

Test methods for electrical materials, interconnection structures and assemblies —

Part 3: Test methods for interconnection structures (printed boards)

The European Standard EN 61189-3:1997, with the incorporation of amendment A1:1999 has the status of a British Standard

ICS 31.180

National foreword

This British Standard is the English language version of EN 61189-3:1997, including amendment A1:1999. It is identical with IEC 61189-3:1997, including amendment 1:1999.

The start and finish text introduced or altered by amendment is indicated in the text by tags **A1** **A1**. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by **A1** **A1**.

Changes to Annex ZA introduced by CENELEC amendment A1 are also indicated by **A1** **A1**.

The UK participation in its preparation was entrusted to Technical Committee EPL/52, Printed circuits, which has the responsibility to:

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- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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Summary of pages

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English version

Test methods for electrical materials, interconnection
structures and assemblies —
Part 3: Test methods for interconnection structures
(printed boards)

(includes amendment A1:1999)
(IEC 61189-3:1997 + A1:1999)

Méthodes d'essai pour les matériaux
électriques, les structures d'interconnexion et
les ensembles — Partie 3: Méthodes d'essai des
structures d'interconnexion (cartes imprimées)
(inclut l'amendement A1:1999)
(CEI 61189-3:1997 + A1:1999)

Prüfverfahren für Elektromaterialien,
Verbindungsstrukturen und Baugruppen —
Teil 3: Prüfverfahren für
Verbindungsstrukturen (Leiterplatten)
(enthält Änderung A1:1999)
(IEC 61189-3:1997 + A1:1999)

This European Standard was approved by CENELEC on 1997-03-11. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B-1050 Brussels

Foreword

The text of document 52/627/FDIS, future edition 1 of IEC 61189-3, prepared by IEC TC 52 Printed circuits, in cooperation with IEC TC 91, Surface mounting technology, and IEC TC 50, Environmental testing, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61189-3 on 1997-03-11.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1998-01-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 1998-01-01

This part 3 of EN 61189 is to be used in conjunction with the other parts of EN 61189 and with the EN 60068 series.

Annexes designated “normative” are part of the body of the standard.

Annexes designated “informative” are given for information only.

In this standard, Annex ZA is normative and Annex A and Annex B are informative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61189-3:1997 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A1

The text of document 52/805/FDIS, future amendment 1 to IEC 61189-3, prepared by IEC TC 52, Printed circuits, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 61189-3:1997 on 1999-08-01.

The following dates were fixed:

- latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2000-05-01
- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 2002-08-01

Annexes designated “normative” are part of the body of the standard.

In this standard, Annex ZA is normative. Annex ZA has been added by CENELEC.

Endorsement notice

The text of amendment 1:1999 to the International Standard IEC 61189-3:1997 was approved by CENELEC as an amendment to the European Standard without any modification.

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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 evaluating printed boards and other forms of interconnection structures. 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 “3D02” represents the second dimensional test method described in this publication.

In short, for this example, 3 is the part of IEC standard (61189-3), D is the group of methods, and 02 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.

1 Scope and object

This part of IEC 61189 is 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 normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 61189. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 61189 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

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

IEC 60068-2-3:1969, *Environmental testing — Part 2: Tests — Test Ca: Damp heat, steady state*.

IEC 60068-2-20:1979, *Environmental testing — Part 2: Tests — Test T: Soldering*.
Amendment 2 (1987)

A1

IEC 60454-1:1992, *Specifications for pressure-sensitive adhesive tapes for electrical purposes — Part 1: General requirements.*

IEC 60695-2-2:1991, *Fire hazard testing — Part 2: Test methods — Section 2: Needle-flame test.*

IEC 62326-4:1996, *Printed boards — Part 4: Rigid multilayer printed boards with interlayer connections — Sectional specification.*

IEC 62326-4-1:1996, *Printed boards — Part 4: Rigid multilayer printed boards with interlayer connections — Sectional specification — Section 1: Capability Detail Specification — Performance levels A, B and C.*

ISO 4046:1978, *Paper, board, pulp and related terms — Vocabulary.* **A1**

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:

- to monitor a process;
- to enhance confidence in quality conformance;
- to arbitrate 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 4.11 of ISO 9002.

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.

$$U_r = t \sigma / \sqrt{n}$$

where

- U_r is random uncertainty;
- n is the sample size;
- t is the percentage point of the “ t ” distribution (from 3.5, statistic 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 used;
- 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.

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: $\pm 10 \%$

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

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

6 V: Visual test methods

6.1 Test 3V01: 3 X magnification (under consideration)

6.2 Test 3V02: 10 X magnification (under consideration)

6.3 Test 3V03: 250 X magnification (under consideration)

6.4 Test 3V04: General visual (under consideration)

7 D: Dimensional test methods

7.1 Test 3D01: Optical method (under consideration)

A₁

7.2 Test 3D02: Conductor width and spacing

7.2.1 Object

The purpose of this test method is to provide a procedure for determining the conductor width and spacing of a printed board.

7.2.2 Test specimens

The specimen shall be a suitable printed board having conductor patterns for test.

Where the use of test coupons, as specified in IEC 62326-4-1, is agreed between the user and the supplier, the measurement shall be carried out on specimen F.

7.2.3 Test apparatus and materials

An illuminated eyepiece or microscope or projector having an ocular micrometer with a resolution of 0,01 mm or better shall be used.

7.2.4 Procedure

The conductor width and spacing between conductors shall be measured at random points, including central and corner areas, according to the relevant specification, and viewed vertically from above. The measured value shall be recorded to the nearest 0,01 mm. Edge defects such as indentations, projections, and slivers shall be excluded from measurement.

7.2.5 Report

The report shall include

- a) the test method number and revision;
- b) the date of the test;
- c) the identification and description of the specimen;
- d) the conductor width and spacing measured;
- e) the layer number;
- f) the number of measurements;
- g) the maximum and minimum observed conductor widths and spaces;
- h) the average conductor width and spaces;
- i) any deviation from this test method;
- j) the name of the person conducting the test.

7.2.6 Additional information

None. $\triangleleft A_1$

7.3 Test 3D03: Automated optical inspection (under consideration)

7.4 Test 3D04: Dimensional examination, general (under consideration)

8 C: Chemical test methods

8.1 Test 3C01: Flammability, rigid printed board metal removal (under consideration)

8.2 Test 3C02: Flammability, rigid printed board glow-wire test (under consideration)

$\triangleleft A_1$

8.3 Test 3C03: Flammability; needle flame test, rigid printed boards

8.3.1 Object

The object of the test is to determine the effect upon a printed board of exposure to a glowing wire under specific conditions.

The intensity of the ignition source is similar to that of an accidentally overheating or glowing of a single electronic component.

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

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

8.3.2 Test specimen

The test specimen shall be a production board or a test board that is representative of the production board in terms of:

- base materials;
- surface coating(s);
- type (for example multilayer, single-sided, etc.);
- size;
- design;
- surface area;
- thickness;
- metal distribution.

Test boards of 150 mm × 150 mm may be considered large enough to represent larger production boards. Smaller production boards should be tested in their actual size.

A minimum of five specimens shall be tested.

8.3.3 Test apparatus and materials

The following test apparatus and materials shall be used:

- a) A room or compartment, in which the test is conducted, having dimensions adequate to ensure that the test is carried out in a substantially draught-free atmosphere, but which allows a sufficient supply of air for normal combustion. Subdued light is advantageous.
- b) A burner to produce the test flame, which is a tube with a length of at least 35 mm with an internal diameter of $(0,5 \pm 0,1)$ mm and an external diameter not exceeding 0,9 mm. The burner shall be held in a movable fixture.
- c) A burner shall be supplied with butane gas having a minimum purity of 95 %. No air may be admitted to the burner tube. Propane gas may be used, but butane gas shall be the reference.

The burner shall be adjusted whilst in a vertical axis, in order to produce a flame having a height of (12 ± 1) mm. See Figure 10a.

- d) A wooden board to be placed underneath the specimen. The board shall be covered with tissue paper which complies with 6.86 of ISO 4046. The distance between the lower edge of the specimen and the tissue paper shall be (200 ± 5) mm.
- e) A hand-operated timing device with a resolution of $\pm 0,5$ s or better.
- f) An air circulating oven capable of maintaining (125 ± 5) °C.
- g) A dessicator capable of maintaining 20 % R.H. or less.

8.3.4 Test procedure

The test specimens shall be pre-conditioned for 24 h at (125 ± 5) °C in an air-circulating oven. The test specimens shall then be allowed to stabilize for 4 h at room temperature in a dessicator over anhydrous calcium chloride.

The relevant specification shall detail the position of the test specimen and the point of application of the flame (for example surface, edge). The attitude of the specimen (for example horizontal or vertical) should mimic the intended mode of operation in the assembled equipment.

Where surface application is used, the point of application of the flame shall, specimen size permitting, not be less than 10 mm from the nearest edge, in order to minimize edge effects.

Where edge application is used, the flame shall not, specimen size permitting, be less than 10 mm from the nearest corner.

The burner shall be mounted at an angle of about 45°, so that any drops from the test specimen can fall freely onto the underlying tissue paper.

If the intended operational attitude of the printed board is not known or is variable, the test specimens shall be positioned as follows.

Edge application: The lower edge shall be horizontal and the specimen shall be inclined at approximately 80°. The flame shall be applied to the lower side of the test specimen.

The burner shall be ignited away from the test specimen, and the height of the flame shall be adjusted to (12 ± 2) mm. The burner shall then be positioned as described, so that the test specimen penetrates the flame by approximately 2 mm. A vertical distance of between 8 mm and 10 mm from the tip of the burner and the surface or edge to be tested is adequate for this purpose. In the case of application to a vertical surface, a horizontal distance of approximately 5 mm is necessary.

The detail specification shall state the severity to be used.

Test flame application times as detailed in clause 5 of IEC 60695-2-2 are preferred. These severities are: 5 s – 10 s – 20 s – 30 s – 60 s – 120 s.

8.3.5 Report

The report shall include

- a) the test number and revision;
- b) the date of the test;
- c) the identification and description of the specimen;
- d) the number of specimens, if other than five;
- e) the position of the test specimens;
- f) the point of application of the test flame;
- g) the duration of application of the test flame;
- h) for each specimen whether flames and/or burning or glowing particles fall from the test specimen spreading fire to surrounding parts of the test specimen or to the tissue paper beneath the test specimen;
- i) for each specimen whether there is flame or glowing at the end of the application of the test flame;
- j) for each specimen whether the duration of burning is less than 30 s;
- k) any deviation from this test method;
- l) the name of the person conducting the test.

8.3.6 Additional information

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

The smoothness of the specimen edges can be critical to the performance of the sample. 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.

Detail requirements to be stated in specifications which reference this test method should be based on clause 11 of IEC 60695-2-2.

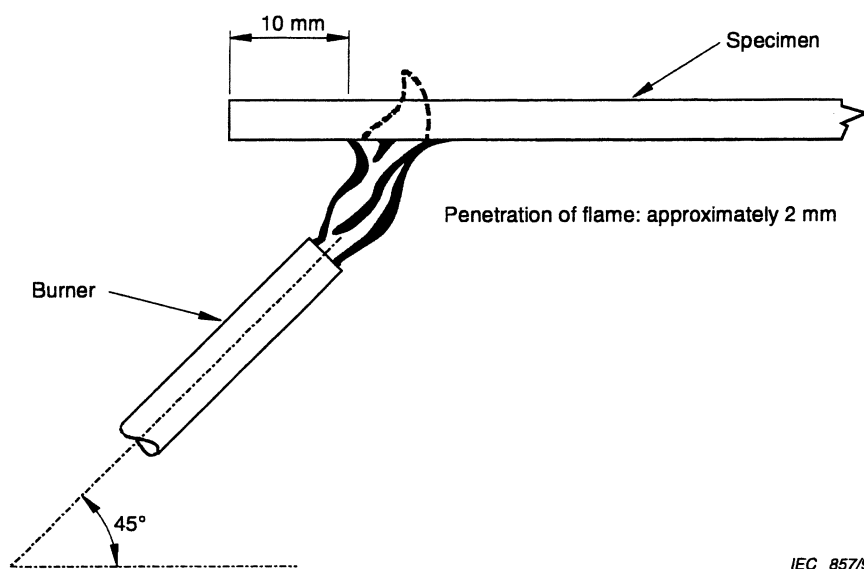


Figure 10a — Horizontal specimen — Flame applied to surface

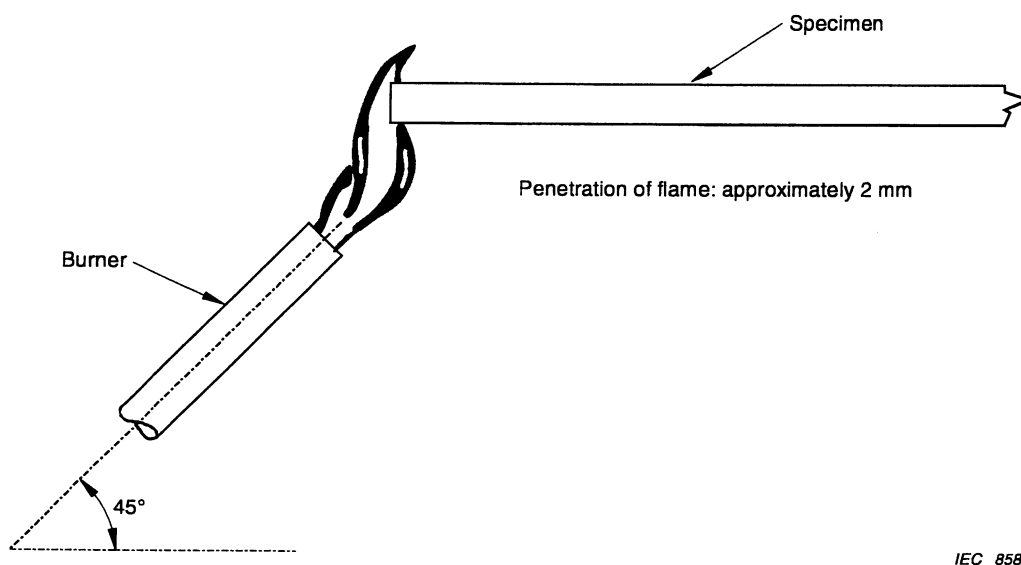


Figure 10b — Horizontal specimen — Flame applied to edge
Figure 10 — Needle burner test

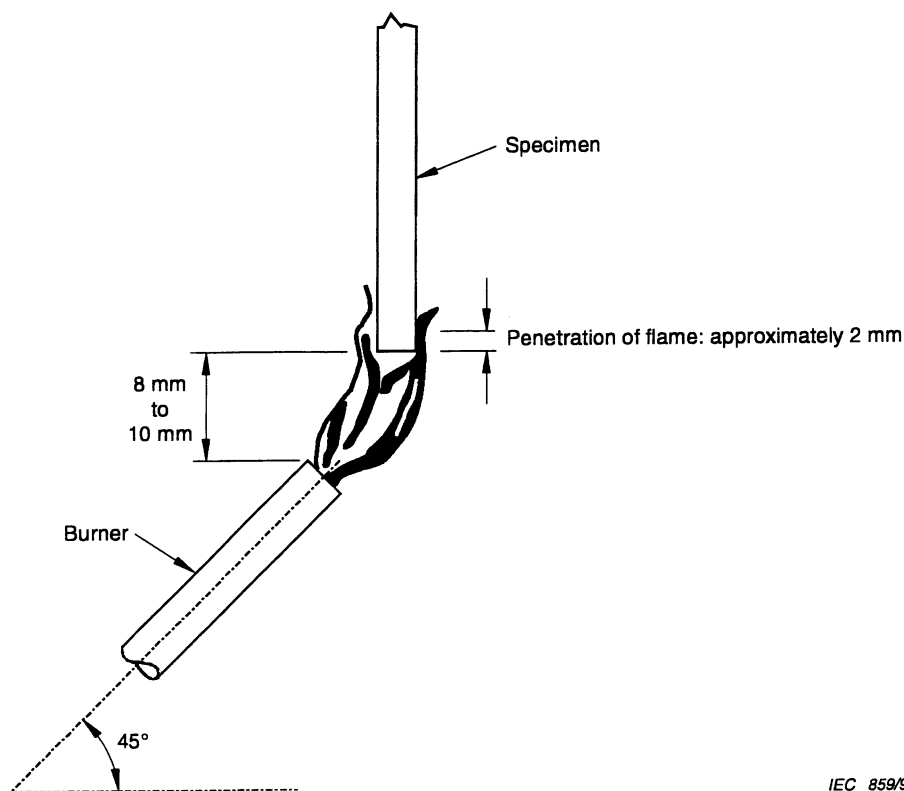


Figure 10c — Vertical specimen — Lower edge horizontal — Flame applied to edge

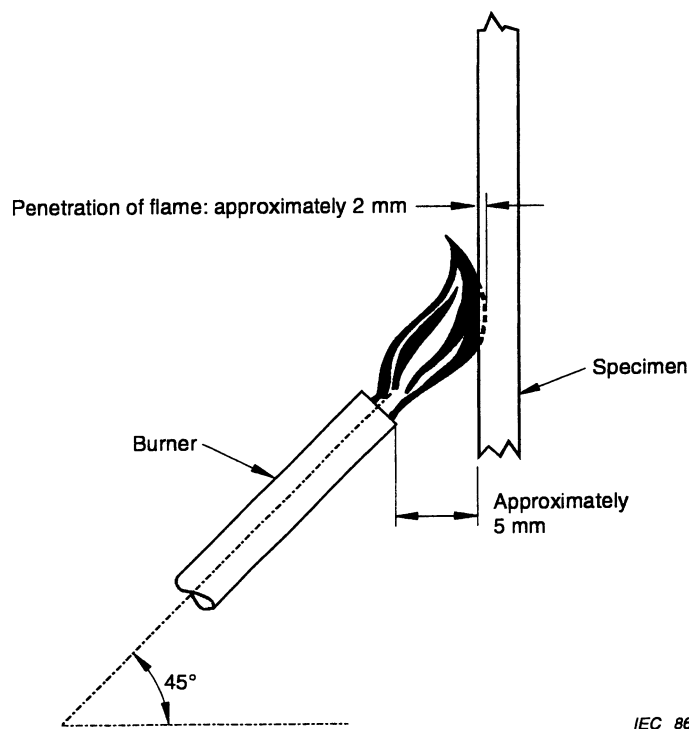
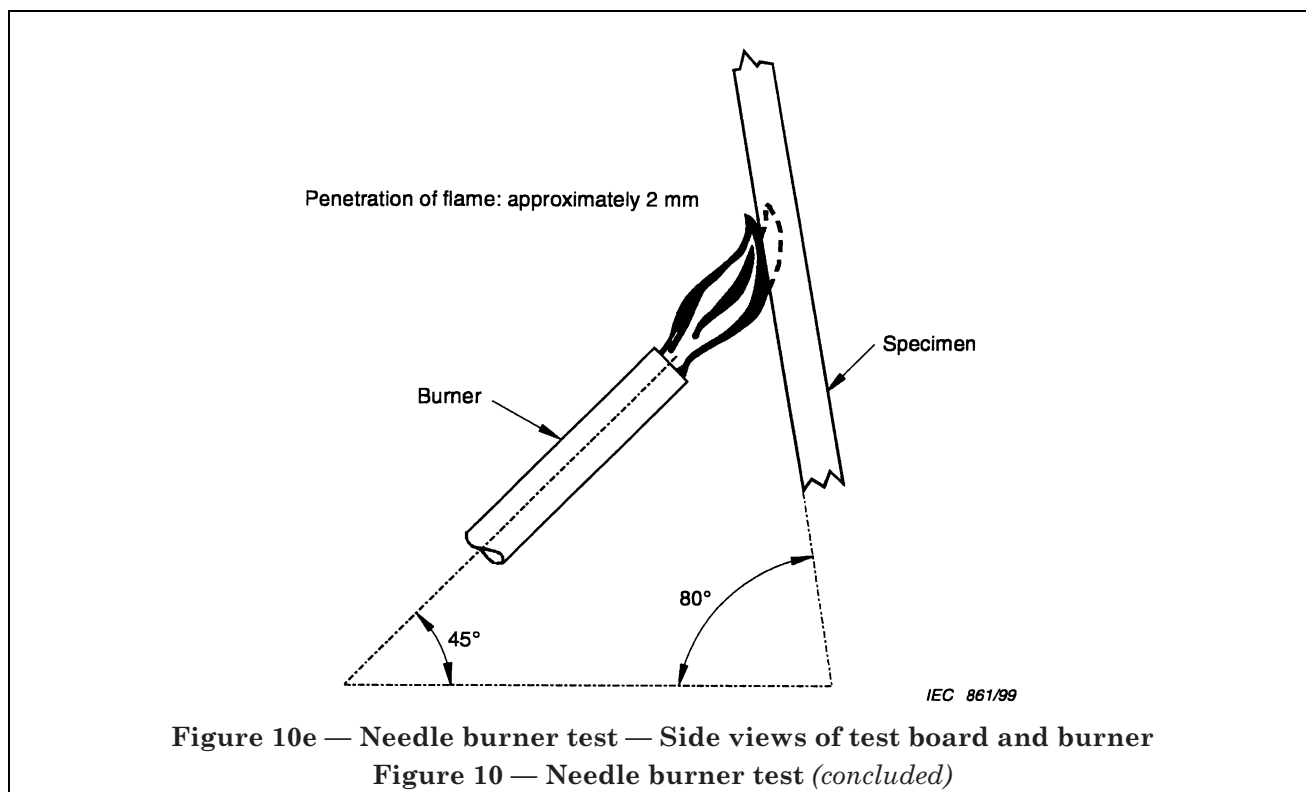


Figure 10d — Vertical specimen — Lower edge horizontal — Flame applied to surface

Figure 10 — Needle burner test (continued)



A1

8.4 Test 3C04: Solvent and flux resistance (under consideration)

8.5 Test 3C05: Electrolytic corrosion, rigid and thin film (under consideration)

8.6 Test 3C06: Flammability, glow-wire test, rigid printed boards (under consideration)

8.7 Test 3C07: Flammability, needle flame, rigid printed boards (under consideration)

8.8 Test 3C08: Vertical burning (under consideration)

8.9 Test 3C09: Water absorption (under consideration)

8.10 Test 3C10: Surface organic contaminates (in-house) (under consideration)

8.11 Test 3C11: Resistivity of solvent extract (ionic contaminates) (under consideration)

8.12 Test 3C12: Surface organic contaminates (infrared) (under consideration)

9 M: Mechanical test methods

9.1 Test 3M01: Peel strength, standard atmospheric conditions (under consideration)

9.2 Test 3M03: Pull-out strength, landless plated through hole (under consideration)

9.3 Test 3M02: Peel strength, elevated temperature (under consideration)

9.4 Test 3M04: Flatness (under consideration)

9.5 Test 3M05: Peel strength, flexible printed boards

9.5.1 Object

To determine the peel strength of a 1 mm and/or 3 mm wide printed conductor on a flexible printed board.

9.5.2 Test specimens

- The test shall be carried out on a minimum of four straight conductors of suitable length and uniform width taken from specified parts of a production board, of a test coupon, or of a composite test coupon.
- The conductor length should preferably be not less than 75 mm.
- Conductors less than 0,8 mm wide shall not be tested.
- Where plated conductors are present on the board, some of them shall be tested.

In the case where the sheets of copper-clad base film are to be tested instead of the production boards, the sample unit of the material shall have a minimum of four etched conductor patterns of 1 mm and/or 3 mm width and 230 mm length, two in the machine direction and two in the transverse direction. For a double-clad laminate, a separate sample unit shall be prepared and tested for each side. The copper foil on the untested side may remain to provide stability and to prevent tenting of the specimen from the rotary drum during testing. In the case of materials clad with copper foil of nominal mass per unit area less than 305 g/m², the foil mass per unit area may be increased to not more than 335 g/m² by any procedure in which ductile copper is deposited.

9.5.3 Test apparatus and material

The following test apparatus and material shall be used:

- a) a tensile testing machine that achieves a peel rate of (50 ± 5) mm/min;
- b) a clamp to grip the detached end of the foil over its entire width;
- c) an adequate digital type recorder which is able to record the peel load at a rate of not less than three points per second. Otherwise, an adequate analogue type recorder which is able to record and display the peel load profile;
- d) free wheeling rotary drum (Figure 1a), to keep the direction of pull at $(90 \pm 5)^\circ$ to the plane of the printed board;
- e) adequate production processes shall be used to prepare the test patterns on a sheet of copper-clad panel;
- f) a suitable straight rule or optical devices, reading to 0,01 mm, for measuring the width of the conductors to be tested.

9.5.4 Procedure

9.5.4.1 Conditioning

As a referee condition specimens for 24 h at standard laboratory conditions $(23 \pm 2)^\circ\text{C}$ and $(45 \pm 5)\%$ RH. Stabilization time may be reduced if statistically sound evidence has been generated on the specific product line to support the shorter stabilization time. For normal testing, standard atmospheric conditions shall be used.

9.5.4.2 Measurement

Measure and record the width of the tested conductor to the nearest 0,01 mm. One end of the conductor shall be detached from the base material for a distance of about 10 mm, and sufficient for the apparatus used. The test board shall be supported in a suitable way, for example by clamping between two flat rigid plates with a cutout in the upper plate for the conductor to be peeled, or by attaching to a rotating drum as shown in Figure 1 and Figure 2 (see also IEC 60249-1, Figure 6). The detached end of the conductor shall be gripped over its entire width or in the jaws of the clamp on the tensile testing machine, and a steadily increasing pull shall be applied in a direction $(90 \pm 5)^\circ$ to the plane of the printed board until the conductor peels off at a rate of (50 ± 5) mm/min, the force required to do this being measured. A length of at least 25 mm shall be peeled at this rate from each of four conductors.

The peel load shall be continuously recorded in the recorder, and the average values of the loads during each 1 s shall be calculated automatically, and be printed out on a form, or a profile of loads shall be drawn on a chart.

9.5.4.3 Evaluation

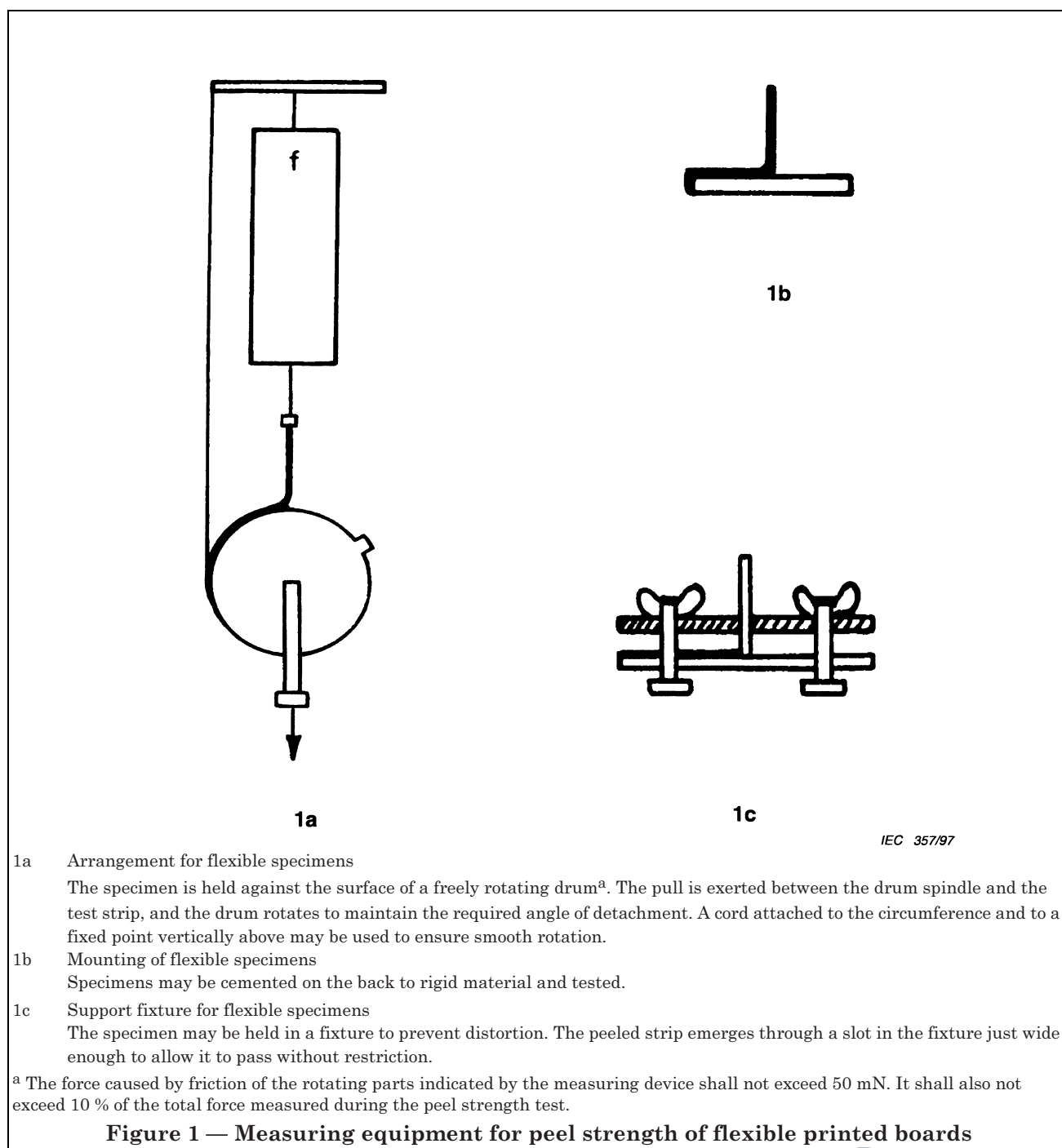
A minimum of 50 mm must be peeled; the pull loads corresponding to either the first 1 s or the first 5 mm distance shall be disregarded.

Where a digital recorder is used, compute the peel strength for each conductor using the following formula:

$$\text{peel strength (N/mm of width)} = \frac{\text{average load (N) as in 9.5.4.2}}{\text{conductor width (mm)}}$$

Where an analogue recorder is used, average the chart recordings for the specimen over the minimum stable region of the chart.

The average of the four test values shall be calculated and recorded as the peel strength.



9.5.5 Report

The report shall include:

- a) the test number and revision index;
- b) the test date;
- c) the identification of the material tested;
- d) conductors being tested;
- e) minimum peel strength;
- f) any deviation from this test method.

9.5.6 Additional information

The force required to bend the test conductor will affect the measured peel strength. The magnitude of this effect will increase as the conductor thickness increases.

In the event that excessive tenting of the peel specimens occur, suitable support material may be applied to the back of the test specimen. A reference support material may be unclad epoxy glass material.

9.6 Test 3M06: Flexural fatigue, flexible printed board (under consideration)

9.7 Test 3M07: Pull off strength, lands with plain holes (under consideration)



9.8 Test 3M08: Hardness (resistance to abrasion) of organic surface coatings of printed circuit boards

9.8.1 Object

This test method details the procedure for the determination of the hardness of permanent organic surface coatings used on printed boards.

Organic materials suitable for testing in accordance with this procedure include:

- permanent polymeric coatings;
- conductive inks;
- marking legend inks.

Hardness is determined by comparison with a standard set of pencils with increasing hardness.

9.8.2 Test specimens

The test specimen shall consist of a piece of metal-clad base material (100 ± 10) mm $\times$ (100 ± 10) mm, with the organic surface coating applied and cured as recommended by the supplier.

Alternatively, a coated portion of a production board may be used as agreed between the customer and the supplier.

A minimum of three specimens (separate boards) shall be tested.

9.8.3 Test apparatus and materials

The following test apparatus and materials shall be used.

- a) Test device (pencil holder, see Figure 11).
- b) Standard set of pencils of hardness from 4B to 8H.

4B, 3B, 2B, B, HB, F, H, 2H, 3H, 4H, 5H, 6H, 7H, 8H
Soft ————— Hard

9.8.4 Procedure

Place the specimen on a firm horizontal surface.

The tips of all pencils shall be sharpened as shown in Figure 11.

Starting with the hardest pencil in the carriage, push the carriage in the direction as illustrated in Figure 11 with a uniform forward force in a 20 mm to 30 mm stroke, whereby, because of the weight of the specimen holder of (750 ± 25) g, a downward directed force of $(7,65 \pm 0,25)$ N will result at the pencil tip. Proceed with the next softest pencil in succession until a pencil is used which will not cut into or gouge the coating material. Used pencils shall be resharpened after every test.

The hardness is an attribute, rather than a variable. No statement of uncertainty is required.

9.8.5 Report

The report shall include

- a) the test method and revision;
- b) the date of the test;
- c) the identification and description of the specimen(s);
- d) the achieved hardness: i.e. the hardness of the pencil which failed to cut into or gouge the organic surface coating;
- e) the supplier and description of the pencil set;
- f) any deviation from this test method;
- g) the name of the person conducting the test.

9.8.6 Additional information

It is accepted that the results achieved using this method are subjective in nature. To limit this subjectivity, it is recommended that only professional grade draftsman's pencils are used. Where disputes between testing agencies result, an agreed single source of pencil should be used for the test.

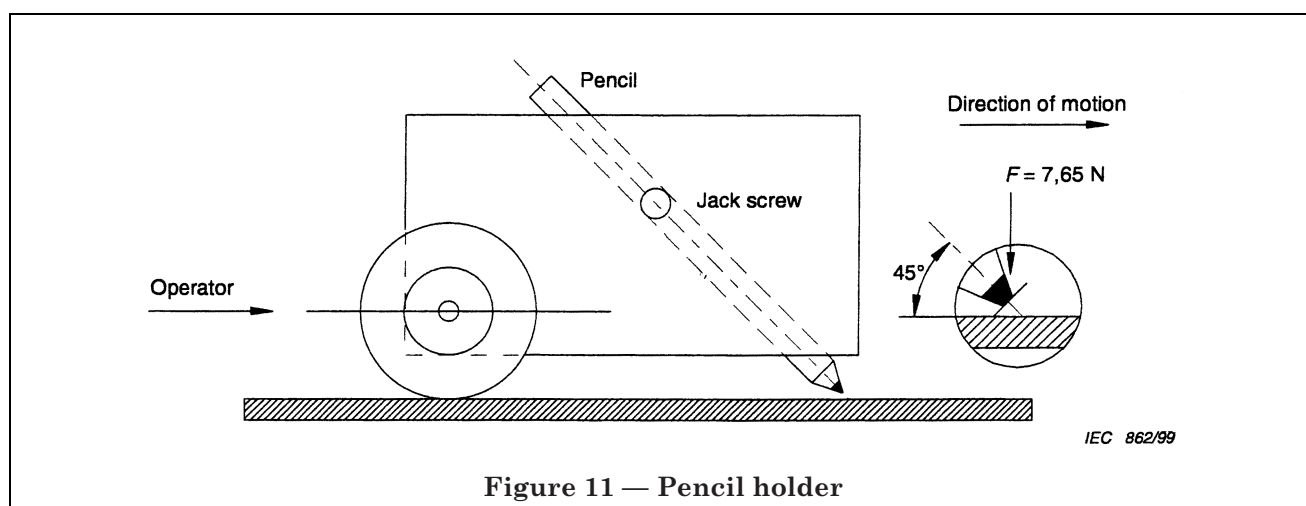


Figure 11 — Pencil holder

9.9 Test 3M09: Degree of cure of printed board organic surface coatings (under consideration)

10 E: Electrical test methods

10.1 Test 3E01: Circuit isolation (under consideration)

10.2 Test 3E02: Circuit continuity (under consideration)

10.3 Test 3E03: Insulation resistance, surface layers (under consideration)

10.4 Test 3E04: Insulation resistance, internal layers (under consideration)