IEC 61189-5-4

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Test methods for electrical materials, printed boards and other interconnection structures and assemblies –
Part 5-4: General test methods for materials and assemblies – Solder alloys and fluxed and non-fluxed solid wire for printed board assemblies

Méthodes d'essai pour les matériaux électriques, les cartes imprimées et autres structures d'interconnexion et ensembles –
Partie 5-4: Méthodes d'essai générales pour les matériaux et les assemblages – Alliages à braser et brasages solides fluxés et non fluxés pour les assemblages de cartes imprimées

IEC 61189-5-4:2015-01(en-fr)

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International Standard IEC 61189-5-4 has been prepared by IEC technical committee 91: Electronics assembly technology.

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

FDIS	Report on voting
91/1212/FDIS	91/1225/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 publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

This International Standard is used in conjunction with IEC 61189-1:1997, IEC 61189-2:2006, IEC 61189-3:2007.

A list of all parts in the IEC 61189 series, published under the general title *Test methods for electrical materials, printed boards and other 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 stability 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- withdrawn,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 materials or component robustness for printed board assemblies, 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 robustness of materials or component for 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 a possible 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 "5-4C01" represents the first chemical test method described in IEC 61189-5-4.

In short, in this example, 5-4 is the number of the part of IEC 61189, C is the group of methods, and 01 is the test number.

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

Part 5-4: General test methods for materials and assemblies – Solder alloys and fluxed and non-fluxed solid wire 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.

This part of IEC 61189 focuses on test methods for solder alloys, fluxed and non-fluxed solid wire, based on existing IEC 61189-5 and IEC 61189-6. In addition, it includes test methods for solder alloys, fluxed and non-fluxed solid wire, and for lead free soldering.

2 Normative references

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

IEC 61189-5, *Test methods for electrical materials, interconnection structures and assemblies – Part 5: Test methods for printed board assemblies*

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

IEC 61190-1-3, *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*

3 Accuracy, precision and resolution

3.1 General

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.

3.2 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 should 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.

3.3 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 a 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}).

3.4 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).

3.5 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.

3.6 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

3.7 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 to 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 to 75) % RH: ±5 % RH

Plating thicknesses

s) Backscatter method: ±10 %

t) Microsection: ±2 µm

u) Ionic contamination: ±10 %

4 C: Chemical test methods

4.1 Test 5-4C01: Determination of the percentage of flux on/in flux-coated and/or flux-cored solder

4.1.1 Object

This test method provides a procedure for determining the flux percentage on flux-coated and/or in flux-cored solder.

4.1.2 Test specimen

For test A, use approximately 200 g of flux-coated and/or flux-cored solder; for test B, use approximately 30 g of flux-coated and/or flux-cored solder. For solders whose flux percentage is expected to be 1 % or more, the test specimen may be approximately 100 g. For solders whose flux percentage is expected to be 2 % or more, the test specimen may be approximately 50 g.

4.1.3 Apparatus

a) One hot plate capable of being set to (50^{+5}_{0}) °C above the liquidus temperature of the solder specimen alloy.

b) One suitably sized pyrex or equivalent beaker.

4.1.4 Test procedure

4.1.4.1 Test procedure A

a) Determine the liquidus temperature of the solder alloy from IEC 61190-1-3.

b) Weigh the solder specimen to the nearest 0,01 g ($W1$).

c) Carefully pack the solder specimen as tightly as possible in the bottom of the beaker. Weigh the beaker and solder specimen to the nearest 0,01 g ($W2$).

d) Preheat the hot plate to (50^{+5}_{0}) °C above the liquidus temperature of the solder specimen alloy.

e) Place the beaker with the solder specimen on the hot plate. Remove the beaker as soon as all of the solder has melted and allow it to cool at room temperature for about 30 min.

f) Using highly pure propan-2-ol, or other suitable solvent recommended by the solder manufacturer, some slight agitation, and gentle heat, thoroughly extract the flux residues from the beaker. Decant the extraction solution through coarse filter paper, taking care that no solder escapes the beaker. Repeat the extraction procedure as necessary to remove all traces of flux residue. Evaporate the remaining solvent from the beaker by warming under a gentle stream of air until the residue in the beaker is completely dry.

g) Weigh the beaker and melted solder metal to the nearest 0,01 g ($W3$).

h) Repeat the flux residue extraction procedure until a constant final weight $W3$ is obtained.

4.1.4.2 Test procedure B

a) Clean the specimen of the flux cored solder wire under test with a tissue soaked in the degreasing solvent.

b) Using the balance weigh 30 g of the cleaned wire to the nearest 0,01 g. Place the specimen into the glycerine. Heat to (50 ± 5) °C above the liquidus temperature of the wire under test.

c) Remove the flux from the resin flux cored wire completely. Allow the flux to cool and solidify.

d) Remove the solidified solder pellet and wash it in water. Immerse the pellet in alcohol for approximately 5 min. Re-wash the pellet in water and allow it to dry at room temperature.

e) Using the balance, measure the mass of the pellet to constant weight, to the nearest 0,01 g.

4.1.4.3 Evaluation

Calculate the flux content F_A of the specimen as percentage by mass for procedure A from the following formula:

$$F_A\ (\%) = 100 \times (W3 - W2)\ /\ W1$$

Calculate the flux content F_B of the specimen as percentage by mass for procedure B from the following formula.

$$F_B\ (\%) = \frac{m_1 - m_2}{m_1} \times 100 = \%\ (\text{mass})$$

where

m_1 is the mass, in g, of the flux cored solder wire used in the test;

m_2 is the mass, in g, of the solder pellet.

4.2 Test 5-4CXX

Under consideration.

5 X: Miscellaneous test methods

5.1 Test 5-4X01: Spread test, extracted cored wires or preforms

5.1.1 Object

This test method gives an indication of activity of cored solder or preform fluxes. The test method offers two methods.

Method A measures the solder spread area.

Method B measures the solder spread ratio.

5.1.2 Method A

5.1.2.1 Test specimen

a) 10 ml of the extracted material.

b) Vacant.

5.1.2.2 Apparatus and reagents

a) Five replicates 0,25 mm thick 70/30 brass of a size of approximately 40 mm × 75 mm.

b) Degreased very fine steel wool (for example, #00).

c) Solder wire from Sn63Pb37A, or Sn96.5Ag3Cu0.5, or any other solder alloy wire agreed between user and supplier according to IEC 61190-1-3 with a diameter with 1,5 mm.

d) A solder pot not less than 25 mm in depth containing at least 2 kg solder.

5.1.2.3 Test specimen preparation

a) Clean five brass coupons with steel wool.

b) Flatten the brass coupon by bending the opposite sides of the coupon. The two bends should be parallel to the curve of the metal coil in which the brass was provided in order to stiffen and flatten the test specimen.

c) Cut a 30 mm length of solid wire solder.

d) Wrap the cut length of solder around a 3 mm mandrel.

e) Cut the coil into individual rings to make a preform of the solder.

f) Adjust 25 mass % test solution with propan-2-ol or suitable solvent and measure and take (0,05 ± 0,005) ml by using micro syringe or micro pipet.

5.1.2.4 Test

a) Maintain the solder bath at (260 ± 3) °C for Sn60Pb40, or at (255 ± 3) °C for Sn96.5Ag3Cu0.5, or at (35 ± 3) °C higher than the liquidus temperature for any other solder alloy agreed between the user and the supplier.

b) Place the preformed solder in the centre of the test specimen.

c) Place one drop (0,05 ml) of flux in the centre of the preform of the test specimen.

d) Carefully place the coupon on the surface of the solder bath for 15 s.

e) Remove the coupon in a horizontal position and place on a flat surface allowing the adhered solder to solidify undisturbed.

f) Remove all flux residue with a suitable solvent.

5.1.2.5 Evaluation

Measure the solder spread area by comparing to circles (pre-drawn) with areas similar to those listed in Table 2. The mean of the spread of all five specimens tested shall be reported.

Table 2 is intended as an aid in defining areas in mm^2.

Table 2 – Typical spread areas defined in mm^2

Diameter mm	Area mm^2
10,00	78,54
10,70	90,00
11,28	100,00

5.1.3 Method B

5.1.3.1 Test specimen

a) Extracted flux from cored wire or preforms

b) For solid flux, 25 mass % propan-2-ol or other appropriate solvent solution.

c) Solder wire of Sn63Pb37, or Sn96.5Ag3Cu0.5, or any other solder alloy agreed between the user and the supplier specified in IEC 61190-1-3 shall be wrapped on a ring bar with a diameter of 3,3 mm.

5.1.3.2 Apparatus and reagents

a) Solder bath: A solder bath with a depth of not less than 30 mm, 100 mm × 150 mm or more in width and length, provided with a temperature controller up to (50 ± 2) °C above the liquidus temperature of the tested solder.

b) Dryer: An air convection oven with a temperature controller up to (150 ± 3) °C and capable of maintaining the temperature.