the specimen or an empty pan may be used.

The specimen should be placed in the pan. After closing it with the relevant top by squeezing together the lower part and the top (cramping), a small hole shall be made in the top to allow vapour to escape. The crucible is then inserted into the test chamber of the instrument. The same procedure is followed for the reference as applicable.

Initiate flow of purge gas, as applicable.

Perform an initial thermal cycle from 30 °C to a temperature 15 °C above the expected T_g to erase previous thermal history at a rate of (20 ± 2) K/min.

Hold temperature until a steady state is achieved (usually 5 min to 10 min).

Quench cool to (30 ± 2) °C as rapidly as possible.

Hold temperature until a steady state is achieved (usually 5 min to 10 min).

As a referee, reheat at a rate of (10 ± 2) K/min and record the heating curve until a temperature 25 °C higher than the observed T_g. For normal quality conformance testing, (20 ± 2) K/min may be used.

Determine the midpoint temperature T_m (°C) as described in figure 17, and report it as T_g.

9.10.5 Report

The report shall include

a) the test number and revision;
b) the identification of the material tested;
c) the quantity, form and weight of the specimens;
d) the date of testing;
e) the reference (i.e. empty crucible, etc.) and weight;
f) the method of preparation of the specimens;
g) the reheating rate if other than 10 °C per minute;
h) the glass transition temperature (including information about the number of determinations used);
i) additional information about test apparatus.

9.10.6 Additional information

The calibration of the DSC instrument shall be performed according to the recommendations of the manufacturer with a standard reference material appropriate to the temperature regions of interest.

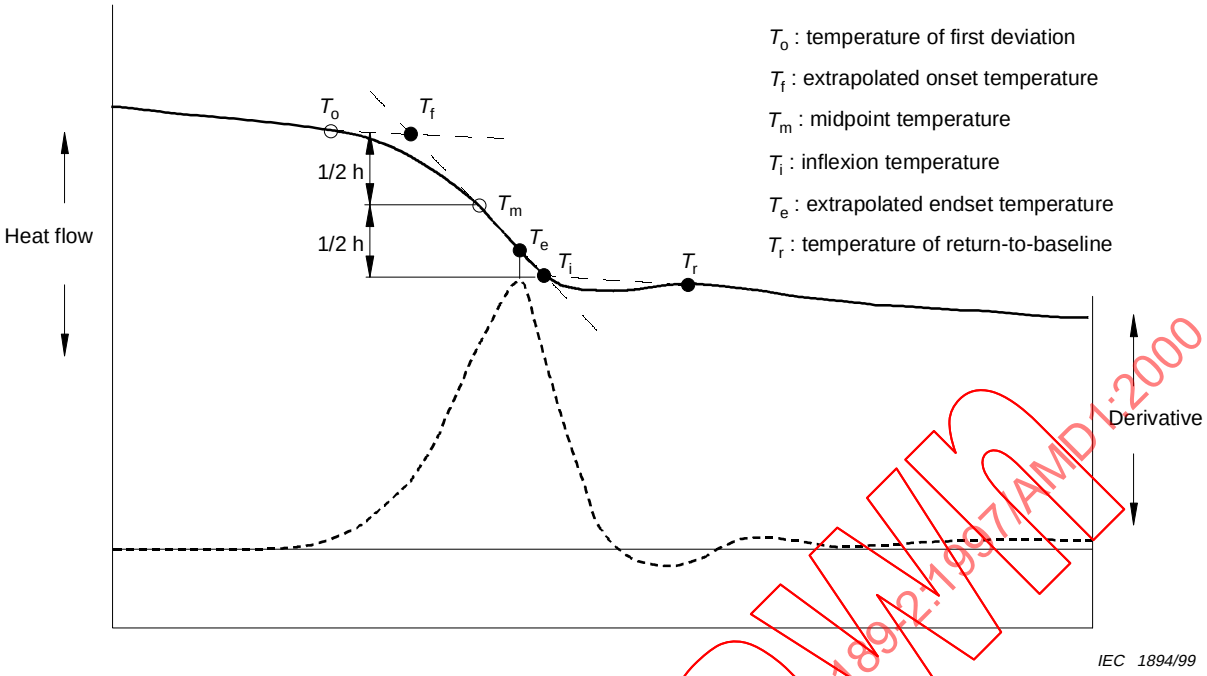


Figure 17 – Differential scanning calorimeter

(Characteristic transition points associated with glass transition)

9.11 Test 2M11: Glass transition temperature (TMA) (under consideration)

Replace this subclause by the following subclause:

9.11 Test 2M11: Glass transition temperature of base materials by thermomechanical analysis (TMA)

9.11.1 Object

The test method covers the procedure for the determination of the glass transition temperature of base materials by thermomechanical analysis (TMA). The glass transition temperature is indicated by the change in slope of the probe displacement curves in expansion mode resulting from a change in the rate of Z-axis expansion at that temperature.

9.11.2 Test specimens

The specimens shall be taken from the sheet in such a manner that they are not less than 25 mm from the edge.

The specimens shall be of suitable size and shape for the specimen holder of the measuring system and weigh (7,5 to 10) mg. The specimens shall be flat and parallel sided cross to direction of measurement and shall be free from burrs and fibres. The specimen may be prepared by sawing or punching.

For referee testing, a minimum of three specimens shall be tested.

9.11.3 Test apparatus and materials

The following test apparatus and materials shall be used.

a) A thermomechanical analyser or similar device consisting of a specimen holder into which the specimen can be placed. Changes in the length or in the compressive modulus of the specimen are sensed by the movement of a probe.

b) A probe whose shape and size shall be such that the load applied to the specimen by the probe shall not cause indentation of the specimen. Flat, circular probes whose diameters are (2 to 5) mm are used.

c) Means for sensing movement of the probe resulting from changes in length or compressive modulus of the specimen and for translating these movements into signals suitable for input to a chart recorder or data processing system. The sensing element should be capable of producing an electrical output of at least 1 mV per micrometer of probe movement with provision for less sensitive ranges when needed.

d) A means of recording changes on specimen length or probe position as a function of specimen temperature. X-Y chart or strip chart recorders that have sensitivities of 1 µm of probe deflection per centimetre of chart width or greater are acceptable. Instruments with digital data processing require an appropriate plotter or printer plotter.

e) A means for uniformly heating the specimen at a predetermined rate over the temperature range of interest. Provisions should be made for pre-cooling the furnace and specimen where near ambient or sub-ambient temperature measurements are to be made. Heating and cooling rates of up to at least 10 K/min are required;

f) Means for measuring the temperature of the test specimen.

g) Means of purging the specimen environment with a dry inert gas, such as nitrogen or helium (the latter preferred due to its higher thermal conductivity). The dew point of the selected gas must be below the lowest operating temperature.

9.11.4 Procedure

After mechanical removal of the metal, the specimens shall be dried for a minimum of 1 h at a temperature 20 °C below the expected T_g, but at a maximum of 110 °C.

Place a specimen having a thickness of 1 mm to 3 mm in the specimen holder under the probe. The specimen temperature sensor is placed in contact with the specimen or as near to the specimen as possible (whichever is recommended by the instrument manufacturer).

Move the furnace to enclose the specimen holder. Start the dry inert purge gas before cooling or heating the specimen. If measurements near ambient or sub-ambient temperatures are to be made, cool the specimen and furnace to at least 30 °C below the lowest temperature of interest. The refrigerant used for cooling should not come into direct contact with the specimen.

A load of 2 g shall be used.

Select an appropriate sensitivity setting on the recorder. Pre-analysis on a similar specimen may be run to provide this information.

Heat the specimen at a constant heating rate of (10 ± 2) K/min over the desired temperature range. Other rates may be used but must be noted in the report.

An abrupt change in the slope of the displacement curve indicates a transition of the material from one state to another. The projected temperature from the intersection of the extrapolated linear portions of the curve is used as the transition temperature T_g.

If residual stresses are evident (a sudden irreversible deflection at the glass transition) the heating should be stopped about 20 °C above this temperature. The temperature is then returned to the initial conditions and the run is repeated. The glass transition determined on this second run is reported along with the supplied heat treatment.

Determination of the glass transition temperature shall be made as follows (see figure 18).

1) Construct tangents to the curve below and above the sharp bend. The intersection point of the tangents is the glass transition temperature of a specimen. For referee measurements the average of three determinations shall be reported as the T_g (°C).
2) Results obtained by retesting some specimens shall not be treated as an independent test of a new specimen.

9.11.5 Report

The report shall include

a) the test number and revision;
b) the identification of the material tested;
c) the dimensions of the test specimen;
d) the method of preparation of the test specimen;
e) the specimen orientation with respect to the machine direction of the original base material;
f) the specimen orientation in the holder;
g) the temperature range;
h) the heating range if other than 10 K/min;
i) the glass transition temperature, with information about the number of determinations used;
j) additional information about test apparatus;

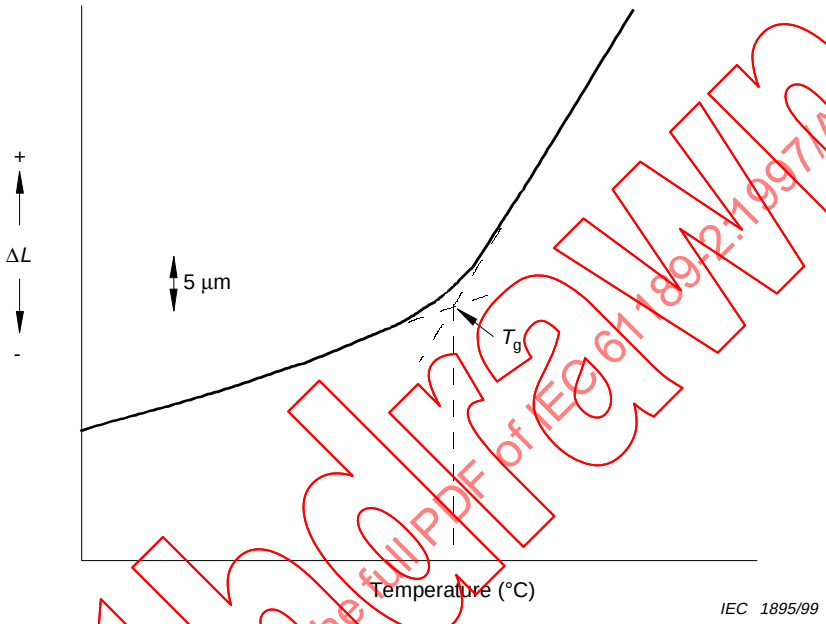
k) the testing date;

l) any deviation from this test method;

m) the name of the person conducting the test.

9.11.6 Additional information

Calibration of the thermomechanical analyser shall be conducted in the temperature region of interest against appropriate standard reference materials. The calibration procedure shall employ the same heating rate, purge gas and purge gas flow as the test specimens.



Size: 1,50 mm

Rate: K

Atmosphere: inert gas

Figure 18 – Thermomechanical analysis (expansion mode)

9.12 Test 2M12: Surface waviness (under consideration)

Replace this subclause by the following subclause:

9.12 Test 2M12: Surface waviness

9.12.1 Object

The test method covers the procedure for the determination of the surface waviness of metal-clad base materials essentially caused by the warp and fill threads of the glass fabric reinforcement.

9.12.2 Test specimens

The test specimens shall be cut not less than 25 mm from the edge of the sheet.

The test specimens shall be prepared from a sample of the metal-clad base material under test. They shall be of suitable size and shape for the measuring apparatus.

A single specimen should suffice for testing.

9.12.3 Test apparatus and materials

The following test apparatus and materials shall be used.

A contact profile meter for the measurement of surface roughness parameters by the profile method described in ISO 3274 shall be used, but with the following properties.

a) The profile meter shall be able to record the wave spectrum of the surface roughness with a low pass filter characteristic. (The transmission of the instrument shall be in the range of low frequencies or long wave lengths.)

b) The tip radius of the stylus shall be 5 µm or 10 µm.

9.12.4 Procedure

The procedure shall be carried out according to the instructions of the test equipment manufacturer using the following parameters:

– measuring length L_{MW} = 4 mm;

– cut off λ_B = 0,8 mm (for low pass filter).

During the measurement the specimen shall be held stable in horizontal position.

Five measurements shall be made in machine (warp) and transverse (fill) direction each.

The average of the five measurements in either direction shall be recorded as surface waviness in the relevant direction.

In the case of materials clad on both sides, tests have to be carried out on each of them.

9.12.5 Report

The report shall include

a) the test number and revision;

b) the identification of the material tested;

c) the date of the test;

d) the surface waviness in the machine direction (first side);

e) the surface waviness in the transverse direction (first side);

f) the surface waviness in the machine direction (second side);

g) the surface waviness in the transverse direction (second side);

h) any deviation from this test method;

i) the name of the person conducting the test.

9.12.6 Additional information

Surface waviness is essentially caused by the type of reinforcement of the base material, for example the warp and fill threads of the glass fabric.

If no profile meter with low pass filter is available, an instrument with high pass filter can be used with the parameters

L_{MW} = 12,5 mm λ_B = 2,5 mm

The resulting error in measurement is negligible; but, in this case, the information that an instrument with high pass filter is used shall be included in the report.

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9.22 Test 2M22: Weight of foil after lamination (etching) (under consideration)

Replace this subclause by the following subclause:

9.22 Test 2M22: Weight of foil after lamination

9.22.1 Object

To determine the mass per unit area of metal foils after lamination (by etching).

9.22.2 Test specimens

Three specimens, approximately 100 mm × 100 mm, from a sample of the metal-clad base material under test.

9.22.3 Test apparatus and materials

The following test apparatus and materials shall be used.

a) Analytical balance with an accuracy of 0,002 g.

b) Slide caliper.

c) An oven capable of maintaining a temperature of (105 ± 5) °C.

d) Any suitable etching solution of commercial practice may be used. As referee solution ferrichloride with a density of (1,32 – 1,41) g/cm^3 room temperature shall be used.

e) A desiccator or drying chamber with calcium chloride or similar as drying medium.

9.22.4 Procedure

Measure the dimensions of the specimens to an accuracy of ±0,1 mm. Calculate the areas in m^2 (A).

Precondition the specimens for 24 h at (23 ± 2) °C, (50 ± 5) % relative humidity, then weigh to an accuracy of 0,002 g (M_1).

Remove the copper foil completely by etching. Rinse the specimens in cold running water until the water forms an intact film on the surface.

Dry the specimens for 1 h at (105 ± 5) °C, Allow to cool down to room temperature in a desiccator and reweigh it (M_2).

Materials clad with metal foils on both sides shall be tested as above unless it is necessary to determine the mass of the individual foils, for example, when different foils are used on opposite sides or in case of dispute. In these cases, separate specimens shall be used to determine the foil mass on each side. The foil on the reverse side shall be protected by a suitable resist applied before the copper foil on the upper side is removed.

Calculation:

Metal foil on one side, or different foils on opposite sides:

$$\text{Mass per unit area} = \frac{(M_1 - M_2)}{A} \text{ g/m}^2$$

An average of the three measurements is reported.

Metal foil on both sides, the same nominal thickness:

$$\text{Mass per unit area} = \frac{(M_1 - M_2)}{2A} \text{ g/m}^2$$

An average of the three measurements is reported.

9.22.5 Report

The report shall include

a) test method number and revision;
b) identification of the test material;
c) date of test;
d) mass per unit area in g/m^2 for each side;
e) any deviation from this test method;
f) the name of the person conducting the test.

9.22.6 Additional information

None

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9.26 Test 2M26: Scaled flow of prepregnation (under consideration)

Replace this subclause by the following subclause:

9.26 Test 2M26: Scaled flow test for prepreg materials

9.26.1 Object

This procedure defines a test method used to determine the pressed thickness of a prepreg comprised of epoxide resin and reinforcement. The test is appropriate for checking prepreg consistency, but is not intended to define the suitability of the prepreg for use in a specific printed board process or application.

9.26.2 Test specimens

The prepreg specimen size shall be (140 ± 1) mm × (180 ± 1) mm. Specimens shall be cut with the 180 mm dimension parallel to the machine direction of the prepreg.

Each laminated specimen shall be comprised of the number of prepreg plies specified in table 5.

9.26.3 Test apparatus and materials

The following test apparatus and materials shall be used.

a) A lamination press with a minimum heating platen size of 200 mm × 200 mm, capable of maintaining uniform pressure of (21 ± 1) N/cm^2, and capable of maintaining a temperature of (150 ± 2) °C. The heating platen shall be flat and parallel within 0,25 mm.

b) Press plates. The press plates used shall be steel metal between 3,0 mm and 6,5 mm thick, and shall be (115 ± 1) mm × (150 ± 1) mm in size. The press plate shall be flat and parallel within 0,025 mm.

c) Release material. The release material shall be polyvinyl fluoride (PVF) or equivalent, at least 220 mm × 220 mm in size.

d) Temperature-resistant adhesive tape. The tape shall be suitable for holding the specimens during lamination.

e) Prepreg cutting equipment. The cutter shall be capable of maintaining the specimen tolerances outlined in clause 3.

f) Micrometer. A measuring instrument with a resolution of 0,002 mm.

g) Stabilization chamber. A stabilization chamber (dry cabinet) with suitable desiccant (calcium chloride or equivalent) capable of maintaining less than 10 % RH at (21 ± 2) °C.

9.26.4 Procedure

The specimens shall be cut to size and then placed in the stabilization chamber for a period of 24 h. The laminating process shall be performed within 15 min of removal from the chamber. Specimens tested within 15 min after manufacture (impregnation) need not be stabilized.

Specimens shall be gathered into a stack for test purposes. The number of plies in the stack shall be determined from table 5.

Close the press and allow the press platens to preheat to (150 ± 2) °C.

Table 5 – Number of plies per specimen as a function of glass thickness

Glass thickness mm	Number of plies
≤0,065	10
>0,065	5

On the top of one press plate, place a release sheet, then a stack of prepreg. Use tape to hold the stack in place. Position the tape on opposing corners so that it does not interfere with the 115 mm × 150 mm working area to be tested. A second release sheet is placed on top of the stack to form a sandwich (see figure 19). Then cover with the second press plate.

Open press and immediately place the prepreg stack and release sheets on the bottom press platen, making sure the plates are centred on the press plate.

NOTE – Make sure the release material is in place.

Press the specimens with a uniform pressure of (21 ± 1) N/cm^2 for a minimum of 10 min. Full pressure is to be applied within 15 s after the package of prepreg and release films are placed on the press plates.

Open the press and carefully remove the laminated package, placing it onto a smooth flat surface and cool for 5 min before making measurements.

Remove release films from the laminated specimen. Using the template shown in figure 20, mark the points to be measured. Cut the laminated specimen along the cut line shown in figure 20, to facilitate access to measuring points.

Measure the thickness to the nearest 0,002 mm with the micrometer at the three points defined by figure 20. Record all three measurements for each laminated specimen. Average the three measurements to determine the average measured thickness.

The thickness per ply is calculated by dividing the average measured thickness by the number of plies used in the laminated specimens.

9.26.5 Report

The report shall include

a) test method number and revision;
b) the test date;
c) the average thickness per ply of the prepreg in mm;
d) identification and description of specimen(s);
e) the number of plies and glass fabric style of the prepreg used for the laminated specimens;
f) any deviation from this test method;
g) the name of the person that conducted the test.

9.26.6 Additional information

A thickness variation between the three measurements of 0,06 mm or more is typically the result of prepreg shifting during the lamination. To verify the validity of the results, it may be necessary to repeat the test once.