IEC 60068-2-82

Edition 2.0 2019-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Environmental testing –
Part 2-82: Tests – Test Xw_1: Whisker test methods for components and parts used in electronic assemblies

Essais d'environnement –
Partie 2-82: Essais – Essai Xw_1: Méthodes de vérification des trichites pour les composants et les pièces utilisés dans les ensembles électroniques

IEC 60068-2-82:2019-05(en-fr)

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ENVIRONMENTAL TESTING –

Part 2-82: Tests – Test Xw_1: Whisker test methods for components and parts used in electronic 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 60068-2-82 has been prepared by IEC technical committee 91: Electronics assembly technology.

This second edition cancels and replaces the first edition published in 2007. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

– extension of the scope of the test standard from electronic to electromechanic components and press-fit pins, which are used for assembly and interconnect technology;

– significant reduction of the testing effort by a knowledge-based selection of test conditions i.e. tests not relevant for a given materials system can be omitted (see Annex D);

– harmonization with JESD 201A by omission of severities M, N for temperature cycling tests;

– highly reduced test duration (1 000 h instead of 4 000 h) for damp-heat test by introducing test condition at elevated humidity of 85 % R.H. and a temperature of 85 °C providing increased severity.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
91/1562/FDIS	91/1573/RVD

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

A list of all parts in the IEC 60068 series, published under the general title *Environmental testing*, can be found on the IEC website.

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

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

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ENVIRONMENTAL TESTING –

Part 2-82: Tests – Test Xw_1: Whisker test methods for components and parts used in electronic assemblies

1 Scope

This part of IEC 60068 specifies tests for the whiskering propensity of surface finishes of electric or electronic components and mechanical parts such as punched/stamped parts (for example, jumpers, electrostatic discharge protection shields, mechanical fixations, press-fit pins and other mechanical parts used in electronic assemblies) representing the finished stage, with tin or tin-alloy finish. Changes of the physical dimensions of mould compounds, plastics and the like during the required test flow are not considered or assessed. The test methods have been developed by using a knowledge-based approach.

This document can also be used at sub-suppliers, like plating shops, stamping shops or other service providers to ensure a consistent surface quality within the supply chain.

These test methods are employed with defined acceptance criteria by a relevant component or application specification.

The tests described in this document are applicable for initial qualification, for periodic monitoring in accordance with Clause 7, and for changes of technology or manufacturing processes of existing surfaces in accordance with Clause 9.

The mating area of connectors is not covered by this test method. IEC 60512-16-21 applies for the mating areas of connectors.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60068-1:2013, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-14:2009, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-20, *Environmental testing – Part 2-20: Tests – Test T: Test methods for solderability and resistance to soldering heat of devices with leads*

IEC 60068-2-58, *Environmental testing – Part 2-58: Tests – Test Td: Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*

IEC 60068-2-67, *Environmental testing – Part 2-67: Tests – Test Cy: Damp heat, steady state, accelerated test primarily intended for components*

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

IEC 61192-3:2002, *Workmanship requirements for soldered electronic assemblies – Part 3: Through-hole mount assemblies*[1]

IEC 60512-16-21:2012, *Connectors for electronic equipment – Tests and measurements – Part 16-21: Mechanical tests on contacts and terminations – Test 16u: Whisker test via the application of external mechanical stresses*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
whisker
metallic protrusion that grows spontaneously during storage or use

Note 1 to entry: Whiskers typically do not require any electrical field for their growth and are not to be confused with products of electrochemical migration. Signs of whiskers include:

– striations in growth direction;

– typically no branching;

– typically constant diameters.

Exceptions are known, but are rare and can require detailed investigation.

For the purposes of this document, whiskers are considered if:

– they have an aspect ratio (length/width) greater than 2;

– they have a length of 10 µm or more.

Note 2 to entry: For the purposes of this document, whiskers have the following characteristics (see also Annex B):

– they can be kinked, bent, or twisted; they usually have a uniform cross-sectional shape;

– they may have rings around the circumference of the column.

Note 3 to entry: Whiskers are not to be confused with dendrites, which are fern-like growths on the surface of a material, which can be formed as a result of electro(chemical)-migration of an ionic species or produced during solidification.

Note 4 to entry: Whiskers are not to be confused with slivers as generated by mechanical metal processing. Whiskers are not to be confused with tubular SnO structures, which may develop under damp-heat test conditions. These structures are hollow and are typically lacking striations occurring on Sn whiskers.

3.2
termination
solderable element of a component consisting of the following elements

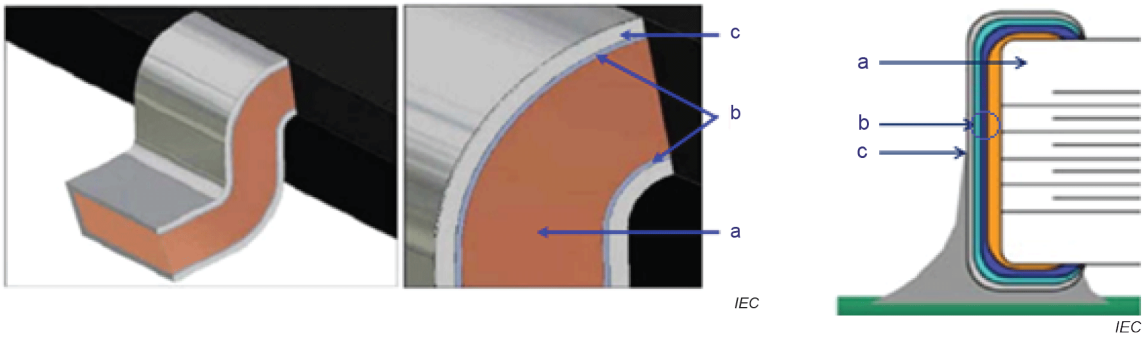
– base material;

– underlayer (or underlayer system, if more than one underlayer is present), if any, located under the final plating;

– final tin or tin alloy finish

[1] Withdrawn publication.

SEE: Figure 1



a) Gull wing termination **b) Chip termination**

Key

a base material

b underlayer (or underlayer system, if more than one underlayer is present), if any, located under the final plating

c final tin or tin alloy finish

Figure 1 – Cross-sectional views of component termination surface finishes

3.3
ΔCTE
CTE mismatch
coefficient of thermal expansion mismatch
coefficient calculated by taking the absolute after subtracting the CTE of the base material from the CTE of the surface finish layer:

$$\Delta CTE = | CTE_{finish} - CTE_{base\ material} |$$

Note 1 to entry: No underlayer system (e.g. Ni, Cu) has any influence on the CTE mismatch.

3.4
mechanical load
load related to the intended mounting/assembly condition of a particular specimen (e.g. press-fit application: stress exerted by the plated through-hole on the press-fit pin), or as a transitional load related to a mechanical process in a trim and form operation to adapt the shape of the specimen to the intended use condition (e.g. bending of a connector pin)

Note 1 to entry: Mechanical load in the context of these test methods is not related to external factors, e.g. thermo-mechanical loads arising from the mismatch of the coefficients of thermal expansion of the various constituents of a particular test specimen upon temperature change.

3.5
classification

3.5.1
level A
<general electronics products> consumer products, some computer and computer peripherals, and hardware suitable for applications where the major requirement is function of the completed assembly

3.5.2
level B
<dedicated service electronics products> communications equipment, sophisticated business machines, and instruments where high performance and extended life is required, and for which uninterrupted service is desired but not mandatory

Note 1 to entry: Typically, the end-use environment would not cause failures.

3.5.3
level C
<high performance electronics products> equipment where continued performance or performance-on-demand is mandatory; equipment downtime cannot be tolerated, end-use environment may be uncommonly harsh, and the equipment shall function when required, such as life support systems and other critical systems

Note 1 to entry: The classification of levels A, B and C is based on IEC 61191-1.

4 Test equipment

4.1 General

The test equipment shall comprise the following elements.

4.2 Desiccator

The desiccator shall be capable of providing the conditions of temperature and humidity specified in 6.2 and 6.5.

4.3 Humidity chamber

The humidity chamber shall meet all the requirements of IEC 60068-2-78 and be capable of providing the conditions specified in 6.3.

4.4 Thermal cycling chamber

The thermal cycling chamber shall meet all the requirements of IEC 60068-2-14, test Na and be capable of providing the conditions specified in 6.4.

4.5 Equipment for visual inspection

4.5.1 Scanning electron microscope

A scanning electron microscope (SEM) capable of investigating the surface of the specimen, preferably equipped with a handling system capable of tilting and rotating the specimen, is the preferred method of investigation owing to its high depth of focus.

4.5.2 Optical microscope/Confocal laser microscope

If not otherwise specified by the relevant specification, an optical microscope shall meet the following requirements:

– A stereo light microscope capable of using a magnification of at least 50 × (but variable magnification can be required for investigating different features) should be used for surveying the specimens.
– An optical microscope allowing at least magnifications of 200 × should be used for measuring whisker lengths. Illumination and/or specimen stage should be capable of illuminating whiskers from different directions (e.g. use of ring lights, flexible light-guides or rotatable fixing jigs).
– Availability of a wide range of working distances to achieve multiple focal planes.
– A suitable confocal laser microscope may also be employed.

4.6 Fixing jig

The jigs used for inspecting specimens in the optical microscope and the SEM shall meet the following requirements:

– the jig shall be capable of tilting in every direction, up to a tilt angle of 45°;

– parts shall be firmly attached on the fixture when the jig is tilted.

Care shall be taken to avoid whiskers breaking off while attaching the specimen to, and handling the specimen with, the fixture jig.

5 Preparation for test

5.1 Selection of relevant tests

5.1.1 General

The samples shall represent finished (final) products as supplied to the customer (including sub-process steps like trim and form, brushing, post-plating). The appropriate test methods shall be selected according to the decision tree given in Figure 2.

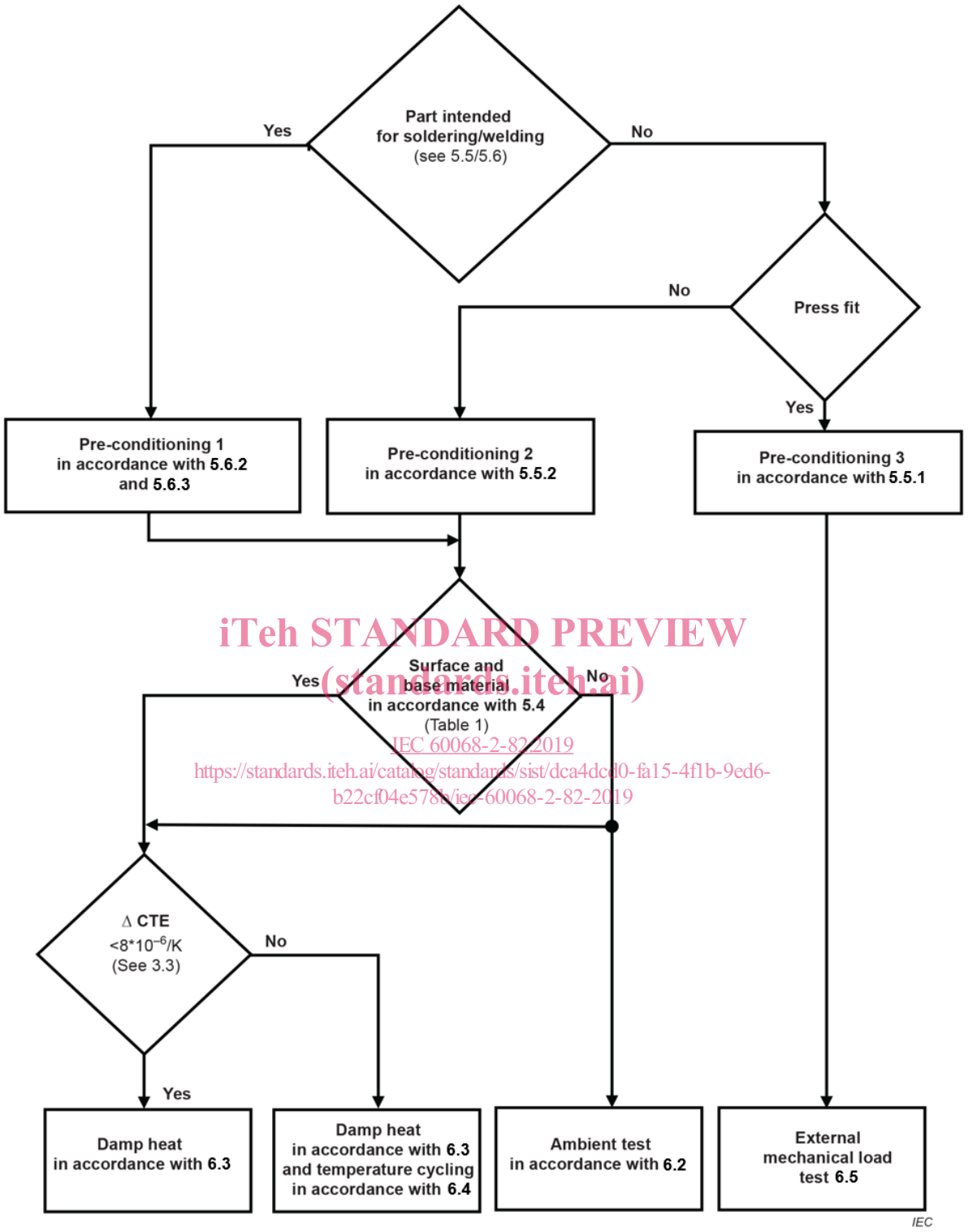


Figure 2 – Selection of test methods

5.1.2 Storage conditions prior to testing

The specimen shall be kept for at least 2 h in the standard atmospheric conditions defined by IEC 60068-1:2013, 4.3 prior to any preconditioning or test.

5.1.3 Pre-aging (storage in the supply chain) before testing

Different manufacturing processes and different manufacturing routes require adapted pre-aging times. The storage time prior to submitting specimens to preconditioning and testing shall be at least 30 days, but not longer than 120 days after tin (alloy) plating.

5.2 Handling of the specimens

It is recommended that specimens be handled with a fixing jig as specified in 4.6 to prevent contamination. Wherever possible, the fixing jig should not make contact with the metallic surfaces of the specimens. However, contamination inherent to the production process and the pre-conditioning shall not be removed (e.g. residues from plating or soldering, such as flux residues).

The specimens shall be handled carefully to prevent whiskers from breaking off unexpectedly. For required intermediate results reporting, already identified and broken whiskers (e.g. by handling) shall be recorded in the final report (see Clause 10).

5.3 Sample size

The following minimum sample size shall be adopted for each test condition and for each kind of preconditioning, unless other sample sizes are prescribed by the relevant specification.

Sample sizes for tests:

- All pins from 40 components with pin count per component < 4 pins.
- All pins from 20 components with pin count per component ≥ 4 pins and < 20 pins.
- All pins from 10 components with pin count per component ≥ 20 pins and < 40 pins.
- All pins from 5 components with pin count per component ≥ 40 pins, but not more than 400 pins.

- For mechanical parts like ESD protection shields, mechanical fixtures: ≥ 10 parts, up to an area of 25 cm^2.
- For press-fit applications: ≥ 200 single pins.
- For all other parts like jumpers, wires, parts for electrical connections, male multipoint connectors: ≥ 80 parts.
- For strip/belt galvanic: 25 cm^2 or minimum 30 cm taken from the start and the end of the coil.

The sample size applies to specimens with or without heat treatment in accordance with 5.5 and 5.6 and to each test condition selected from 5.1.

Similarity rules as given in 7.2 may be employed for the selection of samples.

5.4 Surface and base materials for test selection

Table 1 summarizes material systems recognized for their effective whisker mitigation, for which certain test conditions may be omitted (see Figure 2 and Annex D). The technical background for the omission of certain test conditions is briefly discussed in Annex D.

Table 1 applies to:

– copper-based base materials;
– ceramic-based materials;
– Fe and FeNi alloy base materials;

– other base materials which are covered with by a continuous Cu underlayer (those shall be treated as 'Cu alloy' in Table 1), with the exception of CuZn alloys. If a CuZn alloy is used, an Ni underlayer (0,5 µm to 4 µm) not exhibiting voids or cracks is required.

Table 1 – Material systems recognized for effective whisker mitigation

Part	Sn finish layer		Top underlayer	Base material	Post-treatment [d]
Electronic components Solder area of electro-mechanic components such as connectors, shieldings, etc.	Galvanic matt (Carbon content in the finish < 150 parts per million in weight. Target value, measured minimum 2 µm below the surface).	Minimum 3 µm Sn	Galvanic Ni [c] 0,5 µm to 4 µm	Cu alloy	No post-treatment
			Galvanic Ni [c] 2 µm to 15 µm	Ceramic, Fe and FeNi alloy	
		Minimum 3 µm Sn		Cu alloy	Reflow process [a]
				Ceramic, Fe and FeNi alloy	No post-treatment
		Minimum 7 µm Sn		Cu alloy	Annealing [b]
				Ceramic, Fe and FeNi alloy	No post-treatment
			Galvanic Ni [c] 1 µm to 3 µm	Cu alloy	No post-treatment
	Hot dip plating of Sn/SnAg/SnAgCu/SnCu0,7	Minimum 3 µm Sn		Cu alloy	No post-treatment
				Ceramic, Fe and FeNi alloy	
			Galvanic Ni [c] 1 µm to 3 µm	Cu alloy	
Other Sn alloys not covered by Table 1 may be used, but for these alloys, the ambient test cannot be omitted. Concerning the effectiveness of whisker mitigation, the use of galvanic matt Sn alloy finishes is currently under discussion. In particular, the following alloying elements are considered: Ag, Bi, Cu and Pb.					

[a] The Sn finish shall melt during the reflow process (e.g. > 10 s at 235 °C), without exhibiting discoloration or de-wetting.

[b] Annealing shall take place within 24 h after plating for at least one hour at a temperature of 150 °C or comparable conditions (e.g. 10 min at a temperature of 180 °C).

[c] Ni-layer shall not exhibit voids or cracks (ductile Ni).

[d] The post-treatment shall establish a homogeneous layer of Cu_6Sn_5 and/or Cu_3Sn with a thickness of at least 0,5 µm.

The temperature-cycling test of 6.4 may be omitted if the CTE mismatch (ΔCTE) (see 3.3) is less than 8×10^{-6}/K. The test conditions and the selection of test methods do not depend on the presence of any underlayer system (e.g. Ni, Cu).

5.5 Preconditioning of test specimen not intended for soldering/welding

5.5.1 Preconditioning of test specimen intended for press-fit applications

Unless otherwise specified by the relevant specification, press-fit pins shall be inserted into a plated through-hole of a laminated circuit board consisting of copper-clad epoxy woven E-glass (for example, in accordance with IEC 61249-2-7, IEC 61249-2-35 or IEC 61249-2-22) with the appropriate thickness and nominal finished hole diameter.