INTERNATIONAL STANDARD

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Test methods for electrical materials, interconnection structures and assemblies –

**Part 5:
Test methods for printed board assemblies**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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TEST METHODS FOR ELECTRICAL MATERIALS, INTERCONNECTION STRUCTURES AND ASSEMBLIES –

Part 5: Test methods for printed board assemblies

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61189-5 has been prepared by IEC technical committee 91: Electronic assembly technology.

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

FDIS	Report on voting
91/608/FDIS	91/619/RVD

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

This standard is to be used in conjunction with the following parts of IEC 61189:

Part 1: General test methods and methodology

Part 2: Test methods for materials for interconnection structures

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

Part 4: Test methods for electronic components assembling characteristics

Part 6: Test methods for materials used in electronic assemblies

and also the following standard:

IEC 60068: Environmental testing

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

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC website 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 (for example, TC 104) 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 board assemblies. The methods are self-contained, with sufficient detail and description so as to achieve uniformity and reproducibility in the procedures and test methodologies.

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

P: preparation/conditioning methods

V: visual test methods

D: dimensional test methods

C: chemical test methods

M: mechanical test methods

E: electrical test methods

N: environmental test methods

X: miscellaneous test methods

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

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

The letter and number combinations are for reference purposes to be used by the relevant specification. Thus "5C01" represents the first chemical test method described in IEC 61189-5.

In short, in this example, 5 is the number of the part of IEC 61189, C is the group of methods, and 01 is the test number.

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

TEST METHODS FOR ELECTRICAL MATERIALS, INTERCONNECTION STRUCTURES AND ASSEMBLIES –

Part 5: Test methods for printed board assemblies

1 Scope

This part of IEC 61189 is a catalogue of test methods representing methodologies and procedures that can be applied to test printed board assemblies.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60068-2-20, *Environmental testing – Part 2-20: Tests – Test T: Soldering*

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

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

IEC 61189-6, *Test methods for electrical materials, interconnection structures and assemblies – Part 6: Test methods for materials used in manufacturing electronic assemblies*

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

IEC 61190-1-2:2002, *Attachment materials for electronic assembly – Part 1-2: Requirements for solder pastes for high-quality interconnections in electronics assembly*

IEC 61190-1-3, *Attachment materials for electronic assembly– Part 1-3: Requirements for electronic grade solder alloys and fluxed and non-fluxed solid solders for electronic soldering applications*

IEC 61249-2-7, *Materials for printed boards and other interconnecting structures – Part 2-7: Reinforced base materials clad and unclad – Epoxide woven E-glass laminated sheet of defined flammability (vertical burning test), copper-clad*

IEC 62137:2004, *Environmental and endurance testing - Test methods for surface-mount boards of area array type packages FBGA, BGA, FLGA, LGA, SON and QFN*

ISO 5725-2, *Accuracy (trueness and precision) of measurement methods and results – Part 2: Basic method for the determination of repeatability and reproducibility of a standard measurement method*

ISO 9001, *Quality management systems – Requirements*

ISO 9455-1, *Soft soldering fluxes – Test methods – Part 1: Determination of non-volatile matter, gravimetric method*

ISO 9455-2, *Soft soldering fluxes –Test methods – Part 2: Determination of non-volatile matter, ebulliometric method*

3 Accuracy, precision and resolution

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

Test data serve a number of purposes which include

– monitoring of a process;
– enhancing of confidence in quality conformance;
– arbitration 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 test instrument and/or system.

3.1 Accuracy

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

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 ± % deviation) in order that uncertainties of measurement can be aggregated and determined.

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

3.2 Precision

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

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

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

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

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

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

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

where

U_t is the total uncertainty;

U_s is the systematic uncertainty;

U_r is the random uncertainty;

U_i is the interpolation error.

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

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

where

U_r is the random uncertainty;

n is the sample size;

t is the percentage point of the t distribution as shown in Table 1;

σ is the standard deviation (σ_{n-1}).

3.3 Resolution

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

It is accepted that some technologies will place a physical limitation upon resolution (for example, optical resolution).

3.4 Report

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

a) the test method used;
b) the identity of the sample(s);
c) the test instrumentation;
d) the specified limit(s);

e) an estimate of measurement uncertainty and resultant working limit(s) for the test;

f) the detailed test results;

g) 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.

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: ± 1,5 %

b) Voltage > 1 kV: ± 2,5 %

c) Current < 20 A: ± 1,5 %

d) Current > 20 A: ± 2,5 %

Resistance

e) Earth and continuity: ± 10 %

f) Insulation: ± 10 %

g) Frequency: ± 0,2 %

Time

h) Interval < 60 s: ± 1 s

i) Interval > 60 s: ± 2 %

j) Mass < 10 g: ± 0,5 %

k) Mass 10 g – 100 g: ± 1 %

l) Mass > 100 g: ± 2 %

m) Force: ± 2 %

n) Dimension < 25 mm: ± 0,5 %

o) Dimension > 25 mm: ± 0,1 mm

p) Temperature < 100 °C: ± 1,5 %

q) Temperature > 100 °C: ± 3,5 %

r) Humidity (30 – 75) % RH: ± 5 % RH

Plating thicknesses

s) Backscatter method: ± 10 %

t) Microsection: ± 2 microns

u) Ionic contamination: ± 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, those described in IEC 61189-1 and IEC 60068-1, and when applicable, is a mandatory part of the test method standard.

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

5 P: Preparation/conditioning test methods

5.1 Test 5P01: Test-board design guideline

For the details of this test method, see IEC 62137:2004, Clause A.4, the requirements of which become mandatory when referenced as test 5P01.

5.2 Test 5P02: Standard mounting process for CSP/BGA packages

For the details concerning this test method, see Annex B of IEC 62137:2004, the requirements of which become mandatory when referenced as test 5P02.

6 V: Visual test methods

(Under consideration)

7 D: Dimensional test methods

(Under consideration)

8 C: Chemical test methods

8.1 Test 5C01: Corrosion, flux

8.1.1 Object

This test method is designed to determine the corrosive properties of flux residues under extreme environmental conditions. A pellet of solder is melted in contact with the test flux on a sheet metal test piece. The solder is then exposed to prescribed conditions of humidity and the resulting corrosion, if any, is assessed visually.

8.1.2 Test specimen

At least 0,035 g of flux solids, 1 g solder paste, 1 g wire, or 1 g preform with an equivalent amount of solids. Flux solids are defined as the residue from the solid content, flux test described in IEC 61189-6, test method 6C03. All solvent shall have been evaporated from the specimen in a chemical fume hood.

8.1.3 Apparatus and reagents

a) Solder pot.

b) Humidity chamber capable of achieving (40 ± 1) °C and (93 ± 2) % relative humidity.

c) Air-circulating drying oven.

d) Microscope having 20× min.

e) Chemicals: All chemicals shall be reagent grade (highly pure, without contamination) and water shall be distilled or deionized: ammonium persulphate; sulphuric acid, % volume (v/v); degreasing agent; acetone, or petroleum ether.

f) Analytical balance capable of weighing 0,001 g

g) Copper sheet of a thickness of (0,50 ± 0,05) mm and a purity of 99 %.

8.1.4 Procedures

8.1.4.1 Chemicals

a) Ammonium persulphate (25 % m/v in 0,5 % v/v sulphuric acid). Dissolve 250 g of ammonium persulphate in water and add cautiously 5 ml of sulphuric acid (density 1,84 g/cm^3). Mix, cool, dilute to 1 litre and mix. This solution should be freshly prepared.

b) Sulphuric acid (5 % v/v). To 400 ml of water cautiously add 50 ml of sulphuric acid (density 1,84 g/cm^3). Mix, cool, dilute to 1 litre and mix.

8.1.4.2 Test panel preparation

a) Cut a piece of 50 mm × 50 mm from the copper sheet for each test.

b) Form a circular depression in the centre of each test panel 3 mm deep by forcing a steel ball of a diameter of 20 mm into a hole of a diameter of 25 mm to form a cup.

c) Bend one corner of each test panel up to facilitate subsequent handling with tongs.

8.1.4.3 Preconditioning test panels

Immediately before performing the test, precondition as follows using clean tongs for handling.

a) Degrease with a suitable neutral organic solvent such as acetone or petroleum ether.

b) Immerse in 5 % sulphuric acid (by volume) at (65 ± 5) °C for 1 min to remove the tarnish film.

c) Immerse in a solution of 25 % m/v ammonium persulphate (0,5 % v/v sulphuric acid) at (23 ± 2) °C for 1 min to etch the surface uniformly.

d) Wash in running tap water for a maximum of 5 s.

e) Immerse in 5 % sulfuric acid (by volume) at (23 ± 2) °C for 1 min.

f) Wash for 5 s in running tap water, then rinse thoroughly in deionized water.

g) Rinse with acetone.

h) Allow to dry in clean air.

i) Use the test piece as soon as possible or store up to 1 h in a closed container.