JOINT INDUSTRY STANDARD

Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount 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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Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount 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

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

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Members of the Joint IPC/JEDEC Moisture Classification Task Group have worked to develop this document. We would like to thank them for their dedication to this effort. Any standard involving a complex technology draws material from a vast number of sources. While the principal members of the Joint Moisture Classification Working Group are shown below, it is not possible to include all of those who assisted in the evolution of this Standard. To each of them, the members of the JEDEC and IPC extend their gratitude.

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Handling, Packing, Shipping, and Use of Moisture/Reflow and/or Process Sensitive Components

1 FOREWORD
The advent of surface mount devices (SMDs) introduced a new class of quality and reliability concerns regarding damage from the solder reflow process, such as cracks and delamination. 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 and J-STD-075 define the classification procedure and JEP113 defines the labeling requirements.

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 infrared (IR), convection/IR, convection, vapor phase reflow (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 infrared (IR), convection/IR, convection, and vapor phase reflow (VPR) processes. It does not apply to bulk 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.

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. (Refer to Clause 6.)

1.3.3 Socketed Components 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 components.

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 manufacturer’s 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 components 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 fixture used to store and transport devices and components.

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

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

1.5.7 **Humidity Indicator Card (HIC)**  A card on which a moisture-sensitive chemical is applied such that it will make a significant, perceptible change in color (hue), typically from blue (dry) to pink (wet) when the indicated relative humidity is exceeded.

**Note:** 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.

1.5.8 **Manufacturer’s Exposure Time (MET)**  The maximum cumulative time after bake that components 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 **Rework**  The removal of a component for scrap, reuse, or failure analysis; the replacement of an attached component; or the heating and repositioning of a previously attached component.

1.5.12 **Shelf Life**  The minimum time that a dry-packed, moisture-sensitive device can be stored in an unopened moisture barrier bag (MBB) such that a specified interior bag ambient humidity is not exceeded.

1.5.13 **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.

1.5.14 **Solder Reflow**  A solder attachment process in which previously applied solder or solder paste is melted to attach a component to a printed circuit board.
1.5.15 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 392 Standard Test Method for Flex Durability of Flexible Barrier Materials

2.2 Electronic Industries Alliance (EIA, JEDEC)²

EIA-541 Packaging Material Standards for ESD Sensitive Items

JESD625 Requirements for Handling Electrostatic Discharge Sensitive Devices (ESDS)

JEP113 Symbol and Labels for Moisture Sensitive Devices

JESD22-A113 Preconditioning of Non-hermetic Surface Mount Components 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 Standards³

IPC-7711 Rework of Electronic Assemblies

IPC-7721 Repair and Modification of Printed Boards and Electronic Assemblies

2.4 Joint Industry Standards⁴


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

2.5 Department of Defense⁵

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 environmental reliability testing. As a minimum, all materials used in dry packing should conform to EIA-541.

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 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.

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/m² (0.002 g/100 in²) in 24 hrs 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:

\[
U = \frac{0.304 \times M \times WVTR \times A}{D}
\]

Where:
- \(U\) = Amount of desiccant in UNITS
- \(M\) = Shelf life desired in months (see Clause 3.3.6 for shelf life)
- \(WVTR\) = Water vapor transmission rate in grams/m² in 24 hrs.
- \(A\) = Total exposed surface area of the MBB in square decimeters
- \(D\) = 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 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 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 component 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 baking. Any such material that is included increases the amount of desiccant needed to meet the calculated shelf life (see Clause 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 at 25 °C, must be added to absorb the amount of water, in grams, egressed from the packing materials (dunnage) after baking.

### 3.3.2.2.2 Desiccant Handling and Storage

Desiccant capacity decreases rapidly when exposed to 30 °C/60% RH. Therefore the desiccant shall 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.

### 3.3.2.3 Humidity Indicator Card (HIC)

At minimum, the HIC shall have three (3) color spots with sensitivity values of 5%, 10%, and 60% RH. An example HIC is shown in Figure 3-2. 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 changed color. Reuse is not allowed, due to loss of accuracy of the 5% and 10% spot chemistry, if the 60% spot has changed color. 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.

#### 3.3.2.3.1 HIC Paper

White blotting paper made from fibrous, cellulosic material, with a minimum basis weight of 255 g/m² (equivalent to a nominal 170 pounds basis weight) shall be used for HICs.

#### 3.3.2.3.2 Visual Defects

HICs 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

HICs 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.
### 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 as specified in JEDEC JEP113 (see Figures 3-3 and 3-4). 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 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.

#### 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 at 220 - 225 °C [428 - 437 °F] maximum reflow temperature do not require any moisture related labels. Level 1 parts classified for other than 220 - 225 °C [428 - 437 °F] 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.

#### 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 shall not be placed under a desiccant pouch.

---

#### Table 3-2 Typical HIC Spot Compliance

<table>
<thead>
<tr>
<th>Indication at 2% RH Environment</th>
<th>Indication at 5% RH Environment</th>
<th>Indication at 10% RH Environment</th>
<th>Indication at 55% RH Environment</th>
<th>Indication at 60% RH Environment</th>
<th>Indication at 65% RH Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5% Spot</strong></td>
<td>Blue (dry)</td>
<td>Lavender (spot value) change ≥7% hue</td>
<td>Pink (wet)</td>
<td>Pink (wet)</td>
<td>Pink (wet)</td>
</tr>
<tr>
<td><strong>10% Spot</strong></td>
<td>Blue (dry)</td>
<td>Blue (dry)</td>
<td>Lavender (spot value) change ≥10% hue</td>
<td>Pink (wet)</td>
<td>Pink (wet)</td>
</tr>
<tr>
<td><strong>60% Spot</strong></td>
<td>Blue (dry)</td>
<td>Blue (dry)</td>
<td>Blue (dry)</td>
<td>Lavender (spot value) change ≥10% hue</td>
<td>Pink (wet)</td>
</tr>
</tbody>
</table>

*Note: Other color schemes may be used.*

---

#### Figure 3-3 Moisture-Sensitive Identification Label (Example)

#### Figure 3-4 Moisture-Sensitive Caution Label (Example)
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).

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 Figure 3-4).

4 DRYING

Component drying options for various moisture sensitivity levels and ambient humidity exposures are given in the following three 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.

4.1 Post Exposure to Factory Ambient  Placing SMD packages that 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 Clause 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.
Table 4-1 Reference Conditions for Drying Mounted or Unmounted SMD Packages (User Bake: Floor life begins counting at time = 0 after bake)

<table>
<thead>
<tr>
<th>Package Body</th>
<th>Level</th>
<th>Bake @ 125 °C +10/-0 °C</th>
<th>Bake @ 90 °C +8/-0 °C ≤5% RH</th>
<th>Bake @ 40 °C +5/-0 °C ≤5% RH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Exceeding Floor Life by &gt;72 h</td>
<td>Exceeding Floor Life by ≤72 h</td>
<td>Exceeding Floor Life by &gt;72 h</td>
</tr>
<tr>
<td>Thickness ≤1.4 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>5 hours</td>
<td>3 hours</td>
<td>17 hours</td>
<td>11 hours</td>
</tr>
<tr>
<td>2a</td>
<td>7 hours</td>
<td>5 hours</td>
<td>23 hours</td>
<td>13 hours</td>
</tr>
<tr>
<td>3</td>
<td>9 hours</td>
<td>7 hours</td>
<td>33 hours</td>
<td>23 hours</td>
</tr>
<tr>
<td>4</td>
<td>11 hours</td>
<td>7 hours</td>
<td>37 hours</td>
<td>23 hours</td>
</tr>
<tr>
<td>5</td>
<td>12 hours</td>
<td>7 hours</td>
<td>41 hours</td>
<td>24 hours</td>
</tr>
<tr>
<td>5a</td>
<td>16 hours</td>
<td>10 hours</td>
<td>54 hours</td>
<td>24 hours</td>
</tr>
<tr>
<td>Thickness &gt;1.4 mm ≤2.0 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>18 hours</td>
<td>15 hours</td>
<td>63 hours</td>
<td>2 days</td>
</tr>
<tr>
<td>2a</td>
<td>21 hours</td>
<td>16 hours</td>
<td>4 days</td>
<td>2 days</td>
</tr>
<tr>
<td>3</td>
<td>27 hours</td>
<td>17 hours</td>
<td>5 days</td>
<td>3 days</td>
</tr>
<tr>
<td>4</td>
<td>34 hours</td>
<td>20 hours</td>
<td>6 days</td>
<td>4 days</td>
</tr>
<tr>
<td>5</td>
<td>40 hours</td>
<td>25 hours</td>
<td>7 days</td>
<td>5 days</td>
</tr>
<tr>
<td>5a</td>
<td>48 hours</td>
<td>40 hours</td>
<td>8 days</td>
<td>6 days</td>
</tr>
<tr>
<td>Thickness &gt;2.0 mm ≤4.5 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>48 hours</td>
<td>48 hours</td>
<td>10 days</td>
<td>7 days</td>
</tr>
<tr>
<td>2a</td>
<td>48 hours</td>
<td>48 hours</td>
<td>10 days</td>
<td>7 days</td>
</tr>
<tr>
<td>3</td>
<td>48 hours</td>
<td>48 hours</td>
<td>10 days</td>
<td>8 days</td>
</tr>
<tr>
<td>4</td>
<td>48 hours</td>
<td>48 hours</td>
<td>10 days</td>
<td>10 days</td>
</tr>
<tr>
<td>5</td>
<td>48 hours</td>
<td>48 hours</td>
<td>10 days</td>
<td>10 days</td>
</tr>
<tr>
<td>5a</td>
<td>48 hours</td>
<td>48 hours</td>
<td>10 days</td>
<td>10 days</td>
</tr>
<tr>
<td>BGA package &gt;17 mm x 17 mm or any stacked die package</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2-5a</td>
<td>96 hours (See Note 2)</td>
<td>As above per package thickness and moisture level</td>
<td>Not applicable</td>
<td>As above per package thickness and moisture level</td>
</tr>
</tbody>
</table>

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 nonhermetic 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 ensure parts are dry.

Note 2: For 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.

Note 3: If baking of packages >4.5 mm thick is required see appendix B.
Table 4-2  Default Baking Times Used Prior to Dry-Pack
that were Exposed to Conditions ≤60% RH (MET = 24 h)

<table>
<thead>
<tr>
<th>Package Body Thickness</th>
<th>Level</th>
<th>Bake @ 125 °C +10/-0 °C</th>
<th>Bake @ 150 °C +10/-0 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤1.4 mm</td>
<td>2</td>
<td>7 hours</td>
<td>3 hours</td>
</tr>
<tr>
<td></td>
<td>2a</td>
<td>8 hours</td>
<td>4 hours</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>16 hours</td>
<td>8 hours</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>21 hours</td>
<td>10 hours</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>24 hours</td>
<td>12 hours</td>
</tr>
<tr>
<td></td>
<td>5a</td>
<td>28 hours</td>
<td>14 hours</td>
</tr>
<tr>
<td>&gt;1.4 mm ≤2.0 mm</td>
<td>2</td>
<td>18 hours</td>
<td>9 hours</td>
</tr>
<tr>
<td></td>
<td>2a</td>
<td>23 hours</td>
<td>11 hours</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>43 hours</td>
<td>21 hours</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>48 hours</td>
<td>24 hours</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>48 hours</td>
<td>24 hours</td>
</tr>
<tr>
<td></td>
<td>5a</td>
<td>48 hours</td>
<td>24 hours</td>
</tr>
<tr>
<td>&gt;2.0 mm ≤4.5 mm</td>
<td>2</td>
<td>48 hours</td>
<td>24 hours</td>
</tr>
<tr>
<td></td>
<td>2a</td>
<td>48 hours</td>
<td>24 hours</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>48 hours</td>
<td>24 hours</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>48 hours</td>
<td>24 hours</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>48 hours</td>
<td>24 hours</td>
</tr>
<tr>
<td></td>
<td>5a</td>
<td>48 hours</td>
<td>24 hours</td>
</tr>
</tbody>
</table>

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 4-2 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 shall be determined using the procedure in JEDEC JESDI22-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

<table>
<thead>
<tr>
<th>Moisture Sensitivity Level</th>
<th>Exposure Time @ Temp/Humidity</th>
<th>Floor Life</th>
<th>Desiccator Time @ Relative Humidity</th>
<th>Bake</th>
<th>Reset Shelf Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>2, 2a, 3, 4, 5, 5a</td>
<td>≤ 40 °C/85% RH reset</td>
<td>NA</td>
<td>Table 4.1</td>
<td>Dry Pack after Bake</td>
<td></td>
</tr>
<tr>
<td>2, 2a, 3, 4, 5, 5a</td>
<td>≤ 30 °C/60% RH reset</td>
<td>NA</td>
<td>Table 4.1</td>
<td>Dry Pack after Bake</td>
<td></td>
</tr>
<tr>
<td>2, 3, 3</td>
<td>≥ 12 hrs ≤ 30 °C/60% RH reset</td>
<td>NA</td>
<td>Table 4.1</td>
<td>Dry Pack after Bake</td>
<td></td>
</tr>
<tr>
<td>2, 2a, 3</td>
<td>≤ 12 hrs ≤ 30 °C/60% RH</td>
<td>5X exposure time ≤ 10% RH</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>4, 5, 5a</td>
<td>&gt; 8 hrs ≤ 30 °C/60% RH</td>
<td>NA</td>
<td>Table 4.1</td>
<td>Dry Pack after Bake</td>
<td></td>
</tr>
<tr>
<td>4, 5, 5a</td>
<td>≤ 8 hrs ≤ 30 °C/60% RH</td>
<td>10X exposure time ≤ 5% RH</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>2, 2a, 3</td>
<td>Cumulative time &lt; floor life ≤ 30 °C/60% RH</td>
<td>SA</td>
<td>Anytime &lt;10% RH</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>
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 Clause 3.3 or a dry cabinet that is capable of maintaining not greater than 10% RH.

For components exposed anytime less than their stated floor life, dry packing or placing the components 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 Clause 5.3 for safe storage conditions.

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 Clause 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 component 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 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 to be used and shelf life if the parts are to be dry packed.

5.1.2 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 Clause 4.1.2.

5.2 Floor Life  The floor life of SMDs per Table 5-1 will be modified by environmental conditions other than 30 °C/60% RH. 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 Clause 5.3). If one hour exposure is exceeded, refer to Clause 4.1.

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.

5.3.1 Dry Pack  Dry-packed SMD packages in intact MBBs, stored per Clause 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.

5.3.2 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) (see Clause 5.5.1) indicates that baking is not required, then it is safe to reflow the components 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.

5.3.3 Dry Atmosphere Cabinet  A storage cabinet which maintains low humidity by purging with dry air or nitrogen at 25 ± 5 °C. The cabinet must be capable of recovering to its 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. A dry cabinet should not be considered a MBB. Storage of SMD packages in a dry cabinet should be limited to a maximum time per Table 7-1. If the time limit is exceeded the packages 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 a dry cabinet 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 component 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 Clause 4.1. If the floor life or factory ambient conditions are exceeded, refer to Clause 5.5.2.

5.4.2 Reflow Temperature Extremes  During reflow the component body temperature must 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 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 component 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 component 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 component on the board has exceeded its floor life, the board needs to be baked prior to the next reflow. Refer to Clause 6 for the baking of populated boards.

Note 1: The floor-life clock is NOT reset by any reflow or rework process.

Note 2: Water clean processes after the first reflow can be an additional source of moisture for cavity packages in which water may be entrapped. 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 component. 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 component 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: Witness cards may be available from the HIC manufacturer if needed to confirm the wet/dry colors.

5.5.1.1 HIC Indication 1  If the 5%, 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 Clause 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.

Note: If the factory ambient temperature and/or humidity conditions per Table 5-1 cannot be met, the component 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 Component Removal, Rework, and Remount

If a component is to be removed from the board, it is recommended that localized heating be used and the maximum body temperatures of any surface mount component on the board not exceed 200 °C. This method will minimize moisture related component damage. If any component temperature exceeds 200 °C, the board must be baked dry per Clause 6.2 prior to rework and/or component removal. Component 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 components should be removed prior to rework.

6.1.1 Removal for Failure Analysis

Not following the requirements of Clause 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 component should be conducted following IPC-7711 or IPC-7721. If a component is to be removed and reinstalled it may be necessary to first bake the printed wiring assembly to eliminate moisture from the component. 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 components and materials on the subject printed wiring assembly must be considered, and an appropriate time temperature profile (see IPC-7711) 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 components and/or board materials cannot withstand this condition. Examples of temperature sensitive components include organic LEDs, batteries, and electrolytic capacitors. With component and board temperature restrictions in mind, choose a bake temperature from Table 4-1; then determine the appropriate bake duration based on the component to be removed. For additional considerations see IPC-7711 and IPC-7721.

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 component packaging materials (refer to JESD22-A120). Recommended equivalent total floor-life exposures can be estimated for a range of humidities 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 humidities ranging from 5-90% RH for temperatures of 20 °C, 25 °C, 30 °C, 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) mm²/s (this uses smallest known Diffusivity @ 30 °C).
3. For >60% RH, use Diffusivity = 1.320exp (-0.35eV/kT) mm²/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 component was classified) Maximum Percent Relative Humidity

<table>
<thead>
<tr>
<th>Package Type and Body Thickness</th>
<th>Moisture Sensitivity Level</th>
<th>5%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Level 2a</strong></td>
<td></td>
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</tr>
<tr>
<td>Body Thickness is ≥3.1 mm including:</td>
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</tr>
<tr>
<td>PQFPs &gt;84 pins</td>
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</tr>
<tr>
<td>All MQFPs</td>
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<tr>
<td>All BGAs ≥1 mm</td>
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<tr>
<td><strong>Level 3</strong></td>
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<tr>
<td>Body Thickness is &lt;3.1 mm down to 2.1 mm including:</td>
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<tr>
<td>PLCCs (rectangular) 18-32 pins</td>
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<tr>
<td>SOICs (wide body)</td>
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<td>SOICs &lt;18 pins</td>
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<tr>
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<tr>
<td>All TSOPs</td>
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<tr>
<td>All TQFPs</td>
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</tr>
<tr>
<td>All BGAs &lt;1 mm body thickness</td>
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</tr>
</tbody>
</table>

∞ Represents indefinite exposure time allowed at conditions specified.
APPENDIX A
Test Method for Humidity Indicator Card used with Electronic Component 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 ± 1 °C and a relative humidity from 2% - 65% ± 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:

<table>
<thead>
<tr>
<th>RH Indicating Spot</th>
<th>Initial (Dry)</th>
<th>Conditioned (Spot Value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5%</td>
<td>2%</td>
<td>5%</td>
</tr>
<tr>
<td>10%</td>
<td>5%</td>
<td>10%</td>
</tr>
<tr>
<td>60%</td>
<td>55%</td>
<td>60%</td>
</tr>
</tbody>
</table>

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:

\[ \text{Hue} = |\text{ARCTAN}(b*/a*)| \]

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

\[ \text{Hue} = 180 + \text{ARCTAN}(b*/a*) \]

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

\[ \text{Hue} = 360 + \text{ARCTAN}(b*/a*) \]

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:

\[ \frac{\partial C}{\partial t} = D \frac{\partial^2 C}{\partial x^2} \] (Fick’s Law)

\[ C_{\text{Sat}} (\text{at surface}) \propto \% \text{RH in ambient atmosphere} \] (Henry’s Law)

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

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

2. Diffusivity = 6.2 exp (-0.445eV/kT) mm²/s, (assumes slow diffusing mold compound)
   a. \( D_{30 \, ^\circ C} = 2.48 \times 10^{-7} \) mm²/s
   b. \( D_{40 \, ^\circ C} = 4.27 \times 10^{-7} \) mm²/s
   c. \( D_{90 \, ^\circ C} = 4.13 \times 10^{-6} \) mm²/s
   d. \( D_{125 \, ^\circ C} = 1.44 \times 10^{-5} \) mm²/s

3. Define:
   a. \( L_{\text{centerline}} \) = critical thickness, e.g., thickness of package / 2
   b. \( C_{\text{Critical}} \) = concentration at \( L_{\text{centerline}} \) for given MSL (based on 30 °C/60% RH exposure + 24 hr MET preconditioning)
   c. \( C_{\text{Centerline}} \) = concentration at \( L_{\text{centerline}} \) for any exposure condition

4. Impose following two exposure conditions:
   a. MSL + >72 hr exposure (assume saturated at 30 °C/85% RH where \( C_{\text{Sat}} = 7.8 \text{ mg/cm}^3 \))
   b. MSL + ≤72 hr exposure (assume ambient at 30 °C/60% RH where \( C_{\text{Sat}} = 5.3 \text{ mg/cm}^3 \))

5. Calculate minimum time @ Bake temperature for cases 4a and 4b where an additional MSL exposure will keep \( C_{\text{Centerline}} < C_{\text{Critical}} \).

### APPENDIX C

**Changes in J-STD-033C**

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<th>Reference</th>
<th>J-STD-033B.1 Forward, Purpose, Scope</th>
<th>J-STD-033C Forward, Purpose, Scope</th>
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<td>1.3 Assembly Processes</td>
<td>Forward, Purpose, Scope</td>
<td>Expanded Scope</td>
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<td>3.3.2.2</td>
<td>Added 1.3.5 Aqueous Cleaning</td>
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<td>Changed desiccant calculation Removed formula $U = 5 \times 10^{-3} A$</td>
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<td>Added 3.3.2.2.2 Desiccant Handling and Storage</td>
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<td>Figure 3-4</td>
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<td>Added Dry-Pack Precautions</td>
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</tr>
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<td>5</td>
<td>5</td>
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<td>Modified 2nd sentence and changed Note</td>
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<tr>
<td></td>
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<td>Added Note</td>
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</table>

Editorial Changes throughout
The purpose of this form is to provide the Technical Committee of IPC with input from the industry regarding usage of the subject standard. Individuals or companies are invited to submit comments to IPC. All comments will be collected and dispersed to the appropriate committee(s).

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 __________

2. Recommendations for correction:

   __________________________________________
   __________________________________________
   __________________________________________
   __________________________________________

3. Other suggestions for document improvement:

   __________________________________________
   __________________________________________
   __________________________________________
   __________________________________________

Submitted by:

Name __________________________ Telephone __________________________

Company __________________________ E-mail __________________________

Address __________________________

City/State/Zip __________________________ Date __________