IEC 60749-21

Edition 3.0 2025-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Semiconductor devices - Mechanical and climatic test methods - Part 21: Solderability

Dispositifs à semiconducteurs - Méthodes d'essais mécaniques et climatiques - Partie 21: Brasabilité

IEC 60749-21:2025-12(en-fr)

ICS 31.080.01
ISBN 978-2-8327-0902-3

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IEC 60749-21 has been prepared by IEC technical committee 47: Semiconductor devices. It is an International Standard.

This third edition cancels and replaces the second edition published in 2011. This edition constitutes a technical revision.

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

a) revision to certain operating conditions in line with current working practices.

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

Draft	Report on voting
47/2961/FDIS	47/2982/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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– revised.

1 Scope

This part of IEC 60749 establishes a standard procedure for determining the solderability of device package terminations that are intended to be joined to another surface using tin-lead (SnPb) or lead-free (Pb-free) solder for the attachment.

This test method provides a procedure for "dip and look" solderability testing of through hole, axial and surface mount devices (SMDs) as well as an optional procedure for a board mounting solderability test for SMDs for the purpose of allowing simulation of the soldering process to be used in the device application. The test method also provides optional conditions for ageing.

This test is considered destructive unless otherwise detailed in the relevant specification.

NOTE 1 This test method does not assess the effect of thermal stresses which can occur during the soldering process. More details can be found in IEC 60749-15 or IEC 60749-20.

NOTE 2 If a qualitative test method is preferred, the Wetting balance test method can be found in IEC 60068-2-69.

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 61190-1-2:2014, *Attachment materials for electronic assembly - Part 1-2: Requirements for soldering pastes for high-quality interconnects in electronics assembly*

IEC 61190-1-3:2017, *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 Terms and definitions

No terms and definitions are listed in this document.

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

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

4 Test apparatus and materials

4.1 Solder bath

The solder bath shall be not less than 40 mm in depth and not less than 300 ml in volume such that it can contain at least 1 kg of solder. The apparatus shall be capable of maintaining the solder at the specified temperature within ±5 °C. The solder in solder baths used for solderability testing shall be analysed or replaced to ensure that the composition complies with 4.6.2.

4.2 Dipping device

A mechanical dipping device capable of controlling the rates of immersion and emersion of the terminations and providing a dwell time (time of total immersion to the required depth) in the solder bath as specified shall be used.

4.3 Optical equipment

An optical microscope capable of providing magnification inspection from 10× to 20× shall be used.

4.4 Steam ageing equipment

A non-corrodible container and cover of sufficient size to allow the placement of specimens inside the vessel shall be used. The specimens shall be placed such that the lowest portion of the specimen is a minimum of 40 mm above the surface of the water. A suitable method of supporting the specimens shall be improvised using non-contaminating material.

During steam ageing, the test devices should be located in a manner so as to prevent water (steam condensate) from dripping on them.

4.5 Lighting equipment

A lighting system shall be used that will provide a uniform, non-glare, non-directional illumination of the specimen.

4.6 Materials

4.6.1 Flux

Unless otherwise detailed in the relevant specification, the flux for SnPb solderability tests shall be a standard activated rosin flux (type ROL1 in accordance with Table 2 of IEC 61190-1-3:2017), having a composition of 25 % ± 0,5 % by weight of colophony and 0,15 % ± 0,01 % by weight of diethylammonium hydrochloride, in 74,85 % ± 0,5 % by weight of in 2-propanol (isopropanol). The specific gravity of the standard activated rosin flux shall be 0,843 ± 0,005 at (25 °C ± 2) °C.

The specification shall be as follows:

- Colophony
  - colour: to WW colour specification or paler;
  - acid value (mg KOH/g colophony): 155 (minimum);
  - softening point (ball and ring): 70 °C (minimum);
  - flow point (Ubbelohde): 76 °C (minimum);
  - ash: 0,05 % (maximum);
  - solubility: A solution of the colophony in an equal part by weight of 2-propanol (isopropanol) shall be clear, and after a week at room temperature there shall be no sign of a deposit.
- 2-propanol (isopropanol)
  - purity: minimum 99,5 % 2-propanol (isopropanol) by weight;
  - acidity as acetic acid: maximum 0,002 % weight (other than carbon dioxide);
  - non-volatile matter: maximum 2 mg per 100 ml.

Unless otherwise detailed in the relevant specification, the flux for Pb-free solderability tests shall be standard activated rosin flux having a composition of 25 % ± 0,5 % by weight of colophony and (0,39 % ± 0,01) % by weight of diethylammonium hydrochloride, in (74,61 % ± 0,5) % by weight of isopropyl.

4.6.2 Solder

4.6.2.1 Tin-lead

Unless otherwise detailed in the relevant specification, the solder specification for SnPb shall be as follows:

- chemical composition

The composition in percentage by weight shall be as follows:

- tin: 59 % to 61 %
- antimony: 0,5 % maximum
- copper: 0,1 % maximum
- arsenic: 0,05 % maximum
- iron: 0,02 % maximum
- lead: the remainder

The solder shall not contain such impurities as aluminium, zinc or cadmium in amounts which will adversely affect the properties of the solder.

- melting temperature range

The melting temperature range of the 60 % solder is as follows:

- completely solid: 183 °C
- completely liquid: 188 °C

4.6.2.2 Lead-free

Unless otherwise detailed in the relevant specification, the solder specification for Pb-free shall be as follows:

The composition in percentage by weight shall be as follows:

- tin: 95 % to 96,5 %
- silver: 3 % to 4 %
- copper: 0,5 % to 1 %

4.7 SMD reflow equipment

4.7.1 Stencil or screen

A stencil or screen with pad geometry opening that is appropriate for the terminals being tested. Unless otherwise agreed upon between vendor and user, nominal stencil thickness should be 0,1 mm for terminals with less than 0,5 mm component lead pitch, 0,15 mm for a component with lead pitch of 0,5 mm to 0,65 mm and 0,2 mm for a component with lead pitch greater than 0,65 mm.

4.7.2 Rubber squeegee or metal spatula

Solder paste shall be applied on to the stencil or screen using a spatula for fine pitch or a squeegee for standard pitch.

4.7.3 Test substrate

SMD specimens for simulated board mounting reflow solderability testing shall be evaluated using a substrate.

A ceramic (alumina 90 % – 98 %) may be used for all reflow requirements.

A glass epoxy substrate may be used for all reflow requirements. The glass epoxy substrate should be capable of withstanding the soldering temperature (e.g. it is not suitable for hot plate soldering).

For visual inspection of the tested device terminations, the test substrate should be unmetallized (no lands).

4.7.4 Solder paste

4.7.4.1 Requirements

Unless otherwise specified, the composition of the solder paste shall be as follows.

4.7.4.2 Pb-containing paste

The solder composition shall be as specified in 4.6.2.

Unless otherwise specified in the relevant specification, the particle size of the solder powder shall be 20 µm to 45 µm.

The composition of the flux shall be as specified in 4.6.1.

The viscosity range of the solder paste and method of measurement shall be detailed in the relevant specification.

4.7.4.3 Pb-free paste

The solder composition shall be as specified in 4.6.2.

The solder powder size shall be 4 as defined in Table 2 of IEC 61190-1-2:2014, as follows:

- less than 0,5 %, larger than 50 µm;
- 10 % maximum, between 38 µm and 50 µm;
- 80 % minimum, between 20 µm and 40 µm;
- less than 10 %, smaller than 20 µm.

The shape of solder powder shall be spherical.

The flux to be used shall consist of 30 wt % of polymerization rosin (softening point, approximately 95 °C), 30 wt % of dibasic acid degeneration rosin (softening point, approximately 140 °C), 34,7 wt % of diethylene glycol monobutyl ether, 0,9 wt % of 1,3-diphenylguanidine-HBr, 0,5 wt % of adipic acid (chlorine content less than 0,1 wt %) and 4 wt % of stiffening castor oil.

The solder paste to be used shall consist of 88 wt % of solder powder and 12 wt % of flux. The viscosity range shall be (180 ± 5) Pa s.

Paste storage and shelf life should be in accordance with manufacturer’s specifications.

4.7.5 Reflow equipment

Convection reflow ovens (preferred) or infrared reflow ovens capable of reaching the reflow temperature profile of the paste may be used.

4.7.6 Flux removal solvent

Material used for cleaning flux from leads and terminations shall be capable of removing visible flux residues and meet local environmental regulations.

5 Procedures

5.1 Lead-free backward compatibility

Typically, Pb containing terminations are evaluated using SnPb solderability test conditions and Pb-free terminations use Pb-free test conditions. If Pb-free terminations are to be used in an SnPb solder process (backward compatibility) then they should be evaluated using test parameters consistent with standard SnPb SMT reflow conditions. The backward compatibility test does not apply to Pb-free BGA type packages.

5.2 Preconditioning

5.2.1 General

Preconditioning, also known as accelerated ageing, is an optional step which can be required before solderability testing.

5.2.2 Preconditioning by steam ageing

5.2.2.1 Steam age preconditioning options

Steam age preconditioning options are given in Table 1.

Table 1 – Steam ageing conditions

Condition	Exposure time h ± 0,5
A	1
B	4
C	8
D	16

Ageing may be interrupted once for 10 min maximum.

WARNING: Mounting should be such that water does not collect on the surface to be tested.

Unless otherwise stated in the relevant specification, steam age precondition B should be used.

NOTE Preconditioning in a moist environment in order to test the effects of moisture and soldering heat of surface mount semiconductor packages is not part of this standard solderability test method. See IEC 60749-20.

Steam age precondition A should be used for NiPd and NiPdAu plated finishes.

5.2.2.2 Steam ageing procedure

Prior to solder application, specimens may be subjected to ageing by exposure of the surfaces to be tested to steam in the container specified in 4.4. The specimens shall be suspended so that no portion of the specimen is less than 40 mm above the boiling, distilled or deionized water for the specified exposure time. The water vapour temperature at the component lead level shall be in accordance with Table 2.

The devices shall be removed from the test apparatus upon completion of the specified test period.

Table 2 – Altitude versus steam temperature

Altitude m	**Steam temperature** °C $^{+3}_{-5}$
0 – 600	93
601 – 1 250	91
1 251 – 1 850	89
Greater than 1 850	87

5.2.2.3 Cleaning of the system

The apparatus shall be drained and cleaned at least once per month, or prior to use. A more frequent cleaning cycle can be necessary as indicated by resistivity, visual or general cleanliness of the water. No contaminating solvents shall be used.

5.2.2.4 Drying and storage procedures

Upon removing the test specimens from the apparatus, the parts may be dried using one of the following procedures:

a) bake at 100 °C maximum for no more than 1 h in a dry atmosphere (dry nitrogen atmosphere is recommended);

b) air dry at ambient temperature for a minimum of 15 min.

Parts not solderability tested within 2 h after removal from the ageing apparatus should be stored in a desiccant jar or dry nitrogen cabinet for a maximum of 72 h before testing. The parts should not be used for testing if they have exceeded the storage requirements.

5.2.3 Preconditioning by high temperature storage

As an alternative to steam ageing, specimens may be aged by high temperature storage at 150 °C ± 5 °C for between 4 h and 16 h.

5.3 Dip and look solderability testing

5.3.1 General

The test procedure shall be performed on the number of terminations specified in the relevant specification. During handling, care shall be exercised to prevent the surface to be tested from being abraded or contaminated by grease, perspirants, etc.

All solderability testing shall be carried out under a fume hood in accordance with applicable safety rules and procedures.