

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

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

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

Partie 3: Méthodes d'essai des structures d'interconnexion (cartes imprimées)



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2007 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

Useful links:

IEC publications search - www.iec.ch/searchpub

The advanced search enables you to find IEC publications by a variety of criteria (reference number, text, technical committee,...).

It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available on-line and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary (IEV) on-line.

Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Liens utiles:

Recherche de publications CEI - www.iec.ch/searchpub

La recherche avancée vous permet de trouver des publications CEI en utilisant différents critères (numéro de référence, texte, comité d'études,...).

Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

Just Published CEI - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications de la CEI. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 30 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (VEI) en ligne.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

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

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

Partie 3: Méthodes d'essai des structures d'interconnexion (cartes imprimées)

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX

XE

ICS 31.180

ISBN 978-2-83220-349-1

Warning! Make sure that you obtained this publication from an authorized distributor.

Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope and object.....	7
2 Normative references.....	7
3 Accuracy, precision and resolution	8
4 Catalogue of approved test methods	11
5 P: Preparation/conditioning test methods	11
6 V: Visual test methods	11
7 D: Dimensional test methods	14
8 C: Chemical test methods	17
9 M: Mechanical test methods.....	30
10 E: Electrical test methods	48
11 N: Environmental test methods	75
12 X: Miscellaneous test methods.....	93
Annex A (informative) Worked examples	117
Figure 1 – Glow wire	19
Figure 2 – Test apparatus	20
Figure 3a – Horizontal specimen – Flame applied to surface.....	24
Figure 3b – Horizontal specimen – Flame applied to edge	24
Figure 3c – Vertical specimen – Lower edge horizontal – Flame applied to edge	25
Figure 3d – Vertical specimen – Lower edge horizontal – Flame applied to surface	25
Figure 3e – Needle burner test – Side views of test board and burner	26
Figure 3 – Needle burner test.....	26
Figure 4 – Flux type classification by copper mirror test.....	30
Figure 5a – Hold down clamping system	32
Figure 5b – Single load mode.....	32
Figure 5c – Multiple load mode.....	32
Figure 5d – Keyhole hold down fixture	33
Figure 5 – Copper foil for peel test	33
Figure 6 – Bow.....	36
Figure 7 – Twist	36
Figure 8 – Test set-up for bow measurement.....	37
Figure 9 – Specimen set-up for twist measurement.....	37
Figure 10a – Specimen set-up for referee test for twist, raised parallel surfaces	38
Figure 10b – Specimen set-up for referee test for twist, supporting jacks or blocks	39
Figure 10c – Specimen set-up for referee test for twist measurements.....	39
Figure 10 – Specimen set-up for referee test.....	39
Figure 11 – Bow measurement.....	39
Figure 12 – Twist measurement	40

Figure 13 – Measuring equipment for peel strength of flexible printed boards	43
Figure 14 – Pencil holder	46
Figure 15a – Location of test specimens	54
Figure 15b – Location of test specimens	55
Figure 15 – Composite test pattern	55
Figure 16 – Test specimen artwork	61
Figure 17 – Fluidized sand bath	64
Figure 18 – Possible equipment configuration	68
Figure 19 – Schematic showing undisturbed interval	68
Figure 20 – Test wave form example	70
Figure 21 – Incident wave voltage showing (2 X) air line delay	70
Figure 22 – Details of test specimen	72
Figure 23 – Circuit diagram for measurement of contact resistance	73
Figure 24 – Keypad contact patterns	75
Figure 25 – Plier fixture for thermal shock test, dip soldering	82
Figure 26 – Temperature cycles for moisture and insulation resistance test graph	92
Figure 27 – Insulation resistance coupon (μm)	92
Figure 28 – Typical “comb pattern”	93
Figure 29 – Suggested test specimen for surface mount features	104
Figure 30 – Suggested test specimen for plated through holes	104
Figure 31 – Rotary dip solderability test equipment	107
Figure 32 – Effectiveness of solder wetting of plated through holes	110
Figure 33 – Test specimen	116
Table 1 – Student’s “t” distribution	10
Table 2 – Preferred land, hole and wire dimensions	44
Table 3 – Resistance values	61
Table 4 – Chamber temperatures for one cycle	86
Table 5 – Accelerated ageing and test requirements	105
Table 6 – Maximum limits of solder bath contaminants	106

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**TEST METHODS FOR ELECTRICAL MATERIALS, PRINTED BOARDS AND
OTHER INTERCONNECTION STRUCTURES AND ASSEMBLIES –****Part 3: Test methods for interconnection structures
(printed boards)**

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.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61189-3 has been prepared by IEC technical committee 91: Electronics assembly technology.

This second edition cancels and replaces the first edition, published in 1997, its amendment 1 (1999) and constitutes a technical revision.

The document 91/698/FDIS, circulated to the National Committees as Amendment 2, led to the publication of the new edition.

The major technical changes with regard to the previous edition concern the addition of 25 new tests, as follows:

- 6 V: Visual test methods: 3V01, 3V02 and 3V03;
- 7 D: Dimensional test methods: 3D03;

- 8 C: Chemical test methods: 3C02, 3C13 and 3C14;
- 9 M: Mechanical test methods: 3M01, 3M03, 3M04, 3M07 and 3M09;
- 10 E: Electrical test methods: 3E03, 3E04, 3E05, 3E11, 3E12, 3E13, 3E16, 3E17 and 3E18;
- 11 N: Environmental test methods: 3N03, 3N07 and 3N12;
- 12 X: Miscellaneous test methods: 3X01.

This edition also includes the deletion of Annex B: Conversion table, as the referred documents were disbanded in 2005 and do not officially exist. Should any one wish to consult such information, they should refer to the first edition of IEC 61189-3 (1997).

This bilingual version (2012-09) corresponds to the monolingual English version, published in 2007-10.

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

FDIS	Report on voting
91/698/FDIS	91/727/RVD

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

The French version of this standard has not been voted upon.

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

A list of all the parts in the IEC 61189 series, under the general title *Test methods for electrical materials, printed boards and other interconnection structures and assemblies*, can be found on the IEC website.

NOTE Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

This standard should be used in conjunction with the following parts:

- Part 1: General test methods and methodology
 - Part 2: Test methods for materials for interconnection structures
 - Part 4: Test methods for electronic components assembling characteristics
 - Part 5: Test methods for printed board assemblies and also the following standard
 - Part 6: Test methods for materials used in manufacturing electronic assemblies
- IEC 60068 (all parts), Environmental testing

The committee has decided that the contents of the base publication and its amendments 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.

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.

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

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

1 Scope

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 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 60051 (all parts), *Direct acting indicating analogue electrical measuring instruments and their accessories*

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

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

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

IEC 60169-15, *Radio-frequency connectors – Part 15: RF coaxial connectors with inner diameter of outer conductor 4,13 mm (0,163 in) with screw coupling – Characteristic impedance 50 ohms (Type SMA)*

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

IEC 60454-3-1:1998, *Pressure-sensitive adhesive tapes for electrical purposes – Part 3: Specifications for individual materials – Sheet 1: PVC film tapes with pressure-sensitive adhesive*

IEC 60584-1, *Thermocouples – Part 1: reference tables*

IEC 60695-11-5, *Fire hazard testing – Part 11-5: Test flames – Needle flame test method – Apparatus, confirmatory test arrangement and guidance*

IEC 61188-1-2:1988, *Printed boards and printed board assemblies – Design and use – Part 1-2: Generic requirements – Controlled impedance*

IEC 61189-1:1997, *Test methods for electrical materials, interconnection structures and assemblies – Part 1: General test methods and methodology*

IEC 61190-1-1, *Attachment materials for electronic assembly – Part 1-1: Requirements for soldering fluxes for high quality interconnections in electronics assembly*

IEC 61190-1-2, *Attachment materials for electronic assembly – Part 1-2: Requirements for solder pastes for high quality interconnections in electronic assembly*

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 (withdrawn)*¹

ISO 9002:1994, *Quality systems – Model for quality assurance in production, installation and servicing (withdrawn)*

ISO 9453:2006, *Soft solder alloys – Chemical compositions and forms*

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.

¹ ISO 4046 has been withdrawn and replaced by ISO 4046: Parts 1 to 5.

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)

F is the standard deviation (F_{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.

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: $\pm 2 \text{ }\mu\text{m}$
- 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**6 V: Visual test methods****6.1 Test 3V01: Visual examination, 3× magnification****6.1.1 Object**

This method describes the procedure for visual examination of materials and finished printed boards, where 3× magnification is required by the relevant sectional specification (SS) or customer detail specification (CDS).

6.1.2 Test specimen

Finished printed board(s), portion of finished printed board, or test coupon(s), as specified by the relevant sectional specification (SS) or customer detail specification (CDS).

6.1.3 Test apparatus and materials

The following test apparatus and materials shall be used:

- a) Optical device capable of providing 3× magnification.
- b) Referee optical device capable of providing 10× magnification.

6.1.4 Procedure

The following steps shall be taken:

- a) The product shall be carefully examined, per the specified requirement, under 3× magnification device.
- b) In the case of a questionable evaluation at 3×, a referee examination may be performed at 10×.

6.1.5 Report

The report shall include:

- a) the test method number and revision;
- b) the date of evaluation;
- c) identification and description of specimen;
- d) the magnification used for the examination;
- e) the referee magnification examination, if applicable;
- f) the results of evaluation, including requirement(s) failed, failure modes and degree of failure, in case of failure;
- g) any deviation from this test method;
- h) the name of the person that conducted the test.

6.1.6 Additional information

In addition to stated requirements, any other objective evidence of defective and/or substandard conditions should be noted, such as dirt, oil, corrosion, fingerprints, foreign matter, etc.

6.2 Test 3V02: Visual examination, 10× magnification

6.2.1 Object

This method describes the procedure for visual examination of materials and finished printed boards where 10× magnification is required by the relevant sectional specification (SS) or customer detail specification (CDS).

6.2.2 Test specimen

Finished printed board(s) or test coupon(s), as specified in the relevant specification.

6.2.3 Test apparatus and materials

The following test apparatus and materials shall be used:

- a) Optical device capable of providing 10× magnification.
- b) Referee optical device capable of providing 50× magnification.

6.2.4 Procedure

The following steps shall be taken:

- a) The product shall be carefully examined, per the specified requirement, under 10× magnification device.
- b) In the case of a questionable evaluation at 10×, a referee examination may be performed at 50×.

6.2.5 Report

The report shall include:

- a) the test method number and revision;
- b) the date of evaluation;
- c) identification and description of specimen;
- d) the magnification used for the examination;
- e) the referee magnification examination, if applicable;
- f) results of evaluation, including requirement(s) failed, failure modes and degree of failure, in case of failure;
- g) any deviation from this test method;
- h) the name of the person that conducted the test.

6.2.6 Additional information

In addition to stated requirements, any other objective evidence of defective and/or sub-standard conditions should be noted, such as dirt, oil, corrosion, fingerprints, foreign matter, etc.

6.3 Test 3V03: Visual examination, 250× magnification

6.3.1 Object

This method describes the procedure for visual examination of materials and finished printed boards, where 250× magnification is required by the relevant sectional specification (SS) or customer detail specification (CDS).

6.3.2 Test specimen

Finished printed board(s), portion of finished printed board, or test coupon(s), as specified in the relevant specification.

6.3.3 Test apparatus and materials

The following test apparatus and materials shall be used:

- a) Optical device capable of providing 250× magnification.
- b) Referee optical device capable of providing at least double the power magnification.

NOTE Caution is advised not to falsely identify problems at this magnification.

6.3.4 Procedure

The following steps shall be taken:

- a) The product shall be carefully examined, per the specified requirement, magnification device under 250×
- b) In the case of a questionable evaluation at 250×, a referee examination may be performed at any magnification of at least double the power.

6.3.5 Report

The report shall include:

- a) the test method number and revision;
- b) the date of evaluation;
- c) identification and description of specimen;
- d) the magnification used for the examination;
- e) the referee magnification examination, if applicable;
- f) the results of evaluation, including requirement(s) failed, failure modes and degree of failure, in case of failure;
- g) any deviation from this test method;
- i) the name of the person that conducted the test.

6.3.6 Additional information

In addition to stated requirements, any other objective evidence of defective and/or substandard conditions should be noted, such as dirt, oil, corrosion, inclusions, foreign matter, etc.

6.4 Test 3V04: General visual (under consideration)

7 D: Dimensional test methods

7.1 Test 3D01: Optical method (under consideration)

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 specimen

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

The following test apparatus and materials shall be used:

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 following steps shall be taken:

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.

7.3 Test 3D03: Automated optical inspection (AOI)

7.3.1 Object

AOI is an integrated system for the automated visual inspection and verification of printed boards, printed board inner layers, and printed board artworks. Software and hardware combinations are available which enable accurate inspection at a high throughput.

AOI is undertaken to ensure that a printed board complies with the customer's requirements. AOI is capable of detecting many defect types (as listed in 7.3.6), and may be used as a screening process (100 %), or in accordance with a sampling plan.

The benchmark for AOI verification may be physical ("golden board" or artwork) or theoretical (design rules or CAD data).

The principal of operation of AOI equipment is the interpretation/comparison of data from the item under test with the benchmark. The equipment either operated on a "reflected light" principle, or uses the fluorescence of substrates subjected to laser light.

7.3.2 Test specimen

The test specimens shall comprise of production artwork, printed boards or inner layers.

7.3.3 Test apparatus and materials

The following test apparatus and materials shall be used:

- a) Automated equipment capable of viewing an area equal to 500 mm × 700 mm using raster scanning techniques. The resolution of the machine shall be 4× greater than the feature size being determined.

- b) Light sensors and recording mechanisms shall be capable of determining feature ambiguities as programmed into the equipment to facilitate identification of non-conforming feature sizes of printed boards, artwork, etc.

7.3.4 Procedure

The test procedure differs for new and repeat jobs:

7.3.4.1 Procedure for new jobs

The AOI equipment requires undertaking a learning stage followed by an inspection stage.

7.3.4.1.1 Learning stage

During the learning stage, the AOI equipment acquires the parameters required for the inspection stage. These typically include:

- inspection areas
- non-inspection areas
- minimum conductor width
- minimum conductor spacing

The AOI uses the data to create a data file for reference during the inspection stage. Data may be collected from a "golden board" or from CAD data.

A database should be maintained in order to expedite repeat jobs/orders.

7.3.4.1.2 Inspection stage

During the inspection stage, the AOI equipment uses the learned data to perform the inspection of the test item. Detected defects may be marked, or logged as (X, Y) coordinates.

Detected defects should then be verified by the operator.

7.3.4.2 Repeat jobs

Learned data from previous jobs shall be loaded from the database, and the procedure detailed in 7.3.4.1.1 shall then be followed.

7.3.5 Report

The report should include:

- a) test number and revision
- b) date of test
- c) description and identification of the test items
- d) details of verified defects
- e) a statistical analysis of the defect data (optional);
- f) identification of AOI apparatus if AOI is subcontracted;
- g) the name of the person that conducted the test.

7.3.6 Additional information

AOI apparatus should be capable of detecting:

- a) design rule defects

- open circuit
- conductor width violation
- conductor spacing violation
- copper splash
- pin holes
- b) reference defects
 - short circuits
 - missing conductors
 - missing spacing
 - pad violation (incorrect number of conductors entering a pad)
 - errors in clearances in power and ground planes
 - multiple line width defects (MLW)
 - short circuit between split planes
- c) outer layer defects
 - annular ring defects
 - break out
 - missing holes
 - conductor dish down
- d) general
 - dimension error measurements

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 method 3C02: Flammability; glow wire test, rigid printed boards

8.2.1 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 single electronic component.

Timings measured by this test are an indication of the ability of the printed board to self-extinguish. Correlation with other properties of the material(s), such as Oxygen Index, is not possible.

Materials suitable for testing in accordance with this technique include rigid printed boards.

8.2.2 Test specimen

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

- a) Base material(s)
- b) Surface coating(s)

- c) Type (e.g. multilayer, single-sided etc.)
- d) Size ²
- e) Design
- f) Surface area
- g) Thickness
- h) Metal distribution

A minimum of five specimens shall be used.

8.2.3 Test apparatus and materials

The following test apparatus and materials shall be used:

- a) The glow-wire shall consist of a loop of nickel/chromium (80 % / 20 %) wire having a diameter of 4 mm (see Figure 1). Care must be taken when forming the loop to avoid fine cracking at the tip.
- b) A sheathed fine-wire thermocouple, having an overall diameter of 0,5 mm and wires of NiCr and NiAl with the welded point located inside the sheath, is used for measuring the temperature of the glow-wire.
- c) The sheath consists of a metal which must be resistant to a temperature of at least 960 °C. The thermocouple is arranged in a pocket hole, 0,6 mm in diameter, drilled in the tip of the glow wire, as shown in “detail Z” of Figure 1. The thermo-voltages shall comply with IEC 60584-1; the characteristics given in that publication are practically linear. The cold connection shall be kept in melting ice unless a reliable reference temperature is obtained by other means.
- d) The instrument for measuring the thermo-voltage should be accurate to 1 % (i.e. Class 0,5 according to IEC 60051).
- e) The glow-wire is electrically heated. The current necessary for heating the specified tip to a temperature of 960 °C is between 120 A and 150 A.
- f) The test apparatus shall be so designed that the glow-wire is kept in a horizontal plane and that it applies a force of between 0,8N and 1,2N to the specimen. The force shall be maintained at this value whilst the glow-wire or test specimen is moved horizontally in relation to each other over a distance of at least 7mm.
- g) A wooden board shall be placed underneath the specimen. The board shall be covered with tissue paper which complies with 6.86 of ISO 4046.
- h) An example of the test apparatus is shown in Figure 2.

8.2.4 Procedure

The following steps shall be taken:

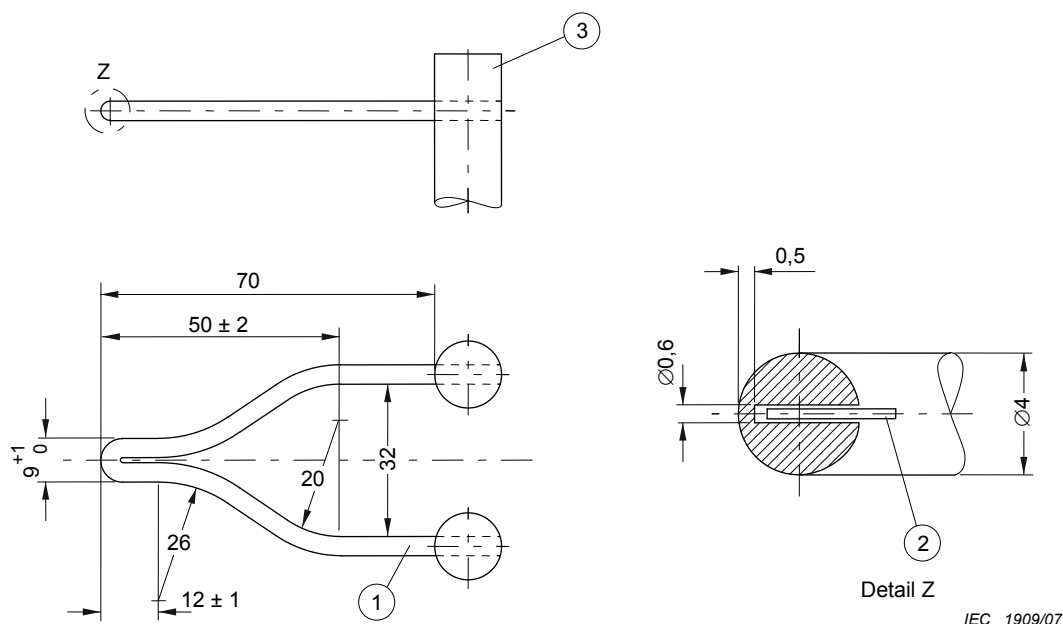
- a) The test specimens shall be pre-conditioned for 24 h at (124 ± 2) °C in an air-circulating oven. The test specimens shall then be allowed to stabilize for 4 h at room temperature in a desiccator over anhydrous calcium chloride.
- b) The relevant specification shall detail the orientation of the test specimen, if other than vertical.
- c) The thermocouple shall be calibrated at a temperature of 960 °C. The standard calibration technique shall be to place silver foil (99,8 % pure, 2 mm², 0,6 mm thick) on the upper

² Test boards of 150mm × 150mm may be considered large enough to represent larger production boards. Smaller production boards should be tested in their actual size.

face of the tip of the glow-wire. The glow-wire is heated by increasing current, and a temperature of 960 °C has been achieved when the silver foil melts.

- d) Calibration should be repeated after five measuring runs in order to compensate for alterations in the thermocouple and in the connections.
- e) Care should be taken to ensure that the thermocouple can follow the movement of the tip of the glow-wire caused by thermal elongation.
- f) The test specimen shall be held in a manner that minimizes heat loss into the test fixture.
- g) The tip of the glow-wire shall be applied to a part of the test specimen that is likely to be subjected to thermal stresses in normal use and/or which features the greatest combination of base material and surface coating(s). The tip shall be applied at least 15 mm below the upper edge of the test specimen. The glow wire shall be electrically heated to one of the preferred temperatures as given in the detail specification. This temperature shall be measured by means of the calibrated thermocouple. Care must be taken to ensure that, before starting the test, the temperature and heating current are stable for a minimum period of 60 s, and that heat radiation does not influence the specimen during this period or during the calibration (e.g. by providing an adequate separation or by using a screen).
- h) The tip of the glow-wire shall be brought into contact with the test specimen for a period of (30 ± 1) s, or a period as given in the appropriate detail specification. The heating current shall be maintained during this period. After this period, the glow-wire and test specimen shall be slowly separated, avoiding any further heating of the test specimen and any movement of air which might prejudice the result of the test.
- i) Before each test or calibration, it is necessary to remove any residue from the tip of the glow wire (by means of brushing).

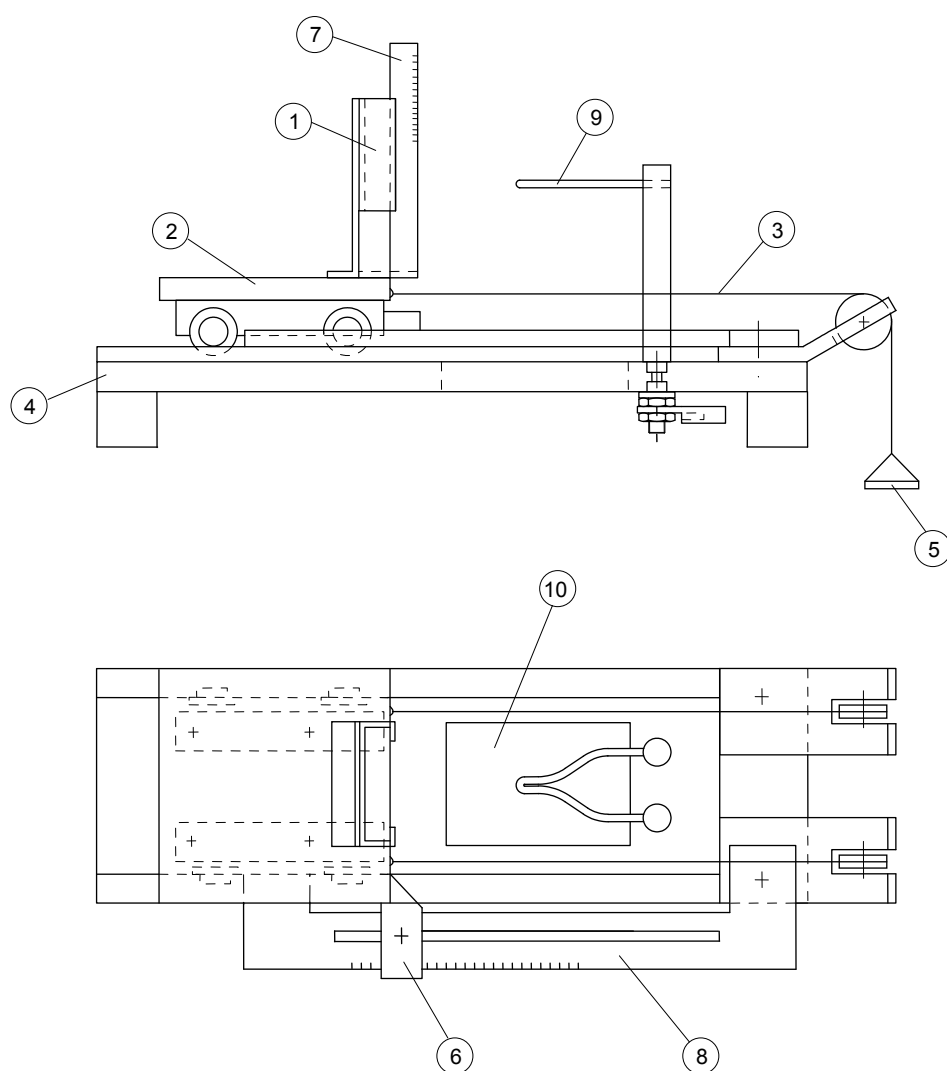
Dimensions in millimetres



Key:

- 1 glow-wire hard soldered at 3
- 2 thermocouple
- 3 stud

Figure 1 – Glow wire



IEC 1910/07

Key:

- | | |
|---------------------|--|
| 1 positioning clamp | 6 stop |
| 2 carriage | 7 scale for measure of flame |
| 3 tensioning cord | 8 scale for penetration |
| 4 base plate | 9 glow-wire (Figure 1) |
| 5 weight | 10 break-through in base plate for particles falling from the specimen |

Figure 2 – Test apparatus

8.2.5 Report

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

- the number of specimens, if other than five;
- the duration between the beginning of the tip application and the time at which the test specimen or the tissue paper beneath ignites;
- the duration between the beginning of the tip application and the time at which flames extinguish, during or after the period of glow-wire application;
- the maximum height of any flame. The height of the flame is the vertical distance measured between the upper edge of the glow-wire when applied to the test specimen and the visible tip of the flame. Any high flame produced at ignition, lasting approximately 1 s, shall be ignored;

- e) whether the test specimen flames or glows and whether it, or the tissue paper, has been completely consumed by the flames;
- f) whether flaming or glowing extinguishes within 30 s from the removal of the glow-wire tip from the test specimen, and whether this applies to the test specimen and/or the tissue paper.

8.2.6 Additional information

- a) There are obvious hazards associated within flammability testing. Training of test operators, and familiarity with laboratory safety procedures is paramount. All fire effluent should be considered to be toxic, for the purposes of safety if not in fact.
- b) Small scale flammability tests such as that described herein give 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.
- c) Test methods in development by IEC Technical Committees include the use of a Cone Calorimeter for the determination of fire integrity of materials.

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.

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 material(s);
- 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 3.
- 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 desiccator capable of maintaining 20 % R.H. or less.

8.3.4 Procedure

The following steps shall be taken:

- a) 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 desiccator over anhydrous calcium chloride.
- b) 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.
- c) 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.
- d) Where edge application is used, the flame shall not, specimen size permitting, be less than 10 mm from the nearest corner.
- e) 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.
- f) If the intended operational attitude of the printed board is not known or is variable, the test specimens shall be positioned as follows.
- g) 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.
- h) 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.
- i) The detail specification shall state the severity to be used.

- j) Test flame application times as detailed in Clause 7 of IEC 60695-11-5 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 12 of IEC 60695-11-5.

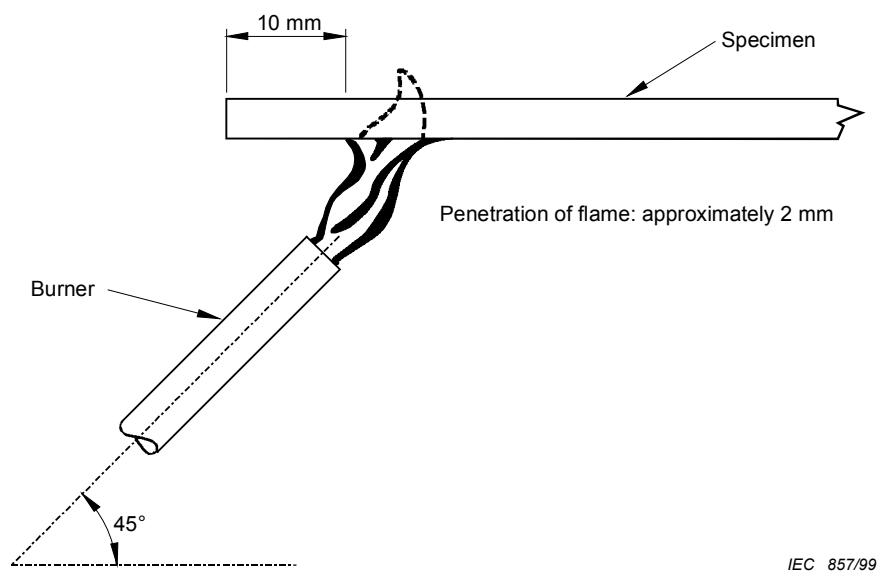


Figure 3a – Horizontal specimen – Flame applied to surface

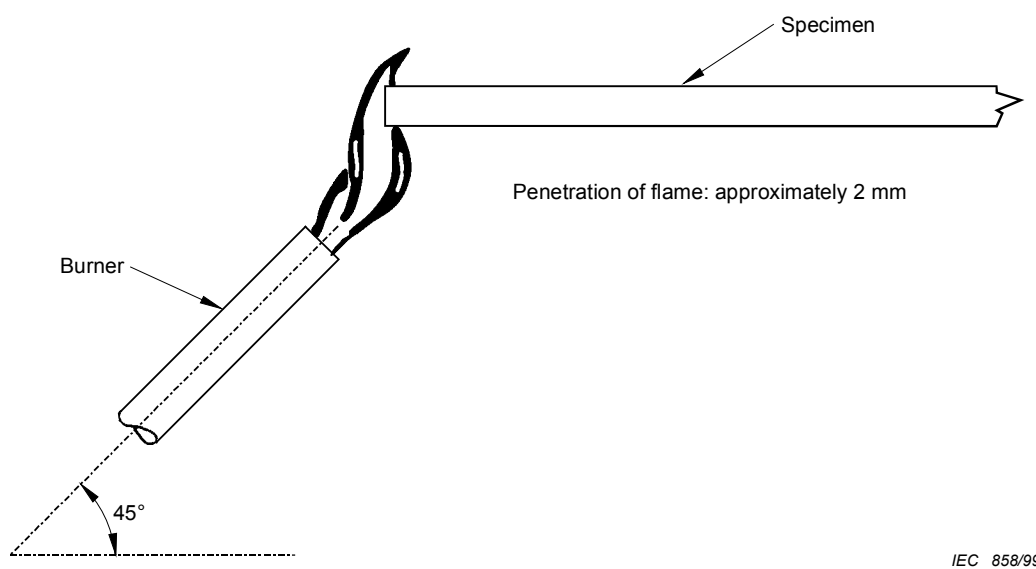


Figure 3b – Horizontal specimen – Flame applied to edge

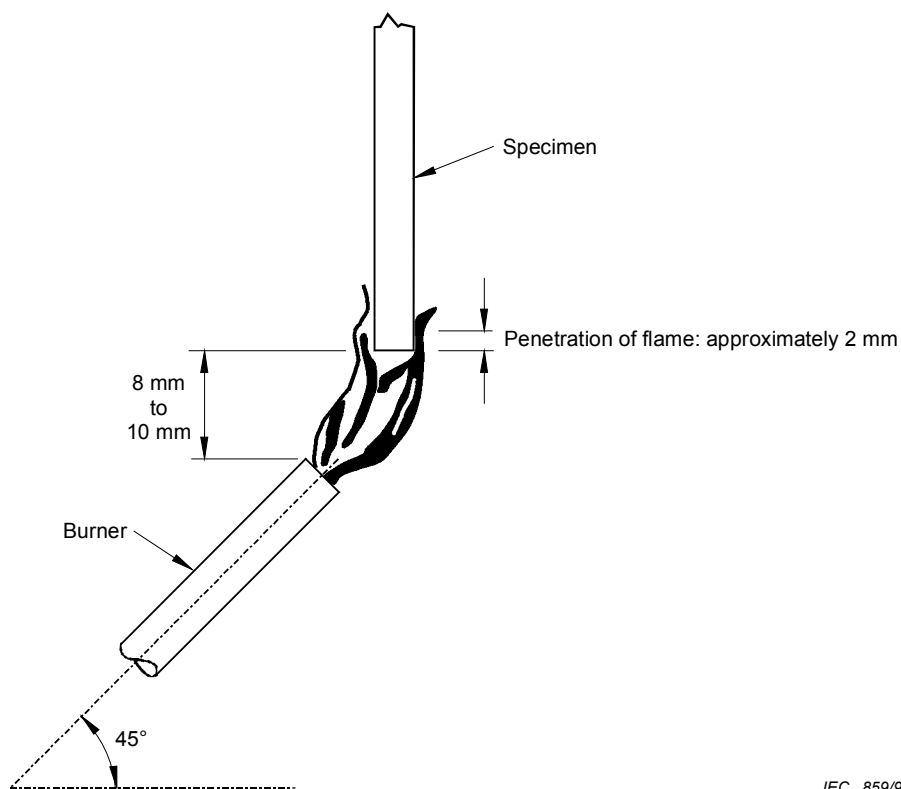


Figure 3c – Vertical specimen – Lower edge horizontal – Flame applied to edge

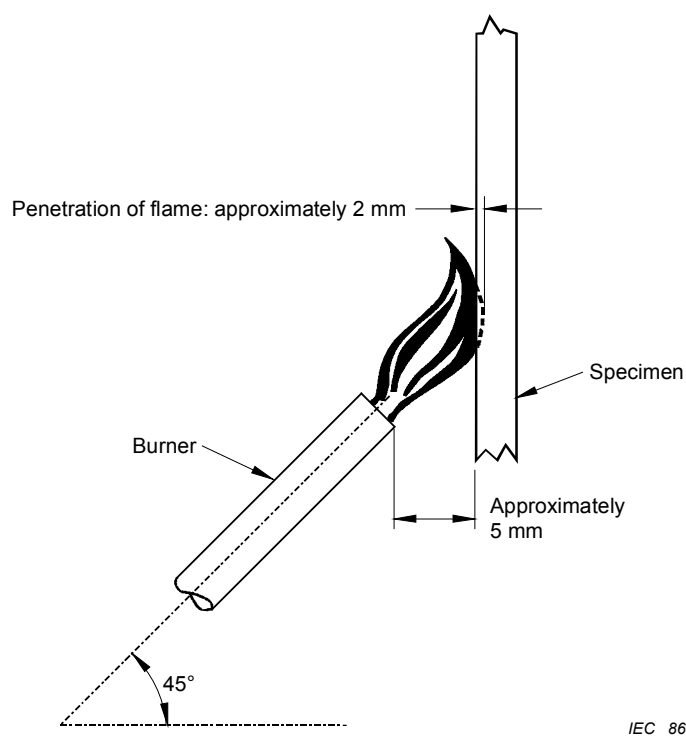


Figure 3d – Vertical specimen – Lower edge horizontal – Flame applied to surface

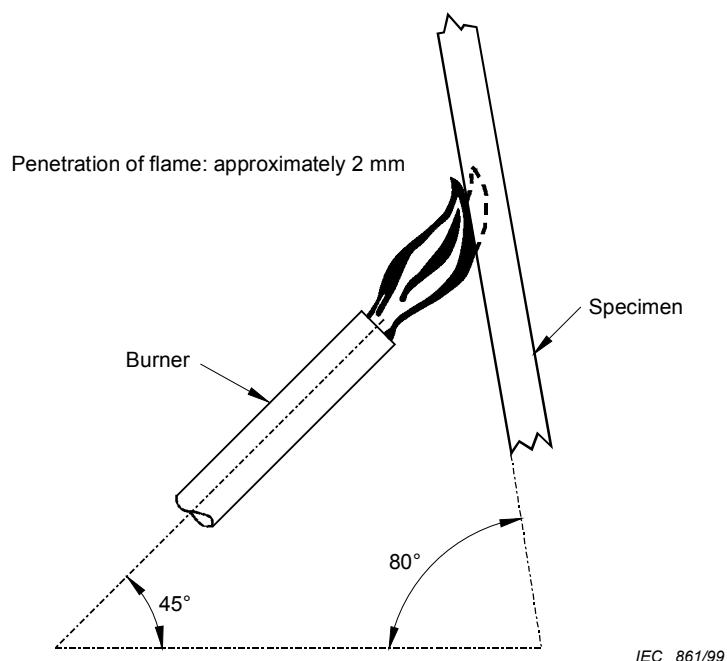


Figure 3e – Needle burner test – Side views of test board and burner

Figure 3 – Needle burner test

- 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 contaminants (in-house)** (under consideration)
- 8.11 Test 3C11: Resistivity of solvent extract (ionic contaminants)** (under consideration)
- 8.12 Test 3C12: Surface organic contaminants (infrared)** (under consideration)
- 8.13 Test 3C13: Ionic analysis of printed circuit boards, ion chromatography method**

8.13.1 Object

This test procedure is designed to measure the level of anionic contaminants on the surface of printed boards by ion chromatography.

8.13.2 Test specimen

Three specimens of printed board (PWB) for extraction

8.13.3 Test apparatus and materials

The following test apparatus and materials shall be used:

- a) an Ion chromatograph apparatus. The system consists of a pump and an anion column, and a conductivity detector. A system which is operating properly should be capable of providing an accuracy of 50^{-9} or better. The equipment and chemistry should be set up and standardized per manufacturers' instructions;
- b) hot water bath capable of maintaining $(80 \pm 5) ^\circ\text{C}$;
- c) use a clean heat sealable bag with less than 250^{-9} extractable contaminants. (Specify cleanliness level or part number of manufacturers.);
- d) cleanroom vinyl gloves. ($<3^{-6}$ of Cl);
- e) hi-purity deionized water (18,3 M Ω -cm grade and chloride levels of less than 50^{-9});
- f) hi-purity chemicals necessary for ion chromatography;
- g) isopropanol, electronic grade.

8.13.4 Procedure

The following steps shall be taken:

8.13.4.1 Extraction

- a) Record area of PWB. General rule on surface area is (length x width x 2).
- b) Use clean gloves when handling the specimens to be tested, and then place each specimen in the extraction bag.
- c) Prepare 75 % / 25 % isopropanol/H₂O solutions for the extraction.
- d) Add (100-250) ml of the extraction solution to the extraction bag (enough to cover the printed board).
- e) Heat seal the extraction bag and place it in the $80 ^\circ\text{C}$ water bath for one hour (cut a vent hole in the bag).
- f) Measure solution volume after extraction.
- g) Prepare unprocessed PWB as control.

8.13.4.2 Standard and specimen analysis

- a) Inject solution into ion chromatograph (IC) unit and calculate the concentration of from known reference data.
- b) Values of chemicals obtained from the IC are expressed in parts per billion ($^{-9}$).
- c) Standards should be used per instruction of the manufacturer. (Chloride levels of 100^{-9} are recommended).
- d) A calculation to take into account for surface area and evaporation must be done so as to compare all different sizes of circuit boards.

$$\mu\text{g}/\text{cm}^2 = \frac{(\text{ppb value from IC}/1000) \times (\text{final volume} / \text{original volume})}{\text{Surface area}(\text{cm}^2)}$$

8.13.5 Additional information

None.

8.13.6 Reference documents

IPC-TP-1043 "Cleaning and Cleanliness Test Program, Phase III, Water Soluble Fluxes, Part 1: B-Z4, interactions of Water Soluble Fluxes with Metal/Substrates. October, 1992."

IPC-TP-1044 "Cleaning and Cleanliness Test Program, Phase III, Water Soluble Fluxes, Part 2: B-36, Comparison to Phase 1 Rosin Benchmark", September 1992.

8.14 Test 3C14: Flux induced corrosion (copper mirror method)

8.14.1 Object

This test method is designed to determine the effect the flux has (if any) to remove the copper film that is vacuum deposited on a glass slide.

8.14.2 Test specimen

A minimum of 100 ml of liquid flux, a representative container of solder paste, reflowed solder-paste flux, extracted solder preform flux or extracted flux from a flux-cored solder wire.

8.14.3 Test apparatus and materials/reagents

- a) 0,5l of control standard rosin flux to be agreed upon between user and supplier;
- b) 0,5l of reagent grade (99 % pure) isopropanol;
- c) a vacuum deposition system or the means to procure glass test panels having a copper mirror coating as described in this method;
- d) 0,5l of reagent grade 0,5 % solution of ethylene diamine tetra acetic acid (EDTA);
- e) 0,5l of reagent grade ethanol or methanol;
- f) 100ml medicine bottle with dropper;
- g) test cabinet capable of achieving $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 5) \%$ relative humidity;
- h) glass slides;
- i) a relative humidity gauge having an accuracy of $\pm 2 \%$ or better, shall be used to continuously monitor the test environment. The gauge should be calibrated periodically.

8.14.4 Procedure

The following steps shall be taken:

8.14.4.1 Preparation

8.14.4.1.1 Preparation of control standard flux

Dissolve 35 g the rosin into 100 ml of reagent grade 99 % isopropanol and stir thoroughly.

8.14.4.1.2 Preparation of temperature/humidity chamber

When acid or salt solutions are used the chamber shall be conditioned for a minimum of 48 h prior to exposing the copper mirror specimens, to assure compliance with the $(50 \pm 5) \%$ relative humidity requirement.

8.14.4.1.3 Preparation of copper mirror test panels

- a) Apply by vacuum deposition, a film of copper metal on one surface of a flat sheet of clear, polished glass.
- b) Apply a uniform thickness of approximately 50 nm and assure that the finished mirror permits $(10 \pm 5) \%$ transmission of normal incident light of nominal wave length of 500 nm. This may be determined using a suitable photoelectric spectrophotometer. Commercially available copper mirrors meeting the above specifications are acceptable. (See 8.14.6.2.)
- c) Prevent oxidation of the copper mirror by storing in a closed container which has been flushed with nitrogen.

- d) Immediately before testing, immerse the copper mirror in a 5 g/l solution of EDTA for copper oxide removal. Mirrors stored in a non-oxidizing environment, do not require cleaning with the EDTA solution prior to testing. The cleaning step must be used if test results are in dispute.
- e) Rinse thoroughly in running water, immerse in clean ethanol or methanol and dry with clean, oil free air.
- f) Carefully examine the mirror before testing. There must be no oxide.

8.14.4.2 Test

- a) Place the copper mirror test panel on a flat surface (see Figure 4), mirror side up, and protect from dust and dirt at all times.
- b) Place one drop of test flux or extract to be tested (approximately 0,05 ml) on each copper mirror test panel. The number of panels per test is no less than 3. Do not allow the dropper to touch the test panel. The number of tests shall be specified in the relevant specification
- c) Solder-paste shall be applied directly to the mirror without scratching the copper mirror, with a volume approximating a 0,5 mm thickness and 8 mm diameter. (It has been determined that significant variations from this quantity have little effect for most fluxes.)
- d) Immediately also place one drop of the control standard flux adjacent to the test flux. Do not allow drops to touch.
- e) Place test panels in a horizontal position in the dust free cabinet at $(23 \pm 2) ^\circ\text{C}$ and $(50 \pm 5) \%$ relative humidity for $(24 \pm 0,5) \text{ h}$.
- f) At the end of the 24 h period, remove the test panels from the chamber and remove the test flux and control standard flux from the panels by immersing the panels into clean isopropanol.

8.14.4.3 Evaluation

- Carefully examine each test panel for possible copper removal or discoloration.
- If there is any complete removal of the copper film as evidenced by the background showing through the glass, the test flux has failed the L category. Complete removal of the copper only around the perimeter of the drop defines the flux as “M”. Complete removal of the copper places the flux in the “H” category.
- If the control flux fails, repeat the entire test, using new copper mirror test panels.
- Discoloration of the copper film due to a superficial reaction or only a partial reduction of the copper film thickness is not considered a failure.
- A number of chemicals can cause failure of copper mirror: free halides, stronger organic and inorganic acids and free amines.

8.14.5 Notes

8.14.5.1 Safety

Observe all appropriate precautions described in the material safety data sheets (MSDS) for chemicals involved in this test method.

8.14.5.2 Sources for prepared copper mirrors

- EMF Corp., 239 Cherry St., Ithaca, NY 14850, 800-456-7070
- H.L. Clausung, Inc., 8038 Monticello Ave., Skokie, IL 60076, 847-676-0330

8.14.6 Additional information

None.

8.14.7 Reference document

ASTM E104 Maintaining constant relative humidity by means of aqueous solutions

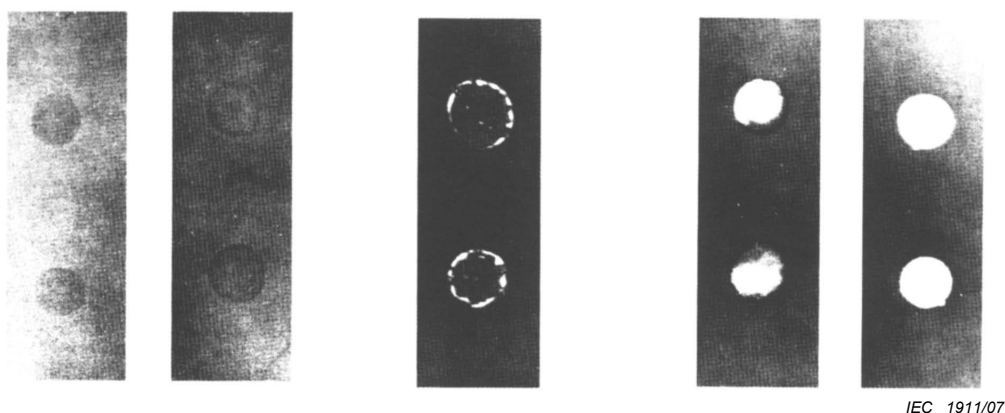


Figure 4 – Flux type classification by copper mirror test

9 M: Mechanical test methods

9.1 Test Method 3M01: Peel strength, standard atmospheric condition

9.1.1 Object

This test method is to determine the peel strength of conductors in the "as received" condition, and is applicable only to external foils that are used in foil lamination processes, and only as specified in customer specification, and/or purchase contract. (Note: Other peel strength tests are performed at the laminated printed board material level.)

9.1.2 Test specimen

The test specimens are individual test specimens (ITS) (coupons). Each coupon shall have 4 strips, parallel to the X-axis and Y-axis as shown in Figure 5 of the applicable printed circuit board. One coupon is necessary for each side of the printed circuit board laminated with foil. The coupons are located on a production board and shall be produced together with the applicable printed circuit board produced by the same conditions.

9.1.3 Test apparatus and test materials

The following test apparatus and materials shall be used:

- Tensile tester: A standard calibrated tensile strength tester, equipped with a low load cell, capable of measuring 45 mN, and at least 450 mm long light load wire or chain and clamp, and which includes its weight in the calculation. The clamp jaws must cover the foil width of each peel strip tab. Any equipment or apparatus having the described accuracy, precision, and reproducibility may be used.
- A suitable hold-down clamping system, equivalent in performance to that shown in Figure 5a.
- For qualification testing, a recording system must be incorporated into the test apparatus.

9.1.4 Procedure

The following steps shall be taken:

- a) Specimens (coupons) shall be placed on the production panel, such that the peel strips on each cut specimen are in both directions, and such that the copper can be completely removed (etched) from the opposite side of the test specimens.
- b) Pull two strips per specimen (coupon) for conformance testing; Pull four strips per specimen (coupon) for qualification.
- c) Cut the specimens from the panel, parallel to the glass fibres. The outside 25 mm border shall be excluded. Specimens may be cut to facilitate individual testing. Thin specimens must be provided with support by bonding them to a rigid aluminium, or similar base, or may be tested with the aid of a "keyhole" fixture (Figure 5d). Bonding to a rigid base shall be used as a referee evaluation.
- d) Assign an identification number to each specimen, and record relative panel location.
- e) Peel the foil back at the tab end.
- f) Clamp the end of each individual copper foil tab. The wire for connecting the clamp to the tensile tester must be free to pull vertically within $\pm 5^\circ$ angle.
- g) Fasten specimen (coupon) with hold-down fixture, such that an unencumbered vertical pull can be exerted. The tab end of the copper foil strip should be in a vertical position, ready for testing.
- h) Adjust tester to compensate for the weight of the wire or clamp.
- i) Start tester and apply force in the vertical direction at the rate of 50 mm/min, for (30 ± 10) s, until a 25 mm peel is completed, or until metal or foil breaks or tears. If the full width of the strip does not peel, the results shall be discarded, and another strip shall be tested.
- j) Observe and record the average load (Figures 5b and 5c) for each specimen; include assigned identification number.

9.1.5 Report

The report shall include:

- a) test method number and revision
- b) the date of evaluation;
- c) identification and description of specimen;
- d) actual average load for each specimen/test; including relative identification specified by the user.
- e) any deviation from this test method.
- f) the results of evaluation, including requirement(s) failed, failure modes and degree of failure, in case of failure;
- g) the name of the person that conducted the test.

9.1.6 Additional information

- a) Copper foil breaks may be caused by either a superior bond, or by brittle copper. Superior bond is indicated when the value at the break is above specification; in this case the actual load at the break should be reported for each specimen. The report shall indicate that the value is greater than the required specification.
- b) The condition of the underlying base material may also be evaluated after the peel strength test is completed.

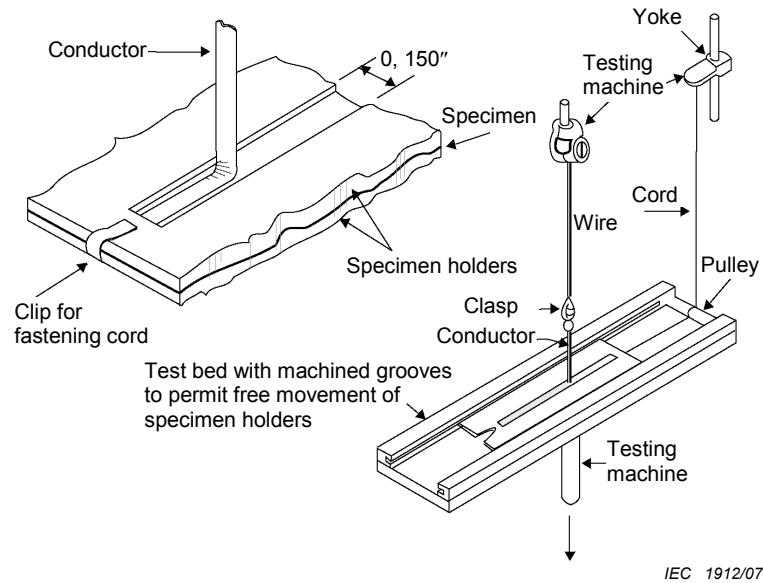


Figure 5a – Hold down clamping system

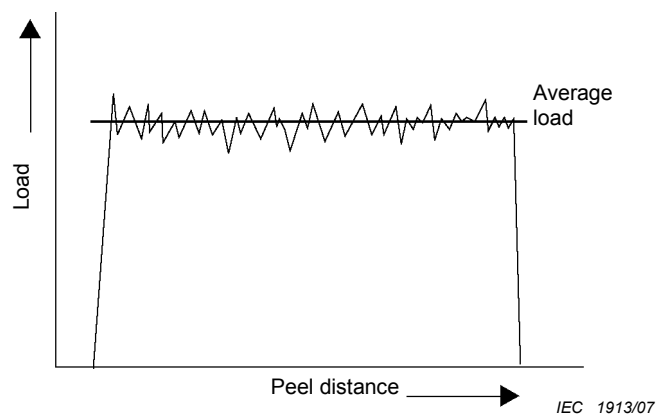


Figure 5b – Single load mode

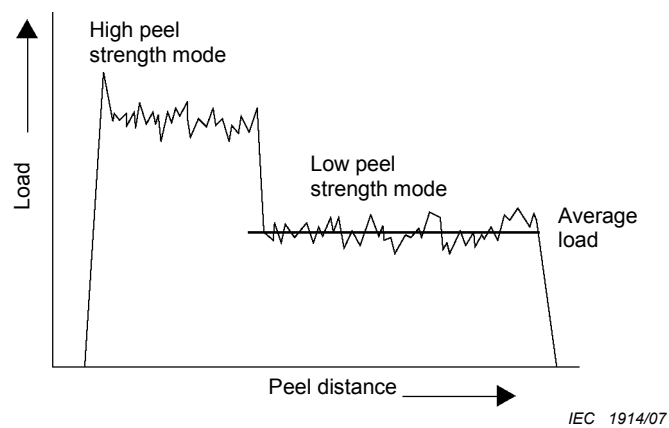


Figure 5c – Multiple load mode

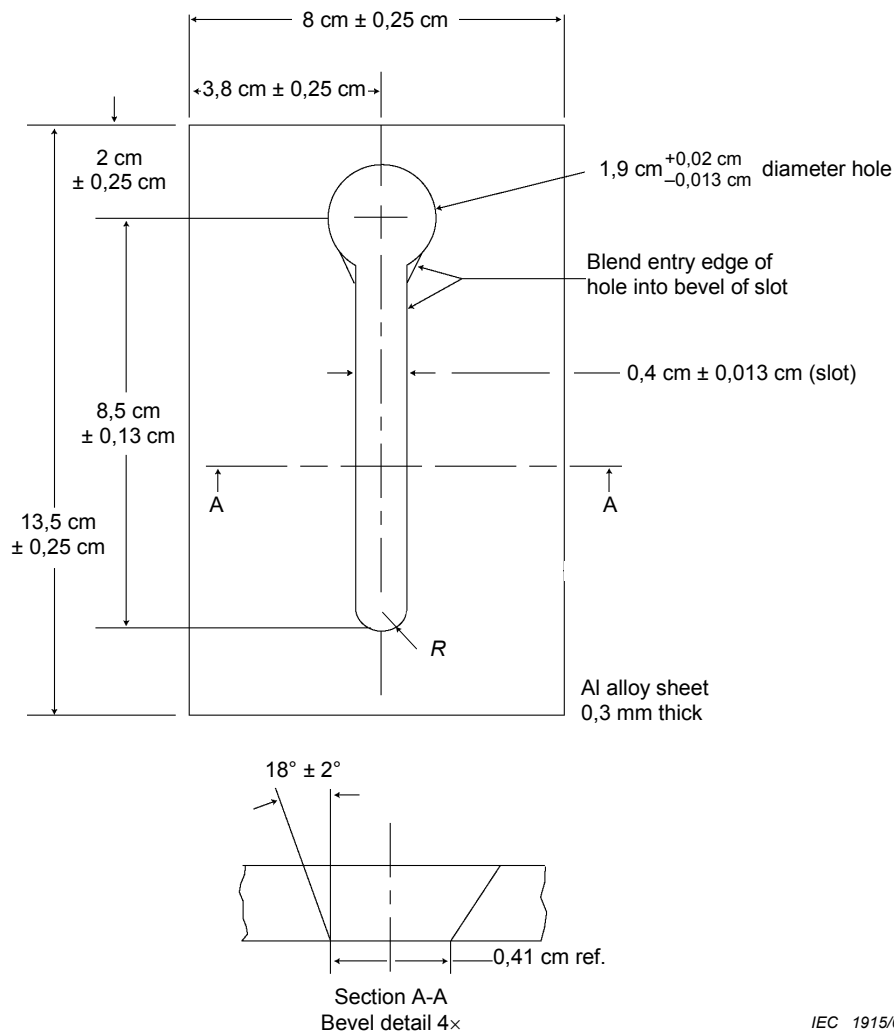


Figure 5d – Keyhole hold down fixture

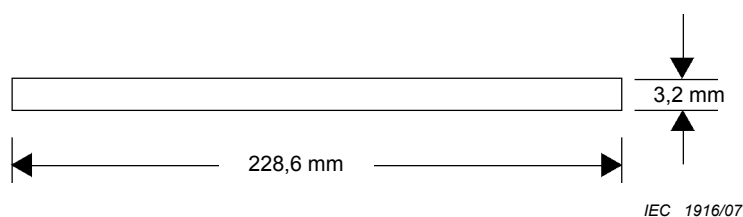


Figure 5 – Copper foil for peel test

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

9.3 Test 3M03: Pull out strength, plated through-holes, with or without lands

9.3.1 Object

This test method is to test the bond strength, or terminal pull strength of plating in plated through holes through-out manufacturing, as well as reworks and/or repairs. The five test cycles are intended to simulate initial soldering, component placement in original manufacturing, and subsequent component replacement for purpose of equipment repair.

9.3.2 Test specimen

A standard test specimen (coupon) or a printed board with plated through holes which can be used for component mounting. The diameter of the holes to be tested shall be no smaller than would normally be used for through-hole component mounting. Via holes, or other small holes, which would normally be considered only as vias, shall not be used for this test.

NOTE This is a destructive test.

The number of holes to be tested shall be specified in the relevant specification.

9.3.3 Test apparatus and materials

The following test apparatus and materials shall be used:

- a) 60 W regulated soldering iron.
- b) Tin plated copper wire. The diameter of the test wires shall be (0,25 to 0,70) mm smaller than the test holes.
- c) Sn60Pb40 or Sn63Pb37 solder as specified in ISO 9453.
- d) Force tester: Vertical pull force tester, capable of operating at a speed of 50 mm/min, and measuring up to 100 N.

9.3.4 Procedure

The following steps shall be taken:

- a) If conductors are connected to the terminal area and/or the plated through hole, cut conductor(s) not exceeding 6 mm away from the terminal area, taking care not to disturb the bond at the terminal area or in the plated through hole.
- b) Insert test wires of sufficient length to connect to gripping mechanism of bond strength tester into plated through test holes, and solder by machine or by hand, as applicable. The wires shall not be clinched.
- c) A wire shall be unsoldered and re-soldered in the same hole(s) by hand, five times following initial soldering. During each cycle, the wire shall be completely removed from the hole. If the same wire is used, it shall be allowed to cool to ambient temperature before being replaced in the test hole, and re-soldered. A new wire may be used for each re-soldering.
 - Operate the 60 W soldering iron at a voltage sufficient to produce a tip temperature of 232 °C to 260 °C.
 - Apply the iron to the test wire and solder or unsolder normally. The iron may touch the land surrounding the hole, however, undue pressure and duration should be avoided to minimize damage to the plated through hole under test. The iron should be applied only as long as necessary to perform the soldering and unsoldering operation. (Note: It is recommended that the soldering and unsoldering portion of this test be performed only by personnel trained and/or certified in soldering and soldering rework.)
- d) Following the fifth cycle, the test specimen shall be clamped in the jaws of the bond tester.
- e) The wire on the “pattern side” of the board shall be pulled at a speed of 50 mm/min with a load giving the force in accordance with the following formula:

$$\frac{4L}{\pi(D_2^2 - D_1^2)} \geq 14 \text{ N/mm}^2$$

where

D_1 is the hole diameter;

D_2 is the terminal diameter;

L is the load.

Apply load perpendicular to the major surface of the terminal area until the required load is reached, or when a failure occurs.

9.3.5 Evaluation

It is a failure when

- a) a plated hole is loosened with soldered wire attached, whether the terminal area is loosened or not,
- b) a terminal area around a hole is loosened.

Breaking of a wire, or wire pull out is not a failure; however, a wire pulled out shall be re-soldered and retested (pulled).

9.3.6 Report

The report shall include:

- a) test method number and revision;
- b) any deviation from this test method;
- c) identification and description of specimen;
- d) hole size(s) and wire size(s) used in the test;
- e) pull out strength;
- f) results of evaluation, including failure modes and degree of failure, in case of failure;
- g) the date of evaluation;
- h) name of the person that conducted the test.

9.3.7 Additional information

It should also be noted that test results can vary greatly, based upon the skill of the operator performing the solder and unsolder operations required in the test.

9.4 Test 3M04: Flatness of laminates and printed boards (bow and twist)

9.4.1 Object

Four procedures are presented to determine the flatness of finished rigid printed boards, including single sided, double sided, and multilayer and the rigid segments of rigid flex printed boards.

9.4.2 Definitions

9.4.2.1 Bow

Bow is illustrated in Figure 6.

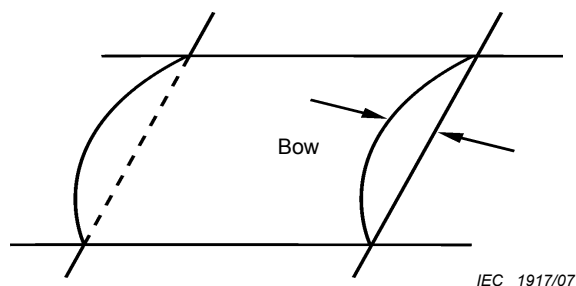


Figure 6 – Bow

9.4.2.2 Twist

Twist is illustrated in Figure 7.

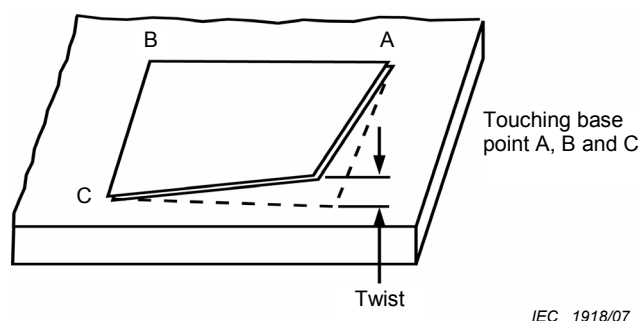


Figure 7 – Twist

9.4.3 Test specimen

- finished boards (single sided, double sided, multilayer, rigid flex boards)

9.4.4 Test apparatus and materials

The following test apparatus and materials shall be used:

- a) Inspection grade surface plate with a flatness tolerance $\pm 0,010$ mm.
- b) Standard metrology height dial indicator gauges.
- c) Thickness measurement feeler gauges.
- d) Standard pin gauges.
- e) Levelling jacks.
- f) Gauge blocks.
- g) Shims of suitable thickness.
- h) Linear measuring devices with an accuracy of $\pm 0,025$ mm.
- i) Micrometer.

9.4.5 Procedure

The following steps shall be taken:

9.4.5.1 Procedure number 1, Bow (see Figure 6)

- a) Place the specimen to be measured on the precision surface plate with its convex side facing upward. For each edge, apply sufficient pressure on both corners of the specimen to

ensure contact with the surface. Take a reading with the height dial indicator at the maximum vertical displacement of the edge including the thickness of the specimen (see Figure 8).

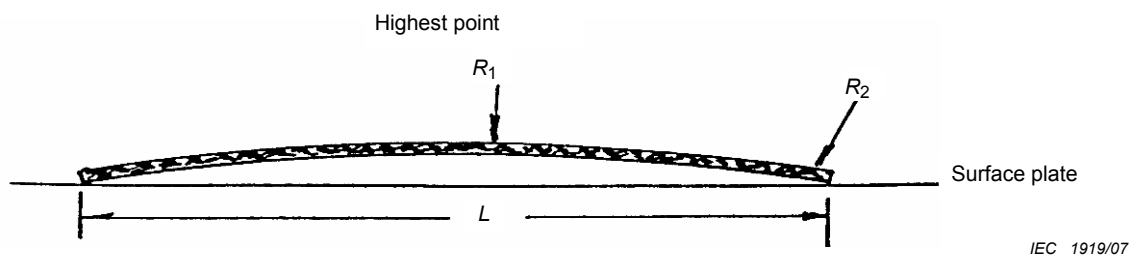


Figure 8 – Test set-up for bow measurement

- b) Repeat this procedure until all four edges of the specimen have been measured. It may be necessary to turn the specimen over to accomplish this procedure. Identify the edge with the greatest deviation from the surface plate; this deviation is to be recorded as R_1 .
- c) Take a reading with the height dial indicator or equivalent measuring device at the corner of the specimen contacting the surface plate, or determine R_2 by measuring the thickness of the specimen with a micrometer.
- d) Apply sufficient pressure so that the entire edge contacts the surface plate. Measure the length of the edge and denote as " L ".
- e) Calculate bow for this edge as follows:

$$\text{Percent bow} = \frac{R_1 - R_2}{L} \times 100$$

The largest bow of all edges is denoted as the bow of the specimen.

9.4.5.2 Procedure number 2, Twist

- a) Place the specimen to be measured on the plate with three corners touching the surface; apply sufficient pressure to ensure that three corners are in contact with the surface plate.
- b) Insert suitable shims under the raised corner so that it is just supported. When the correct shim thickness is used, the three other corners will be in contact with the surface without applying pressure to any corner (see Figure 9).

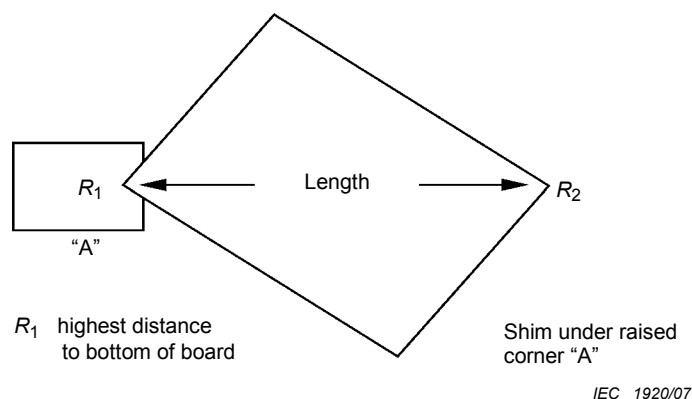


Figure 9 – Specimen set-up for twist measurement

- c) Without exerting any undue pressure on the specimen, take a reading with the height dial indicator, at the maximum vertical displacement (denoted as R_1 in Figure 9), and record the reading.
- d) The thickness R_2 of the specimen shall be measured with a micrometer.

NOTE For fabricated boards, both readings should be made on base material.

- e) Measure the diagonal (length as shown in Figure 9) of the specimen (for rectangular boards) and record the reading. For non-rectangular boards, measure from the corners exhibiting displacement diagonally to the corner on the opposite end of the board.

- f) Calculation:

Deduct R_2 reading from R_1 reading. (This value is divided by 2 in the formula defined because of the method of measurement doubles the vertical deflection).

Divide the measured deviation by the recorded length, and multiply by 100. The result of this calculation is the percent twist, as follows:

$$\text{Per cent twist} = \frac{R_1 - R_2}{2 \times \text{length}} \times 100$$

9.4.5.3 Procedure number 3, Twist referee test

- Place the specimen to be measured on the plate surface, with the two lower opposite corners touching the plate surface, or on raised parallel surfaces of equal height from the plate surface (see Figure 10a).
- Support the board in other two corners with levelling jacks, or other appropriate devices, ensuring that the two raised corners are of equal height from the surface plate. This may be checked by using the height dial indicator (see Figure 10b).
- Using the height dial indicator, measure the highest raised portion of the board, and record the reading as R_1 (see Figure 10c).
- Without disturbing the specimen, take reading with the height dial indicator at one of the corners contacting the surface, and record as R_2 (see Figure 10c).
- Measure the diagonal of the specimen (for rectangular boards) and record the reading. For non-rectangular boards, measure from the corner exhibiting maximum displacement diagonally to the corner on the opposite end of the board.
- Calculation:

Deduct the measurement R_2 from measurement R_1 . This difference is denoted as twist. Divide the measured deviation by the recorded length, and multiply by 100. The result of this calculation is the per cent of twist:

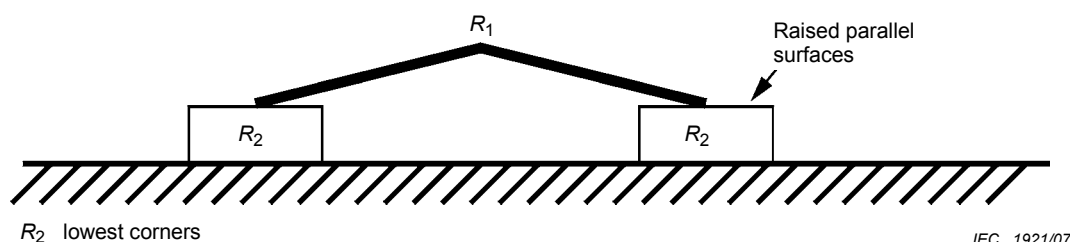


Figure 10a – Specimen set-up for referee test for twist, raised parallel surfaces

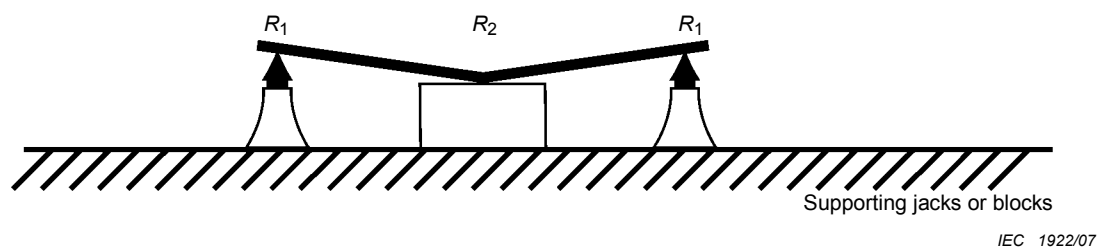


Figure 10b – Specimen set-up for referee test for twist, supporting jacks or blocks

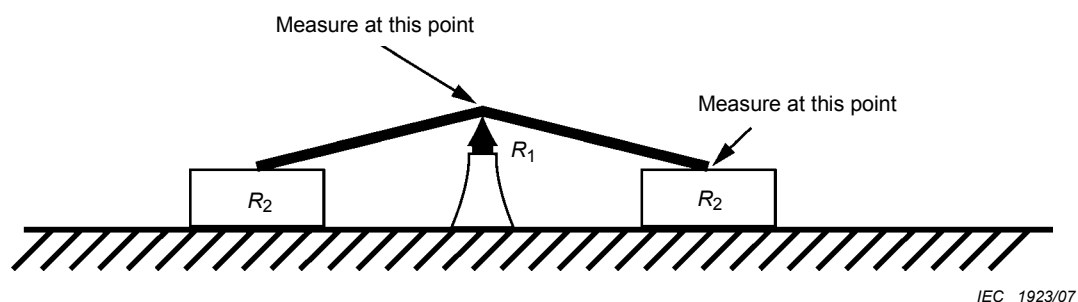


Figure 10c – Specimen set-up for referee test for twist measurements

Figure 10 – Specimen set-up for referee test

9.4.5.4 Procedure number 4, Production testing (bow and twist)

Having previously determined the maximum allowable deviation of a board from a flat plane, the following GO-NO GO procedure may be used.

With both corners of an edge touching the plate, and using a suitable known dimensional standard, such as a pin gauge or feeler gauge conforming to the maximum allowable deviation, attempt to insert the gauge between the raised portion of the board and the datum surface (see Figure 11). Attempt to insert a gauge appropriate to the allowable surface dimension between the raised corner of the board and the datum surface (see Figure 12).

If the gauge does not enter the gap, the board will have met the bow and twist acceptability criteria.

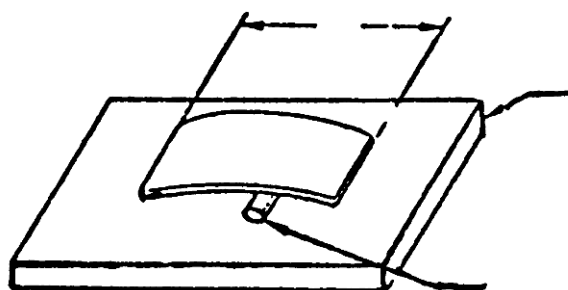
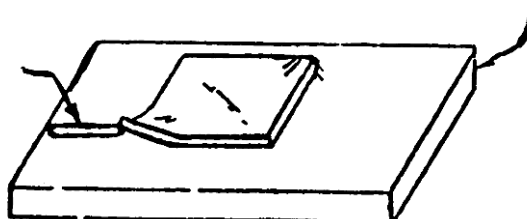


Figure 11 – Bow measurement



IEC 1925/07

Figure 12 – Twist measurement

9.4.6 Report

The report shall include:

- a) the test method number and revision;
- b) the date of the test;
- c) the procedure number(s) used for the test(s);
- d) the description identification of the specimen;
- e) actual calculations, where applicable;
- f) the results of evaluation, including failure modes and degree of failure, in case of failure;
- g) any deviation from this test method;
- h) the name of the person that conducted the test.

9.4.7 Additional information

Forms of distortion other than those defined in this test method (such as multiple convolutions) cannot be evaluated accurately by these test methods and should therefore receive special attention.

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 specimen

- 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 materials

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

The following steps shall be taken:

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 cut-out in the upper plate for the conductor to be peeled, or by attaching to a rotating drum as shown in Figure 13. 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.

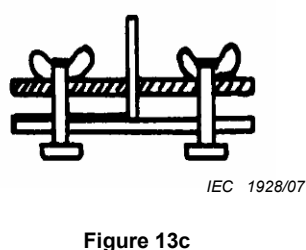
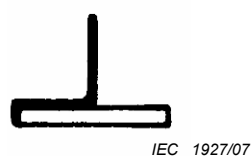
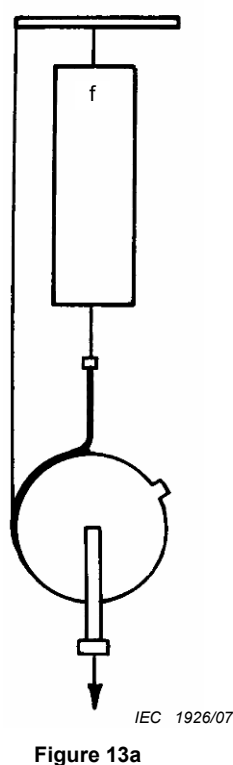


Figure 13a – Arrangement for flexible specimens

The specimen is held against the surface of a freely rotating drum*. The pull is exerted between the drum spindle and the test strip, and the drum rotates to maintain the required angle of detachment. A cord attached to the circumference and to a fixed point vertically above may be used to ensure smooth rotation.

Figure 13b – Mounting of flexible specimens

Specimens may be cemented on the back to rigid material and tested.

Figure 13c – Support fixture for flexible specimens

The specimen may be held in a fixture to prevent distortion. The peeled strip emerges through a slot in the fixture just wide enough to allow it to pass without restriction.

Figure 13 – Measuring equipment for peel strength of flexible printed boards

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

9.7 Test method 3M07: Pull-off strength, lands with plain holes

9.7.1 Object

This test method is to assess the quality of adhesion of lands to the base material under the stress of repeated soldering operations. The pull-off strength is measured as the force, normal to the surface of the printed board required to separate the land from the base material. This test gives an indication of an approximate value of the pull-off strength after soldering operation.

* The force caused by friction of the rotating parts indicated by the measuring device shall not exceed 50 mN. It shall also not exceed 10 % of the total force measured during the peel strength test.

9.7.2 Test specimen

Tests shall be carried out on circular lands that have been isolated from the attached conductors as determined by the applicable specification.

The following land, hole and wire dimensions are shown in Table 2.

Table 2 – Preferred land, hole and wire dimensions

Land diameter mm	Hole diameter mm	Wire diameter mm
$4,0 \pm 0,1$	$1,3 \pm 0,1$	0,9 – 1,0
$2,0 \pm 0,1$	$0,8 \pm 0,1$	0,6 – 0,7

These lands and wires shall be soldered within 3 s by the initial machine or hand soldering.

Other land, wire and hole dimensions may be specified in the relevant specification.

9.7.3 Test apparatus and materials

The following test apparatus shall be used:

- a soldering iron, capable of producing a tip temperature of 232 °C to 260 °C;
- vertical pull force tester capable of operating at a speed of 50 mm/min and measuring up to 50 N load;
- suitable wire of sufficient length to connect to gripping mechanism of bond strength tester;
- the solder to be Sn60Pb40 or Sn63Pb37 as specified in ISO 9453.

9.7.4 Procedure

The following steps shall be taken:

- The wire shall be inserted into the hole located approximately in the centre of the land. And it shall be soldered by hand. The wire shall not be clinched.
- After soldering a specimen must be cool at room temperature for 5 min.
- The iron shall be applied to the leads, not the foil, and shall be applied only as long as is necessary to perform the soldering operation.
- The printed wiring board shall be clamped in horizontal position in the jaws of the bond tester. The wire is connected to the gripping of the tester.
- A force shall then be applied to the wire by means of its tester, pulling at the rate of 50 mm/min the wire at right angle to the printed wiring board. The pulling shall be continued up to the force, that is required to separate the land from the base material.
- The smallest of any of the forces required to detach 5 lands from the base material shall be taken as the pull-off strength of the board under the test.
- Subject wires to four cycles of unsoldering and soldering by hand after the initial machine or hand soldering. During the four cycles the wires shall be completely removed during each unsoldering operation and replaced before each soldering operation.
- The iron shall be applied to the leads, not the foil, and shall be applied only as long as it is necessary to perform the unsoldering or soldering operation.
- After soldering the specimen shall be cooled at room temperature for 5 min each time.
- Following the fourth cycles, the printed board shall be clamped horizontally in the jaws of the bond tester.

- k) A force shall then be applied by means of its tester, pulling at the rate of 50 mm/min the wire at right angles to the printed wiring board. The pulling shall be continued up to the force that is required to separate the land from the base material.
- l) The smallest of any of the forces required to detach 5 lands from the base material shall be taken as the pull-off strength of the board under the test.
- m) Breaking of a wire or a wire pull-out shall not be considered as a failure but the wire shall be soldered and pulled again.

9.7.5 Report

The report shall include:

- a) the test method number and revision;
- b) the test date;
- c) the location of lands to be tested;
- d) soldering method;
- e) the result (each value and the minimum value) of measurement after 1 cycle;
- f) the result (each value and the minimum value) of measurement after 2 cycles;
- g) the name of the person that conducted the test.

9.7.6 Additional information

None.

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 specimen

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 14).

- 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

The following steps shall be taken:

- a) Place the specimen on a firm horizontal surface.
- b) The tips of all pencils shall be sharpened as shown in Figure 14.
- c) Starting with the hardest pencil in the carriage, push the carriage in the direction as illustrated in Figure 14 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 re-sharpened after every test.
- d) The hardness is an attribute, rather than a variable. No statement of uncertainty is required.

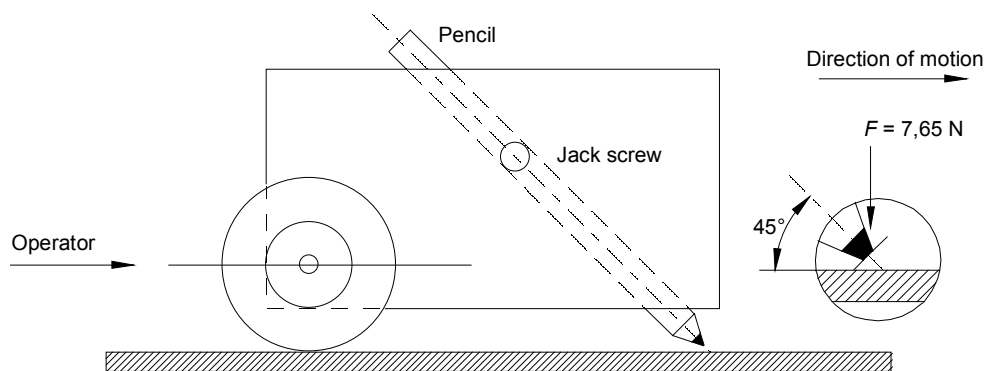
9.8.5 Report

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 test 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.



IEC 862/99

Figure 14 – Pencil holder

9.9 Test 3M09: Degree of cure of organic permanent surface coatings on printed circuit boards

9.9.1 Object

This test method defines the procedure for determining the degree of cure of an organic permanent surface coating used on a printed board.

This technique is qualitative.

This test method is suitable for determining the degree of cure of permanent polymeric solder resistive coating, conductive inks and legend marking inks.

9.9.2 Test specimen

The test specimen may comprise any suitable area of a production board or capability qualifying component (CQC), as agreed between customer and supplier.

A minimum of three separate boards shall be tested.

9.9.3 Test apparatus and materials

The following test apparatus and materials shall be used:

- a) A solvent as agreed upon between user and supplier.
- b) A lint-free cloth or pad.
- c) A stop-watch or stop-clock.

9.9.4 Procedure

The following steps shall be taken:

- a) The material(s) under test shall be processed in accordance with the supplier's instructions.
- b) Three drops of the solvent shall be applied to the same location on the specimen and allowed to stand for 60 s.
- c) The specimen shall be rubbed vigorously with a lint-free cloth or pad.
- d) Excess liquid shall be removed.
- e) Examine the surface if portions of the coating were transferred to the cloth or pad or if the surface of the coating was softened or became tacky.

9.9.5 Report

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

- a) the test method number and revision;
- b) the date of the testing;
- c) the identification and description of the specimen(s);
- d) the type and grade of solvent used;
- e) if the specimen (other than free surface debris) is transferred to the cloth or pad, or if the surface is softened or becomes tacky;
- f) any deviation from this test method
- g) the name of the person that conducted the test.

9.9.6 Additional information

Care should be exercised when using solvents, in accordance with local statutes and procedures.

Instrumentation is available which provides a quantitative assessment of degree of cure for the suggested test materials. The technique described herein is designed to provide an expedient qualitative measure, suitable for use in both production and laboratory environments.

10 E: Electrical test methods

10.1 Test 3E01: Circuit isolation (under consideration)

10.2 Test 3E02: Circuit continuity (under consideration)

10.3 Test method 3E03: Insulation resistance, surface layers

10.3.1 Object

The purpose of this test is to determine the insulation resistance between specified parts of a conductive pattern on the surface of a printed board or of a layer of a multilayer printed board before lamination.

10.3.2 Test specimen

- a) The insulation resistance shall be measured between any two electrically separate points of a conductive pattern on the surface of a production board, a test coupon or a composite test board.
- b) When the use of test coupons specified in IEC 62326-4-1 is agreed, the measurement shall be carried out on "Specimen E".

10.3.3 Test apparatus and materials

The following test apparatus shall be used:

- a megohm meter, capable of applying (10 ± 1) V, (100 ± 15) V and (500 ± 50) V, and of reading from $1 \times 10^6 \Omega$ to $1 \times 10^{13} \Omega$ with an accuracy of 5 % at its highest scale setting.

10.3.4 Procedure

The specimen shall be preconditioned by Test 1P01 of IEC 61189-1.

The insulation resistance shall be measured with the megohm meter. The test voltage shall be

(10 ± 1) V, or

(100 ± 15) V, or

(500 ± 50) V,

as specified in the relevant specification. The test voltage shall be applied for 1 min before measurement.

10.3.5 Report

The report shall include:

- a) the test method number and revision;
- b) the test date;
- c) parts of the pattern to be measured;