

INTERNATIONAL STANDARD



**Semiconductor devices – Mechanical and climatic test methods –
Part 20-1: Handling, packing, labelling and shipping of surface-mount devices
sensitive to the combined effect of moisture and soldering heat**



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IEC 60749-20-1

Edition 2.0 2019-06
REDLINE VERSION

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**Semiconductor devices – Mechanical and climatic test methods –
Part 20-1: Handling, packing, labelling and shipping of surface-mount devices
sensitive to the combined effect of moisture and soldering heat**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.080.01

ISBN 978-2-8322-7124-7

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SEMICONDUCTOR DEVICES – MECHANICAL AND CLIMATIC TEST METHODS –

Part 20-1: Handling, packing, labelling and shipping of surface-mount devices sensitive to the combined effect of moisture and soldering heat

FOREWORD

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This second edition cancels and replaces the first edition published in 2009. This edition constitutes a technical revision.

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

- a) updates to subclauses to better align the test method with IPC/JEDEC J-STD-033C, including new sections on aqueous cleaning and dry pack precautions;
- b) addition of two annexes on colorimetric testing of HIC (humidity indicator card) and derivation of bake tables.

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

FDIS	Report on voting
47/2565/FDIS	47/2579/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.

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 publication will remain unchanged until the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
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INTRODUCTION

The advent of surface-mount devices (SMDs) introduced a new class of quality and reliability concerns regarding package damage "cracks and delamination" from the solder reflow process. This document describes the standardized levels of floor life exposure for moisture/reflow-sensitive SMDs along with the handling, packing and shipping requirements necessary to avoid moisture/reflow-related failures. IEC 60749-20 defines the classification procedure and Annex A of this document defines the labelling requirements.

Moisture from atmospheric humidity enters permeable packaging materials by diffusion. Assembly processes used to solder SMDs to printed circuit boards (PCBs) expose the entire package body to temperatures higher than 200 °C. During solder reflow, the combination of rapid moisture expansion, materials mismatch, and material interface degradation can result in package cracking and/or delamination of critical interfaces within the package.

~~The solder reflow processes of concern are convection, convection/IR, infrared (IR), vapour phase (VPR) and hot air rework tools. The use of assembly processes that immerse the component body in molten solder are not recommended for most SMDs.~~

~~This first edition of IEC 60749-20-1 is based principally on IPC/JEDEC J-STD-033¹ and the permission to use this standard is gratefully acknowledged. It is also based on contributing documents from various national committees.~~

Typical solder reflow processes of concern for all devices are infrared (IR), convection/IR, convection, vapour phase reflow (VPR), hot air rework tools, and wave solder, including full immersion.

Non-semiconductor devices can exhibit additional process sensitivities beyond moisture sensitivity such as thermal sensitivity, flux sensitivity, or cleaning process sensitivity.

¹ ~~Refer to Bibliography.~~

SEMICONDUCTOR DEVICES – MECHANICAL AND CLIMATIC TEST METHODS –

Part 20-1: Handling, packing, labelling and shipping of surface-mount devices sensitive to the combined effect of moisture and soldering heat

1 Scope

This part of IEC 60749 applies to all ~~non-hermetic SMD packages which are subjected to reflow solder processes and~~ devices subjected to bulk solder reflow processes during PCB assembly, including plastic encapsulated packages, process sensitive devices, and other moisture-sensitive devices made with moisture-permeable materials (epoxies, silicones, etc.) that are exposed to the ambient air.

The purpose of this document is to provide SMD manufacturers and users with standardized methods for handling, packing, shipping, and use of moisture/reflow sensitive SMDs that have been classified to the levels defined in IEC 60749-20. These methods are provided to avoid damage from moisture absorption and exposure to solder reflow temperatures that can result in yield and reliability degradation. By using these procedures, safe and damage-free reflow can be achieved, with the dry packing process, providing a minimum shelf life capability in sealed dry-bags from the seal date.

Two test conditions, method A and method B, are specified in the soldering heat test of IEC 60749-20. For method A, moisture soak conditions are specified on the assumption that moisture content inside the moisture barrier bag is less than 30 % RH. For method B, moisture soaking conditions are specified on the assumption that manufacturer's exposure time (MET) does not exceed 24 h and the moisture content inside the moisture barrier bag is less than 10 % RH. In an actual handling environment, SMDs tested by method A are permitted to absorb moisture up to 30 % RH, and SMDs tested by method B are permitted to absorb moisture up to 10 % RH. This document specifies the handling conditions for SMDs subjected to the above test conditions.

NOTE Hermetic SMD packages are not moisture sensitive and do not require moisture precautionary handling.

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

IEC 60749-30, *Semiconductor devices – Mechanical and climatic test methods – Part 30: Preconditioning of non-hermetic surface mount devices prior to reliability testing*

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

active desiccant

desiccant that is either fresh (new) or has been baked according to the manufacturer's recommendations to renew it to original specifications

3.2

bar code label

label that gives information in a code consisting of parallel bars and spaces, each of various specific widths

Note 1 to entry: For the purposes of this document, the bar code label is on the lowest level shipping container and includes information that describes the product, e.g. part number, quantity, lot information, supplier identification, ~~and moisture-sensitivity level etc.~~

3.3

mass reflow

reflow of a number of components with simultaneous attachment by an infrared (IR), convection/IR, convection, or vapour phase reflow (VPR) process

3.4

carrier

container that directly holds components such as a tray, tube, or tape and reel

3.5

desiccant

absorbent material used to maintain a low relative humidity

3.6

floor life

allowable time period for a moisture-sensitive device, after removal from a moisture barrier bag, dry storage or dry bake and before the solder reflow process

3.7

humidity indicator card

HIC

~~card on which a moisture sensitive chemical is applied in such a way that it will make a significant, perceptible change in colour (hue), typically from blue (dry) to pink (wet) when the indicated relative humidity is exceeded~~

card printed with a moisture-sensitive chemical (cobalt bromide) that changes from blue to pink in the presence of water vapour

Note 1 to entry: The HIC is packed inside the moisture-barrier bag, along with a desiccant, to aid in determining the level of moisture to which the moisture-sensitive devices have been subjected.

Note 2 to entry: This note applies to the French language only.

3.8

manufacturer's exposure time

MET

maximum time after bake that the component manufacturer requires to process components prior to bag seal, and that also includes the maximum time allowed at the distributor for having the bag open to split out smaller shipments

Note 1 to entry: This note applies to the French language only.

3.9 **moisture barrier bag** **MBB**

~~bag designed to restrict the transmission of water vapour and used to pack moisture-sensitive devices~~

storage bag manufactured with a flexible laminated vapour barrier film that restricts the transmission of water vapour

Note 1 to entry: This note applies to the French language only.

3.10 **rework**

removal of a component for scrap, reuse, or failure analysis; replacement of an attached component; or heating and repositioning of a previously attached component

3.11 **shelf-life**

maximum storage period for a dry-packed moisture-sensitive device in an unopened moisture barrier bag (MBB) to avoid exceeding the specified interior bag ambient humidity

3.12 **surface-mount device** **SMD**

plastic-encapsulated surface-mount devices made with moisture-permeable materials

Note 1 to entry: For the purposes of this document, the term "SMD" is limited as indicated in the [above](#) definition.

3.13 **solder reflow**

solder attachment process in which previously applied solder or solder paste is melted to attach a component to the printed circuit board

3.14 **water vapour transmission rate** **WVTR**

measure of the permeability of plastic film or metallized plastic film material to moisture

4 General applicability and reliability considerations

4.1 Assembly processes

4.1.1 Mass reflow

This document applies to mass solder reflow assembly by convection, convection/IR, infrared (IR), and vapour phase (VPR), processes. It does not apply to mass solder reflow processes that immerse the component bodies in molten solder (e.g. wave soldering bottom mounted components). Such processes are not allowed for many SMDs and are not covered by the component qualifications standards used as a basis for this document.

4.1.2 Localized heating

This document also applies to moisture-sensitive SMDs that are removed or attached singly by local ambient heating, i.e. "hot air rework". See Annex B.

4.1.3 Socketed components

This document does not apply to SMDs that are socketed and not exposed to solder reflow temperatures. Such SMDs are not at risk and do not require moisture precautionary handling.

4.1.4 Point-to-point soldering

This document does not apply to SMDs in which only the leads are heated to reflow the solder, e.g. hand-soldering, hot bar attach of gull-wing leads, and through hole by wave soldering. The heat absorbed by the SMD body from such operations is typically much lower than that for mass surface mount reflow or hot air rework, and moisture precautionary measures are typically not needed.

4.1.5 Aqueous cleaning

For non-cavity SMDs, typical short-term aqueous cleaning processes will not impact the floor life (internal moisture content). Special consideration should be given to non-hermetic cavity packages.

4.2 Reliability

The methods set forth in this specification ensure that an adequate SMD reliability can be achieved during and after the PCB assembly operation, when the SMDs are evaluated and verified by IEC 60749-20 and/or by IEC 60749-30, together with environmental reliability testing.

This specification does not address or ensure solder joint reliability of attached components.

5 Dry packing

5.1 Requirements

Dry packing requirements for the various moisture sensitivity levels are shown in Table 1. The levels are determined in accordance with IEC 60749-20 and/or IEC 60749-30, together with reliability testing. As a minimum, all materials used in dry packing should conform to relevant national packaging material standards for ESD-sensitive items.

Table 1 – Dry packing requirements

Level	Dry before bag	MBB	Desiccant	MSID ^a label	Caution label
A1 or B1	Optional	Optional	Optional	Not required	Not required if classified at 220 °C to 225 °C
					Required ^b if classified at other than 220 °C to 225 °C
A2 or B2	Optional	Required	Required	Required	Required
B2a-B5a	Required	Required	Required	Required	Required
B6	Optional	Optional	Optional	Required	Required
^a MSID = moisture-sensitive identification label. ^b A "Caution" label is not required if level and reflow temperature are given, in human readable form, on the barcode label attached to the lowest level shipping container.					

5.2 Drying of SMDs and carrier materials before being sealed in MBBs

5.2.1 Drying requirements – level A2

Packing of the SMDs classified as Level A2 into MBBs shall be carried out within one week under the environmental condition below 30 °C/60 % RH after moulding, burn-in, or bake.

MET is not specified for Level A2 SMDs.

MBBs may be opened for a short period of time (less than 1 h) and re-closed provided that the HIC indicates a humidity of less than 30 % RH and provided that the desiccant is replaced with fresh desiccant. When the MBB is next opened, as long as the HIC indicates below 30 % RH, the duration time of the previous MBB's opening may be disregarded. Thus, if the HIC indicates below 30 % RH when MBB is opened, the floor life is not dependent on the duration time of the MBB's opening, and is 168 h at 30 °C/70 % RH.

5.2.2 Drying requirements – levels B2a to B5a

SMDs classified from Levels B2a through to B5a shall be dried (see Clause 6) prior to being sealed in MBBs. The period between drying and sealing shall not exceed the MET less the time allowed for distributors to open the bags and repack parts. If the supplier's actual MET is more than the default 24 h, then the actual time shall be used. If the distributor practice is to repack the MBBs with active desiccant, then this time does not need to be subtracted from the MET.

5.2.3 Drying requirements – carrier materials

The materials from which carriers (such as trays, tubes, reels, ~~etc.~~) are made can affect the moisture level when placed in the MBB. Therefore, the effect of these materials shall be compensated for by baking or, if required, adding additional desiccant in the MBB to ensure the shelf life of the SMDs (see 6.3).

5.2.4 Drying requirements – other

Suppliers may use the drying effect of normal in-line processes such as post-mould cure, marking cure, and burn-in to reduce the bake time. An equivalency evaluation is recommended to ensure that high-temperature processing maintains moisture weight gain to an acceptable level. The total weight gain for the SMD at the time it is sealed in the MBB shall not exceed the moisture gain of that SMD starting dry and then being exposed to 30 °C/60 % RH for MET h (less the time for distributors).

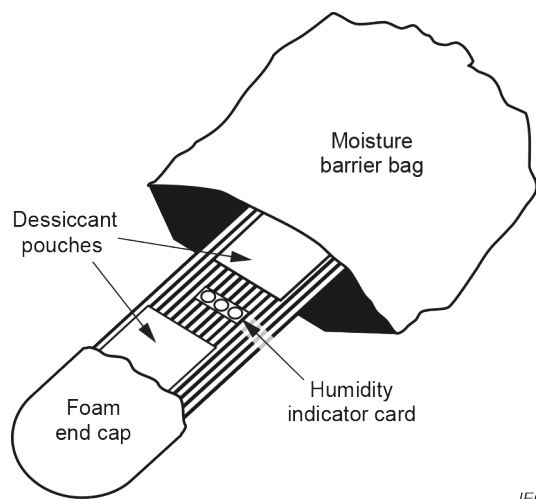
5.2.5 Excess time between bake and bag

If the allowable time between bake and bag is exceeded, the SMDs shall be redried in accordance with Clause 6.

5.3 Dry pack

5.3.1 Description

A dry pack consists of desiccant material and a humidity indicator card (HIC) sealed with the SMDs and their carriers inside a moisture barrier bag (MBB). A representative dry pack configuration is shown in Figure 1.



IEC

Figure 1 – Typical dry pack configuration for moisture-sensitive SMDs in shipping tubes

5.3.2 Materials

5.3.2.1 Moisture barrier bag (MBB)

The moisture barrier bag shall meet relevant national standard requirements for flexibility, ESD protection, mechanical strength, and puncture resistance. The bags shall be heat-sealable. The water vapour transmission rate (WVTR) shall be $\leq 0,03 \text{ g/m}^2$ in 24 h at 40 °C after flex testing in accordance with relevant national standards governing flex durability of flexible barrier materials. The WVTR is measured using relevant national standards governing water vapour transmission rate through plastic film and sheeting using a modulated infrared sensor.

5.3.2.2 Desiccant

The desiccant material shall comply with relevant national standards governing activated desiccants used for the static dehumidification of packaging bags. Desiccant shall be dustless, non-corrosive, and absorbent to amounts specified in the standard. The desiccant shall be packaged in moisture-permeable bags. The amount of desiccant used, per moisture barrier bag, shall be based on the bag surface area and WVTR in order to maintain an interior relative humidity in the MBB of less than 30 % at 25 °C for SMD classification A2 and less than 10 % at 25 °C for SMDs classified from Levels B2a to B5a.

For comparison between various desiccant types, certain specifications adopted the "UNIT" as the basic unit of measure of quantity for desiccant material. A UNIT of desiccant is defined as the amount that will absorb a minimum of 2,85 g of water vapour at 20 % RH and 25 °C. To meet the dry pack requirements of this document, the amount of water vapour that a UNIT of desiccant can absorb at 10 % RH and 25 °C ~~must~~ shall be known.

When the desiccant capacity at 10 % RH and 25 °C is known, the following equation should be used.

$$U = (0,003 \times M \times WVTR \times A)/D \quad (1)$$

where

U = amount of desiccant in UNITS;

M = shelf life desired in months;

$WVTR$ = water vapour transmission rate in g/m^2 in 24 h;

- A = total surface area of the MBB in m^2 ;
 D = amount of water in grams, that a UNIT of desiccant will absorb at 10 % RH and 25 °C.

When the desiccant capacity at 10 % RH and 25 °C is not known, the quantity needed can be estimated using the following simplified equation.

$$U = 8 \times A \quad (2)$$

where

U = amount of desiccant in UNITS;

A = total surface area of the MBB in m^2 .

~~NOTE—If trays, tubes, reels, foam end caps, etc., are placed in the bag without baking, additional desiccant will be required to absorb the moisture contained in these materials.~~

If it is desired to minimize the amount of desiccant used for dry-packing level 2 components, a value of D based on the amount of water in grams that a UNIT of desiccant will absorb at 60 % RH and 25 °C should be used in the formula. This value can be obtained from the desiccant manufacturer. When this option is used, it can be verified that, when the component was classified in accordance with IEC 60749-20, it has achieved full saturation during moisture soak.

No moisture-absorbing material (e.g. trays, tubes, reels, foam end caps) should be placed in the dry bag without baking. Any such material that is included increases the amount of desiccant needed to meet the calculated shelf life (see 7.4.2) by an amount based on the moisture content of the material. This can be determined by weighing a representative quantity of material known to be at equilibrium with the manufacturing environment, baking to a new constant weight, and subtracting the final from the initial weight. Additional UNIT(s) of desiccant, based on 10 % RH at 25 °C, should be added to absorb the amount of water, in grams, egressed from the packing materials (dunnage) after baking.

5.3.2.3 Desiccant handling and storage

Desiccant capacity decreases rapidly when exposed to 30 °C/60 % RH. Therefore, the desiccant should remain in the manufacturer's container or stored in a dry cabinet at < 5 % RH until use. When dry packing, the desiccant shall be removed from the storage container just prior to placing it into the MBB and sealing the MBB.

5.3.2.4 Humidity indicator card (HIC)

The HIC shall comply with relevant national standards governing chemically impregnated humidity indicator cards. For level A2, the HIC shall have a sensitivity value of 30 % RH, which may be indicated by colour dots with sensitivity values of 20 % RH, 30 % RH, 40 % RH. For SMDs classified from Levels B2a through to B5a, as a minimum, the HIC shall have 3 colour dots with sensitivity values of 5 % RH, 10 % RH, 60 % RH. The spots shall indicate the humidity with a significant and perceptible change in colour (hue) as indicated in Table 2. Hue shall be tested using the test method in Annex C. The colours shall be described in writing on the card. HIC reuse is not allowed if the 60 % spot has changed colour. Reuse is not allowed, owing to loss of accuracy of the 5 % and 10 % spot chemistry, if the 60 % spot has changed colour. It is not required to reuse the same HIC from the MBB if the MBB is to be resealed; a fresh HIC may be used.

Examples of HIC are shown in Figures 2a) and 2b).

5.3.2.5 HIC paper

White blotting paper made from fibrous, cellulosic material, with a minimum basis weight of, 255 g/m² shall be used for HICs.

5.3.2.6 Visual defects

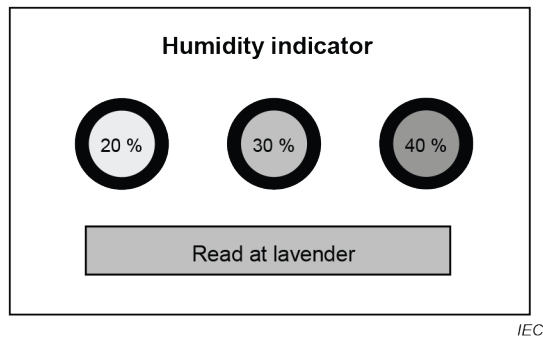
HICs shall be free from defects including missing spots, tears, improperly located spots, and indicating colour overrunning the black circles.

5.3.2.7 Preservation

HICs shall be stored in accordance with the manufacturer's recommendation prior to insertion in the MBB. At a minimum, the 10 % spot shall indicate dry when the cards are removed from the original container.

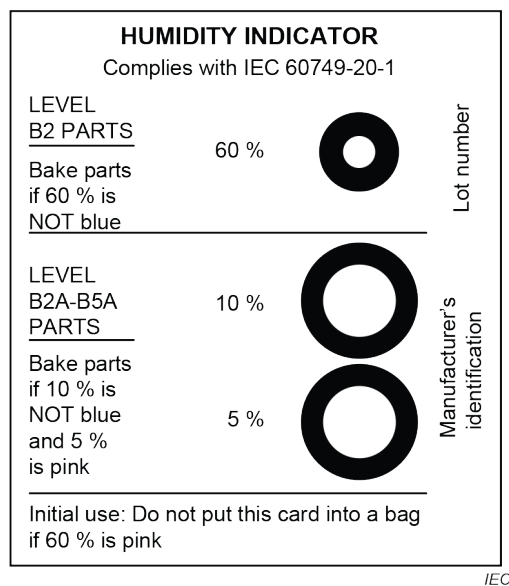
Table 2 –Typical HIC spot compliance

	Indication at 2 % RH environment	Indication at 5 % RH environment	Indication at 10 % RH environment	Indication at 55 % RH environment	Indication at 60 % RH environment	Indication at 65 % RH environment
5 % spot	Blue (dry)	Lavender (spot value) change ≤ 7 % hue	Pink (wet)	Pink (wet)	Pink (wet)	Pink (wet)
10 % spot	Blue (dry)	Blue (dry)	Lavender (spot value) change ≤ 10 % hue	Pink (wet)	Pink (wet)	Pink (wet)
60 % spot	Blue (dry)	Blue (dry)	Blue (dry)	Blue (dry)	Lavender (spot value) change ≤ 10 % hue	Pink (wet)
NOTE Other colour schemes can be used.						



Below 30 % RH can be confirmed by comparison of a colour (lavender).

a) Example of humidity indicator card for level A2



b) Example of humidity indicator card for levels B2a to B5a

Figure 2 – Example humidity indicator cards

5.3.3 Labels

5.3.3.1 Labels – Moisture sensitive identification

Labels relevant to the dry pack process are the moisture-sensitive identification (MSID) label and the caution label as specified in Annex A (see Figures A.2 to A.5). The MSID label shall be affixed to the lowest-level shipping container that contains the MBB. The caution label shall be affixed to the outside surface of the MBB. The caution label includes fields for the moisture classification level in accordance with IEC 60749-20; the peak package body temperature allowed during reflow soldering (the classification temperature); the floor life; and the bag seal date. If the calculated shelf life is greater than 12 months, item # 1 of the caution label shall be changed accordingly.

5.3.3.2 Labels – Level B6 requirements

Level B6 parts not shipped in MBBs shall have both an MSID label and the appropriate caution label affixed to the lowest level shipping container.

5.3.3.3 Labels – Level A1 and B1 requirements

Level A1 and B1 parts classified for other than from 220 °C to 225 °C maximum reflow temperature shall have a caution label with the maximum reflow temperature specified.

caution label shall be affixed to the MBB (if used) or to the lowest-level shipping container. The caution label will not be required if a bar code label includes the level A1 or B1 classification and maximum reflow temperature information in human readable form. Level A1 and B1 parts classified at from 220 °C to 225 °C maximum reflow temperature do not require any moisture-related labels.

5.3.4 Moisture barrier bag sealing

The bag shall be heat sealed so as not to damage or cause delamination of the MBB.

5.3.5 Dry pack precautions

5.3.5.1 HIC placement

The HIC may be placed anywhere in the MBB, but shall not be placed under a desiccant pouch.

5.3.5.2 HIC reuse

HIC cards where the 10 % spot indicates wet shall not be used/reused if the bag will be opened and the HIC card inspected within 48 h.

HIC with 60 % RH indicated shall be discarded if the 60 % spot has indicated wet. HICs that have been exposed to 60 % or greater RH will no longer be accurate.

5.3.5.3 Moisture barrier bag sealing

In actual practice, air evacuation is not required. Light air evacuation is to be used to reduce the packaging bulk and enhance carton packing. Full evacuation shall not be used as it will impede desiccant and HIC performance and possibly lead to MBB puncture.

5.3.6 Shelf life

The calculated shelf life for dry packed SMDs shall be a minimum of 12 months from the bag seal date, when stored in a non-condensing atmospheric environment of <40 °C/90 % RH. If the calculated shelf life is greater than 12 months, item # 1 of the caution label is changed accordingly (see Figures A.4 and A.5).

6 Drying

6.1 Drying options

Component drying options for various moisture sensitivity levels and ambient humidity exposures ~~of ≤60 % RH~~ are given in Tables 3, 4, 5 and 6. Drying using an allowable option resets the floor life clock. If dried and sealed in an MBB with fresh desiccant, the shelf life is reset. Tables 3, 4, 5 and 6 give reference conditions for drying SMDs. Tables 3 and 4 give conditions for re-bake of SMDs at a user site after the floor life has expired or other conditions have occurred to indicate excess moisture exposure. Table 5 gives conditions for bake prior to dry pack at a supplier and/or distributor and allows for a maximum total of 24 h MET. Table 6 summarizes conditions for resetting or pausing the floor-life clock at the user site in accordance with 6.2.1. The supplier shall formally communicate to the distributor the maximum time that the product may be left unsealed (at the distributor) before re-baking is required.

NOTE If the baking process is interrupted for greater than 15 minutes, the total time of the interruption is added to the bake time.

Table 3 – Reference conditions for drying mounted or unmounted SMDs
(user bake: floor life begins counting at time = 0 after bake) – **Level 2**

Level A2

SMD body thickness	Level A2	Bake at 125 °C		Bake at 90 °C ≤5 % HR		Bake at 40 °C ≤5 % HR	
		Saturated at 30 °C/85 %RH	At limit of floor life + 72 h at 30 °C/70 % RH	Saturated at 30 °C/85 %RH	At limit of floor life + 72 h at 30 °C/70 % RH	Saturated at 30 °C/85 %RH	At limit of floor life + 72 h at 30 °C/70 % RH
≤1,4 mm		9 h	7 h	33	23 h	13 days	9 days
≤2,0 mm		27 h	17 h	4 days	2 days	37 days	23 days
≤4,5 mm		48 h	48 h	10 days	8 days	79 days	67 days
BGA package >17 mm x 17 mm or any stacked die package (See Note 2)		96 h	As above per package thickness and moisture level	Not applicable	As above per package thickness and moisture level	Not applicable	As above per package thickness and moisture level

Levels B2a to B5a

SMD body thickness	Level	Bake at 125 °C		Bake at 90 °C ≤5 % HR		Bake at 40 °C ≤5 % HR	
		Saturated at 30 °C/85 %RH	At limit of floor life + 72 h at 30 °C/60 % RH	Saturated at 30 °C/85 %RH	At limit of floor life + 72 h at 30 °C/60 % RH	Saturated at 30 °C/85 %RH	At limit of floor life + 72 h at 30 °C/60 % RH
≤1,4 mm	B2a	7 h	5 h	23 h	13 h	9 days	7 days
	B3	9 h	7 h	33 h	23 h	13 days	9 days
	B4	11 h	7 h	37 h	23 h	15 days	9 days
	B5	12 h	7 h	41 h	24 h	17 days	10 days
	B5a	16 h	10 h	54 h	24 h	22 days	10 days
≤2,0 mm	B2a	21 h	16 h	3 days	2 days	29 days	22 days
	B3	27 h	17 h	4 days	2 days	37 days	23 days
	B4	34 h	20 h	5 days	3 days	47 days	28 days
	B5	40 h	25 h	6 days	4 days	57 days	35 days
	B5a	48 h	40 h	8 days	6 days	79 days	56 days
≤4,5 mm	B2a	48 h	48 h	10 days	7 days	79 days	67 days
	B3	48 h	48 h	10 days	8 days	79 days	67 days
	B4	48 h	48 h	10 days	10 days	79 days	67 days
	B5	48 h	48 h	10 days	10 days	79 days	67 days
	B5a	48 h	48 h	10 days	10 days	79 days	67 days
BGA package >17 mm x 17 mm or any stacked die package (See Note 2)	2-6	96 h	As above per package thickness and moisture level	Not applicable	As above per package thickness and moisture level	Not applicable	As above per package thickness and moisture level

NOTE 1—Tables 2(a) and 2(b) are based on worst-case moulded lead frame SMDs. Users may reduce the actual bake time if technically justified (e.g., absorption/desorption data, etc.). In most cases it is applicable to other non-hermetic SMDs.

NOTE 2—BGA packages >17 mm x 17 mm, that do not have internal planes that block the moisture diffusion path in the substrate, may use bake times based on the thickness/moisture level portion of the table.

SMD body thickness	Level A2	Bake at 125 °C $+10_0^{\circ}\text{C}$		Bake at 90 °C $+8_0^{\circ}\text{C}$ ≤ 5 % HR		Bake at 40 °C $+5_0^{\circ}\text{C}$ ≤ 5 % HR	
		Saturated at 30 °C/85 %RH	At limit of floor life + 72 h at 30 °C/70 % RH	Saturated at 30 °C/85 %RH	At limit of floor life + 72 h at 30 °C/70 % RH	Saturated at 30 °C/85 % RH	At limit of floor life + 72 h at 30 °C/70 % RH
≤ 1,4 mm		9 h	7 h	33 h	23 h	13 days	9 days
≤ 2,0 mm		27 h	17 h	4 days	2 days	37 days	23 days
≤ 4,5 mm		48 h	48 h	10 days	8 days	79 days	67 days
BGA package >17 mm x 17 mm or any stacked die package (See Note 2)		96 h	As above per package thickness and moisture level	Not applicable	As above per package thickness and moisture level	Not applicable	As above per package thickness and moisture level

Table 4 – Reference conditions for drying mounted or unmounted SMDs (user bake: floor life begins counting at time = 0 after bake) – Levels B2, B2a to B5a

SMD body thickness	Level	Bake at 125 °C $+10_0^{\circ}\text{C}$		Bake at 90 °C $+8_0^{\circ}\text{C}$ ≤ 5 % RH		Bake at 40 °C $+5_0^{\circ}\text{C}$ ≤ 5 % RH	
		Saturated at 30 °C/85 %RH	At limit of floor life + 72 h at 30 °C/60 % RH	Saturated at 30 °C/85 %RH	At limit of floor life + 72 h at 30 °C/60 % RH	Saturated at 30 °C/85 % RH	At limit of floor life + 72 h at 30 °C/60 % RH
≤ 1,4 mm	B2a	7 h	5 h	23 h	13 h	9 days	7 days
	B3	9 h	7 h	33 h	23 h	13 days	9 days
	B4	11 h	7 h	37 h	23 h	15 days	9 days
	B5	12 h	7 h	41 h	24 h	17 days	10 days
	B5a	16 h	10 h	54 h	24 h	22 days	10 days
≤ 2,0 mm	B2a	21 h	16 h	3 days	2 days	29 days	22 days
	B3	27 h	17 h	4 days	2 days	37 days	23 days
	B4	34 h	20 h	5 days	3 days	47 days	28 days
	B5	40 h	25 h	6 days	4 days	57 days	35 days
	B5a	48 h	40 h	8 days	6 days	79 days	56 days
≤ 4,5 mm	B2a	48 h	48 h	10 days	7 days	79 days	67 days
	B3	48 h	48 h	10 days	8 days	79 days	67 days
	B4	48 h	48 h	10 days	10 days	79 days	67 days
	B5	48 h	48 h	10 days	10 days	79 days	67 days
	B5a	48 h	48 h	10 days	10 days	79 days	67 days
BGA package > 17 mm × 17 mm or any stacked die package (See Note 2)	B2-B6	96 h	As above per package thickness and moisture level	Not applicable	As above per package thickness and moisture level	Not applicable	As above per package thickness and moisture level

Tables 3 and 4 are based on worst-case moulded lead frame SMDs. Users may reduce the actual bake time if technically justified (e.g. absorption/desorption data). In most cases, it is applicable to other non-hermetic SMDs. If parts have been exposed to > 60 % RH, consideration shall be given to the need to increase the bake time by tracking desorption data to ensure parts are dry.

BGA packages > 17 mm x 17 mm, that do not have internal planes that block the moisture diffusion path in the substrate, may use bake times based on the thickness/moisture level portion of the table.

If baking of packages > 4,5 mm is required, see Annex D.

Table 5 – Default baking times used prior to dry-pack that were exposed to conditions ≤ 60 % RH (supplier bake: MET = 24 h)

SMD body thickness	Level	Bake at 125 °C	Bake at 150 °C
≤ 1,4 mm	B2a	8 h	4 h
	B3	16 h	8 h
	B4	21 h	10 h
	B5	24 h	12 h
	B5a	28 h	14 h
≤ 2,0 mm	B2a	23 h	11 h
	B3	43 h	21 h
	B4	48 h	24 h
	B5	48 h	24 h
	B5a	48 h	24 h
≤ 4,5 mm	B2a	48 h	24 h
	B3	48 h	24 h
	B4	48 h	24 h
	B5	48 h	24 h
	B5a	48 h	24 h

~~NOTE – The bake times specified are based on worst case conditions and are conditions for a supplier and/or distributor. Oxidation may occur. Suppliers may reduce the actual bake time if technically justified (e.g., absorption/ desorption data, etc.).~~

If baking of packages > 4,5 mm is required, see Annex D.

The bake times specified are conservative for packages without blocking planes or stacked die. For a stacked die or BGA package with internal planes that impede moisture diffusion the actual bake time may be longer than that required in this table if packages have had extended exposure to factory ambient before bake. Also, the actual bake time may be reduced if technically justified. The increase or decrease in bake time is determined using the procedure in IEC 60749-39 (i.e. < 0,002 % weight loss between successive readouts) or in accordance with critical interface concentration calculations.

Table 6 – Resetting or pausing the ‘floor life’ clock at user site

Moisture sensitivity level	Exposure time at temp./humidity	Floor life	Desiccator time at relative humidity	Bake	Reset shelf life
B2a, B3, B4, B5, B5a	Anytime ≤40 °C/85 % RH	reset	N/A	Table 4	Dry pack after bake
B2a, B3, B4, B5, B5a	>floor life ≤30 °C/60 % RH	reset	N/A	Table 4	Dry pack after bake
B2a, B3	>12 h ≤30 °C/60 % RH	reset	N/A	Table 4	Dry pack after bake
B2a, B3	≤12 h ≤30 °C/60 % RH	reset	5 x exposure time ≤10 % RH	N/A	N/A
B4, B5, B5a	>8 h ≤30 °C/60 % RH	reset	N/A	Table 4	Dry pack after bake
B4, B5, B5a	≤8 h ≤30 °C/60 % RH	reset	10 x exposure time ≤5 % RH	N/A	N/A
B2a, B3	Cumulative time <floor life ≤30 °C/60 % RH	pause	any time ≤10 % RH	N/a	N/A

6.2 Post exposure to factory ambient

6.2.1 Floor life clock

Placing SMDs, which have been exposed to factory ambient conditions for greater than 1 h, in a dry cabinet or dry pack does not necessarily stop/pause the floor life clock. However, if the conditions of 6.2.3 are met, the floor life clock can be stopped or reset (see Table 6).

6.2.2 Any duration exposure

Moisture sensitive SMDs which have been exposed only to ambient conditions of $\leq 60\%$ RH for any length of time may be adequately dried by high or low temperature baking in accordance with Tables 3 and 4 for rebake prior to reflow, or Table 5 for drying prior to dry pack.

6.2.3 Short duration exposure

6.2.3.1 General considerations for short duration exposure

Previously dry SMDs, which have been exposed only to ambient conditions not exceeding $30\text{ }^{\circ}\text{C}/60\%$ RH, may be adequately dried by room temperature desiccation using a dry pack or a dry cabinet. ~~If dry pack is used and the total desiccant exposure is not greater than 30 min, the original desiccant may be reused.~~

6.2.3.2 Moisture sensitivity levels B2, B2a and B3

For moisture sensitivity levels B2, B2a and B3 with floor life exposure not greater than 12 h at $30\text{ }^{\circ}\text{C}/60\%$ RH, a minimum desiccating period of $5\times$ the exposure time is required to dry the SMDs enough to reset the floor life clock (see Table 6). This can be accomplished by dry pack in accordance with 5.3 or a dry cabinet that is capable of maintaining not greater than 10% RH.

NOTE For components classed as moisture-sensitive levels B2, B2a or B3, that are exposed for any time less than their stated floor life, dry packing or placing the components in a dry cabinet that maintains not greater than 10% RH, will stop/pause the floor life clock. However, the cumulative floor life should meet the conditions in Table 7 and/or Table E.2. This does not apply to level B4.

6.2.3.3 Moisture sensitivity levels B4, B5 and B5a

For moisture sensitivity levels B4, B5 and B5a with floor life exposure not greater than 8 h at $30\text{ }^{\circ}\text{C}/60\%$ RH, a minimum desiccating period of $10\times$ the exposure time is required to dry the SMDs enough to reset the floor life clock (see Table 6). This can be accomplished by dry pack in accordance with 5.3 or a dry cabinet that is capable of maintaining not greater than 5% RH.

Once the floor life clock has been reset, refer to 7.4 for safe storage conditions.

6.3 General considerations for baking

6.3.1 High-temperature carriers

Unless otherwise indicated by the manufacturer, SMDs shipped in high-temperature carriers (e.g. high-temperature trays) can be baked in the carriers at $125\text{ }^{\circ}\text{C}$.

6.3.2 Low-temperature carriers

SMDs shipped in low-temperature carriers (e.g. tubes, low-temperature trays, tape and reel) may not be baked in the carriers at any temperature higher than $40\text{ }^{\circ}\text{C}$. If a higher bake

temperature is required, SMDs shall be removed from the low-temperature carriers to thermally safe carriers, baked, and returned to the low-temperature carriers.

NOTE 1 Manual handling ~~may~~ can increase the risk of mechanical and/or ESD damage.

NOTE 2 If SMDs are placed in dry bags with unbaked carriers, refer to 5.3.2.2.

6.3.3 Paper and plastic container items

Paper and plastic container items such as cardboard boxes, bubble pack, and plastic wrap, ~~etc.~~ shall be removed from around the carriers prior to baking. Rubber bands around tubes and plastic tray ties shall also be removed prior to the high-temperature (125 °C) bake.

6.3.4 Bakeout times

Bakeout times start when all SMDs reach the specified temperature.

6.3.5 ESD protection

Proper ESD handling precautions should be observed, in accordance with relevant national standards for ESD-sensitive items. This is particularly critical if SMDs are manually handled by vacuum pencils under low-humidity conditions, e.g. in a dry environment, after baking, ~~etc.~~

6.3.6 Reuse of carriers

The appropriate materials specification should be consulted before reusing carriers.

6.3.7 Solderability limitations

6.3.7.1 Oxidation risk

Baking SMDs can cause oxidation and/or intermetallic growth of the terminations, which, if excessive, can result in solderability problems during board assembly. The temperature and time for baking SMDs are therefore limited by solderability considerations. Unless otherwise indicated by the supplier, the cumulative bake time at a temperature greater than 90 °C and up to 125 °C shall not exceed 96 h. If the bake temperature is not greater than 90 °C, there is no limit on bake time. Bake temperatures higher than 125 °C are not allowed without consulting the supplier.

6.3.7.2 Carrier out-gassing risk

Care should be taken to ensure that out-gassing of materials from the component carriers does not occur to any significant extent, such that solderability might be affected.

7 Use

7.1 Floor life clock start

Upon opening the MBB, the floor life clock starts. If an MBB is opened and the ~~SMDs will not be used within the specified floor life~~ ambient conditions are other than 30 °C/60 % RH, the procedures in ~~Clause 6~~ Annex E should be followed.

7.2 Incoming bag inspection

7.2.1 Upon receipt

Dry packed SMDs should be inspected for a bag seal date located on the caution or bar code label to determine remaining shelf life. The bags should be inspected to verify there are no holes, gouges, tears, punctures or openings of any kind that would expose either the contents or an inner layer of a multilayer bag. If openings are found, and the humidity indicator card

(HIC) indicates maximum humidity has been exceeded, then the parts should be baked for 48 h at 125 °C or using the saturated bake times of Tables 3 and 4.

7.2.2 Component inspection

Intact bags may be opened for component inspection by cutting at the top of the bag near the seal. If the bags are opened under factory ambient conditions, see 6.2.3.

7.3 Floor life

The floor life of SMDs given in Table 7 will be modified by environmental conditions other than those stated in the table. Refer to Annex E to determine maximum allowable time before rebake would be necessary. If partial lots are used, the remaining SMDs shall be resealed or placed in safe storage within 1 h of bag opening (see 7.4). If one-hour exposure is exceeded, refer to 6.2.

Table 7 – Moisture classification level and floor life

Level	Floor life (out of bag) at factory ambient
A1 or B1	Unlimited at ≤30 °C/85 % RH
B2	1 year at ≤30 °C/60 % RH
B2a	4 weeks at ≤30 °C/60 % RH
A2	168 h at ≤30 °C/70 % RH
B3	168 h at ≤30 °C/60 % RH
B4	72 h at ≤30 °C/60 % RH
B5	48 h at ≤30 °C/60 % RH
B5a	24 h at ≤30 °C/60 % RH
B6	Mandatory bake before use. After bake, shall be reflowed within the time limit specified on the label.

7.4 Safe storage

7.4.1 Safe storage categories

"Safe storage" means dry SMDs held in a controlled humidity condition such that the floor life clock remains at zero. Acceptable safe storage conditions for SMDs classified as level B2 to B5a are listed below (in 7.4.2 to 7.4.4).

7.4.2 Dry pack

Dry packed SMDs in intact MBBs, stored in accordance with 5.3, shall have a calculated shelf life of at least 12 months from the bag seal date shown on the caution or bar code label.

7.4.3 Shelf life

The minimum calculated shelf life is 12 months from bag seal date. If the actual shelf life has exceeded 12 months, but less than 2 years, from the bag seal date and the humidity indicator card (HIC) (7.6.2) indicates that baking is not required, then it is safe to reflow the components as per the original MSL rating. Although unanticipated, factors other than moisture sensitivity could affect the total shelf life of components.

NOTE An HIC that has been continuously sealed in the MBB is typically accurate for at least 2 years.

7.4.4 Dry atmosphere cabinet

7.4.4.1 Dry cabinet capability

These are storage cabinets that maintain low humidity by purging with dry air or nitrogen at $25\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$. The cabinets ~~must~~ shall be capable of recovering to their stated humidity rating within 1 h from routine excursions such as door opening/closing.

7.4.4.2 Dry cabinet at 10 % RH

SMDs not sealed in a MBB may be placed in a dry atmosphere cabinet, maintained at not greater than 10 % RH. These dry cabinets should not be considered as MBBs. The storage of SMDs in these dry cabinets should be limited to a maximum time in accordance with Tables E.1 and E.2. If the time limit is exceeded, they should be baked in accordance with Table 5 to restore the floor life.

7.4.4.3 Dry cabinet at 5 % RH

SMDs not sealed in a MBB may be placed in a dry atmosphere cabinet, maintained at not greater than 5 % RH. Storage in these dry cabinets may be considered equivalent to storage in a MBB with unlimited shelf life.

7.4.4.4 Dry cabinet at 30 %RH

SMDs of class A2 not sealed in a MBB may be placed in a dry atmosphere cabinet, maintained at not greater than 30 % RH. Storage in these dry cabinets may be considered equivalent to storage in an MBB with unlimited shelf life.

7.5 Reflow

7.5.1 Reflow categories

Reflow includes single and multi-pass assembly reflow and single component attach/removal for rework.

7.5.2 Opened MBB

After a dry pack (MBB) has been opened, all SMDs within that bag ~~must~~ shall complete all solder reflow processing, including rework, prior to the stated floor life, resealed in the MBB, or stored in a dry atmosphere cabinet in accordance with 6.2. If the floor life or factory ambient conditions are exceeded, refer to 7.6.3.

7.5.3 Reflow temperature extremes

During reflow, the component body temperature shall not exceed the rated value, stated on the caution label. The body temperature during reflow directly influences component reliability.

NOTE 1 The component body temperature can be very different from the lead or solder ball temperature, particularly in IR and IR/convection processes, and should be checked separately.

NOTE 2 Some hot air attach processes can require heating the component body to very high temperatures. If that temperature exceeds the classification temperature, moisture precautions and/or time-temperature limitations beyond the scope of this specification can be required. The supplier should be consulted.

7.5.4 Additional thermal profile parameters

During reflow, the additional thermal profile parameters stated in IEC 60749-30 should not be exceeded. Although the body temperature during reflow is the most critical parameter, other

profile parameters such as the total exposure time to hot temperatures, and the heating rates, ~~may~~ can also influence component reliability.

7.5.5 Multiple reflow passes

If more than one reflow pass is used, care shall be taken to ensure that no moisture-sensitive SMDs, mounted or unmounted, have exceeded their floor life prior to the final pass. If any component on the board has exceeded its floor life, the board needs to be baked prior to the next reflow. Annex B should be referenced for the baking of populated boards.

NOTE 1 The floor life clock is not reset by any reflow or rework process.

NOTE 2 For cavity packages in which water can be entrapped, water cleaning processes after the first reflow can be an additional source of moisture. This can present an additional risk, which should be evaluated.

7.5.6 Maximum reflow passes

A maximum of three reflow passes is allowed per component. If more than three are required for any reason, the supplier shall be consulted (see IEC 60749-20).

7.6 Drying indicators

7.6.1 Drying requirements

These are events and conditions that require component drying prior to reflow or continued safe storage.

7.6.2 Excess humidity in the dry pack

7.6.2.1 Humidity indicator cards

Excess humidity in the dry pack is noted by the humidity indicator card (HIC). It can occur due to misprocessing (e.g. missing or inadequate desiccant), mishandling (e.g. tears or rips in the MBB), or improper storage.

The HIC should be read immediately upon removal from the MBB. For best accuracy, the HIC should be read at $23\text{ °C} \pm 5\text{ °C}$. The following conditions apply regardless of the storage time, i.e. whether or not the shelf life has been exceeded.

NOTE Witness cards can be available from the HIC manufacturer if needed to confirm the wet/dry colours.

7.6.2.2 HIC indication 1

For SMDs of class A2, if the HIC indicates that humidity inside MBB does not exceed 30 % RH, the parts are still adequately dry.

For SMDs of classes B2a to B5a, if the 10 % RH dot is blue, the parts are still adequately dry. The desiccant shall be replaced by active desiccant if the bag is going to be resealed.

7.6.2.3 HIC indication 2

For SMDs of class A2, if the HIC indicates that there is a possibility of the humidity inside MBB exceeding 30 % RH, the SMDs have been exposed to an excessive level of moisture, and drying shall be done in accordance with Clause 6.

For SMDs of classes B2a to B5a, if the 5 % RH dot is pink and the 10 % RH dot is not blue, the SMDs have been exposed to an excessive level of moisture, and drying shall be done in accordance with Clause 6.

7.6.2.4 HIC indication 3

If the 5 %, 10 %, and 60 % RH spots indicate wet, class A2 parts have been exposed to an excessive level of moisture, and drying shall be done in accordance with Clause 6.

7.6.3 Floor life or ambient temperature/humidity exceeded

If the floor life or ambient temperature/humidity conditions given in Table 7 have been exceeded, SMDs shall be dried ~~per~~ in accordance with Clause 6 prior to reflow or safe storage. If the factory ambient temperature and/or humidity conditions given in Table 7 cannot be met, the component floor life shall be derated to compensate. Floor life derating is discussed in Annex E.

7.6.4 Level B6 SMDs

SMDs classified as level B6 shall be dried by baking, then reflowed within the time limit specified on the label.

Annex A (normative)

Symbol and labels for moisture-sensitive devices

A.1 Object

The purpose of Annex A is to provide a distinctive symbol and labels to be used to identify those devices that require special packing and handling precautions.

A.2 Symbol and labels

A.2.1 "Moisture-sensitive" symbol

This symbol (see Figure A.1) indicates that devices are moisture sensitive to level A2 or to a level from B2 to B6 and it appears on all moisture-sensitive caution labels (see Figure A.4).



Figure A.1 – Moisture-sensitive symbol (example)

A.2.2 Moisture-sensitive identification (MSID) label

This label should be on the lowest-level shipping container to indicate that moisture-sensitive devices are in the container. This label is recommended to be a minimum of 20 mm in diameter. See Figure A.2.

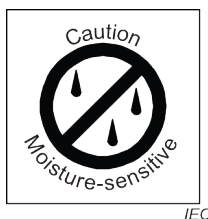


Figure A.2 – MSID label (example)

A.2.3 Moisture-sensitive caution labels

A.2.3.1 Level A1 or B1

This label is required only if the classification temperature is $> 225\text{ }^{\circ}\text{C}$ and shall be placed on the lowest-level shipping container to indicate classification temperature and to identify the devices as "NOT MOISTURE SENSITIVE". See Figure A.3.

<p>NOT MOISTURE SENSITIVE</p> <p>These devices do not require special storage conditions, provided:</p> <ol style="list-style-type: none"> 1. they are maintained at conditions equal to or less than 30 °C/85 % RH, and 2. they are solder reflowed at a peak body temperature which does not exceed 225 °C. <p>NOTE Level and body temperature are defined in IEC 60749-20</p>	<p>LEVEL</p> <div style="border: 1px solid black; width: 50px; height: 20px; margin: 5px auto;"></div>
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Figure A.3 – Information label for level A1 or B1 (example)**A.2.3.2 Level A2**

The moisture-sensitive caution label may be used for level A2 as defined by IEC 60749-20. See Figure A.4. This label is required on the moisture barrier bag and will provide the following information:

- the calculated shelf life in the sealed bag;
- the peak SMD body temperature (top surface) used for device classification as defined by IEC 60749-20;
- the floor life of the device at 30 °C/70 % RH as defined by IEC 60749-20.

	<p>CAUTION This bag contains MOISTURE SENSITIVE DEVICES</p>	<p>LEVEL</p> <div style="border: 1px solid black; padding: 5px; text-align: center;">A2</div>
	<p>If blank, see adjacent bar code label</p>	
<ol style="list-style-type: none"> 1. Calculated shelf life in sealed bag : _____ months at <40 °C and <90 % relative humidity (RH). If blank, shelf life is 12 months. 2. Peak package body temperature : _____ °C If blank, see peak temperature of IEC 60749-20. 3. After bag is opened, devices that will be subjected to reflow solder or other high temperature process must be: <ol style="list-style-type: none"> a) mounted within : <u>168</u> hours of factory conditions ≤30 °C/70 % RH, or b) stored at <30 % RH. 4. Devices require bake, before mounting, if : <ol style="list-style-type: none"> a) Humidity indicator card is >30 % when read at 25 °C ± 5 °C ; b) 3a or 3b not met. 5. If baking is required, devices may be baked on conditions of Table 2(a) of IEC 60749-20-1. 		
<p>NOTE Level and body temperature defined by IEC 60749-20.</p>		

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Figure A.4 – Moisture-sensitive caution label for level A2 (example)

A.2.3.3 Levels B2 to B5a

The moisture-sensitive caution label shall be used for levels B2, B2a, B3, B4, B5, and B5a as defined by IEC 60749-20. See Figure A.5. This label is required on the moisture barrier bag and will provide the following information:

- moisture classification level;
- the calculated shelf life in the sealed bag;
- the peak SMD body temperature (top surface) used for device classification as defined by IEC 60749-20;
- the floor life of the device at 30 °C/60 % RH as defined by IEC 60749-20;
- the bag seal date using “MMDDYY”, “YYWW” or equivalent format.

An acceptable alternative will be to provide the above information on the adjacent bar code label.

	CAUTION This bag contains MOISTURE SENSITIVE DEVICES	LEVEL <div style="border: 1px solid black; width: 50px; height: 20px; margin: 0 auto;"></div> <small>If blank, see adjacent bar code label</small>
<p>1. Calculated shelf life in sealed bag : 12 months at <40 °C and <90 % relative humidity (RH).</p> <p>2. Peak package body temperature : _____ °C. <small>If blank, see adjacent bar code label.</small></p> <p>3. After bag is opened, devices that will be subjected to reflow solder or other high temperature process must be:</p> <p style="margin-left: 20px;">a) mounted within : _____ hours of factory <small>If blank, see adjacent bar code label</small> conditions ≤30 °C/60 % RH, or</p> <p style="margin-left: 20px;">b) stored at <10 % RH.</p> <p>4. Devices require bake, before mounting, if :</p> <p style="margin-left: 20px;">a) Humidity indicator card is >10 % when read at 23 °C ± 5 °C ;</p> <p style="margin-left: 20px;">b) 3a or 3b not met.</p> <p>5. If baking is required, devices may be baked for 48 hours at 125 °C ± 5 °C.</p> <p>NOTE If device containers cannot be subjected to high temperature or shorter bake times are desired, reference IEC 60749-30 for bake procedure.</p> <p>Bag seal date : _____ <small>If blank, see adjacent bar code label.</small></p> <p>NOTE Level and body temperature defined by IEC 60749-20.</p>		

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Figure A.5 – Moisture-sensitive caution label for levels B2-B5a (example)

A.2.3.4 Level B6

Level B6 devices shall be identified as “EXTREMELY MOISTURE SENSITIVE”. See Figure A.6. This label is required on the moisture barrier bag and/or the lowest-level shipping container. The label shall specify the peak SMD body temperature at which the device was classified. If the required information is not provided on the caution label, then it ~~must~~ shall be on the adjacent bar code label.

Level B6, as defined by IEC 60749-20, does not require that devices be shipped in a moisture-barrier bag with desiccant, etc. (dry-pack), since these devices require baking by the end user before use. However, moisture-barrier bags have become a “symbol” for moisture-sensitive devices and, therefore, are recommended to be used with level B6 device shipments. It is also recommended that these bags be sealed even though desiccant and humidity indicator cards (HIC) may not be inside the bags.

	CAUTION EXTREMELY MOISTURE SENSITIVE	LEVEL <div style="border: 1px solid black; padding: 2px; display: inline-block;">B6</div>
Peak package body temperature : _____ °C. <small style="display: block; text-align: center;">If blank, see adjacent bar code label.</small>		
1. Must be baked before mounting for 48 hours at 125 °C ± 5 °C in high temperature device containers.		
NOTE If device containers cannot be subjected to high temperature or if shorter bake times are desired, reference IEC 60749-30 for bake procedure.		
2. After baking devices must be mounted within 6 hours at factory conditions of ≤30 °C/60 % RH.		
NOTE Level and body temperature defined by IEC 60749-20.		

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Figure A.6 – Moisture-sensitive caution label for level B6 (example)

A.2.3.5 Label size

Labels are recommended to be a minimum of 75 mm by 75 mm square.

A.2.3.6 Label colours

The MSID and caution labels shall be contrasting colours. These labels shall be legible to normal vision at a distance of 1 m. Monochromatic reproduction in any colour that contrasts with the background may be used. Where the choice of colour is arbitrary, it is suggested that

- the MSID label background be blue (Pantone-~~#297C~~® 297 C²) with a black symbol and letters;
- the caution label background be white with a blue (Process Blue³) symbol and letters.

Wherever possible, the colour red should be avoided as red suggests a personal hazard.

² Pantone® 297 C is the trade name or trademark of a product supplied by Pantone. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

³ Pantone® Process Blue C is the trade name or trademark of a product supplied by Pantone. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

Annex B (informative)

Board rework

B.1 Component removal, rework and remount

B.1.1 Removal precautions

If a component is to be removed from the board, it is recommended that localized heating is used and the maximum body temperatures of any surface mount component on the board do not exceed 200 °C. This method will minimize moisture related component damage. If any component temperature exceeds 200 °C, the board ~~must~~ shall be baked dry in accordance with B.2 prior to rework and/or component removal. Component temperatures shall be measured at the top centre of the SMD body. Any SMDs that have not exceeded their floor life can be exposed to a maximum body temperature as high as their specified maximum reflow temperature.

Socketed components should be removed prior to rework.

B.1.2 Removal for failure analysis

Failure to follow the requirements of B.1.1 may cause moisture/reflow damage that could hinder or completely prevent the determination of the original failure mechanism.

B.1.3 Removal and remount

Removal and reinstallation or replacement of a component should be conducted in accordance with national standards governing rework, repair and modification of printed boards and electronic assemblies. If a component is to be removed and reinstalled, it ~~may~~ can be necessary to first bake the printed wiring assembly to eliminate moisture from the component. The guidelines of Table 2 may be used in identifying an appropriate bake cycle. When identifying a bake cycle, the maximum exposure temperature and maximum rate of temperature change of components and materials on the subject printed wiring assembly shall be considered and an appropriate time-temperature profile (see national standards governing the rework of electronic assemblies) used. Replacement SMDs shall not have exceeded their specified floor life. Localized replacement reflow heating is recommended, so that the entire board is not re-subjected to reflow temperature profiles.

NOTE Temperatures on neighbouring SMDs above the melting point of the solder being used ~~may~~ can cause some solder joints to partially reflow, which ~~may~~ could result in a potential solder joint reliability concern.

B.2 Baking of populated boards

Some SMDs and board materials are not able to withstand long duration bakes at ≥ 125 °C. Examples of this are some FR-4 materials, which cannot withstand a 24 h bake at 125 °C, and some organic LEDs that have maximum temperatures of around 70 °C. Batteries and electrolytic capacitors are also temperature-sensitive. With component and board temperature restrictions in mind, choose a bake temperature from Table 2; then determine the appropriate bake duration based on the component to be removed.

NOTE For additional considerations, see national standards governing rework, repair and modification of printed boards and electronic assemblies.

Annex C (normative)

Test method for humidity indicator cards used with electronic component packaging

C.1 HIC testing method

To function properly, the spots shall show a visually perceptible colour change to indicate a change in the amount of humidity. This testing method uses a colorimeter to measure the colour (hue) of humidity indicating spots. The percentage of change in hue from one humidity value to another is then calculated.

C.2 Testing apparatus

The testing apparatus consists of:

- a chamber capable of maintaining atmosphere at a temperature of $23\text{ °C} \pm 1\text{ °C}$ and a relative humidity from 2 % RH to $(65\text{ %} \pm 1\text{ %})$ RH. The cards inside the chamber shall be observable from outside the chamber. Nominally, an acrylic box with a capacity of approximately 60 l, having facilities for access to the box interior while maintaining atmosphere is used. Humidity conditions can be achieved by placing combinations of molecular sieve desiccant, glycerin, and water inside the chamber;
- a colorimeter capable of measuring L, a*, and b* values (where L indicates lightness, a* is the red/green coordinate, and b* is the yellow/blue coordinate);
- an electronic hygrometer, with the minimum range of 1 % RH to 90 % RH.

C.3 Testing procedure

Place the sealed container of cards into the chamber. Set the chamber to the first humidity listed in Table 2. Open the container and suspend two cards inside the chamber so that the spots can be observed from outside the chamber. Allow the cards to condition for a minimum of 24 hours. All testing occurs inside the chamber, while the cards are exposed to the test humidity. Using a colorimeter, measure and record the L, a*, and b* values for each spot on the cards.

Set the chamber for the next humidity and continue in this manner until data has been collected for all conditions.

Table C.1 – HIC spot compliance

RH indicating spot	Hue value reading	
	Initial (dry)	Conditioned (spot value)
5 %	2 %	5 %
10 %	5 %	10 %
60 %	55 %	60 %
Printing in the indicating spot (coloured area) will affect the hue measurement, Spots without printing should be used		

C.4 Data analysis

Using the a^* and b^* data, calculate the hue value, h_{ab} for each spot at each humidity condition in Table 2,

where:

If a^* and b^* are negative, then:

h_{ab} = the absolute value of $\arctan(b^*/a^*)$

If a^* and b^* are positive, or if a^* is positive and b^* is negative, then:

$h_{ab} = 180 + \arctan(b^*/a^*)$

If a^* is negative and b^* is positive, then:

$h_{ab} = 360 + \arctan(b^*/a^*)$

Calculate the percent change in hue value at the humidity values shown in Table 2. Accept cards that show a 10 % or greater change in hue value reading from initial dry to the conditioned spot value in accordance with Table C.1. Cards with spots that do not indicate dry or wet conditions, in accordance with Table 2, should be rejected.

Annex D (informative)

Derivation of bake tables

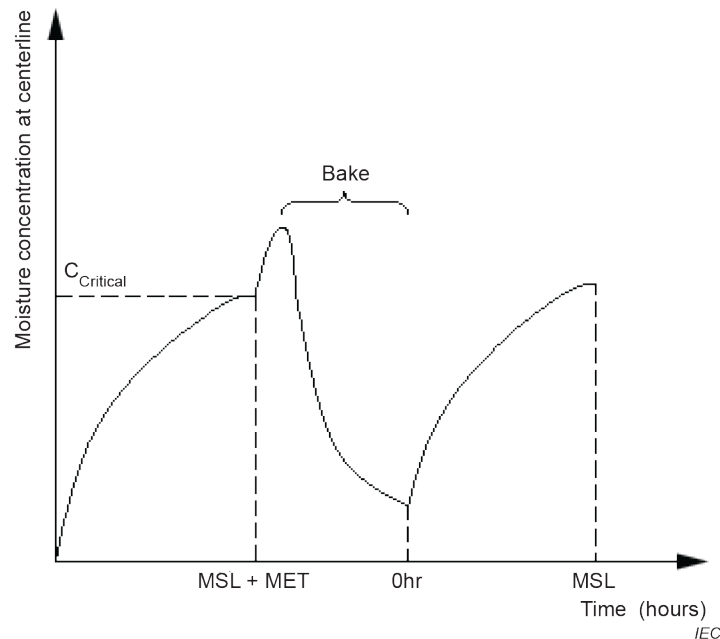


Figure D.1 –Typical moisture concentration over time

The derivation of the bake table process is illustrated graphically in Figure D.1.

Bake Tables 3, 4 and 5 were calculated using the following assumptions/approach:

a) Assume Fickian 1-D diffusion and Henry's Law apply:

$$\frac{\partial C}{\partial t} = D \frac{\partial^2 C}{\partial x^2} \quad (\text{Fick's law})$$

C_{Sat} (at surface) $\propto$ % RH in ambient atmosphere (Henry's Law)

Where C as a function of time (t) is:

$$C(t) = C_{\text{Sat}} \left(1 - \frac{4}{\pi} \sum_{n=0}^{\infty} \left\{ \frac{(-1)^n}{(2n+1)} e^{-D(2n+1)^2 \pi^2 t / 4L^2} \right\} \right)$$

b) Diffusivity = $6,2 \exp(-0,445 \text{ eV}/kT)$ mm²/s, (assumes slow diffusing mold compound)

- 1) $D_{30^\circ\text{C}} = 2,48 \times 10^{-7} \text{ mm}^2/\text{s}$
- 2) $D_{40^\circ\text{C}} = 4,27 \times 10^{-7} \text{ mm}^2/\text{s}$
- 3) $D_{90^\circ\text{C}} = 4,13 \times 10^{-6} \text{ mm}^2/\text{s}$
- 4) $D_{125^\circ\text{C}} = 1,44 \times 10^{-5} \text{ mm}^2/\text{s}$.

c) Define:

- 1) $L_{\text{centerline}}$ = critical thickness, e.g. thickness of package / 2
- 2) C_{Critical} = concentration at $L_{\text{centerline}}$ for given MSL (based on 30 °C/60 % RH exposure + 24 h MET preconditioning)

- 3) $C_{\text{Centerline}}$ = concentration at $L_{\text{centerline}}$ for any exposure condition
- d) Impose following two exposure conditions:
 - 1) MSL + > 72 h exposure (assume saturated at 30 °C/85 % RH where $C_{\text{Sat}} = 7,8 \text{ mg/cm}^3$)
 - 2) MSL + ≤ 72 h exposure (assume ambient at 30 °C/60 % RH where $C_{\text{Sat}} = 5,3 \text{ mg/cm}^3$)
- e) Calculate minimum time at bake temperature for cases d)1) and d)2) where an additional MSL exposure will keep $C_{\text{Centerline}} < C_{\text{Critical}}$.

Annex E (informative)

Derating due to factory environmental conditions

Factory floor life exposures for SMDs removed from the dry bags will be a function of the ambient environmental conditions. A safe, yet conservative, handling approach is to expose the SMDs only up to the maximum time limits for each moisture-sensitivity level as shown in Table 4. This approach, however, does not work if the factory humidity or temperature is greater than the testing conditions of 30 °C/60 % RH. A solution for addressing this problem is to derate the exposure times based on the knowledge of moisture diffusion in the component packaging materials (see IEC 60749-39). Recommended equivalent total floor life exposures can be estimated for a range of humidities and temperatures based on the nominal plastic thickness for each device. Tables E.1 and E.2 list equivalent derated floor lives for humidities ranging from 20 % RH to 90 % RH for four temperatures, 20 °C, 25 °C, 30 °C and 35 °C. These tables are applicable to SMDs moulded with novolac, biphenyl or multifunctional epoxy mould compounds. The following assumptions were used in calculating Tables E.1 and E.2:

- a) activation energy for diffusion = 0,35 eV (smallest known value);
- b) for ≤ 70 % RH (for level A2) or 60 % RH (for level B2a to B5a), use
diffusivity = $0,121 e^{-0,35\text{eV}/kT} \text{ mm}^2 \cdot \text{s}^{-1}$ (this uses smallest known diffusivity at 30 °C);
- c) for > 70 % RH (for level A2) or 60 % RH (for level B2a to B5a), use
diffusivity = $1,320 e^{-0,35\text{eV}/kT} \text{ mm}^2 \cdot \text{s}^{-1}$ (this uses largest known diffusivity at 30 °C).