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JOINT INDUSTRY STANDARD

Handling, Packing, Shipping and Use of Moisture, Reflow, and Process Sensitive Devices

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The material in this joint standard was developed by the JEDEC JC-14.1 Committee on Reliability Test Methods for Packaged Devices and the IPC Plastic Chip Carrier Cracking Task Group (B-10a)

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IPC/JEDEC J-STD-033D

Handling, Packing, Shipping and Use of Moisture, Reflow, and Process Sensitive Devices

A joint standard developed by the JEDEC JC-14.1 Committee on Reliability Test Methods for Packaged Devices and the B-10a Plastic Chip Carrier Cracking Task Group of IPC

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Users of this publication are encouraged to participate in the development of future revisions.

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In Memorium

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Handling, Packing, Shipping and Use of Moisture, Reflow, and Process Sensitive Devices

1 FOREWORD

The advent of surface mount devices (SMDs) introduced a new class of quality and reliability concerns regarding damage such as ''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. Companion documents J-STD-020, J-STD-075 and JEP113 define the classification procedure and the labeling requirements, respectively.

For moisture sensitivity, 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 cracking and/or delamination of critical interfaces within the device.

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

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

1.1 Purpose The purpose of this document is to provide manufacturers and users with standardized methods for handling, packing, shipping, and use of moisture/reflow and process sensitive devices that have been classified to the levels defined in J-STD-020 or J-STD-075. 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. The dry-packing process defined herein provides a minimum shelf life of 12 months from the seal date.

1.2 Scope This standard applies to all 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.

1.3 Assembly Processes

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

1.3.2 Localized Heating This standard also applies to moisture/reflow sensitive SMD packages that are removed or attached singly by local ambient heating, i.e., ''hot air rework.'' See Clause 6.

1.3.3 Socketed Devices

This standard does not apply to SMD packages that are socketed and not exposed to solder reflow temperatures during either bulk reflow or rework of adjacent devices. Such SMD packages are not at risk and do not require moisture precautionary handling.

1.3.4 Point-to-Point Soldering This standard does not apply to SMD packages 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 package body from such operations is typically much lower than for bulk surface mount reflow or hot air rework and moisture precautionary measures are typically not needed.

1.3.5 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.

1.4 Reliability The methods set forth in this specification ensure that an adequate SMD package reliability can be achieved during and after the PCB assembly operation, when the SMD packages are evaluated and verified by J-STD-020, J-STD-075, and/or by JESD22-A113 plus environmental reliability testing.

Note: This specification does not address or ensure solder joint reliability of external interconnects for attached devices.

1.5 Terms and Definitions

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

1.5.2 Bar Code Label A label that includes information in a code consisting of parallel bars and spaces or a 2-D matrix format.

Note: For the purpose of this standard, 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.

1.5.3 Bulk Reflow Reflow of multiple devices with simultaneous attachment by an infrared (IR), convection/IR, convection, or vapor phase reflow (VPR) process.

1.5.4 Carrier A pocket tape, tray, tube, or other container used to store and transport packaged devices.

1.5.5 Desiccant An absorbent material used to maintain a low relative humidity.

1.5.6 Floor Life The allowable time period after removal of moisture-sensitive devices from a moisture-barrier bag, dry storage, or dry bake and before the solder process.

1.5.7 Humidity Indicator Card (HIC) A card on which a moisture-sensitive chemical is applied as a spot that will make a significant, perceptible change when the indicated relative humidity is exceeded.

Note 1: Two types of HICs have been defined.

Type 1 HIC (reversible) For reversible spots the change is temporary and occurs as a change in color (hue), typically from blue (dry) to pink (wet). A perceptible change will be seen if the humidity threshold is only momentarily surpassed.

Type 2 HIC (nonreversible) For nonreversible spots the change is not temporary and can be a spot color migration outside of the spot border or some other nonreversible indicator. A nonreversible HIC includes at least a 60% RH indicator spot, but can have other nonreversible RH% indicators that do not revert after exposure to a humidity threshold.

Note 2: 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. Type 1 and Type 2 HICs that have been exposed to 60% or greater RH will no longer be considered accurate.

1.5.8 Manufacturer's Exposure Time (MET) The maximum cumulative time after bake that devices may be exposed to ambient conditions prior to shipment to end user.

1.5.9 Moisture-Barrier Bag (MBB) A bag designed to restrict the transmission of water vapor and used to pack moisture-sensitive devices.

1.5.10 Moisture-Sensitive Identification (MSID) A symbol indicating that the contents are moisture-sensitive.

1.5.11 Moisture-Sensitivity Level (MSL) A rating indicating a device's susceptibility to damage due to absorbed moisture when subjected to reflow soldering as defined in J-STD-020.

1.5.12 Rework The removal of a device for scrap, reuse, or failure analysis; the replacement of an attached device; or the heating and repositioning of a previously attached device.

1.5.13 Process-Sensitivity Level (PSL) A rating used to identify a device that is solder-process-sensitive because the device cannot be used in one or more of the base solder process conditions defined in J-STD-075.

1.5.14 Shelf Life (of a device in a sealed MBB) The allowable time that a dry-packed moisture or reflow-sensitive device can be stored in an unopened moisture-barrier bag (MBB).

1.5.15 SMD Surface mount device.

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

1.5.16 Solder Reflow A solder attachment process in which previously applied solder or solder paste is melted to attach a device to a printed circuit board.

1.5.17 Water Vapor Transmission Rate (WVTR) A measure of the permeability of plastic film or metallized plastic film material to moisture.

2 APPLICABLE DOCUMENTS (Normative)

2.1 American Society for Testing and Materials (ASTM)[1]

ASTM F 1249 Standard Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor.

ASTM F 392 Standard Test Method for Flex Durability of Flexible Barrier Materials

2.2 Electronic Industries Alliance (ECIA, ESDA, JEDEC) ANSI/ESD S541 Packaging Material for ESD Sensitive Items [2]

ANSI/ESD S541 Packaging Material Standards for ESD Sensitive Items

JESD625 Requirements for Handling Electrostatic Discharge Sensitive (ESD) Devices

JEP160 Long Term Storage Guidelines for Electronic Solid State Wafers, Dice, and Devices

JESD22-A113 Preconditioning of Non-hermetic Surface Mount Devices Prior to Reliability Testing

JESD22-A120 Test Method for the Measurement of Moisture Diffusivity and Water Solubility in Organic Materials Used in Integrated Circuits

2.3 IPC Standards[3]

IPC-7711/21 Rework, Modification and Repair of Electronic Assemblies

2.4 Joint Industry Standards[4]

J-STD-020 Moisture/Reflow Sensitivity Classification for Non-hermetic Solid State Surface Mount Devices

J-STD-075 Classification of Non-IC Electronic Components for Assembly Processes

2.5 Department of Defense[5]

MIL-PRF-81705 Type I - Barrier Materials Flexible. Electrostatic-free. Heat Sealable

MIL-D-3464 Type II - Desiccant, Activated, Bagged, Packaging Use and Static Dehumidification

3 DRY PACKING

3.1 Requirements Dry-packing requirements for the various moisture sensitivity levels are shown in Table 3-1. The levels are determined per J-STD-020, J-STD-075, and/or per JESD22-A113 plus reliability testing. As a minimum all materials used in dry packing should conform to ANSI/ESD S541.

1. www.astm.org
2. www.ecianow.org; www.esda.org; www.jedec.org
3. www.ipc.org
4. www.eia.org; www.jedec.org; www.ipc.org
5. http://quicksearch.dla.mil/qsSearch.aspx

Table 3-1 Dry-Packing Requirements

Level	Dry Before Bag	MBB With HIC	Desiccant	MSID Label	Caution Label
1	Optional	Optional	Optional	Not Required	Not Required if classified at 220 ºC –225 ºC Required* if classified at other than 220 ºC – 225 ºC
2	Optional	Required	Required	Required	Required
2a-5a	Required	Required	Required	Required	Required
6	Optional	Optional	Optional	Required	Required
Socket Only	Not Applicable	Not Applicable	Not Applicable	Not Required	Not Required

Note: * 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.

3.2 Drying of SMD Packages and Carrier Materials Before Being Sealed in MBBs

3.2.1 Drying Requirements - Levels 2a - 5a SMD packages classified at Levels 2a through 5a must be dried (see Clause 4.) prior to being sealed in MBBs. The period between drying and sealing must 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 hours, then the actual MET must 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.

3.2.2 Drying Requirements for Carrier Materials Carrier materials, such as trays, tubes, reels, etc., that are placed in the MBB can affect the moisture level within the MBB. Therefore, the effect of these materials must be compensated for by baking or, if required, adding additional desiccant in the MBB to ensure the calculated shelf life of the SMD packages.

3.2.3 Drying Requirements Suppliers may use the drying effect of normal in-line processes such as post mold 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 package at the time it is sealed in the MBB must not exceed the moisture gain of that package starting dry and then being exposed to 30 °C/60% RH for MET hours (less the time for distributors).

3.2.4 Excess Time Between Bake and Bag If the allowable time between bake and bag is exceeded, the SMD packages must be dried again per Clause 4.

3.3 Dry Pack

3.3.1 Description Dry pack consists of desiccant material and a Humidity Indicator Card (HIC) sealed with the SMD packages inside a Moisture Barrier Bag (MBB). A representative dry-pack configuration is shown in Figure 3-1.

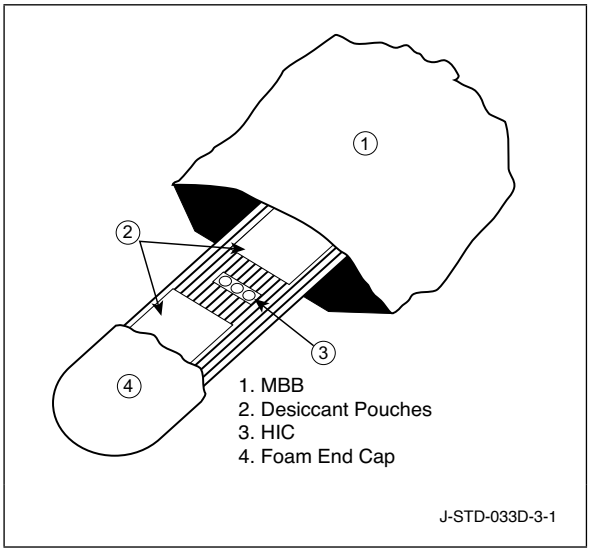


Figure 3-1 Typical Dry-Pack Configuration for Moisture-Sensitive SMD Packages in Shipping Tubes

3.3.2 Materials

3.3.2.1 Moisture Barrier Bag (MBB) The moisture barrier bag **shall** meet MIL-PRF-81705, TYPE I requirements for flexibility, ESD protection, mechanical strength, and puncture resistance. The bags **shall** be heat sealable. The Water Vapor Transmission Rate (WVTR) **shall** be ≤ 0.0310 g/m^2 [0.002 g/100 in^2] in 24 hours at 40 °C after flex testing per condition "E" ASTM F 392. The WVTR is measured using ASTM F 1249.

3.3.2.2 Desiccant The desiccant material **shall** meet MIL-D-3464, TYPE II. Desiccant **shall** be dustless, non-corrosive, and absorbent to amounts specified in the standard. Desiccant has a very limited floor life and should be stored and handled per the manufacturer's recommendation prior to insertion in the MBB. The desiccant material **shall** be packaged in moisture permeable bags or pouches. The amount of desiccant used, per moisture barrier bag, **shall** be based on the bag surface area and WVTR in order to limit the interior relative humidity in the MBB, at the end of the calculated shelf life, to less than 10% at 25 °C.

For comparison between various desiccant types, military 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 vapor at 20% RH and 25 °C.

3.3.2.2.1 Desiccant Quantity Calculation

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

$$U = (0.304 * M * WVTR * A) / D$$

Where:
U = Amount of desiccant in UNITS
0.304 = Average number of days per month/100 in^2 (30.4/100)
M = Shelf life desired in months (see 3.3.6 for shelf life)
WVTR = Water vapor transmission rate in grams/m^2 [grams/100 in^2] in 24 hrs
A = Total exposed surface area of the MBB in square decimeters (square inches)
D = The 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 a conservative value of D = 1.40 can be used.

Note 1: If it is desired to minimize the amount of desiccant used for dry-packing level 2 devices 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 must be used in the formula. This value should to be obtained from the desiccant manufacturer. When this option is used it must be verified that when the device was classified per J-STD-020 it must have achieved full saturation during moisture soak.

Note 2: No moisture-absorbing material (e.g., trays, tubes, reels, foam end caps) should be placed in the dry bag without low temperature baking. Any such material that is included increases the amount of desiccant needed to meet the calculated shelf life (see 5.3.1) 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 @ 25°C, must be added to absorb the amount of water, in grams, egressed from the packing materials (dunnage) after baking.

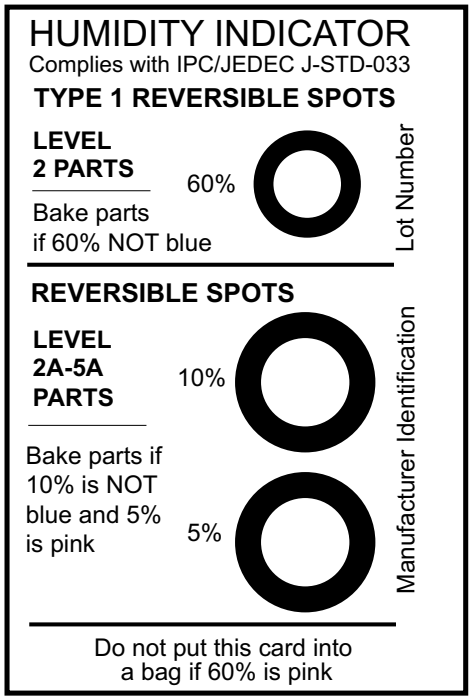


Figure 3-2A Humidity Indicator Card (HIC) – Type 1

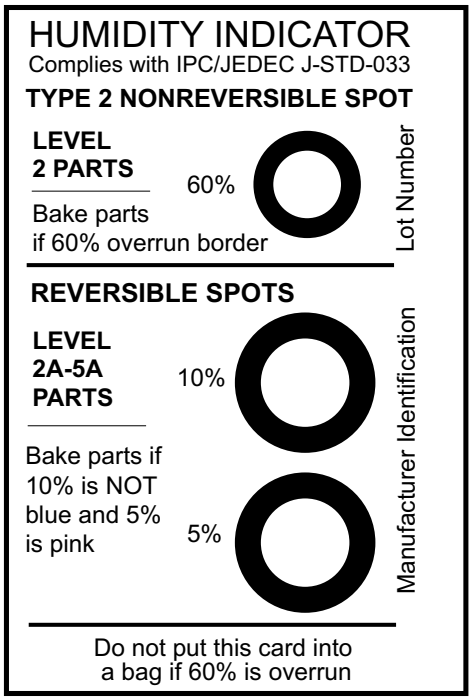


Figure 3-2B Humidity Indicator Card (HIC) – Type 2

3.3.2.2.2 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. Appendix C provides a method to validate the desiccant unit absorption capacity.

3.3.2.3 Humidity Indicator Cards (HIC) Type 1 (Reversible) and Type 2 (Nonreversible) At a minimum, the HIC **shall** have three (3) color spots with sensitivity values of 5%, 10% RH and 60% RH. An example Type 1 HIC is shown in Figure 3-2A. The spots **shall** indicate the humidity with a significant, perceptible change in color (hue) as indicated in Table 3-2. Hue **shall** be tested using the test method in Appendix A. The colors **shall** be described in writing on the card. The 5% and 10% HIC spots **shall** be reversible to allow reuse. HIC reuse is not allowed if the 60% spot has indicated it has surpassed the threshold. Reuse is not allowed, due to loss of accuracy of the 5% and 10% spot chemistry, if the 60% spot has changed color or colored spot migration outside of the spot border has occurred. Therefore the use of a Type 2 HIC as shown in Figure 3-2B, with a nonreversible 60% spot indicator is preferred. 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. At a 30 °C/60% RH environment the 5% spot **shall** begin to change from dry indication in a maximum of 4 minutes and complete change (to wet indication) in 7 minutes and the 10% spot **shall** begin to change from dry indication in a maximum of 6 minutes and complete change (to wet indication) within 10 minutes when removed from manufacturer's original container.

Note 1: For proper disposal of HICs, please consult the HIC supplier.

Note 2: For appropriate use of HICs that include reversible (Type 1) and/or nonreversible (Type 2) spots, please consult the HIC supplier.

3.3.2.3.1 HIC Paper White blotting paper made from fibrous cellulosic material, with a minimum basis weight of, 255 g/m^2 (equivalent to a nominal 170 pounds basis weight) **shall** be used for HIC's.

3.3.2.3.2 Visual Defects HIC's as manufactured **shall** be free from defects including missing spots, tears, improperly located spots, and indicating color overrunning the black circles.

3.3.2.3.3 Preservation HIC's should be stored per 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 3-2 Typical Reversible (Type 1) 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	Dry (blue)	Spot Value change ≥7% hue (lavender)	Wet (pink)	Wet (pink)	Wet (pink)	Wet (pink)
10% Spot	Dry (blue)	Dry (blue)	Spot Value **change ≥10% hue** (lavender)	Wet (pink)	Wet (pink)	Wet (pink)
60% Spot	Dry (blue)	Dry (blue)	Dry (blue)	Dry (blue)	Spot Value **change ≥10% hue** (lavender)	Wet (pink)

Note: Other color change schemes may be used to indicate dry to wet. Please consult with the supplier for specific interpretation.

3.3.3 Labels

3.3.3.1 Labels - Moisture Sensitive Identification labels relevant to the dry-pack process are the Moisture-Sensitive Identification (MSID) label and the Caution label (see Figures 3-3 and 3-4). The MSID and Caution labels **shall** be contrasting colors. These labels **shall** be legible to normal vision at a distance of three feet. Monochromatic reproduction in any color that contrasts with the background may be used. Where the choice of color is arbitrary, it is recommended that:

- The MSID label background should be blue (Pantone #297C) with a black symbol and letters.
- The Caution label background should be white with a blue (Process blue) symbol and letters.

Note: Wherever possible, the color red should be avoided as red suggests a personal hazard.

Figure 3-3 Moisture-Sensitive Identification Label (Examples)

3.3.3.1.1 Moisture-Sensitive Identification (MSID) Label The MSID label **shall** be affixed to or printed on the lowest-level shipping container that contains the MBB. This label is recommended to be a minimum of 19 mm [0.75 in] in diameter. See examples in Figure 3-3.

3.3.3.1.2 Caution Label The Caution label **shall** be affixed to the outside surface of the MBB. The Caution label includes fields for the moisture classification level per J-STD-020 or process classification level per J-STD-075; 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 should be changed accordingly. The Caution Label **shall** be a minimum of 76 mm [3.0 in] by 76 mm [3.0 in] square.

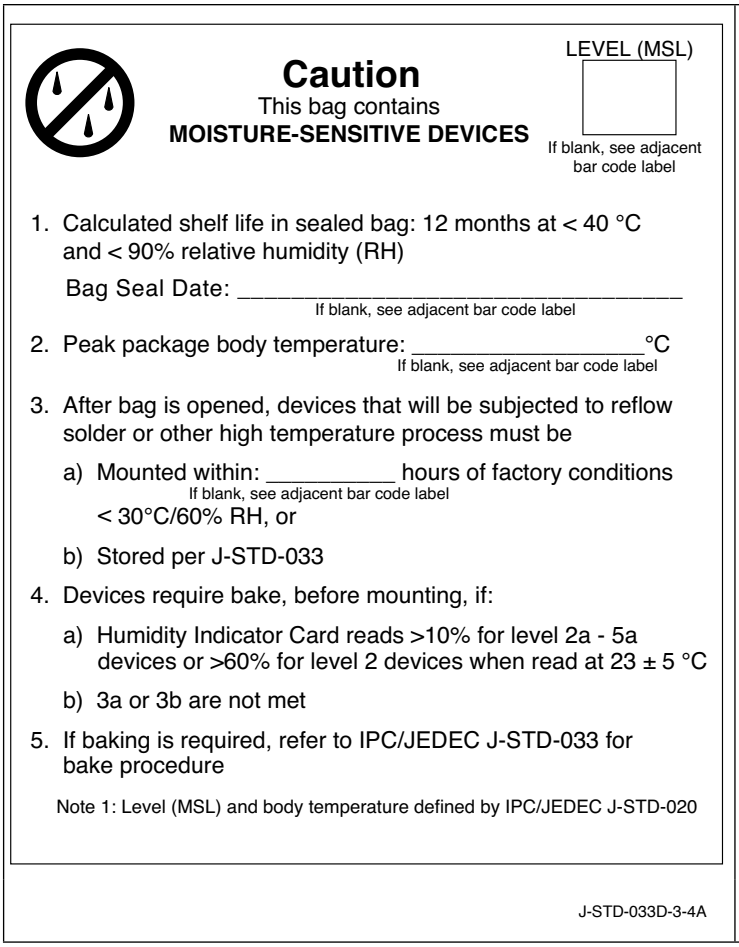


Figure 3-4A Caution Label (Examples with MSL only)

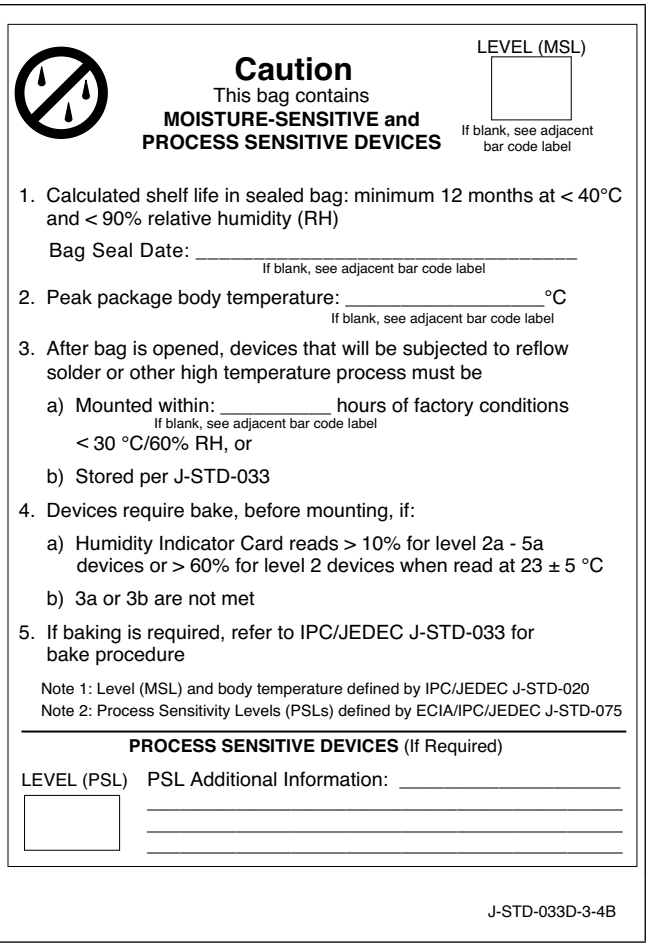


Figure 3-4B Caution Label (Examples with MSL and PSL)

3.3.3.2 Labels - Level 6 Requirements Level 6 parts not shipped in MBBs **shall** have both an MSID label and the appropriate Caution label affixed to the lowest level shipping container.

3.3.3.3 Labels - Level 1 Requirements Level 1 parts classified for other than 220 °C - 225 °C maximum reflow temperature **shall** have a Caution label with the maximum reflow temperature specified. The Caution label **shall** be affixed to the MBB (if used) or to the lowest-level shipping container. The Caution label is not required if a "Bar Code" label includes the Level 1 classification and maximum reflow temperature information in human readable form. Level 1 parts classified at 220 °C - 225 °C maximum reflow temperature do not require any moisture related labels.

3.3.4 Moisture Barrier Bag Sealing The bag **shall** be heat sealed so as not to damage or cause delamination of the MBB.

3.3.5 Dry-Pack Precautions

3.3.5.1 HIC Placement The HIC may be placed anywhere in the MBB, but should not be placed under, on top or touching a desiccant pouch.

3.3.5.2 HIC Reuse

3.3.5.2.1 HIC with 10% RH Indicated 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 hours.

3.3.5.2.2 HIC with 60% RH Indicated HIC **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.

3.3.5.3 Moisture Barrier Bag Sealing In actual practice air evacuation is not required (Figure 3-5). Light air evacuation may be used to reduce the packaging bulk and enhance carton packing (Figure 3-6). Full evacuation **shall not** be used as it will impede desiccant and HIC performance and possibly lead to MBB puncture (Figure 3-7).

Note: Typically the equilibrium within MBB is not reached until 7 days from bag seal date.

3.3.6 Shelf Life The calculated shelf life for dry-packed SMD packages **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 should be changed accordingly (see Fig. 3-4).

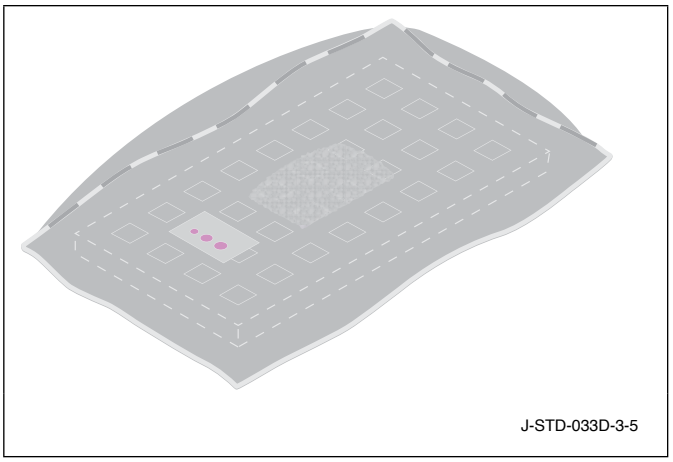


Figure 3-5 MBB with No Evacuation (Example)

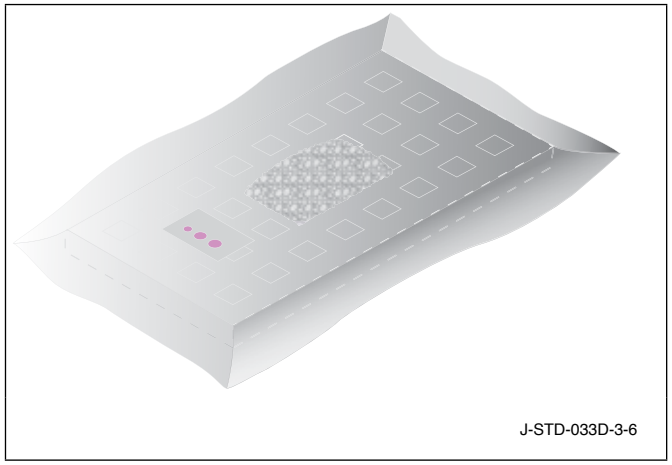


Figure 3-6 MBB with Recommended Light Air Evacuation (Example)

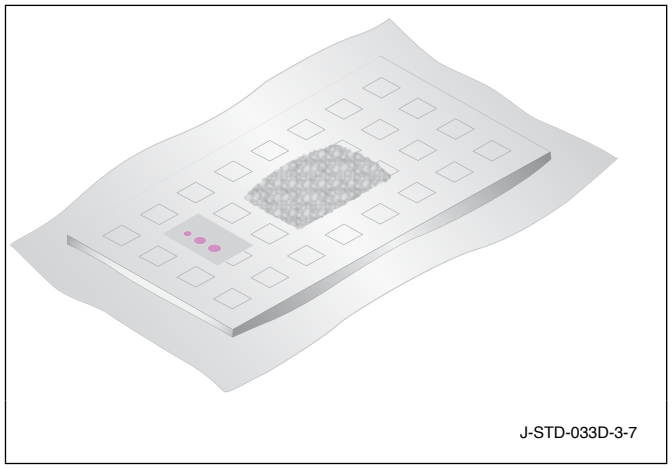


Figure 3-7 MBB with Too Much (Full) Evacuation (Example)

4 DRYING

Device drying options for various moisture sensitivity levels and ambient humidity exposures are given in the following two tables. Drying per an allowable option resets the floor-life clock. If dried and sealed in an MBB with fresh desiccant, the shelf life is reset. Tables 4-1, 4-2 and 4-3 give reference conditions for drying SMD packages. Table 4-1 gives conditions for rebake of SMD packages at a user site after the floor life has expired or other conditions have occurred to indicate excess moisture exposure.

Table 4-2 gives conditions for bake prior to dry pack at a supplier and/or distributor and allows for a maximum total of 24 hour MET. Table 4-3 summarizes conditions for resetting or pausing the floor-life clock at the user site per clause 4.1. The supplier **shall** formally communicate to the distributor the maximum time that the product may be left unsealed (at the distributor) before rebaking is required.

Note: If bake is interrupted for greater than 15 minutes the total time of the interruption should be added to the bake time.

Table 4-1 Reference Conditions for Drying Mounted or Unmounted SMD Packages (User Bake: Floor life begins counting at time = 0 after bake)

Package Body	Level	Bake @ 125 °C + 10/-0 °C < 5% RH		Bake @ 90 °C + 8/-0 °C ≤ 5% RH		Bake @ 40 °C + 5/-0 °C ≤ 5% RH	
		Exceeding Floor Life by > 72 h	Exceeding Floor Life by < 72 h	Exceeding Floor Life by > 72 h	Exceeding Floor Life by < 72 h	Exceeding Floor Life by > 72 h	Exceeding Floor Life by < 72 h
Thickness < 0.5 mm (see Note 5)	2	Not Required (see Note 4)	Not Required (see Note 4)	Not Required (see Note 4)	Not Required (see Note 4)	Not Required (see Note 4)	Not Required (see Note 4)
	2a	1 hour	1 hour	2 hours	1 hour	12 hours	8 hours
	3	1 hour	1 hour	3 hours	1 hour	22 hours	8 hours
	4	1 hour	1 hour	3 hours	1 hour	22 hours	8 hours
	5	1 hour	1 hour	3 hours	1 hour	23 hours	8 hours
	5a	1 hour	1 hour	4 hours	1 hour	26 hours	8 hours
Thickness > 0.5 mm ≤ 0.8 mm (see Note 5)	2	Not Required (see Note 4)	Not Required (see Note 4)	Not Required (see Note 4)	Not Required (see Note 4)	Not Required (see Note 4)	Not Required (see Note 4)
	2s	4 hours	3 hours	15 hours	13 hours	4 days	3 days
	3	4 hours	3 hours	15 hours	13 hours	4 days	3 days
	4	4 hours	3 hours	16 hours	13 hours	4 days	3 days
	5	4 hours	3 hours	16 hours	13 hours	4 days	3 days
	5a	4 hours	3 hours	16 hours	13 hours	4 days	3 days
Thickness > 0.8 mm ≤ 1.4 mm (see Note 5)	2	Not Required (see Note 4)	Not Required (see Note 4)	Not Required (see Note 4)	Not Required (see Note 4)	Not Required (see Note 4)	Not Required (see Note 4)
	2a	8 hours	6 hours	25 hours	20 hours	8 days	7 days
	3	8 hours	6 hours	25 hours	20 hours	8 days	7 days
	4	9 hours	6 hours	27 hours	20 hours	10 days	7 days
	5	10 hours	6 hours	28 hours	20 hours	11 days	7 days
	5a	11 hours	6 hours	30 hours	20 hours	12 days	7 days
Thickness > 1.4 mm ≤ 2.0 mm (see Note 5)	2	18 hours	15 hours	63 hours	2 days	25 days	20 days
	2a	21 hours	16 hours	3 days	2 days	29 days	22 days
	3	27 hours	17 hours	4 days	2 days	37 days	23 days
	4	34 hours	20 hours	5 days	3 days	47 days	28 days
	5	40 hours	25 hours	6 days	4 days	57 days	35 days
	5a	48 hours	40 hours	8 days	6 days	79 days	56 days
Thickness > 2.0 mm ≤ 4.5 mm (see Note 5)	2	48 hours	48 hours	10 days	7 days	79 days	67 days
	2a	48 hours	48 hours	10 days	7 days	79 days	67 days
	3	48 hours	48 hours	10 days	8 days	79 days	67 days
	4	48 hours	48 hours	10 days	10 days	79 days	67 days
	5	48 hours	48 hours	10 days	10 days	79 days	67 days
	5a	48 hours	48 hours	10 days	10 days	79 days	67 days
Exception for BGA package > 17 mm x 17 mm or any stacked die package	2 -5a	96 hours (See Note 2 and Note 5	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: Table 4-1 is based on worst-case molded lead frame SMD packages. 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 surface mount SMD packages. If parts have been exposed to > 60% RH it may be necessary to increase the bake time by tracking desorption data to insure parts are “dry”.

Note 2: For BGA packages > 17 mm x17 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.

Note 3: If baking of packages > 4.5 mm thick is required see appendix B.

Note 4: Baking not required if Floor Life exposure is limited to < 30C & < 60%RH for thin (< 1.4 mm) MSL2 devices. This is due to the moisture diffusion behavior of the thin devices, which were fully saturated after the absorption at MSL 2 (168 hours @85C/60%RH).

Note 5: 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 Table 4-1.

Table 4-2 Supplier Bake: Default Baking Times Used Prior to Dry Pack that were Exposed to Conditions ≤ 60% RH (''MET'' = 24 h)

Package Body Thickness	Level	Bake @ 125ºC + 10/-0 ºC < 5% RH	Bake @ 150ºC + 10/-0 ºC < 5% RH
≤ 1.4 mm	2 2a 3 4 5 5a	7 hours 8 hours 16 hours 21 hours 24 hours 28 hours	3 hours 4 hours 8 hours 10 hours 12 hours 14 hours
> 1.4 mm ≤ 2.0 mm	2 2a 3 4 5 5a	18 hours 23 hours 43 hours 48 hours 48 hours 48 hours	9 hours 11 hours 21 hours 24 hours 24 hours 24 hours
> 2.0 mm ≤ 4.5 mm	2 2a 3 4 5 5a	48 hours 48 hours 48 hours 48 hours 48 hours 48 hours	24 hours 24 hours 24 hours 24 hours 24 hours 24 hours

Note 1: If baking of packages > 4.5 mm thick is required see appendix B.

Note 2: 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 Table 4-2if 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 **shall** be determined using the procedure in JEDEC JESD22-A120 (i.e., < 0.002 % weight loss between successive readouts) or per critical interface concentration calculations.

Table 4-3 Resetting or Pausing the Floor-Life Clock at User Site

MSL Level	Exposure time @ temp/humidity	Floor Life	Desiccator time @ relative humidity	Bake	Reset shelf life
2, 2a, 3, 4, 5, 5a	Anytime ≤ 40 ºC/85% RH	reset	NA	Table 4.1	Dry Pack after Bake
2, 2a, 3, 4, 5, 5a	> floor life ≤ 30 ºC/60% RH	reset	NA	Table 4.1	Dry Pack after Bake
2, 2a, 3	> 12 hrs ≤ 30 ºC/60% RH	reset	NA	Table 4.1	Dry Pack after Bake
2, 2a, 3	≤ 12 hrs ≤ 30 ºC/60% RH	reset	5X exposure time ≤ 10% RH	NA	NA
2, 2a, 3	Cumulative time < floor life ≤ 30 ºC/60% RH	pause	Anytime ≤ 10% RH	NA	NA
4, 5, 5a	> 8 hrs ≤ 30 ºC/60% RH	reset	NA	Table 4.1	Dry Pack after Bake
4, 5, 5a	≤ 8 hrs ≤ 30 ºC/60% RH	reset	10X exposure time ≤ 5% RH	NA	NA

4.1 Post Exposure to Factory Ambient Placing SMD packages which have been exposed to factory ambient conditions for greater than one hour in a dry cabinet or dry pack does NOT necessarily stop/pause the floor-life clock. However, if the conditions of 4.1.2 are met, the floor-life clock can be paused or reset (see Table 4-3).

4.1.1 Any Duration Exposure Moisture sensitive SMD packages that have been exposed only to ambient conditions of ≤60% RH for any length of time may be adequately dried by high or low temperature baking according to Table 4-1 for rebake prior to reflow or Table 4-2 for drying prior to dry pack.

4.1.2 Short Duration Exposure Previously dry SMD packages, which have been exposed only to ambient conditions not exceeding 30 °C/60% RH may be adequately dried by room temperature desiccation using dry pack or a dry cabinet.

4.1.2.1 Moisture Sensitivity Levels 2-3 For moisture sensitivity Levels 2, 2a, 3 with floor-life exposure not greater than 12 hours, a minimum desiccating period of 5X the exposure time is required to dry the SMD packages enough to reset the floor-life clock (see Table 4-3). This can be accomplished by dry pack according to 3.3 or a dry cabinet that is capable of maintaining not greater than 10% RH.

For devices exposed anytime less than their stated floor life, dry packing or placing the devices in a dry cabinet maintaining not greater than 10% RH, will stop/pause the floor-life clock as long as the cumulative floor life meets the conditions in Table 5-1 and/or Table 7-1.

4.1.2.2 Moisture Sensitivity Levels 4, 5, 5a For moisture sensitivity Levels 4, 5, 5a with floor-life exposure not greater than 8 hours, a minimum desiccating period of 10X the exposure time is required to dry the SMD packages enough to reset the floor-life clock (see Table 4-3). This can be accomplished by a dry cabinet that is capable of maintaining not greater than 5% RH.

Once the floor-life clock has been reset, refer to 5.3 for safe storage conditions. Check with the device supplier if the floor-life clock can be stopped/paused.

4.2 General Considerations for Baking The oven used for baking **shall** be vented and capable of maintaining the required temperatures at less than 5% RH.

4.2.1 High Temperature Carriers Unless otherwise indicated by the manufacturer, SMD packages shipped in high temperature carriers can be baked in the carriers at 125 °C.

4.2.2 Low Temperature Carriers SMD packages shipped in low temperature carriers may not be baked in the carriers at any temperature higher than 40 °C. If a higher bake temperature is required, SMD packages must be removed from the low temperature carriers to thermally safe carriers, baked, and returned to the low temperature carriers.

Note 1: Manual handling may increase the risk of mechanical and/or ESD damage.

Note 2: If SMD packages are placed in dry bags with unbaked carriers, refer to 3.3.2.2.

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

4.2.4 Bakeout Times Bakeout times start when all SMD packages reach the specified temperature.

4.2.5 ESD Protection Proper ESD handling precautions **shall** be observed, per JESD625. This is particularly critical if SMD packages are handled under low humidity conditions, e.g., in a dry environment, after baking, etc.

4.2.6 Reuse of Carriers The appropriate materials specification should be consulted before reusing carriers.

4.2.7 Solderability Limitations

4.2.7.1 Oxidation Risk Baking SMD packages may 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 SMD packages 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 should not exceed 96 hours. If the bake temperature is not greater than 90 °C, there is no practical limit on bake time. Bake temperatures higher than 125 °C are not allowed without consulting the supplier.

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

5 USE

Upon opening the MBB, the floor-life clock starts. If an MBB is opened and the ambient conditions are other than 30°C/60% RH the procedures in Clause 7 and Table 7-1 should be followed.

5.1 Incoming Bag Inspection

5.1.1 Upon Receipt Dry-packed SMD packages 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 hours at 125 °C or using the saturated bake times of Table 4-1. This will reset the floor life if the parts are to be used and shelf life if the parts are to be dry packed.

5.1.2 Device Inspection Intact bags may be opened for device inspection by cutting at the top of the bag near the seal. If the bags are opened under factory ambient conditions, see 4.1.2.

5.2 Floor Life The floor life of SMDs per Table 5-1 will be modified by environmental conditions greater than 30 °C/60% RH or conditions in Table 7-1. Refer to Clause 7 to determine maximum allowable time before rebake would be necessary. If partial lots are used, the remaining SMD packages must be resealed or placed in safe storage within one hour of bag opening (see 5.3). If one hour exposure is exceeded, refer to 4.1.

Table 5-1 Moisture Classification Level (MSL) and Floor Life per J-STD-020

MSL 1	**Floor Life (out of bag) is Unlimited**
Other MSLs	**Floor Life (out of bag) at factory ambient ≤ 30 ºC/60% RH**
2	1 year
2a	4 weeks
3	168 hours
4	72 hours
5	48 hours
5a	24 hours
6	Mandatory bake before use. After bake, must be reflowed within the time limit specified on the label

5.3 Safe Storage 'Safe storage' means dry SMD packages held in a controlled humidity condition such that the floor-life clock remains at zero. Acceptable safe storage conditions for SMD packages classified as Level 2 through 5a are listed below. For longer term storage refer to JEP160.

Note: Appropriate controls for temperature and moisture should also be in place for Level 1 devices.

5.3.1 Dry Pack Dry-packed SMD packages in intact MBBs, stored per 3.3, **shall** have a calculated shelf life of at least 12 months from the bag seal date shown on the caution or bar code label.

Note: Typically the equilibrium within MBB is not reached until 7 days from bag seal date.

5.3.2 Shelf Life The minimum calculated shelf life is 12 months from bag seal date or indicated on barcode. If the actual shelf life has exceeded 12 months from the bag seal date and the humidity indicator card (HIC) (see 5.5.1) indicates that baking is not required; then it is safe to reflow the devices per the original MSL rating. However, unanticipated factors other than moisture/reflow sensitivity could affect the total shelf life of the devices.

5.3.3 Dry Atmosphere Cabinet Storage cabinets which maintain low humidity by purging with dry air or nitrogen at 25 ± 5 °C. The cabinets must be capable of recovering to their stated humidity rating within one hour from routine excursions such as door opening/closing.

5.3.3.1 Dry Cabinet at 10% RH SMD packages 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 a MBB. Storage of SMD packages in these dry cabinets should be limited to a maximum time per Table 7-1. If the time limit is exceeded they should be baked according to Table 4-2 to restore the floor life.

5.3.3.2 Dry Cabinet at 5% RH SMD packages 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 dry pack with unlimited shelf life.

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

5.4.1 Opened MBB After a dry pack (MBB) has been opened, all SMD packages within that bag must complete all solder reflow processing, including rework, prior to the stated floor life, resealed in the MBB, or stored in a dry atmosphere cabinet per 4.1. If the floor life or factory ambient conditions are exceeded, refer to 5.5.2.

5.4.2 Reflow Temperature Extremes During reflow the device body temperature must not exceed the rated value stated on the Caution label. The body temperature during reflow directly influences device reliability.

Note 1: The device body temperature may 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 may require heating the device body to temperatures hotter than 225 °C. If that temperature exceeds the classification temperature, moisture precautions and/or time-temperature limitations beyond the scope of this specification may be required. The supplier should be consulted.

5.4.3 Additional Thermal Profile Parameters During reflow, the additional thermal profile parameters stated in JESD22- A113 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 also influence device reliability.

5.4.4 Multiple Reflow Passes If more than one reflow pass is used; care must be taken to ensure that no moisture sensitive SMD packages, mounted or unmounted, have exceeded their floor life prior to the final pass. If any device on the board has exceeded its floor life the board needs to be baked prior to the next reflow. Clause 6 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 may be entrapped, water clean processes after the first reflow can be an additional source of moisture. This may present an additional risk, which should be evaluated.

5.4.5 Maximum Reflow Passes A maximum of three reflow passes is allowed per device. If more than three are required for any reason, the supplier should be consulted (reference J-STD-020).

5.5 Drying Indicators Events and conditions that require device drying prior to reflow or continued safe storage.

5.5.1 Excess Humidity in the Dry Pack 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 ± 5 °C. The following conditions apply regardless of the storage time, i.e., whether or not the shelf life has been exceeded.

Note 1: "Witness" cards may be available from the HIC manufacturer if needed to confirm the Wet/dry colors.

Note 2: Typically the equilibrium within MBB is not reached until 7 days from bag seal date.

5.5.1.1 HIC Indication 1 If the 10% and 60% RH spots indicate dry, then Levels 2, 2a, 3, 4, 5, and 5a parts are still adequately dry. If the bag is to be resealed refer to 4.1.

5.5.1.2 HIC Indication 2 If the 5% RH spot indicates wet and the 10% RH spot does not indicate dry, and the 60% spot indicates dry, the Levels 2a, 3, 4, 5, and 5a parts have been exposed to an excessive level of moisture, and drying **shall** be done per Clause 4. Level 2 parts are still adequately dry.

5.5.1.3 HIC Indication 3 If the 5%, 10%, and 60% RH spots indicate wet, Level 2 parts have been exposed to an excessive level of moisture, and drying **shall** be done per Clause 4.

Note: Discard HICs where the 60% spot indicates wet.

5.5.2 Floor Life or Ambient Temperature/Humidity Exceeded If the floor life or ambient temperature/humidity conditions per Table 5-1 have been exceeded, SMD packages must be dried per Clause 4 prior to reflow or safe storage.

If the factory ambient temperature and/or humidity conditions per Table 5-1 cannot be met, the device floor life must be derated to compensate. Floor-life derating is discussed in Clause 7.

5.5.3 Level 6 SMD Packages SMD packages classified as Level 6 must be dried by baking, and then reflowed within the time limit specified on the label.

6 BOARD REWORK

6.1 Device Removal, Rework and Remount If a device is to be removed from the board, it is recommended that localized heating be used and the maximum body temperatures of any surface mount device on the board not exceed 200 °C. This method will minimize moisture related device damage. If any device temperature exceeds 200 °C, the board must be baked dry per 6.2 prior to rework and/or device removal. Device temperatures **shall** be measured at the top center of the package body. Any SMD package that has not exceeded its floor life can be exposed to a maximum body temperature as high as its maximum reflow temperature as defined by J-STD-020.

Note: Socketed devices should be removed prior to rework.

6.1.1 Removal for Failure Analysis Not following the requirements of 6.1 may cause moisture/reflow damage that could hinder

or completely prevent the determination of the original failure mechanism.

6.1.2 Removal and Remount Removal and reinstallation or replacement of a device should be conducted following IPC-7711/21. If a device is to be removed and reinstalled it may be necessary to first bake the printed wiring assembly to eliminate moisture from the device. Table 4-1 may be used as a guide in identifying an appropriate bake cycle. When identifying a bake cycle, the maximum exposure temperature and maximum rate of temperature change of devices and materials on the subject printed wiring assembly must be considered, and an appropriate time temperature profile (see IPC-7711/21) used. An SMD package **shall not** exceed its MSL ratings per J-STD-020 at any time during replacement. Localized replacement reflow heating is recommended so that the entire board is not re-subjected to reflow temperature profiles.

Note: Temperatures on neighboring SMD packages above the melting point of the solder being used may cause some solder joints to partially reflow, which may result in a potential solder joint reliability concern.

6.2 Baking of Populated Boards A default board assembly bake-out temperature of 125 °C **shall** be used, except in cases where devices and/or board materials cannot withstand this condition. Examples of temperature sensitive devices include organic LEDs, batteries and electrolytic capacitors. With device and board temperature restrictions in mind, choose a bake temperature from Table 4-1; then determine the appropriate bake duration based on the device to be removed. For additional considerations see IPC-7711/21.

7 DERATING DUE TO FACTORY ENVIRONMENTAL CONDITIONS

Factory floor-life exposures for SMD packages removed from the dry bags will be a function of the ambient environmental conditions. A safe, yet conservative, handling approach is to expose the SMD packages only up to the maximum time limits for each moisture sensitivity level as shown in Table 5-1. 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 device packaging materials (ref. JESD22- A120). Recommended equivalent total floor-life exposures can be estimated for a range of humidity's and temperatures based on the worst case exposure conditions and the nominal plastic thickness for each device. Table 7-1 lists equivalent derated floor lives for humidity's ranging from 5-90% RH for temperatures of 20 °C, 25 °C, 30 ºC and 35 °C. This table is applicable to SMDs molded with novolac, biphenyl or multifunctional epoxy mold compounds. The following assumptions were used in calculating Table 7-1:

1. Activation Energy for diffusion = 0.35eV (smallest known value).
2. For ≤ 60% RH, use Diffusivity = 0.121exp (- 0.35eV/kT) mm^2/s (this uses smallest known Diffusivity @ 30 °C).
3. For >60% RH, use Diffusivity = 1.320exp (- 0.35eV/kT) mm^2/s (this uses largest known Diffusivity @ 30 °C).

Table 7-1 Recommended Equivalent Total Floor Life (days) @ 20 °C, 25 °C & 30 °C, 35 °C For ICs with Novolac, Biphenyl and Multifunctional Epoxies (Reflow at same temperature at which the device was classified)

		Maximum Percent Relative Humidity										
Package Type and Body Thickness	**Moisture Sensitivity Level**	**5%**	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	
Body Thickness is ≥ 3.1 mm including: PQFPs > 84 pins, PLCCs (square), All MQFPs, All BGAs ≥ 1 mm	Level 2a	∞	∞	94	44	32	26	16	7	5	4	35 °C
		∞	∞	124	60	41	33	28	10	7	6	30 °C
		∞	∞	167	78	53	42	36	14	10	8	25 °C
		∞	∞	231	103	69	57	47	19	13	10	20 °C
	Level 3	∞	∞	8	7	6	6	6	4	3	3	35 °C
		∞	∞	10	9	8	7	7	5	4	4	30 °C
		∞	∞	13	11	10	9	9	7	6	5	25 °C
		∞	∞	17	14	13	12	12	10	8	7	20 °C
	Level 4	∞	3	3	3	2	2	2	2	1	1	35 °C
		∞	5	4	4	4	3	3	3	2	2	30 °C
		∞	6	5	5	5	5	4	3	3	3	25 °C
		∞	8	7	7	7	7	6	5	4	4	20 °C
	Level 5	∞	2	2	2	2	1	1	1	1	1	35 °C
		∞	4	3	3	2	2	2	2	1	1	30 °C
		∞	5	5	4	4	3	3	2	2	2	25 °C
		∞	7	7	6	5	5	4	3	3	3	20 °C
	Level 5a	∞	1	1	1	1	1	1	1	1	1	35 °C
		∞	2	1	1	1	1	1	1	1	1	30 °C
		∞	3	2	2	2	2	2	1	1	1	25 °C
		∞	5	4	3	3	3	2	2	2	2	20 °C
Body Thickness is < 3.1 mm down to 2.1 mm including: PLCCs (rectangular) 18-32 pins, SOICs (wide body), SOICs ≥ 20 pins, PQFPs ≤ 80 pins	Level 2a	∞	∞	∞	∞	58	30	22	3	2	1	35 °C
		∞	∞	∞	∞	86	39	28	4	3	2	30 °C
		∞	∞	∞	∞	148	51	37	6	4	3	25 °C
		∞	∞	∞	∞	∞	69	49	8	5	4	20 °C
	Level 3	∞	∞	12	9	7	6	5	2	2	1	35 °C
		∞	∞	19	12	9	8	7	3	2	2	30 °C
		∞	∞	25	15	12	10	9	5	3	3	25 °C
		∞	∞	32	19	15	13	12	7	5	4	20 °C
	Level 4	∞	5	4	3	3	2	2	1	1	1	35 °C
		∞	7	5	4	4	3	3	2	2	1	30 °C
		∞	9	7	5	5	4	4	3	2	2	25 °C
		∞	11	9	7	6	6	5	4	3	3	20 °C
	Level 5	∞	3	2	2	2	2	1	1	1	1	35 °C
		∞	4	3	3	2	2	2	1	1	1	30 °C
		∞	5	4	3	3	3	3	2	1	1	25 °C
		∞	6	5	5	4	4	4	3	3	2	20 °C
	Level 5a	∞	1	1	1	1	1	1	1	0.5	0.5	35 °C
		∞	2	1	1	1	1	1	1	0.5	0.5	30 °C
		∞	2	2	2	2	2	2	1	1	1	25 °C
		∞	3	2	2	2	2	2	2	2	1	20 °C
Body Thickness is < 2.1 mm including: SOICs < 18pins, All TQFPs, All TSOPs, All BGAs < 1 mm body thickness	Level 2a	∞	∞	∞	∞	∞	∞	17	1	0.5	0.5	35 °C
		∞	∞	∞	∞	∞	∞	28	1	1	1	30 °C
		∞	∞	∞	∞	∞	∞	∞	2	1	1	25 °C
		∞	∞	∞	∞	∞	∞	∞	2	2	1	20 °C
	Level 3	∞	∞	∞	∞	∞	8	5	1	0.5	0.5	35 °C
		∞	∞	∞	∞	∞	11	7	1	1	1	30 °C
		∞	∞	∞	∞	∞	14	10	2	1	1	25 °C
		∞	∞	∞	∞	∞	20	13	2	2	1	20 °C
	Level 4	∞	∞	∞	7	4	3	2	1	0.5	0.5	35 °C
		∞	∞	∞	9	5	4	3	1	1	1	30 °C
		∞	∞	∞	12	7	5	4	2	1	1	25 °C
		∞	∞	∞	17	9	7	6	2	2	1	20 °C
	Level 5	∞	∞	7	3	2	2	1	1	0.5	0.5	35 °C
		∞	∞	13	5	3	2	2	1	1	1	30 °C
		∞	∞	18	6	4	3	3	2	1	1	25 °C
		∞	∞	26	8	6	5	4	2	2	1	20 °C
	Level 5a	∞	7	2	1	1	1	1	1	0.5	0.5	35 °C
		∞	10	3	2	1	1	1	1	1	0.5	30 °C
		∞	13	5	3	2	2	2	1	1	1	25 °C
		∞	18	6	4	3	2	2	2	2	2	20 °C

Note: ∞ Represents indefinite exposure time allowed at conditions specified.

APPENDIX A
Test Method for Reversible (Type 1) RH Spots on a Humidity Indicator Card (HIC) used with Electronic Device Packaging

Note: It is intended to make the HIC test method and criteria a separate standard in the future.

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

Testing Apparatus A test environment capable of maintaining atmosphere at a temperature of 23 ºC + 1 ºC and a relative humidity from (2% RH to 65% RH) + 1% RH. The cards inside the chamber must be observable from outside the chamber. Nominally, an acrylic box with a volume of approximately 2 cubic feet, having facilities for access to the box interior while maintaining atmosphere is used. Refer to Figure A-1. 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 (AccuProbe HH06, Accuracy Microsensors, Pittsford, NY or equivalent)

An electronic hygrometer, with the minimum range of 1% RH to 90% RH.

Testing Procedure Place the sealed container of cards into the chamber. Set the chamber to the first humidity listed in Table 3-2. 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.

HIC Spot Compliance:

	Hue Value Reading Taken At	
RH Indicating Spot	Initial (Dry)	Conditioned (Spot Value)
5%	2%	5%
10%	5%	10%
60%	55%	60%

Note: Printing in the indicating spot (colored area) will affect hue measurement. Spots without printing **shall** be tested.

Data Analysis Using the a* and b* data, calculate the hue value for each spot at each humidity condition in Table 3-2 where:

If a* and b* are negative then:

Hue = the absolute value of ARCTAN(b*/a*)

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

Hue = 180 + ARCTAN(b*/a*)

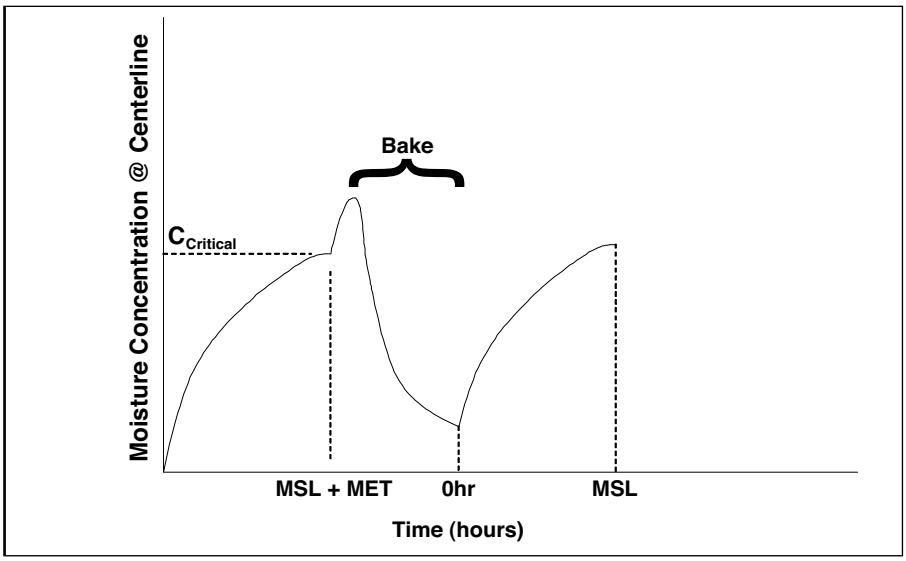
If a* is negative and b* is positive then:

Hue = 360 + ARCTAN(b*/a*)

Calculate the percent change in hue value at the humidity values shown in Table 3-2. Accept cards that show a 10% or greater change in hue value reading from initial dry to the conditioned spot value per the above spot compliance table. Cards with spots that do not indicate 'dry' or 'wet' conditions, per Table 3-2, should be rejected.

Figure A-1 Photo of Testing Apparatus

APPENDIX B
Derivation of Bake Tables



Bake Tables 4.1 and 4.2 were calculated using the following assumptions/approach:

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

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

CSat (@ surface) ∞ %RH in ambient atmosphere (Henry's Law)

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

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

2. Diffusivity = 6.2exp(-0.445eV/kT) mm^2/s, (assumes slow diffusing mold compound)
   a. $D_{30\ °C} = 2.48x10^{-7}\ mm^2/s$
   b. $D_{40\ °C} = 4.27x10^{-7}\ mm^2/s$
   c. $D_{90\ °C} = 4.13x10^{-6}\ mm^2/s$
   d. $D_{125\ °C} = 1.44x10^{-5}\ mm^2/s$
3. Define:
   a. $L_{centerline}$ = critical thickness, e.g., thickness of package / 2
   b. $C_{Critical}$ = concentration at $L_{centerline}$ for given MSL (based on 30 ºC/60%RH exposure + 24hr MET preconditioning)
   c. $C_{Centerline}$ = concentration at $L_{centerline}$ for any exposure condition
4. Impose following two exposure conditions:
   a. MSL + >72hr exposure (assume saturated at 30 ºC/85%RH where $C_{Sat} = 7.8mg/cm^3$)
   b. MSL+ ≤72hr exposure (assume ambient at 30 ºC/60%RH where $C_{Sat} = 5.3mg/cm^3$)
5. Calculate minimum time @ Bake temperature for cases 4a and 4b where an additional MSL exposure will keep $C_{Centerline} < C_{Critical}$.

Ref: R. L. Shook and J. P. Goodelle, "Handling of Highly-Moisture Sensitive Components - An Analysis of Low-Humidity Containment and Baking Schedules", ECTC, 1999, pp. 809-15.

APPENDIX C
Desiccant Unit Absorption Capacity Test Method for Verification

This test should be used to determine if a desiccant is active and fit for use in dry-packing. It **shall** meet the adsorption requirements per MIL-D-3464 when tested in the following method:

1. Use a commercial environmental chamber capable of maintaining a RH% range of 20 to 80% at 25°C. For this routine verification test the temperature of the chamber **shall** be controlled to 25 +/- 2°C.
2. As per J-STD-033, for comparison between various desiccant types, military 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 adsorb a minimum of 2.85 g of water vapor at 20% RH and 25 °C. It is recommended to test bagged desiccant at 20% RH to simulate normal use. As an alternative, at 40% RH a unit **shall** adsorb 5.7 g. Tests are to be conducted with bagged desiccant fit for use in dry-packing.
3. A UNIT sample of the desiccant **shall** be weighed on a glass dish. Care **shall** be exercised to ensure that the material is exposed to the lab air environment for a minimum amount of time. The dish **shall** then be placed in the environmental chamber that has been set for either 20% or 40% RH at 25°C. Periodically the dish **shall** be removed from the chamber and weighed. This process **shall** be repeated until two successive weighings, approximately 1 hour apart, show a weight variation not exceeding 0.005 gram. The test **shall** be considered complete if at any time the minimum weight variation is attained. The adsorption capacity of the desiccant **shall** be determined by the following equation for the specified RH.

Unit adsorption capacity = (U * G) / W

Where: U = Unit weight (grams) or 10 grams
G = Gain in weight of sample (grams)
W = Original weight of sample (grams)

Note: Sample size can be multiples or fractions of a UNIT. If using a sample other than a UNIT, the calculations must be normalized to one UNIT.

3. Compare the unit adsorption capacity obtained from the test to the specified adsorption amount at the corresponding condition (see MIL-D-3464 3.4.1). If the desiccant material does not adsorb the required amount of water vapor it **shall** be considered compromised and unfit for use.

APPENDIX D
Changes in J-STD-033D

Reference	J-STD-033C	J-STD-033D
Terms and Definitions	Terms and Definitions	Added MSL definition per J-STD-020
Terms and Definitions	Terms and Definitions	Added PSL definition per J-STD-075
Terms and Definitions	Terms and Definitions	Clarification of “Shelf life” definition
Terms and Definitions	Terms and Definitions	Revised humidity indicator card (HIC) definition to include Type 1 (Reversible) and Type 2 (Nonreversible)
Applicable Documents	Applicable Documents	Added reference to JEP160
Applicable Documents	Applicable Documents	Removed reference to JEP113, since needed label information has been added
Table 3-1	Table 3-1	Added row for “Sockets” to clarify it is N/A (Not Applicable)
3.3.2.2.1	3.3.2.2.1	Added clarification of (0.304 = Average number of days per month/100 in^2 (30.4/100)
3.3.2.2.2	3.3.2.2.2	Added reference to Appendix C for verification of desiccant unit absorption capacity
3.3.2.3	3.3.2.3	Revised to include Type 1 (Reversible) and Type 2 (Nonreversible) HICs & Handling (use / disposal) of HICs
Table 3-2	Table 3-2	Revised for Type 1 HICs for indicator (Dry or Wet) over color reading
3.3.3.1	3.3.3.1	Added info for MSID and Caution Labels that was previously referenced to JEP113
Figure 3-3	Figure 3-3	Added 2nd label example from JEP113 for MSID labels
Figure 3-4	Figure 3-4	Updated MSL and added MSL/PSL Caution label examples
3.3.5.3, 5.3.1 & 5.5.1	3.3.5.3, 5.3.1 & 5.5.1	Added Note on MBB equilibrium not typically reached until 7 days
Table 4-1	Table 4-1	Update column (<5% RH) Added new bake times values for thinner packages (< 1.4mm) & “<5% RH” to 125°C bake condition. Plus added Notes 4 & 5 for clarification of table
Table 4-2	Table 4-2	Added “<5% RH” to 125°C & 150°C bake conditions for clarification
Table 4-3	Table 4-3	Fixed typos in “MSL Level” column & sorted the table order based on that column
4.1.2.2	4.1.2.2	Added to check with supplier if floor life clock can be stopped/paused
Table 5-1	Table 5-1	Removed factory ambient temperature & humidity conditions for MSL 1 floor life
5.3	5.3	Added reference to JEP160 for longer term storage & Note for appropriate controls of temperature & humidity should be used for MSL 1 devices
5.3.2	5.3.2	Removed 2 year limit and Note based on data shown HICs are accurate beyond 2 years
Appendix A	Appendix A	Updated title to clarify that the TM for Type 1 (Reversible) HICs
Appendix C	New to 033D	Added TM for verification of desiccant unit absorption capacity
Editorial Changes Throughout		

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ANSI/IPC-T-50 Terms and Definitions for Interconnecting and Packaging Electronic Circuits Definition Submission/Approval Sheet

The purpose of this form is to keep current with terms routinely used in the industry and their definitions. Individuals or companies are invited to comment. Please complete this form and return to:

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❑ This is a **NEW** term and definition being submitted.
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If space not adequate, use reverse side or attach additional sheet(s).

Artwork: ❑ Not Applicable ❑ Required ❑ To be supplied
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Standard Improvement Form

IPC/JEDEC J-STD-033D

The purpose of this form is to provide the Technical Committee of IPC with input from the industry regarding usage of the subject standard.

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1. I recommend changes to the following:

___ Requirement, paragraph number _____

___ Test Method number _____, paragraph number _____

The referenced paragraph number has proven to be:

___ Unclear ___ Too Rigid ___ In Error

___ Other _____

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