

INTERNATIONAL STANDARD

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Second edition
2006-05

**Test methods for electrical materials, printed
boards and other interconnection structures
and assemblies –**

**Part 2:
Test methods for materials
for interconnection structures**



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Test methods for electrical materials, printed boards and other interconnection structures and assemblies –

Part 2: Test methods for materials for interconnection structures

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CONTENTS

FOREWORD.....	6
INTRODUCTION.....	8
1 Scope.....	9
2 Normative references.....	9
3 Accuracy, precision and resolution	9
3.1 Accuracy	10
3.2 Precision	10
3.3 Resolution	11
3.4 Report.....	11
3.5 Student's "t" distribution.....	11
3.6 Suggested uncertainty limits	12
4 Catalogue of approved test methods	13
5 P: Preparation/conditioning test methods	13
5.1 Test 2P01: Dry heat (under consideration)	13
5.2 Test 2P02: Solder float stress (under consideration)	13
6 V: Visual test methods	13
7 D: Dimensional test methods	13
7.1 Test 2D01: Thickness of base materials and rigid boards	13
8 C: Chemical test methods	15
8.1 Test 2C01: Resistance to sodium hydroxide of base materials.....	15
8.2 Test 2C02: Gel time of epoxy based prepreg materials.....	16
8.3 Test 2C03: Resin content of prepreg materials by treated weight.....	17
8.4 Test 2C04: Volatile content of prepreg materials	19
8.5 Test 2C05: Blistering during heat shock	21
8.6 Test 2C06: Flammability, vertical burning test for rigid materials	23
8.7 Test 2C07: Flammability; horizontal burning test for rigid materials.....	26
8.8 Test 2C08: Flammability, flex material	29
8.9 Test 2C09: Melting viscosity of prepreg materials.....	33
8.10 Test 2C10: Resin content of prepreg materials by sublimation.....	35
8.11 Test 2C11: UV blocking characteristics of laminates	37
8.12 Test 2C12: Total halogen content in base materials	38
9 M: Mechanical test methods.....	42
9.1 Test 2M01: Test method for bow and twist	42
9.2 Test 2M02: Bow/twist after etching and heating.....	43
9.3 Test 2M03: Cure factor of base materials by differential scanning calorimetry (DSC) or thermomechanical analysis (TMA).....	45
9.4 Test 2M04: Twist after heating (under consideration)	46
9.5 Test 2M05: Pull-off strength.....	46
9.6 Test 2M06: Peel strength after exposure to solvent vapour.....	48
9.7 Test 2M07: Peel strength after immersion in solvent	50
9.8 Test 2M08: Flexural strength (under consideration).....	51
9.9 Test 2M09: Resin flow of prepreg material	51
9.10 Test 2M10: Glass transition temperature of base materials by differential scanning calorimetry (DSC)	53

9.11	Test 2M11: Glass transition temperature of base materials by thermomechanical analysis (TMA)	55
9.12	Test 2M12: Surface waviness	58
9.13	Test 2M13: Peel strength as received	59
9.14	Test 2M14: Peel strength after heat shock	60
9.15	Test 2M15: Peel strength after dry heat.....	63
9.16	Test 2M16: Peel strength after simulated plating	64
9.17	Test 2M17: Peel strength at high temperature	66
9.18	Test 2M18: Surface quality (under consideration)	68
9.19	Test 2M19: Punching (under consideration)	68
9.20	Test 2M20: Flexural strength	68
9.21	Test 2M21: Rolling fatigue of flexible base materials	69
9.22	Test 2M22: Weight of foil after lamination	71
9.23	Test method 2M23: Rectangularity of cut panels	73
9.24	Test 2M24: Coefficient of thermal expansion (under consideration)	74
9.25	Test 2M25: Time to delamination by thermomechanical analysis (TMA).....	74
9.26	Test 2M26: Scaled flow test for prepreg materials	75
9.27	Test 2M27: The resin flow properties of coverlay films, bonding films and adhesive cast films used in the fabrication of flexible printed boards	78
10	Electrical test methods.....	83
10.1	Test 2E01: Surface tracking, moisture condition (under consideration)	83
10.2	Test 10.2 2E02: Dielectric breakdown of base materials parallel to laminations	83
10.3	Test 2E03: Surface resistance after damp heat, steady state	85
10.4	Test 2E04: Volume resistivity and surface resistivity.....	90
10.5	Test 2E05: Permittivity and dielectric dissipation (under consideration).....	94
10.6	Test 2E06: Volume and surface resistivity, 3 electrodes (under consideration).....	94
10.7	Test 2E07: Surface and volume resistivity, elevated temperature (under consideration).....	94
10.8	Test 2E08: Surface corrosion.....	94
10.9	Test 2E09: Comparative tracking index (CTI)	96
10.10	Test 2E10: Permittivity and dissipation factor (under consideration).....	100
10.11	Test 2E11: Electric strength (under consideration)	100
10.12	Test 2E12: Resistance of foil (under consideration).....	100
10.13	Test 2E13: Corrosion at edge (under consideration).....	100
10.14	Test 2E14: Arc resistance	100
10.15	Test 2E15: Dielectric break-down (under consideration)	104
10.16	Test 2E16: Contact resistance of printed circuit keypad cont (under consideration).....	104
10.17	Test 2E17: Insulation resistance of printed board materials	104
10.18	Test 2E18: Fungus resistance of printed board materials	105
11	N: Environmental test methods	109
11.1	Test 2N01: Pressure cooker test (under consideration)	109
11.2	Test 2N02: Water absorption	109
12	X: Miscellaneous test methods	110
12.1	Test 2X02: Dimensional stability of thin laminates	110

Annex A (informative) Worked examples	114
Annex B (informative) Conversion table	116
Annex C (informative) Laboratory pro forma (form)	121
Annex D (informative) Laboratory pro forma	122
Figure 1 – Thickness measuring points	14
Figure 2 – Position of specimens	20
Figure 3 – Fluidized sand bath	22
Figure 4 – Test fixture	28
Figure 5 – V method (Vertical flammability method)	32
Figure 6 – VTM method (vertical flammability method for recaltrant specimens)	32
Figure 7 – Example of prepreg melting viscosity	35
Figure 8 – Position of specimens for resin content	36
Figure 9 – Absorption of combustion gas using a combustion flask set-up	40
Figure 10 – Composition of ion exchange chromatograph	40
Figure 11 – Specimen for peel strength measurement	49
Figure 12 – Differential scanning calorimetry	54
Figure 13 – Thermomechanical analysis (expansion mode)	57
Figure 14 – Test specimen pattern	70
Figure 15 – General arrangement of apparatus	70
Figure 16 – Scaled flow test specimen before lamination	77
Figure 17 – Scaled flow test specimen measurement points	77
Figure 18 – Test patterns for clearance filling test	79
Figure 19 – Punched test pattern for squeeze-out test	80
Figure 20 – Standard lay-up of materials in the press to prepare the test specimens for referee tests	81
Figure 21 – Profiles of press conditions to prepare the test specimens for referee tests	82
Figure 22 – Measurement of volume resistance	89
Figure 23 – Measurement of surface resistance	89
Figure 25 – Electrode connections for measuring volume resistance	93
Figure 26 – Electrode connections for measuring surface resistance	93
Figure 27 – Ring and disk pattern	95
Figure 28 – Comb pattern	96
Figure 31 – Example of test apparatus	98
Figure 32 – Example of test circuit	98
Figure 33 – Arc-resistance test circuit	101
Figure 34 – Tungsten steel rod electrode assembly	102
Figure 35 – Test specimen for insulation resistance	104
Figure 36 – Location of specimens on original sheet for dimensional stability test	111
Figure 37 – Location of marks on specimen for dimensional stability	112

Table 1 – Student's "t" distribution	12
Table 2 – Example of analysing conditions for the ion exchange chromatography	41
Table 3 – Specimen dimensions	68
Table 4 – Number of plies per specimen as a function of glass thickness	76
Table 6 – Specimen dimension (cm)	86
Table 7 – Test pattern dimensions	91
Table 8 – Arc resistance	103

INTERNATIONAL ELECTROTECHNICAL COMMISSION

TEST METHODS FOR ELECTRICAL MATERIALS, PRINTED BOARDS AND OTHER INTERCONNECTION STRUCTURES AND ASSEMBLIES –

Part 2: Test methods for materials for interconnection structures

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61189-2 has been prepared by IEC technical committee 91: Surface mounting technology, in cooperation with technical committee 52: Printed circuits (now disbanded), and technical committee 50: Environmental testing.

This second edition replaces the first edition, published in 1997, and its Amendment 1 (2000). It constitutes a technical revision.

The document 91/564/FDIS, circulated to the National Committees as Amendment 2, led to the publication of this new edition.

The text of this standard is based on the first edition, its amendment 1 and on the following documents:

FDIS	Report on voting
91/564/FDIS	91/572/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.

The significant technical changes with respect to the previous edition concern the addition of several new tests in the following categories:

- C: Chemical test methods
- D: Dimensional test methods:
- E: Electrical test methods
- M: Mechanical test methods
- N: Environmental test methods
- X: Miscellaneous test methods

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

This standard forms part of a series and should be used in conjunction with other parts in the same series, all under the main title *Test methods for electrical materials, interconnection structures and assemblies*:

- Part 1: General test methods and methodology
- Part 2: Test methods for materials for interconnection structures
- Part 3: Test methods for interconnection structures (printed boards)
- Part 4: Test methods for electronic components assembling characteristics¹
- Part 5: Test methods for printed board assemblies
- Part 6: Test methods for materials used in electronic assemblies

It should also be read in conjunction with IEC 60068: Environmental testing.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

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

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

¹ Under consideration.

INTRODUCTION

IEC 61189 relates to test methods for printed boards and printed board assemblies, as well as related materials or component robustness, irrespective of their method of manufacture.

The standard is divided into separate parts, covering information for the designer and the test methodology engineer or technician. Each part has a specific focus; methods are grouped according to their application and numbered sequentially as they are developed and released.

In some instances test methods developed by other TCs (e.g. TC 50) have been reproduced from existing IEC standards in order to provide the reader with a comprehensive set of test methods. When this situation occurs, it will be noted on the specific test method; if the test method is reproduced with minor revision, those paragraphs that are different are identified.

This part of IEC 61189 contains test methods for materials used to produce interconnection structures (printed boards) and electronic assemblies. The methods are self-contained, with sufficient detail and description so as to achieve uniformity and reproducibility in the procedures and test methodologies.

The tests shown in this standard are grouped according to the following principles:

- P: preparation/conditioning methods
- V: visual test methods
- D: dimensional test methods
- C: chemical test methods
- M: mechanical test methods
- E: electrical test methods
- N: environmental test methods
- X: miscellaneous test methods

To facilitate reference to the tests, to retain consistency of presentation, and to provide for future expansion, each test is identified by a number (assigned sequentially) added to the prefix (group code) letter showing the group to which the test method belongs.

The test method numbers have no significance with respect to an eventual test sequence; that responsibility rests with the relevant specification that calls for the method being performed. The relevant specification, in most instances, also describes pass/fail criteria.

The letter and number combinations are for reference purposes, to be used by the relevant specification. Thus "2D01" represents the first dimensional test method described in this publication.

In short, for this example, 2 is the part of IEC standard (61189-2), D is the group of methods, and 01 is the test number.

A list of all test methods included in this standard, as well as those under consideration is given in Annex B. This annex will be reissued whenever new tests are introduced.

TEST METHODS FOR ELECTRICAL MATERIALS, PRINTED BOARDS AND OTHER INTERCONNECTION STRUCTURES AND ASSEMBLIES –

Part 2: Test methods for materials for interconnection structures

1 Scope

This part of IEC 61189 provides a catalogue of test methods representing methodologies and procedures that can be applied to test materials used for manufacturing interconnection structures (printed boards) and assemblies.

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

IEC 60068-2-2:1974, *Environmental testing – Part 2: Tests – Tests B: Dry heat*

IEC 60068-2-78:2001, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60093:1980, *Methods of test for volume resistivity and surface resistivity of solid electrical insulating materials*

IEC 60243-1:1998, *Electrical strength of insulating materials – Test methods: Tests at power frequencies*

IEC 61189-3:1997, *Test methods for electrical materials, interconnection structures and assemblies – Part 3: Test methods for interconnection structures (printed boards)*

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

ISO 9001:2000, *Quality systems – Model for quality assurance in production, installation and servicing*

ANSI/UL-94:1993, *Standard for tests for flammability of plastic materials for parts in devices and appliances, Tests for*

3 Accuracy, precision and resolution

Errors and uncertainties are inherent in all measurement processes. The information given below enables valid estimates of the amount of error and uncertainty to be taken into account.

Test data serve a number of purposes which include:

- monitoring a process;
- enhancing confidence in quality conformance;
- arbitrating between customer and supplier.

In any of these circumstances, it is essential that confidence can be placed upon the test data in terms of:

- accuracy: calibration of the test instruments and/or system;
- precision: the repeatability and uncertainty of the measurement;
- resolution: the suitability of the instruments and/or system for the test.

3.1 Accuracy

The regime by which routine calibration of the test equipment is undertaken shall be clearly stated in the quality documentation of the supplier or agency conducting the test, and shall meet the requirements of ISO 9001:2000.

The calibration shall be conducted by an agency having accreditation to a national or international measurement standard institute. There should be an uninterrupted chain of calibration to a national or international standard.

Where calibration to a national or international standard is not possible, round robin techniques may be used, and documented, to enhance confidence in measurement accuracy.

The calibration interval shall normally be one year. Equipment consistently found to be outside acceptable limits of accuracy shall be subject to shortened calibration intervals. Equipment consistently found to be well within acceptable limits may be subject to relaxed calibration intervals.

A record of the calibration and maintenance history shall be maintained for each instrument. These records should state the uncertainty of the calibration technique (in $\pm$ % deviation) in order that uncertainties of measurement can be aggregated and determined.

A procedure shall be implemented to resolve any situation where an instrument is found to be outside calibration limits.

3.2 Precision

The uncertainty budget of any measurement technique is made up of both systematic and random uncertainties. All estimates shall be based upon a single confidence level, the minimum being 95 %.

Systematic uncertainties are usually the predominant contributor, and will include all uncertainties not subject to random fluctuation. These include:

- calibration uncertainties;
- errors due to the use of an instrument under conditions which differ from those under which it was calibrated;
- errors in the graduation of a scale of an analogue meter (scale shape error).

Random uncertainties result from numerous sources but can be deduced from repeated measurement of a standard item. Therefore, it is not necessary to isolate the individual contributions. These may include:

- random fluctuations such as those due to the variation of an influence parameter. Typically, changes in atmospheric conditions reduce the repeatability of a measurement;
- uncertainty in discrimination, such as setting a pointer to a fiducial mark, or interpolating between graduations on an analogue scale.

Aggregation of uncertainties: Geometric addition (root-sum-square) of uncertainties may be used in most cases. Interpolation error is normally added separately and may be accepted as being 20 % of the difference between the finest graduations of the scale of the instrument.

$$U_t = \pm \sqrt{(U_s^2 + U_r^2)} + U_i$$

where

U_t is the total uncertainty

U_s is the systematic uncertainty

U_r is the random uncertainty

U_i is the interpolation error

Determination of random uncertainties: Random uncertainty can be determined by repeated measurement of a parameter, and subsequent statistical manipulation of the measured data. The technique assumes that the data exhibits a normal (Gaussian) distribution.

$$U_r = \frac{t \times \sigma}{\sqrt{n}}$$

where

U_r is random uncertainty

n is the sample size

t is the percentage point of the “ t ” distribution (from 3.5), statistical tables

σ is the standard deviation (σ_{n-1})

3.3 Resolution

It is paramount that the test equipment used is capable of sufficient resolution. Measurement systems used should be capable of resolving 10 % (or better) of the test limit tolerance.

It is accepted that some technologies will place a physical limitation upon resolution (e.g. optical resolution)

3.4 Report

In addition to requirements detailed in the test specification, the report shall detail:

- the test method number and revision;
- the identity of the sample(s);
- the test instrumentation;
- the specified limit(s);
- an estimate of measurement uncertainty, and resultant working limit(s) for the test;
- the detailed test results;
- the test date, and operators' signature.

3.5 Student's “ t ” distribution

Table 1 gives values of the factor “ t ” for 95 % and 99 % confidence levels, as a function of the number of measurements. It is sufficient to use 95 % limits, as in the case of the worked examples shown in Annex A.

Table 1 – Student's "t" distribution

Sample size	t value 95 %	t value 99 %		Sample size	t value 95 %	t value 99 %
2	12,7	63,7		14	2,16	3,01
3	4,3	9,92		15	2,14	2,98
4	3,18	5,84		16	2,13	2,95
5	2,78	4,6		17	2,12	2,92
6	2,57	4,03		18	2,11	2,9
7	2,45	3,71		19	2,1	2,88
8	2,36	3,5		20	2,09	2,86
9	2,31	3,36		21	2,08	2,83
10	2,26	3,25		22	2,075	2,82
11	2,23	3,17		23	2,07	2,81
12	2,2	3,11		24	2,065	2,8
13	2,18	3,05		25	2,06	2,79

3.6 Suggested uncertainty limits

The following target uncertainties are suggested:

- a) Voltage < 1 kV: $\pm 1,5 \%$
- b) Voltage > 1 kV: $\pm 2,5 \%$
- c) Current < 20 A: $\pm 1,5 \%$
- d) Current > 20 A: $\pm 2,5 \%$

Resistance

- e) Earth and continuity: $\pm 10 \%$
- f) Insulation: $\pm 10 \%$
- g) Frequency: $\pm 0,2 \%$

Time

- h) Interval < 60 s: $\pm 1 \text{ s}$
- i) Interval > 60 s: $\pm 2 \%$
- j) Mass < 10 g: $\pm 0,5 \%$
- k) Mass 10 g to 100 g: $\pm 1 \%$
- l) Mass > 100 g: $\pm 2 \%$
- m) Force: $\pm 2 \%$
- n) Dimension < 25 mm: $\pm 0,5 \%$
- o) Dimension > 25 mm: $\pm 0,1 \text{ mm}$
- p) Temperature < 100 °C: $\pm 1,5 \%$
- q) Temperature > 100 °C: $\pm 3,5 \%$
- r) Humidity 30 to 75 % RH: $\pm 5 \%$ RH

Plating thicknesses

- s) Backscatter method: $\pm 10 \%$
- t) Microsection: $\pm 2 \mu\text{m}$
- u) Ionic contamination: $\pm 10 \%$

4 Catalogue of approved test methods

This standard provides specific test methods in complete detail to permit implementation with minimal cross-referencing to other specific procedures. The use of generic conditioning exposures is accomplished in the methods by reference, for example IEC 61189-1 and IEC 60068, and when applicable, is a mandatory part of the test method standard.

Each method has its own title, number and revision status to accommodate updating and improving the methods as industry requirements change or demand new methodology. The methods are organized in test method groups and individual tests.

5 P: Preparation/conditioning test methods

5.1 Test 2P01: Dry heat (under consideration)

5.2 Test 2P02: Solder float stress (under consideration)

6 V: Visual test methods

7 D: Dimensional test methods

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 1.
- 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.

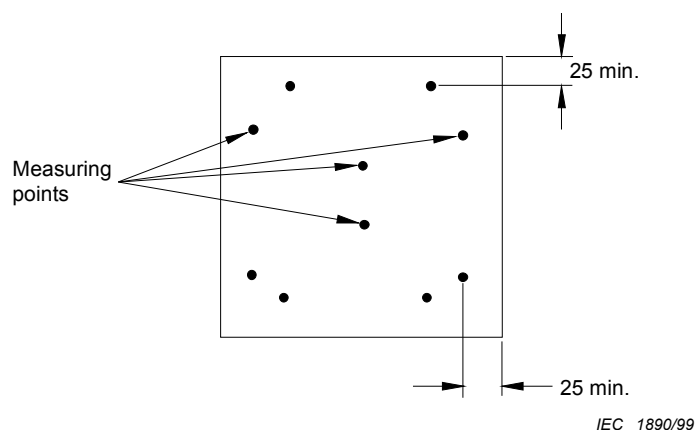


Figure 1 – Thickness measuring points

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.

8 C: Chemical test methods

8.1 Test 2C01: Resistance to sodium hydroxide of base materials

8.1.1 Object

The purpose of this test method is to provide a procedure for determining the alkaline resistance of base materials by exposure to a sodium hydroxide solution.

8.1.2 Test specimens

- a) Specimens shall be taken from the panel or sheet in such a way that they are at least 25 mm from the edge of the sheet.
- b) Specimens shall be prepared from a sample of metal-clad base material from which the metal has been completely removed by any appropriate method reflecting usual practice.
- c) Specimen size is (50 ± 2) mm in both length and width, and shall be cut out using a fine saw to give the edges a smooth finish.
- d) A minimum of three specimens shall be used.

8.1.3 Test apparatus and materials

The following test apparatus and materials shall be used:

- a) an appropriate alkaline-proof container which contains an analytical grade sodium hydroxide solution maintained at a temperature of (40 ± 2) °C at a concentration by weight of $(3 \pm 0,2)$ %. In order to ensure that the concentration remains within the tolerance, the solution must be prepared daily. The number of specimens tested per litre of solution shall not be more than 50;
- b) a rack to hold specimens upright in the container. The design of the rack shall allow maximum exposure of the specimen surfaces to the solution;
- c) a clean dry gauze, cloth or paper to wipe off the water from the specimen surfaces;
- d) a fine blade saw for the sample preparation.

8.1.4 Procedure

Place the specimens in the rack then in the sodium hydroxide solution for $3 \text{ min} \pm 20 \text{ s}$.

Take the rack out of the sodium hydroxide solution and quickly rinse the specimens under running water for a minimum of 5 min.

Wipe the water from the specimen surfaces completely with a clean dry gauze, cloth or paper.

Immediately make a visual check for colour change, swelling, blistering and/or delamination.

8.1.5 Report

The report shall include:

- a) the test number and revision index;
- b) the testing date;
- c) the identification of the material tested;
- d) the changes in surface appearance, if any;
- e) any deviation from this test method.

8.1.6 Additional information

Sodium hydroxide is a powerful alkaline chemical. It shall be handled with care, avoiding eye and skin contact by wearing protective glasses and chemically resistant gloves.

8.2 Test 2C02: Gel time of epoxy based prepreg materials

8.2.1 Object

The purpose of this test method is to provide a means for determining the gel time of epoxide resin impregnated reinforcement cured to the B-stage used in the manufacturing of laminate and printed boards.

8.2.2 Test specimens

A number of pieces approximately 100 mm square or another convenient size, in order to yield approximately 1 g of dry resin, shall be cut from areas uniformly distributed across the width of the sheet or roll, but excluding the area within 25 mm of each edge or selvage.

8.2.3 Test apparatus and material

The following test apparatus and materials shall be used:

- a) heating plate capable of maintaining a temperature of $(170 \pm 0,5) ^\circ\text{C}$;
- b) timer, capable of determining time within ± 1 s;
- c) wooden stick, pointed, approximately 3 mm in diameter;
- d) a measure of capacity for 0,3 g to 0,4 g resin powder;
- e) sieve, 50 mesh per inch.

8.2.4 Procedure

Detach the dry resin from the prepreg (B-stage) by folding or crushing. Remove any glass fibre present by sieving alternatively, in the case of materials too soft to detach dry resin by crushing, the resin required may be obtained by pressing the folded stack of material in contact with the heating plate and squeezing out the melted resin.

Remove any glass fibre present by sieving.

Adjust the heating plate or equivalent to $170 ^\circ\text{C}$ and allow to stabilize at that temperature.

Using the measure of capacity a quantity of 0,3 g to 0,4 g resin powder shall be taken.

Pour the measured dry resin in the form of a small cone on one spot of the heating plate and start the timer immediately. If the alternative method given above is used, the timer shall be started at that moment when the folded stack is brought in contact with the heating plate.

Stir the resin, using a wooden stick approximately 3 mm in diameter, holding the stick as near vertical as possible and mixing the centre as well as the edges of the melted resin. While stirring, the diameter of the pool of melting resin shall not exceed 25 mm.

At the approach of the gel point the resin becomes tacky and forms strings when pulling the stick out. The gel point is reached when it no longer forms strings when pulling the stick out, and is no longer tacky but still elastic. At this point, the timer is stopped and the elapsed time measured in seconds is taken as the gel time. When used as a reference, three separate measurements shall be carried out and the average recorded as gel time.

8.2.5 Report

The report shall include:

- a) the test method number and revision index;
- b) the testing date;
- c) the identification of the material tested;
- d) the gel time in seconds (average);
- e) any deviation from this test method.

8.2.6 Additional information

The determination of gel time may also be carried out using a sample of the resin contained in a rotational viscometer, in which case more information about the flow characteristics of the resin may be obtained. If this method is used, the viscosity value corresponding to the gel point shall be defined by determination of the correlation with the test described above.

8.3 Test 2C03: Resin content of prepreg materials by treated weight

8.3.1 Object

The purpose of this test method is to provide a means for measuring the resin content of resin impregnated reinforcement cured to the B-stage, only if the weight of uncoated reinforcement is known. This method is applicable to both organic and inorganic reinforcements.

8.3.2 Test specimens

- a) Specimens shall be taken from the roll or sheet in such a way that they are at least 25 mm from the edge.
- b) Four specimens $(100 \pm 0,2) \text{ mm} \times (100 \pm 0,2) \text{ mm}$ shall be taken at equal spacing across the web for rolls or from different areas of sheeted material.

8.3.3 Test apparatus and materials

The following test apparatus and materials shall be used:

- a) analytical balance with a 0,001 g or better resolution;
- b) desiccator (stabilization chamber) capable of maintaining 25 % relative humidity (RH) or less at room temperature.

8.3.4 Procedure

8.3.4.1 Determination of weight of reinforcement

The weight of 1 dm² reinforcement may be determined by one of the two methods described below:

8.3.4.1.1 Method 1

Determine the weight of the reinforcement from the actual length, width and weight of roll of reinforcement material:

$$W_B = 10 \times \frac{W_R}{L \times D}$$

where

W_B is the weight of 1 dm² reinforcement (g)

W_R is the roll weight (kg)

L is the roll length (m)

D is the roll width (m)

8.3.4.1.2 Method 2

Determine the weight from median statistical or typical reinforcement weight in grams per metre:

$$W_B = 0,01 W$$

where

W_B is the weight of 1 dm² reinforcement (g)

W is the weight of 1 m² (g)

8.3.4.2 Determination of total weight of prepreg

Determine actual reinforcement weight at the beginning of the roll, using the same measurement technique as described in this method.

All the above methods consider any finishes applied to the reinforcement as part of the reinforcement.

The specimen shall be desiccated unless the prepreg material is tested within 10 min of manufacture to prevent the absorption of moisture.

Determine and record the total weight of the four specimens to the nearest 0,001 g.

8.3.4.3 Resin content

The resin content shall be calculated as follows:

$$C_R = \left(1 - \frac{W_B}{W_T} \right) \times 100$$

where

C_R is the resin content (%)

W_B is the weight of the reinforcement (g/dm²)

W_T is the weight of the treated prepreg (g/dm²)

8.3.5 Report

The report shall include:

- the test method number and revision index;
- the testing date;
- the identification of the material tested;
- the weight of the treated specimen to the nearest 0,001 g and the resin content to the nearest 0,1 %;
- any deviation from this test method.

8.3.6 Additional information

The volatile content of the prepreg (excluding moisture) is considered as part of the treated product using this method. If it is desired to exclude volatile content the specimen should be baked at an appropriate time and temperature.

The accuracy of this test method for determination of resin content is dependent primarily upon the accuracy of the basic weight of the reinforcement.

The effect of static charges may present a serious problem in weighing material which has been stored if the specimen is larger than the sample pan of the analytical balance.

If it is desired to check variation across the width of the roll, four specimens may be cut down the roll at each location to be tested.

In most cases, the amount of organic material from the reinforcement is negligible; however, special attention should be paid to materials such as reinforcement containing finishes, which have a substantial amount of organic content (5 % or more), and for organic reinforcements which may have significant moisture content.

The resin content test by sublimation, Test 2C10, is a more accurate measurement of resin content and shall be used for reference purposes.

8.4 Test 2C04: Volatile content of prepreg materials

8.4.1 Object

The purpose of this test method is to provide a means for measuring the volatile content of resin impregnated B-stage reinforcement in the manufacturing of laminate and multilayer printed boards.

8.4.2 Test specimens

Three specimens $(100 \pm 0,2) \text{ mm} \times (100 \pm 0,2) \text{ mm}$ shall be cut from positions along a line perpendicular to the machine direction of reinforcement, with the diagonals of the specimens parallel to the machine (warp) and cross-machine directions (weft), and no closer than 25 mm from the edge of the prepreg sheet or roll, see Figure 2. A hole approximately 3 mm in diameter shall be punched in the corner of each specimen.

8.4.3 Test apparatus and materials

The following test apparatus and materials shall be used:

- a) analytical balance with a 0,001 g or better resolution;
- b) an air circulating oven capable of achieving a temperature of up to 250 °C and controllable within $\pm 3 \text{ °C}$;
- c) a desiccator (stabilization chamber) capable of maintaining 25 % RH or less at room temperature;
- d) appropriate hanging metal hooks to hang specimens.

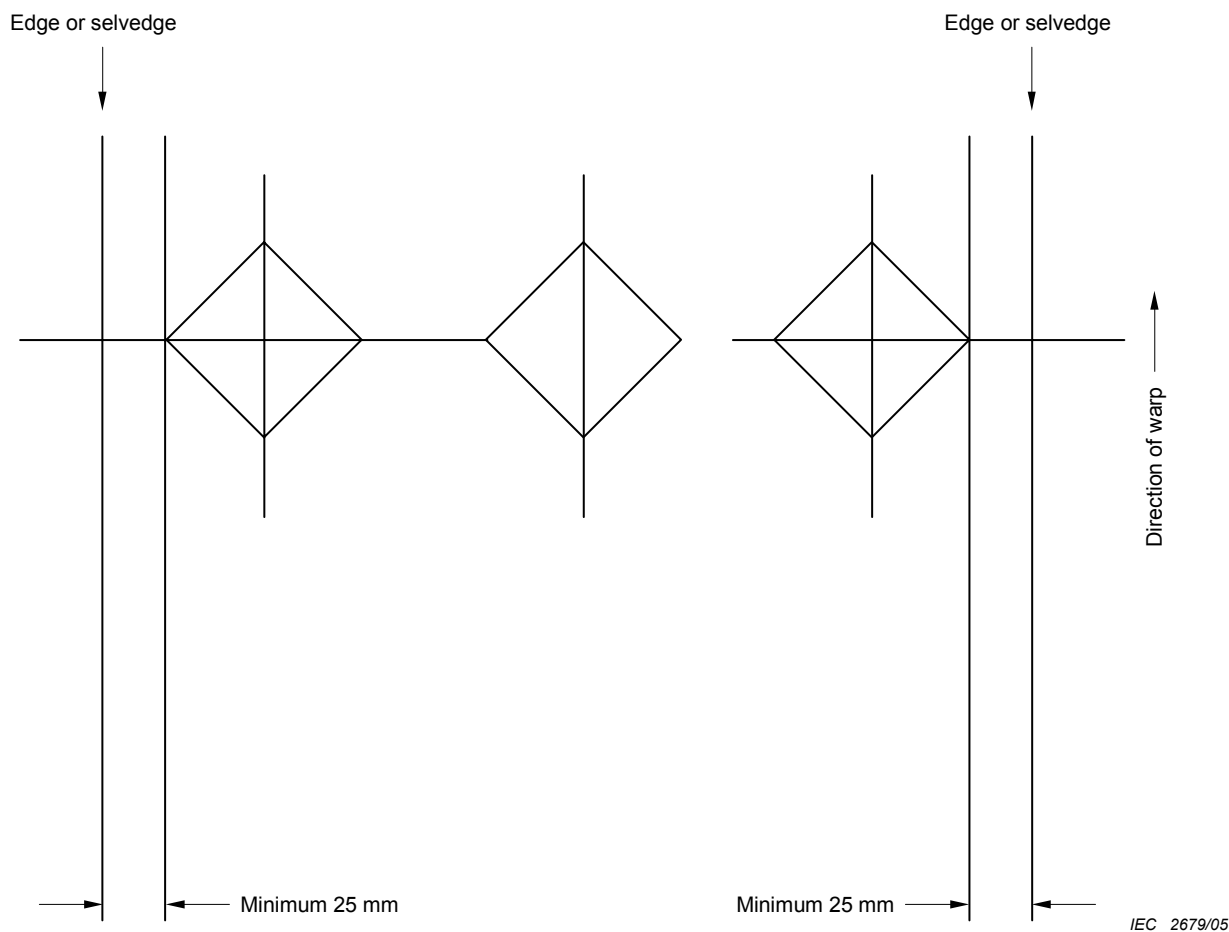


Figure 2 – Position of specimens

8.4.4 Procedure

Weigh each specimen including a hanging metal hook to the nearest 0,001 g and record as M_1 .

Hang each specimen with the metal hook in the circulating air oven at $(163 \pm 3)^\circ\text{C}$ for (15 ± 1) min except for unmodified polyimide prepreg. For unmodified polyimide prepreg, the drying condition in the oven shall be at $(225 \pm 3)^\circ\text{C}$ for (15 ± 1) min.

Remove each specimen with hook from the chamber, one at a time, and cool to room temperature in a desiccator. Reweigh the specimen including the hanging metal hook within 2 min after removal from the desiccator to the nearest 0,001 g and record as M_2 .

The volatile content of each specimen shall be calculated as follows:

$$C_V = \frac{(M_1 - M_2)}{M_1} \times 100$$

where

C_V is the volatile content (%)

M_1 is the weight before oven conditioning (g/100 cm²)

M_2 is the weight after oven conditioning (g/100 cm²)

8.4.5 Report

The report shall include:

- a) the test number and revision index;
- b) the testing date;
- c) the identification of the material tested;
- d) the average of the three volatile content values in per cent (%);
- e) the temperature of the circulating air oven;
- f) any deviation from this test method.

8.4.6 Additional information

The 163 °C oven temperature for epoxide and 225 °C oven temperature for unmodified polyimide are for these resin systems only. For other resin systems, the temperature shall be determined upon agreement between the purchaser and supplier.

8.5 Test 2C05: Blistering during heat shock

8.5.1 Object

To determine the ability of the copper-clad laminate to withstand specified heat shocks, simulating soldering processes, without blistering.

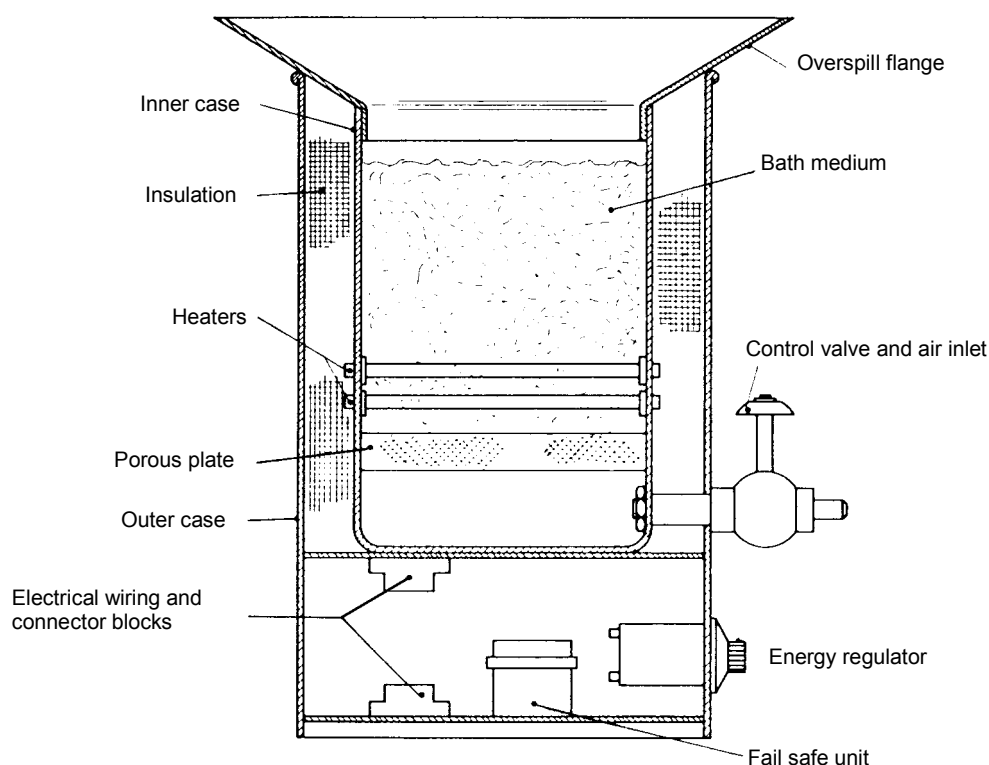
8.5.2 Test specimens

- a) Specimens shall be taken from the panel or sheet in such a way that they are at least 25 mm from the edge.
- b) The test specimen shall be a square of (50 ± 5) mm cut from a sample of the copper-clad base material and shall be unetched. For double-sided metal-clad base material, each face shall be tested separately with separate test specimens. For each side of the laminate tested, three specimens shall be used.

8.5.3 Test apparatus and materials

A bath meeting one of the following requirements:

- a) a liquid bath of well-stirred silicone liquid or equivalent fluid kept throughout the test at (260^{+5}_0) °C. The temperature shall be measured at $(25 \pm 2,5)$ mm below the surface;
- b) a fluidized sand bath (see Figure 3) of suitable design kept at a temperature of (260^{+5}_0) °C measured in approximately the same location that will be occupied by the specimen;
- c) a suitable solder bath of depth not less than 40 mm shall be used. If circular, the bath shall be not less than 120 mm in diameter, and if rectangular, not smaller than 100 mm × 75 mm. The bath shall be protected from draughts. The temperature of the solder shall be kept at (260^{+5}_0) °C throughout the test. The temperature shall be measured at a depth of $(25 \pm 2,5)$ mm below the surface. The bath shall contain solder of nominal 60/40 or 63/37 tin-lead composition. The characteristics of the solder shall be as follows:
 - completely solid 183 °C;
 - completely liquid 188 °C.



IEC 2680/05

PRINCIPLES OF OPERATION

Small solid particles can be readily “fluidized” by means of a suitable gas (air) stream. A diagrammatic cross-section of a fluidized sand bath is shown above. Clean, dry air at a constant pressure of about 2 N/cm² from a pump or from an air line is supplied via a control valve to a chamber beneath the diffuser (porous plate). This porous plate ensures a uniform flow of air across the full section of the container and acts also as a support plate for the solid sand bed.

As the control valve is slowly opened, the solid sand bed remains undisturbed and the air finds its way between the particles; under such conditions the pressure drop is proportional to the rate of flow of air. As the valve is opened further, the air drag on the particles will cause them to separate and the whole mass of the bed can be seen to have expanded. The bed now behaves as a fluid and is said to be “fluidized”. Further opening of the valve is not accompanied by an increase in pressure drop, which remains constant at a value corresponding to the head of the column of particles, but the bed becomes more turbulent and will have the appearance of boiling liquid. The best heat transfer and most uniform temperatures are obtained when the bath is in this “boiling” state.

Figure 3 – Fluidized sand bath

8.5.4 Procedure

8.5.4.1 Liquid bath procedure

The specimen shall be held in a horizontal position, at a depth of $(25 \pm 2,5)$ mm in a holder of heat capacity low enough to avoid the temperature of the fluid falling below 260 °C. The specimen shall be totally immersed in the fluid for the time given in the relevant specification and, immediately after removal, shall be inspected visually for blistering and delamination of the base material.

8.5.4.2 Fluidized sand bath procedure

The specimen shall be immersed edgewise, that is with its surface at a right angle to the bath surface, for the time given in the relevant specification and, immediately after removal, shall be inspected for blistering and for delamination of the base material.

8.5.4.3 Solder bath procedure

The specimen shall be floated on the surface of the clean molten solder with the metal-clad face of the specimen down for the time given in the relevant specification and, immediately after removal, shall be inspected for blistering and for delamination of the base material. The solder bath procedure shall be the method.

8.5.5 Report

The report shall include:

- a) the test number and revision index;
- b) the test date;
- c) the identification of the material tested;
- d) the heat shock method used;
- e) the time during which the specimen was exposed to the heat shock;
- f) whether the specimens have blistered or delaminated; a border of 5 mm around the edge of the specimen is excluded from the requirement;
- g) any deviation from this test method.

8.5.6 Additional information

Safety precautions: avoid skin contact with molten solder.

Cleaning of the surface of the molten solder can easily be done using a strip of unclad laminate.

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 $(13 \pm 0,3)$ 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.

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 $(9,5 \pm 0,5)$ 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/m³. This has been found to produce similar results.
- d) 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.
- e) 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.
- f) 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.

It is understood that a nominal substrate thickness of 1,6 mm will be used throughout the industry. Differences in thickness will prejudice test results.

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 $(13 \pm 0,3)$ mm has therefore been chosen since this will accommodate 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 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.

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 $(13 \pm 0,3)$ 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 $(25 \pm 0,5)$ 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 $(9,5 \pm 0,5)$ 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/m³. 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.

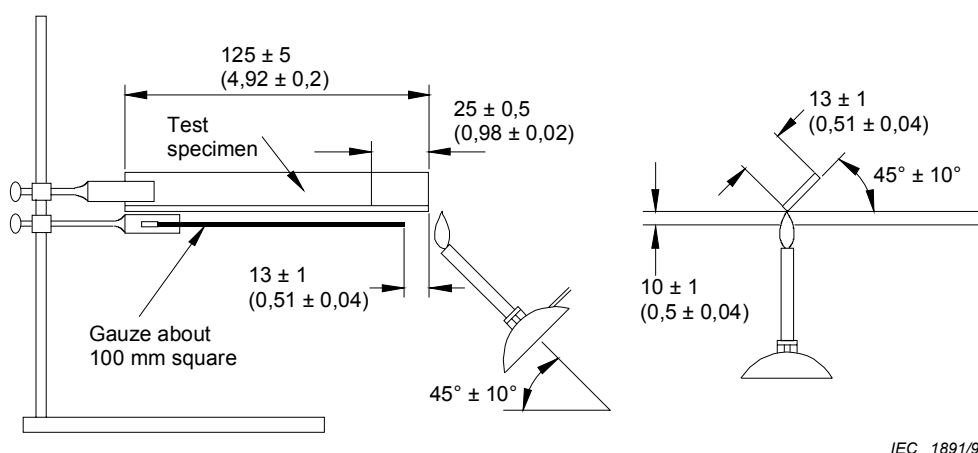
8.7.4 Test procedure

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 $(13 \pm 2) \text{ mm}$ of the unsupported end of the specimen projecting beyond the edge of the gauze as shown in Figure 4.



IEC 1891/99

Figure 4 – Test fixture

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 $(20 \pm 2) \text{ mm}$ 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 $6,5 \text{ mm}$ 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 $(45 \pm 10)^\circ$ 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.

8.7.5 Report

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

- the test method;
- the average of the four burning times;
- the identification and description of the specimens;
- the thickness of the specimen;
- whether the burning of any of the specimens proceeds past the indelible line;
- whether the specimen material melts or produces burning drips;
- any deviation from this test method;
- 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.

It is understood that a nominal substrate thickness of 1,6 mm will be used throughout the industry. Differences in thickness will prejudice test results.

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 $(13 \pm 0,3)$ mm has therefore been chosen since this will accommodate 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.

8.8 Test 2C08: Flammability, flex material

8.8.1 Object

The purpose of this test method is to evaluate the flammability and to determine the degree of flame resistance of thin sheets or films in thickness less than 0,5 mm.

The test is carried out using a small test flame whose intensity is of similar order to that of a fire being started by the accidental overheating of a single electronic component.

8.8.2 Test specimens

8.8.2.1 Choice of specimen shape

Either specimen shown in Figure 5, Flat rectangle for V method, vertical flammability, or Figure 6, wrapped cylindrical for VTM method, vertical flammability for un-reinforced laminate, will be chosen. The latter one is intended especially when the thickness of sample sheet is less than 0,2 mm and test results with former one are not stable due to being too thin or exhibiting excessive distortion or shrinkage of the specimens.

8.8.2.2 Size and quantity of specimens

- a) Figure 5: The test specimen shall be 13 mm wide by 125 mm long by the thickness of the material. Five specimens shall be used for each set of measurements. Two sets shall be required for one test.
- b) Figure 6: The test specimen is wrapped tightly around the longitudinal axis of a 13 mm diameter mandrel to form a lapped cylinder 200 mm long with the 125 mm line exposed. The overlapping ends of the specimen are to be secured within 75 mm portion above the 125 mm mark (upper tube section) by means of pressure sensitive tape. The mandrel is then to be removed.

If the material is prone to developing static charges which make the formation of a cylinder difficult, the unformed specimen is to be discharged by a device or material intended for that purpose.

Different generic materials, although capable of being wrapped and taped around the mandrel, may exhibit varying degrees of flaring out of the untaped end, some of which may result in a nonlapped "U" type specimen. These various forms are considered acceptable to test if the upper end can be formed into the cylinder.

8.8.3 Test apparatus and materials

- a) Test chamber: A laboratory hood, totally enclosed, with a heat-resistant glass window for observing the test, shall be used. The exhaust fan shall be turned off during the test, but may be turned on to clear out the fumes between tests.
- b) Specimen holder: Clamping device shall be provided within the test chamber so that the specimen will hang with its length in a vertical position approximately coincident with the central vertical axis of the test chamber.
- c) Laboratory burner and gas supply: A Bunsen or Tirril burner shall be used having a tube length of 100 mm and an inside diameter of 9,5 mm. The gas supply shall be regulated and metered for uniform flow. The standard gas shall be technical grade methane. Natural gas having a normal heat content of 37 MJ/m³ may be substituted.
- d) Timer: Stopwatch or other suitable timing device with a precision of 1,0 s minimum.
- e) Cotton: A supply of dry absorbent 100 % surgical cotton, cut by 50 mm by 50 mm with normal thickness 6 mm.
- f) Desiccator: Desiccation chamber, containing anhydrous calcium chloride, or other drying agent, capable of maintaining an atmosphere of less than 30 % RH at 23 °C.
- g) Conditioning room or chamber: Capable of being maintained at (23 ± 2)°C and RH of (50 ± 5) %.
- h) Air circulating oven type capable of maintaining (70 ± 2) °C.
- i) Mandrel for wrapping specimens formed from a rod of 12,5 mm diameter.
- j) Thin steel scale or template for gauging flame height.
- k) Etching system capable of complete removal of the metal cladding.
- l) Cutting apparatus such as shears or equivalent equipment.
- m) Tape: Pressure-sensitive adhesive.

8.8.4 Procedure

8.8.4.1 Specimen preparation

Metal-clad laminates shall be completely etched using standard industry practices. Unclad laminate shall be tested in the "as is" condition. Specimens shall be cut and formed in accordance with 8.8.2.2.

8.8.4.2 Conditioning

- a) Before testing, one set (five specimens) of specimens shall be kept for 48 h in the conditions in accordance with 8.8.3 g).
- b) The other set (five specimens) of specimens shall be kept for 168 h in the conditions in accordance with 8.8.3 h) and then allowed to stabilize in the desiccator noted in 8.8.3 f) for at least 4 h at room temperature, prior to testing.
- c) Once removed from the desiccator, specimens shall be tested within 30 min.
- d) All specimens are to be tested in a laboratory atmosphere of (15 to 35) °C and (45 to 75) % RH.

8.8.4.3 Specimen mounting

- a) Clamp the specimen from the upper 6 mm of the specimen, with the longitudinal axis vertical, so that the lower end of the specimen is 300 mm above a horizontal layer of dry absorbent surgical cotton noted in 8.8.3 e).
- b) If the VTM method mentioned in 8.8.2.1 is applied, a heavy spring clamp should be used so that the upper end of the tube is closed to prevent any chimney effects during the test.

8.8.4.4 Adjustment of test flame

Adjust the burner to produce a blue flame 20 mm high. The flame is obtained by adjusting the gas supply and air ports of the burner until a 20 mm yellow-tipped blue flame is produced. Increase the air supply until the yellow tip just disappears. Measure the height of the flame again and readjust it if necessary.

8.8.4.5 Test procedure for Figure 5

- a) Apply the flame centrally to the middle point of the bottom edge of the specimen so that the top of the burner is 10 mm below the lower end of the specimen and maintain it at that distance for 10 s, moving the burner as necessary in response to any changes in the length or position of the specimen. If the specimen drips molten or flaming material during the flame application, tilt the burner at an angle of up to 45° and withdraw it just sufficiently from beneath the specimen to prevent material from dropping into the barrel of the burner while maintaining the 10 mm spacing between the centre of the top of the burner and the remaining portion of the specimen, ignoring any strings of molten material. After the application of the flame to the specimen for 10 s, immediately withdraw the burner to a distance at least 150 mm away from the specimen and simultaneously commence measurement of the afterflame time, t_1 , in seconds. Record t_1 .
- b) After flaming of the specimen ceases, immediately place the burner again under the specimen and maintain the burner at a distance of 10 mm from the remaining portion of the specimen for additional 10 s, keeping the burner so that it is clear of dropping material. After this application of the flame to the specimen, remove the burner to a distance of at least 150 mm from the specimen and simultaneously commence measurement of the afterflame time, t_2 , and the afterglow time, t_3 . Record t_2 and t_3 .

8.8.4.6 Test procedure for Figure 6

- a) Apply the flame centrally to the middle of the bottom edge of the specimen that is unlapped so that the top of the burner is 10 mm below that point of the lower end of the specimen, and maintain it at that distance for 3 s, moving the burner as necessary in response to any changes in the length or position of the specimen.
- b) For specimens that are not lapped at their lower end and that are suspended from the pinched upper end, the flame is to be applied in line with the longitudinal axis of the specimen.
- c) If the specimen drips molten or flaming material during the flame application, tilt the burner at an angle of up to 45° and withdraw it just sufficiently from beneath the specimen to prevent material from dropping into the barrel of the burner while maintaining the 10 mm spacing from the centre of the top of the burner and after the application of the flame to the specimen for 3 s, immediately withdraw the burner to a distance at least 150 mm away from the specimen and simultaneously use the timing device to commence measurement of the afterflame time t_1 in seconds. Record t_1 .
- d) When after-flaming of the specimen ceases, immediately place the burner under the specimen and maintain the burner at a distance of 10 mm from the remaining portion of the specimen for an additional 3 s, while moving the burner clear of dropping material as necessary. After the application of the flame to the specimen, remove the burner to a distance of at least 150 mm from the specimen and simultaneously commence measurement of the afterflame time, t_2 , and the afterglow time, t_3 , of the specimen. Record t_2 and t_3 .

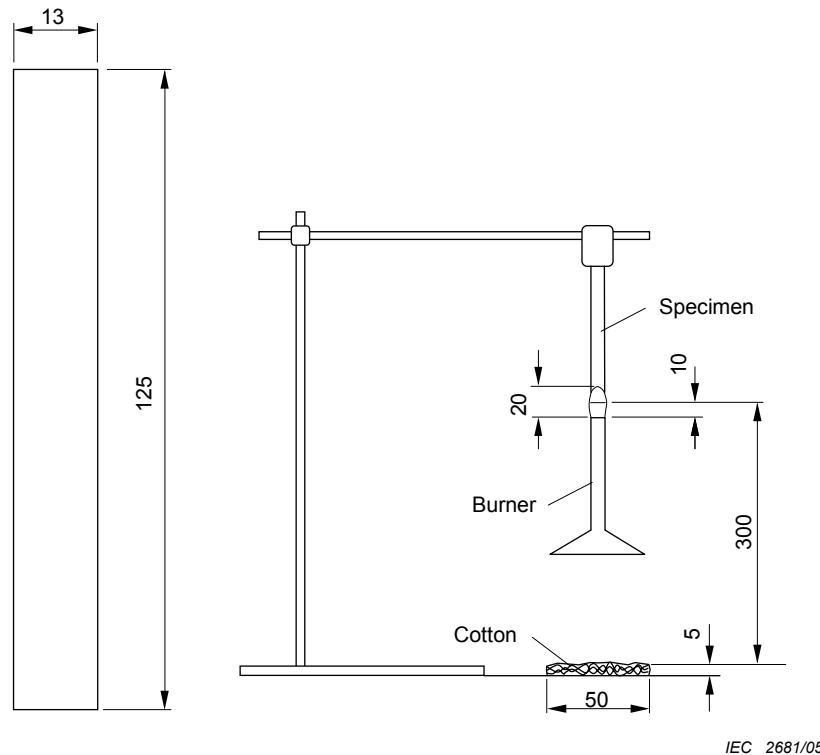


Figure 5 – V method (Vertical flammability method)

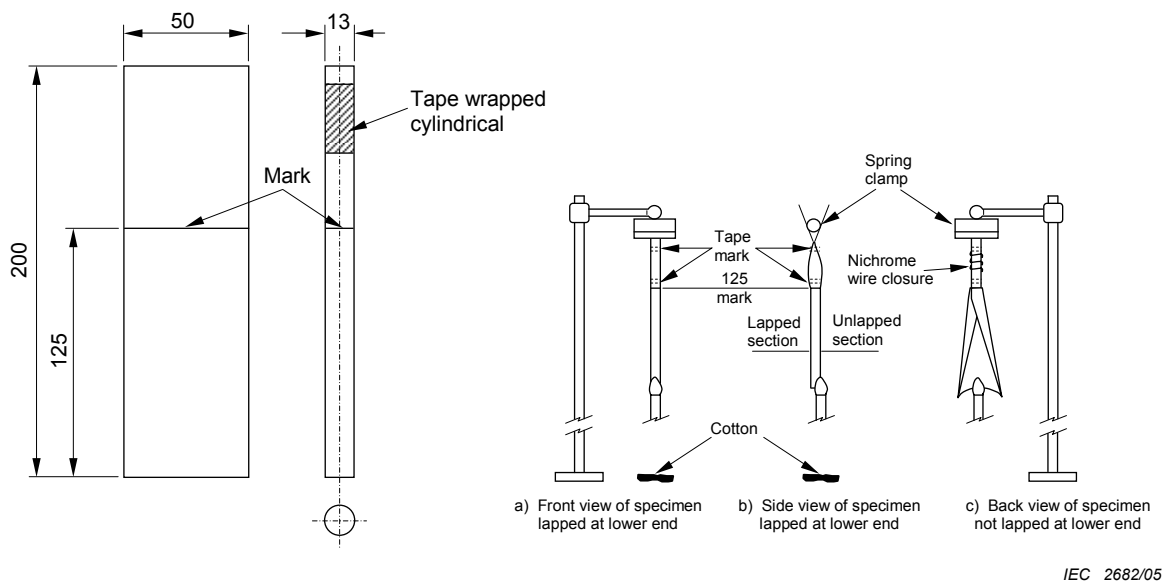


Figure 6 – VTM method (vertical flammability method for recalcitrant specimens)

8.8.5 Report

The report shall include:

- number of the test method and revision;
- procedure used;
- identification of the specimens;
- afterflame time after first flame application, t_1 .
- afterflame time after second flame application, t_2 .

- f) afterglow time after second flame application, t_3 .
- g) Figure 5: whether or not specimens burn up to the holding clamp;
- h) Figure 6: whether or not specimens burn up to the 125 mm mark;
- i) whether or not specimens drip flaming particles ignite the cotton indicator;
- j) date of the test;
- k) name of the person conducting the test

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 prepreps 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 selvage 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 $R = (6,3 \pm 0,1) \mu\text{m}$;

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 $(140 \pm 0,3) ^\circ\text{C}$. 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 $2 \text{ min} \pm 10 \text{ s}$. 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.

$(30 \pm 3) \text{ s}$ 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 7) 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 8.9.3). 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 from the parameters defined (for example plate temperature or cone type).

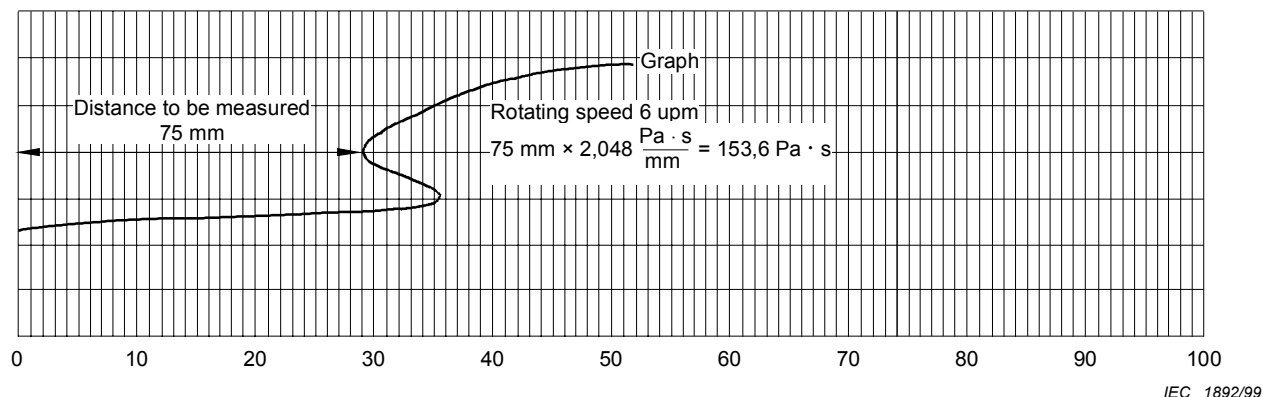


Figure 7 – Example of prepreg melting viscosity

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.

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 selvage (see Figure 8).

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

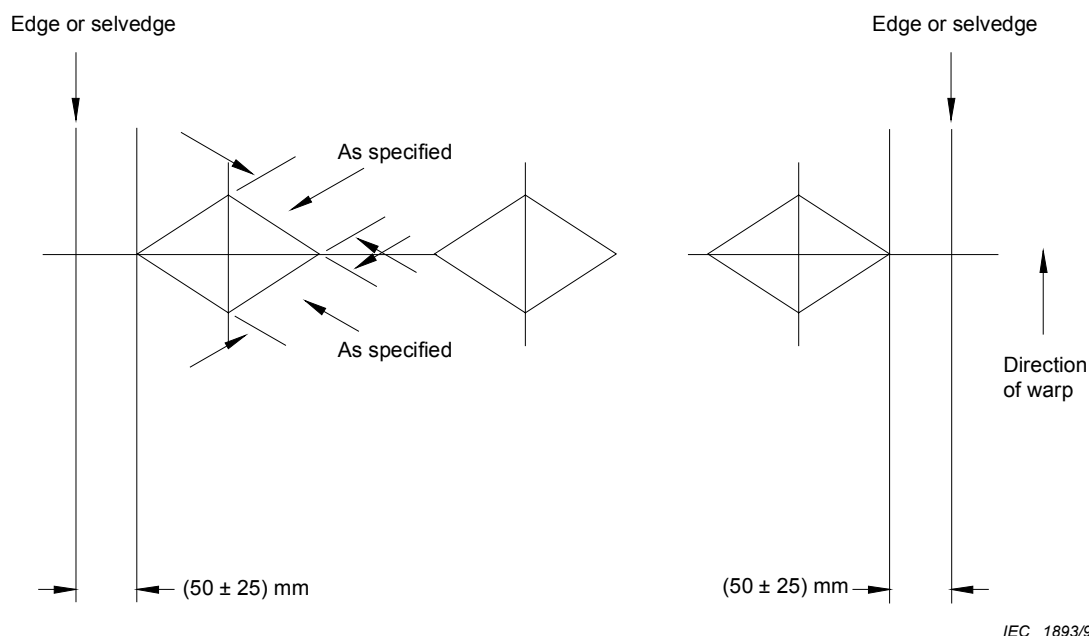


Figure 8 – Position of specimens for resin content

8.10.3 Test apparatus and materials

The following test apparatus and material shall be used.

- An analytical balance with an accuracy of 0,001 g.
- A muffle furnace capable of maintaining a temperature between 550 °C and 800 °C. The muffle furnace must be placed in a ventilation hood.
- A ceramic crucible of sufficient size to hold the specimen.
- 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.