# IEC 60749-30

Edition 2.0 2020-08
REDLINE VERSION

# INTERNATIONAL STANDARD

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## Semiconductor devices – Mechanical and climatic test methods – Part 30: Preconditioning of non-hermetic surface mount devices prior to reliability testing

IEC 60749-30:2020-08 RLV(en)

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# SEMICONDUCTOR DEVICES – MECHANICAL AND CLIMATIC TEST METHODS –

## Part 30: Preconditioning of non-hermetic surface mount devices prior to reliability testing

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International Standard IEC 60749-30 has been prepared by IEC technical committee 47: Semiconductor devices.

This second edition cancels and replaces the first edition published in 2005 and Amendment 1:2011. This edition constitutes a technical revision.

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

a) inclusion of new Clause 3;

b) expansion of 6.7 on solder reflow;

c) inclusion of explanatory notes and clarifications.

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

| FDIS | Report on voting |
|---|---|
| 47/2633/FDIS | 47/2644/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.

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

A list of all parts in the IEC 60749 series, published under the general title *Semiconductor devices – Mechanical and climatic test methods*, can be found on the IEC website.

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

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- withdrawn,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

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# SEMICONDUCTOR DEVICES – MECHANICAL AND CLIMATIC TEST METHODS –

## Part 30: Preconditioning of non-hermetic surface mount devices prior to reliability testing

## 1 Scope

This part of IEC 60749 establishes a standard procedure for determining the preconditioning of non-hermetic surface mount devices (SMDs) prior to reliability testing.

The test method defines the preconditioning flow for non-hermetic solid-state SMDs representative of a typical industry multiple solder reflow operation.

These SMDs ~~should be~~ are subjected to the appropriate preconditioning sequence described in this document prior to being submitted to specific in-house reliability testing (qualification and/or reliability monitoring) in order to evaluate long term reliability (impacted by soldering stress).

NOTE 1 Correlation of moisture-induced stress sensitivity conditions (or moisture sensitivity levels (MSL)) in accordance with IEC 60749-20 and this document and the actual reflow conditions used are dependent upon identical temperature measurement by both the semiconductor manufacturer and the board assembler. Therefore, ~~it is recommended that~~ the temperature at the top of the package on the hottest moisture sensitive SMD during assembly ~~be~~ is monitored to ensure that it does not exceed the temperature at which the components are evaluated.

NOTE 2 For the purpose of this document, SMD is restricted to include only plastic-encapsulated SMDs and other packages made with moisture-permeable materials.

## 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 60749-4, *Semiconductor devices – Mechanical and climatic test methods – Part 4: Damp heat, steady state, highly accelerated stress test (HAST)*

IEC 60749-5, *Semiconductor devices – Mechanical and climatic test methods – Part 5: Steady-state temperature humidity bias life test*

IEC 60749-11, *Semiconductor devices – Mechanical and climatic test methods – Part 11: Rapid change of temperature – Two-fluid-bath method*

IEC 60749-20:~~2002~~2020, *Semiconductor devices – Mechanical and climatic test methods – Part 20: Resistance of plastic encapsulated SMDs to the combined effects of moisture and soldering heat*

IEC 60749-24, *Semiconductor devices – Mechanical and climatic test methods – Part 24: Accelerated moisture resistance – Unbiased HAST*

IEC 60749-25:2003, *Semiconductor devices – Mechanical and climatic test methods – Part 25: Temperature cycling*

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IEC 60749-33, *Semiconductor devices – Mechanical and climatic test methods – Part 33: Accelerated moisture resistance – Unbiased autoclave.*

## 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**
**dead-bug orientation**
orientation of a package with the terminals facing upwards

**3.2**
**floor life**
allowable time period after removal of moisture-sensitive devices from a moisture-barrier bag or dry bake and before the solder reflow process

**3.3**
**live-bug orientation**
orientation of a package when resting on its terminals

**3.4**
**moisture-sensitivity level**
MSL
rating indicating a device's susceptibility to damage due to absorbed moisture when subjected to reflow soldering

**3.5**
**process sensitivity level**
PSL
rating used to identify a component that is solder process sensitive and which cannot be used in one or more of the base solder process conditions

**3.6**
**solder reflow**
solder attachment process in which previously applied solder or solder paste is melted to attach a device to a printed circuit board

## 4 General description

Package cracking and electrical failure in plastic encapsulated SMDs can result when soldering heat raises the vapour pressure of moisture which has been absorbed into SMDs during storage. In this test method, such problems are assessed and SMDs are evaluated for heat resistance after being soaked in an environment which simulates moisture being absorbed while under storage in a warehouse or dry pack.

## 5 Test apparatus and materials

### 5.1 General

This test method requires, as a minimum, access to the following equipment.

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### 5.2 Moisture chamber

Moisture chamber(s) capable of operating at 85 °C/85 % RH (relative humidity), 85 °C/60 % RH, 85 °C/30 % RH, 30 °C/70 % RH and 30 °C/60 % RH. Within the chamber working area, temperature tolerance shall be ±2 °C and the RH tolerance shall be ±3 % RH. A chamber with 60 °C/60 % RH capability is optional for accelerated soak conditions.

### 5.3 Solder equipment

Solder equipment shall consist of the following.

a) 100 % convection reflow system capable of maintaining the reflow profiles required by this document. This is the preferred equipment for solder reflow.

b) VPR (vapour phase reflow) chamber capable of operating ~~from 215-219 °C and/or (235 ± 5) °C~~ the temperature profiles in IEC 60749-20 with appropriate fluids. The chamber shall be capable of heating the packages without collapsing the vapour blanket and of re-condensing the vapour to minimize loss of the vapour phase soldering liquid. The vapour phase soldering fluid shall vaporize at the appropriate temperature specified above.

c) Infrared (IR)/convection solder reflow equipment capable of maintaining the reflow profiles required by this document. It is recommended that this equipment use the IR to heat the air and not directly impinge upon the components under test.

d) Wave-solder equipment capable of maintaining the conditions ~~of item d)3) of Clause 5~~ in 6.4.4 of IEC 60749-20:2020.

NOTE The moisture sensitivity condition (classification) test results are dependent upon the package body temperature, rather than board or lead temperature. Convection and VPR are known to be more controllable and repeatable than IR. When there are correlation problems between VPR, IR/convection, convection and wave solder (if used), the convection results ~~should be~~ are considered as the standard.

### 5.4 Optical microscope

Optical microscope (40X for external visual examination).

### 5.5 Electrical test equipment

Electrical test equipment capable of performing room temperature DC ~~test~~ and functional tests.

### 5.6 Drying (bake) oven

Oven for drying (bake) capable of operating at 125 $^{+5}_{0}$ °C.

### 5.7 Temperature cycle chamber (optional)

A temperature cycle chamber capable of operating as a minimum over a range of −40 $^{0}_{-10}$ °C to +60 $^{+10}_{0}$ °C in accordance with IEC 60749-25. Acceptable alternative test conditions and temperature tolerances are found in Table 1 of IEC 60749-25:2003. This equipment is only required if 6.3 ~~, the shippability option,~~ is used.

## 6 Procedure

### 6.1 General

It is recommended that a prior evaluation ~~should~~ be run according to the moisture sensitivity levels (MSLs) detailed in IEC 60749-20, using the appropriate method and similar devices, to determine which preconditioning sequence is suitable, i.e. likely to pass. Other moisture

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evaluation data ~~may~~ can be consulted. However, the soak sequence in 6.5 needs to be consistent with the floor life information in ~~Tables 4a and 4b~~ Table 1 and Table 2.

Reflow requirements are provided for both Pb-free and legacy SnPb conditions and are used based on the intended end use of the SMD. The same package can have different MSL levels depending on whether the SnPb or Pb-free reflow is used.

At all times the test parts shall be handled using appropriate ESD procedures.

## 6.2 Initial measurements

### 6.2.1 Electrical test

Perform an electrical DC test and functional test to verify that the devices meet the room temperature data sheet specification. Replace any devices that fail to meet this requirement.

### 6.2.2 Visual inspection

Perform an external visual examination under 40X optical magnification to ensure that no devices with external cracks or other damage are used in this test method. If mechanical rejects are found, corrective action shall be implemented in the manufacturing process and a new sample drawn from a product which has been processed with the corrective action.

## 6.3 Temperature cycling (optional)

Perform 5 cycles of temperature cycle from −40 °C (or lower) to +60 °C (or higher) to simulate shipping conditions (the shippability option). This step is optional unless required by the relevant specification.

## 6.4 Drying (bake out)

Bake the devices for at least 24 h minimum at (125 ± 5) °C. This step is intended to remove moisture from the package so that it will be "dry".

NOTE 1 This time ~~may be~~ is modified if desorption data on the particular device being preconditioned shows that more or less time is required to obtain a "dry" package.

NOTE 2 If the preconditioning sequence is being performed by the semiconductor manufacturer, steps 6.2.1, 6.2.2 and 6.4 are optional since they are at the supplier's own risk. If the preconditioning sequence is being performed by the user, step 6.8 is optional.

## 6.5 Soak conditions for dry-packed SMDs

### 6.5.1 General

The following soak conditions shall apply ~~to the levels shown in Table 1, Table 2, Table 4a and Table 4b~~. It is recommended that the soak ~~should~~ be initiated within 2 h of bake.

### 6.5.2 Method A for dry-packed SMDs in accordance with IEC 60749-20

This test shall be carried out in accordance with ~~item c)1)i) of Clause 5~~ 6.3.3.2, method A, of IEC 60749-20:2020 and Table 1 of this document.

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~~**Table 1 – Moisture soak conditions for dry-packed SMDs (method A)**~~

| ~~Condition~~ | | ~~Moisture soak conditions~~ | ~~Permissible storage conditions in the dry pack and the dry cabinet~~ | ~~Condition of floor life~~ |
|---|---|---|---|---|
| ~~First-stage conditioning~~ | ~~A1~~ | ~~(85 ± 2) °C, (30 ± 5) % RH, 168 $^{24}_{-0}$ h~~ | ~~<30 °C, 30 % RH, 1 year~~ | ~~–~~ |
| ~~Second-stage conditioning~~ | ~~A2~~ | ~~(30 ± 2) °C, (70 ± 5) % RH, 168 $^{24}_{-0}$ h~~ | ~~–~~ | ~~<30 °C, 70 % RH, 168 h~~ |

~~NOTE 1 The first stage of conditioning represents storage conditions in the dry pack and the dry cabinet, as well as increasing relative humidity in the dry pack, by repacking the SMDs at the distributor's facility and the user's inspection facility. When condition A1 is applied, the SMDs should be packed into a moisture-proof bag with packing materials and desiccants within a few weeks of drying. They may then be subjected to multiple temporary openings of the moisture-proof bag (for several hours at a time). Repack and inspection of SMDs are possible while the humidity indicator in the dry pack indicates less than 30 % RH, since SMDs will recover the initial condition of absorbed moisture within a few days of repacking. In this case, the moisture content measurement of SMDs (see Clause B.2 of IEC 60749-20) is not needed as a moisture control of the dry pack. A check of the moisture indicator is sufficient for moisture control.~~

~~NOTE 2 When moisture soak of the first-stage conditioning does not result in saturation, the soak time is extended to 336 h, because SMDs in a dry pack or dry cabinet will become saturated with moisture during long-term storage. When moisture soak of the first stage of conditioning reaches saturation, the soak time is shortened.~~

### 6.5.3 Method B for dry-packed SMDs in accordance with IEC 60749-20

~~This shall be carried out in accordance with item c)1)ii) of Clause 5, Method B, of IEC 60749-20 (see Table 2).~~

~~a) Subject condition B1 (MSL level 2) devices to 168 h of 85 °C/60 % RH.~~

~~b) Subject conditions B2–B6 devices to "Z" h (see Table 2) of 30 °C/60 % RH.~~

~~**Table 2 – Required soak times in hours for method B, conditions B2 – B6 (MSL levels 3 – 6)**~~

| ~~Method B condition (MSL level)~~ | ~~Z~~<br>~~Total moisture soak~~<br>~~h~~ | ~~X~~<br>~~Total conditions from baking to dry packing and temporary opening of the dry pack~~<br>~~h~~ | ~~Y~~<br>~~Floor life~~<br>~~h~~ |
|---|---|---|---|
| ~~B2 (3)~~ | ~~192~~ | ~~24~~ | ~~168~~ |
| ~~B3 (4)~~ | ~~96~~ | ~~24~~ | ~~72~~ |
| ~~B4 (5)~~ | ~~72~~ | ~~24~~ | ~~48~~ |
| ~~B5 (5a)~~ | ~~48~~ | ~~24~~ | ~~24~~ |
| ~~B6 (6)~~ | ~~6 or the value shown on the label~~ | ~~0~~ | ~~6 or the value shown on the label~~ |

~~NOTE 1 X is manufacturer's exposure time between bake and dry pack plus the maximum time allowed out of the bag at the distributors (in hours). The X values shown above are default values. If the semiconductor manufacturer's actual time between bake and bag plus the allowed time out of the bag at the distributor is greater than the default value, the actual time should be used. If the actual X value is less than 24 h, the actual time may be used.~~

~~NOTE 2 Y is the floor life (in hours) of the package after opening the dry pack.~~

~~NOTE 3 Z is the total required soak time in hours.~~

~~NOTE 4 The values of Z and Y for condition B6(6) are alternatives.~~

This shall be carried out in accordance with 6.3.3.3, method B, of IEC 60749-20:2020 and Table 2 of this document.

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### 6.6 ~~Method C for~~ Soak conditions for non-dry-packed SMDs in accordance with IEC 60749-20

~~For the one level shown in Table 4c, Condition C (Level 1) devices shall be subjected to 168 h of 85 °C/85 % RH. The soak should be initiated within 2 h of bake.~~

~~**Table 3 – Moisture soak conditions for non-dry-packed SMDs**~~

| ~~Condition~~ | ~~Temperature °C~~ | ~~Relative humidity %~~ | ~~Duration time h~~ | ~~Permissible limit on actual storage~~ |
|---|---|---|---|---|
| ~~C~~ | ~~85 ± 2~~ | ~~85 ± 5~~ | ~~168 ± 24~~ | ~~Unlimited floor life, <30 °C, 85 % RH~~ |

This shall be in accordance with 6.3.2 of IEC 60749-20:2019 and Table 3 of this document.

### 6.7 Solder reflow

#### 6.7.1 Solder reflow procedure

Not sooner than 15 min and not longer than 4 h after removal from the temperature/humidity chamber, submit the devices to three cycles of the appropriate reflow conditions in accordance with IEC 60749-20. All temperatures refer to the top surface of the package. The sample parts shall be cooled sufficiently for at least 5 min (preferably back to room temperature) between reflow cycles so that the reflow temperatures/times of the samples are not affected on the subsequent reflow cycles.

~~The devices shall be allowed to cool at room ambient conditions for 5 min minimum between reflow cycles.~~

Reflow practices shall be sufficient to ensure that all sample parts, in each reflow cycle, will meet the appropriate reflow profile requirements of IEC 60749-20. SMDs intended for use in a "Pb-free" assembly process shall be evaluated using the "Pb-free" reflow temperature whether or not the SMD is Pb-free. If parts are reflowed in other than the normal assembly reflow orientation (i.e. live-bug/dead-bug) the damage response shall be correlated.

The reflow oven shall be loaded with the same configuration or be verified to have an equivalent thermal load when running preconditioning as was used to develop the reflow profile. The reflow profiles in IEC 60749-20 are only for classification and preconditioning and are not intended to specify board assembly profiles. Actual board assembly profiles shall be developed based on specific process needs and board designs and shall not exceed the parameters in IEC 60749-20.

If the timing between removal from the temperature/humidity chamber and initial reflow cannot be met then the parts shall be rebaked and resoaked in accordance with 6.4 and 6.5.

NOTE 1 The three reflow cycles represent the following:

- Cycle 1 – the first pass of a double-sided, double-pass (DSDP) assembly reflow process.
- Cycle 2 – the second pass of a DSDP assembly reflow process.
- Cycle 3 – rework of a near neighbor on the assembly where the SMD being classified experiences reflow-like temperatures.

NOTE 2 For SMDs that cannot be subjected to three reflows, only the number of reflows for which the SMD is classified is performed.

#### 6.7.2 Solder attachment after reflow

If reliability testing is to be performed in a second level configuration, one of the reflow cycles can be used to attach the sample to the test board. If the board assembly is to be performed

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at a later time then the sample, at the user's discretion, can be baked and vacuum sealed until such time that it is solder attached to the test board or facsimile. The profile used to attach the sample to the test board can be optimized for the soldering operation, but the other two passes shall meet the profile requirements of IEC 60749-20.

Since the board attachment replicates a real life process with flux application, reflow and cleaning, steps 6.8.1 and 6.8.2 are no longer necessary or mandated prior to submission to reliability stress testing. Flux type shall be documented in accordance with Clause 7.

NOTE Bumped die devices are commonly soldered to test boards, due to the potential of inflicting handling damage on the loose devices while performing the preconditioning, qualification stresses, and functional testing. If the third reflow pass is used to solder the bumped die devices to boards, one is careful to minimize damage to the bumped die. If the damage is severe, it could cause devices to fail electrically during the next functional test; if the damage is less severe, it could weaken devices that then fail during reliability stress testing. It can be difficult to determine the root cause for fails if handling damage has occurred.

## 6.8 Flux application simulation (optional)

### 6.8.1 Flux application

After the reflow solder cycles are completed, allow the devices to cool at room ambient temperature for at least 15 min ~~minimum~~. Apply an activated water-soluble flux to the device leads by bulk immersion of the entire parts in flux at room ambient temperature for at least 10 s ~~minimum~~. ~~Flux application is optional unless required by the relevant specification.~~

Ball grid array (BGA), column grid array (CGA) and organic substrate land grid array (LGA) packages do not require flux dipping because their typical board application methods do not use liquid fluxes. Step 6.8.2 is not required when flux dipping is omitted for these package types.

Flux application is to be omitted for any surface mount device that has a flux or washing limitation.

### 6.8.2 Cleaning and drying after flux application

Clean devices using multiple agitated deionized water rinses. No waiting time is required between flux application and cleaning. Devices ~~should~~ shall be dried at room ambient temperature prior to the next step.

## 6.9 Final measurements

### 6.9.1 Electrical test

Submit the devices to an electrical DC testing and functional testing in accordance with the room temperature data sheet specification.

### 6.9.2 Visual inspection

Perform an external visual examination under 40X optical magnification to ensure that no devices have developed external cracks.

Any valid failures found at this point due to the preconditioning sequence indicate that the device ~~may~~ can have been classified in the wrong level (MSL or PSL). Failure analysis ~~should~~ shall be conducted, and, if appropriate, this device type ~~should~~ shall be re-evaluated to determine the correct moisture sensitivity level. This would require re-submitting a sample to the correct level preconditioning sequence prior to reliability testing in accordance with 6.10.

NOTE For the semiconductor manufacturer, the final measurement step is optional and ~~may~~ can be omitted since it is at the supplier's own risk.

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