IPC/JEDEC J-STD-020F

Moisture/Reflow Sensitivity Classification for Non-hermetic Surface Mount Devices (SMDs)

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

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

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MOISTURE/REFLOW SENSITIVITY CLASSIFICATION FOR NON-HERMETIC SURFACE MOUNT DEVICES (SMDS)

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LONG-TERM STORAGE GUIDELINES FOR ELECTRONIC SOLID-STATE WAFERS, DICE, AND DEVICES

(From JEDEC Board Ballot JCB-22-52, formulated under the cognizance of the JC-14.1 Committee on Reliability Test Methods for Packaged Devices.)

1 Purpose

The purpose of this standard is to identify the classification level of non-hermetic SMDs designed for surface mount assembly that are sensitive to moisture-induced stress so that they can be properly packaged, stored, and handled to avoid damage during assembly solder reflow attachment and/or repair operations.

This standard may be used to determine what classification level should be used for non-hermetic SMD qualification. Passing the criteria in this test method is not sufficient by itself to provide assurance of long-term reliability. The Moisture Sensitivity Levels (MSLs) rating generated for an SMD by this document is utilized to determine the soak conditions for preconditioning as per JESD22-A113 and how the SMD can be properly packaged, stored, and handled to avoid damage during assembly solder reflow attachment and/or repair operations as per J-STD-033.

For IC devices that may be process sensitive, please refer to J-STD-075 to determine if a PSL (Process Sensitivity Level) classification is required.

2 Scope

This classification procedure applies to all non-hermetic SMDs, which, because of absorbed moisture, could be sensitive to damage during solder reflow. The term SMD as used in this document means plastic encapsulated devices and other devices made with moisture-permeable materials designed for surface mount assemblies. The MSL classification levels are intended to be used by SMD producers to inform users (board assembly operations) of the level of moisture sensitivity of their SMDs, and by board assembly operations to ensure that proper handling precautions are applied to moisture/reflow sensitive devices. If no major changes have been made to a previously qualified SMD, this method may be used for reclassification according to 4.3.

This standard cannot address all possible device, board assembly and product design combinations. However, the standard does provide a test method and criteria for commonly used technologies. Where uncommon or specialized devices or technologies are necessary, the development of the MSL rating should include customer and device supplier involvement and the criteria should include an agreed definition of product acceptance.

SMDs classified to a given moisture sensitivity level by using procedures or criteria defined within any previous version of J-STD-020 do not need to be reclassified to the current revision unless a change in classification level or a higher peak classification temperature is desired.

If the procedures in this document are used on packaged devices that are not included in this specification's scope, the failure criteria for such packages must be agreed upon by the device supplier and their end user.

2 Scope (cont'd)

Past evaluations have shown that SMDs that have been classified to a MSL for SnPb eutectic temperatures per this document may be attached using the same MSL for a Vapor Phase reflow process for SnPb eutectic temperatures only. Currently there is no intent to perform similar evaluations for Pb-free temperatures.

3 Background

The vapor pressure of moisture inside a non-hermetic package increases greatly when the package is exposed to the high temperature of solder reflow. Under certain conditions, this pressure can cause internal delamination of the packaging materials from the die and/or leadframe/laminate, internal cracks that may or may not extend to the outside of the package, bond damage, wire necking, bond lifting, die lifting, thin film cracking, or cratering beneath the bonds. In the most severe case, the stress can result in external package cracks. This is commonly referred to as the "popcorn" phenomenon because the internal stress causes the package to bulge and then delaminate/crack with an audible "pop." SMDs are more susceptible to this problem than through-hole parts because they are exposed to higher temperatures during reflow soldering. The reason for this is that the soldering operation must occur on the same side of the board as the SMD. For through-hole devices, the soldering operation occurs under the board that shields the devices from the hot solder.

4 Terms and Definitions

Other than the following, the definitions of terms used in this standard are in accordance with IPC-T-50. Terms marked with an asterisk (*) are direct excerpts of IPC-T-50 and are reprinted here for convenience.

Accelerated Equivalent Soak A soak at a higher temperature for a shorter time (compared to the standard soak), to provide roughly the same amount of moisture absorption. See also "Soak."

***Acoustic Microscope** Equipment that creates an image using ultrasound to view a specimen's surface or subsurface features, including defects and damage. See J-STD-035 for more information.

***Area Array Package** A package that has terminations arranged in a grid on the bottom of the package and contained within the package outline.

***Classification Temperature (Tc)** The maximum body temperature at which the device supplier guarantees the device MSL as noted on the caution and/or bar code label (per J-STD-033).

Crack A separation within a bulk material. See also "Delamination."

***Damage Response** All irreversible changes caused by exposure to a reflow soldering profile.

Dead-Bug (Orientation) The orientation of the package with the terminals facing up.

Delamination An interfacial separation between two materials intended to be bonded. See also "Crack".

Downbond Area An area for a wire bond on the die paddle, whose dimensions equal those of a single bond pad on the die.

4 Terms and Definitions (cont'd)

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

NOTE For the purposes of this standard, "Unlimited" floor life only refers to moisture/reflow related failures and does not take into consideration other failure mechanisms or shelf life issues due to long term storage. See JEP160.

Full Body Hot Air Rework The process of heating a package by directing heated gas at the package body in order to melt only that package's solder connections.

Live-Bug (Orientation) The orientation of the package when resting on its terminals.

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

Moisture/Reflow Sensitivity Classification The characterization of a device's susceptibility to damage due to absorbed moisture when subjected to reflow soldering.

Moisture Sensitivity Level (MSL) A rating indicating a device's susceptibility to damage due to absorbed moisture when subjected to reflow soldering.

***Package Thickness** The device thickness excluding external terminals (balls, bumps, lands, leads) and/or non-integral heat sinks.

Pb-free; lead-free Having a maximum lead (Pb) concentration value of 0.1% by weight in PCB surface finishes, device terminal finishes, bump or ball materials, and attachment solders.

NOTE 1 Pb-free SAC alloys: tin/silver/copper solders that have a liquidus (upper melting point) in the range of 217°C to 220°C.

NOTE 2 LTS (Low Temperature Solder) alloys: near eutectic-bismuth alloys that have a liquidus (upper melting point) in the range of 150°C to 170°C.

***Peak Package Body Temperature (T_P)** The highest temperature that an individual package body reaches during MSL classification.

Reclassification The process of assigning a new moisture sensitivity level to a previously classified device.

***Soak** The exposure of a device for a specified time at a specified temperature and humidity. See also "Accelerated Equivalent Soak."

Wire-Bond Surface The area where wire bonds are typically placed.

5 Applicable Documents

5.1 JEDEC[1]

JEP140 Beaded Thermocouple Temperature Measurement of Semiconductor Packages

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

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

JESD22-A113 Preconditioning Procedures of Plastic Surface Mount Devices Prior to Reliability Testing

JESD22-B101 External Visual

JESD22-B108 Co-planarity Test for Surface-Mount Semiconductor Devices

JESD22-B112 High Temperature Package Warpage Measurement Methodology

JESD47 Stress Test Driven Qualification Specification

JESD625 Requirements for Handling Electrostatic Discharge Sensitive (ESD) Devices

5.2 IPC[2]

IPC-TM-650 Test Methods Manual[2]

Microsectioning

Microsectioning - Semi or Automatic Technique Microsection Equipment

5.3 Joint Industry Standards[2]

J-STD-033 Standard for Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices

J-STD-035 Acoustic Microscopy for Nonhermetic Encapsulated Electronic Devices

J-STD-075 Classification of Passive and Solid State Devices for Assembly Processes[3]

1 www.jedec.org
2 www.ipc.org
3 www.ecianow.org/eia-technical-standards

6 Apparatus

6.1 Temperature Humidity Chambers

Moisture chamber(s), capable of operating at 85°C/85% RH, 85°C/60% RH, 60°C/60% RH, and 30°C/60% RH. Within the chamber working area, temperature tolerance must be ± 2°C and the RH tolerance must be ± 3% RH.

6.2 Solder Reflow Equipment

6.2.1 Full Convection (Preferred)

Full convection reflow system capable of maintaining the reflow profiles required by this standard.

6.2.2 Infrared

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

NOTE The moisture sensitivity classification test results are dependent upon the package body temperature (rather than the mounting laminate and/or package terminal temperature).

6.3 Ovens

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

6.4 Microscopes

6.4.1 Optical Microscope

Optical Microscope (40X for external and 100X for cross-section exam, higher magnification might be required for verification).

6.4.2 Acoustic Microscope

Typically a scanning acoustic microscope with C-Mode and Through Transmission capability. It should be capable of measuring a minimum delamination of 5% of the area being evaluated.

NOTE 1 The acoustic microscope is used to detect cracking and delamination. However, the presence of delamination does not necessarily indicate a pending reliability problem. The reliability impact of delamination must be established for a particular die/package system.

NOTE 2 Refer to IPC/JEDEC J-STD-035 for operation of the acoustic microscope.

6.5 Cross-Sectioning

Micro-sectioning equipment as recommended per IPC-TM-650, Method 2.1.1 and Method 2.1.1.2 or other applicable document.

6.6 Electrical Test

Electrical test equipment with capabilities to perform appropriate testing on devices.

6.7 Weighing Apparatus (Optional)

Apparatus capable of weighing the package to a resolution of 1 microgram. This apparatus must be maintained in a draft-free environment, such as a cabinet. It is used to obtain absorption and desorption data on the devices under test (see 11).

6.8 Beaded Thermocouple Temperature Measurement

Refer to JEP140 for guidance on procedures to accurately and consistently measure the temperature of devices during exposure to thermal excursions. JEP140 guideline applications can include, but is not limited to, temperature profile measurement in reliability test chambers and solder reflow operations that are associated with device assembly to printed wiring boards (PWBs).

NOTE The moisture sensitivity classification test results are dependent upon the package body temperature (rather than the mounting laminate and/or package terminal temperature).

7 Classification/Reclassification

Refer to 7.3 for guidance on reclassification of previously qualified/classified SMDs.

Engineering studies have shown that thin, small volume SMDs reach higher body temperatures during reflow soldering to boards that have been profiled for larger devices. Therefore, technical and/or business issues normally require thin, small volume SMDs (reference Table 1 and Table 2) to be classified at higher reflow temperatures. To accurately measure actual peak package body temperatures, refer to JEP140 for recommended thermocouple use.

7.1 Classification Temperatures (Tc)

Previously classified SMDs should only be reclassified by the device supplier. Users should refer to the caution label on the bag to determine at which reflow temperature the SMDs were classified.

If the device supplier and user agree, devices can be classified at temperatures other than those in Table 1, Table 2, and Table 3. If a different Tc is used, then the temperature used shall be written on the caution label as defined in J-STD-033.

Table 1 — SnPb Eutectic Process - Classification Temperatures (T_C)

Package Thickness	Volume mm3 < 350	Volume mm3 ≥ 350
< 2.5 mm	235°C	220°C
≥ 2.5 mm	220°C	220°C

7.1 Classification Temperatures (Tc) (cont'd)

Table 2 — Pb-free (SAC Alloys) Process - Classification Temperatures (T_C)

Package Thickness	Volume mm3 < 350	Volume mm3 350 - 2000	Volume mm3 > 2000
< 1.6 mm	260°C	260°C	260°C
1.6 mm - 2.5 mm	260°C	250°C	245°C
> 2.5 mm	250°C	245°C	245°C

Table 3 — LTS Alloys Process - Classification Temperatures (T_C)

All Package Thickness All Volume (mm^3)	190°C

Package "volume" excludes external terminals (e.g., balls, bumps, lands, leads) and/or non-integral heat sinks. Package volume includes the external dimensions of the package body, regardless if it has a cavity or is a passive package style.

At the discretion of the device supplier, but not the board assembler/user, the maximum peak package body temperature (Tp) can exceed the values specified in Table 1 or Table 2. The use of a higher Tp does not change the classification temperature (Tc).

The maximum peak package body temperature reached during reflow depends on package thickness and volume. The use of convection reflow processes reduces the thermal gradients between packages. However, thermal gradients due to differences in thermal mass of SMDs may still exist.

Moisture Sensitivity Levels (MSLs) of devices intended for use in a Pb-free assembly process shall be evaluated using the Pb-free classification temperatures and profiles defined in Table 2 and Table 6 whether or not Pb-free.

SMDs classified to a given moisture sensitivity level by using Procedures or Criteria defined within any previous version of J-STD-020, JESD22-A112 (rescinded), IPC-SM-786 (rescinded) do not need to be reclassified to the current revision unless a change in classification level or a higher peak classification temperature is desired.

7.2 Compatibility with Pb-free (SAC and LTS Alloys) Assembly Rework

Pb-free (SAC alloy) area-array devices classified per Table 2 should be capable of assembly rework at a maximum of 260 °C (unlike Table 2 for mass reflow, maximum rework assembly applies for all package dimensions) within 8 hours of removal from dry storage or bake, per J-STD-033 or for long term storage per the guidelines of JEP160. Devices that do not meet this Pb-free SAC alloy assembly rework requirement in a dry state or for which the device supplier does not support a 260 °C rework temperature shall have their safe rework peak temperature specified by the device supplier.

To verify this capability for devices classified at a temperature below 260 °C, a sample of the size per 8.1.2 shall be soaked per level 6 conditions (see Table 4) using a time on label (TOL) of 8 hours and subjected to a single reflow cycle with Tp of not less than 260 °C. All devices in the sample shall pass electrical test and have a damage response (per 9.1 and 9.2) not greater than that observed for the same package at its rated MSL. Rework compatibility verification is not required for devices in area-array packages rated at 260 °C.

7.2 Compatibility with Pb-free (SAC and LTS Alloys) Assembly Rework (cont'd)

Rework compatibility verification is not required for peripheral leaded metal lead frame packages that do not require full body hot air rework, but may be required for devices in multi-row QFN packages and QFNs with multiple exposed pads.

Rework compatibility verification is not required for area-array devices qualified for LTS alloy assembly, unless the device supplier has stated that the LTS Alloy Process peak reflow temperature for the device is below 190°C as required per Table 3.

7.3 Reclassification

If no major changes have been made to a previously qualified SMD, this method may be used for reclassification to an improved level (i.e., longer floor life) at the same reflow temperature. The reclassification level cannot be improved by more than one level without additional reliability testing. Reclassification to MSL1 requires additional reliability testing.

SMD previously classified to a MSL and classification temperature (Tc) may be reclassified if the damage response (e.g., delamination/cracking) at the more severe condition for items listed in 9.1 and 9.2 is less than, or equal to, the damage response at the original classification condition.

If no major changes have been made to a previously qualified SMD, this method may be used for reclassification at a higher reflow temperature providing the moisture level remains the same or degrades to a more sensitive level.

No SMDs classified as moisture sensitive by any previous version of J-STD-020, JESD22-A112 (rescinded), or IPC-SM-786 (rescinded) may be reclassified as non-moisture sensitive (MSL1) without additional reliability stress testing (e.g., JESD22-A113 and JESD47 or the semiconductor device supplier's in-house procedures).

To minimize testing, the results from a given SMD may be generically accepted to cover all other devices which are manufactured in the same package, using the same packaging materials (e.g., die attach, mold compound, and/or die coating, etc.), with the die using the same wafer fabrication technology, and with die pad dimensions not greater than those qualified.

The following attributes could affect the moisture sensitivity of a device and may require reclassification:

- Die attach material/process.
- Number of pins.
- Encapsulation (mold compound or glob top) material/process.
- Die pad area and shape.
- Body size.
- Passivation/die coating.
- Leadframe, laminate, and/or heat spreader design/material/finish.
- Die size/thickness.
- Wafer fabrication technology/process.
- Interconnect.
- Lead lock taping size/location as well as material.

8 Procedure

The recommended procedure is to start testing at the lowest moisture sensitivity level the evaluation package is reasonably expected to pass (based on knowledge of other similar evaluation packages).

In the case of equipment malfunction, operator error, or electrical power loss, engineering judgment shall be used to ensure that the minimum intent/requirements of this specification are met.

8.1 Sample Requirements

8.1.1 Reclassification (Qualified Package without Additional Reliability Testing)

For a qualified SMD being reclassified without additional reliability, select a minimum sample of 22 devices for each MSL to be tested. A minimum of two nonconsecutive assembly lots must be included in the sample with each lot having approximately the same representation. Sample devices shall have completed all manufacturing processing required prior to shipment. Sample groups may be run concurrently on one or more MSLs.

8.1.2 Classification/Reclassification and Rework

Select a minimum sample of 11 devices for each MSL to be tested. A minimum of two nonconsecutive assembly lots must be included in the sample with each lot having approximately the same representation. Sample devices shall have completed all manufacturing processes required prior to shipment. Sample groups may be run concurrently on one or more MSLs. Testing must be continued until a passing level is found.

SMDs should not be reclassified by the user unless approved by the device supplier.

8.2 Initial Electrical Test

Test appropriate electrical parameters (e.g., data sheet values, in house specifications, etc.). Replace any device, while maintaining the sample requirements of 8.1.2, which fail to meet tested parameters.

8.3 Initial Inspection

Perform an external visual (at 40X) and acoustic microscope examination on all devices to establish a baseline for the delamination criteria in 9.2.1.

Note: This standard does not consider or establish any accept/reject criteria for delamination at initial/time zero inspection.

8.4 Bake

Bake the devices for 24 hours minimum at 125°C +5/-0°C. This step is intended to remove moisture from the package so that it will be “dry.”

This time/temperature may be modified if desorption data on the particular device under test shows that a different condition is required to obtain a “dry” package when starting in the wet condition for 85°C/85% RH (see 11.3).

8.4 Bake (cont'd)

If a bake time is interrupted for greater than 15 minutes; then the total time of the interruption shall be added to the bake time to ensure a minimum of 24 hours. The interruption time should be accounted and no greater than 1 hour. If greater than 1 hour the bake shall be restarted for a full 24 hours of bake time. For instance, if the interruption was 45 minutes, then the total bake test time would be 24 hours and 45 minutes.

8.5 Moisture Soak

Place devices in a clean, dry, shallow container so that the package bodies do not touch or overlap each other. Submit each device to the appropriate soak requirements shown in Table 5. Devices shall be handled using proper ESD procedures in accordance with JESD625.

8.5 Moisture Soak (cont'd)

Table 4 — Moisture Sensitivity Levels

Level	Floor Life (Note 4)		Soak Requirements (Note 3)				
			Standard		Accelerated Equivalent (Note 1 & 5)		
					eV 0.40 - 0.48	eV 0.30 - 0.39	
	Time	Condition	Time (hours)	Condition	Time (hours)	Time (hours)	Condition
1	Unlimited	≤ 30°C/85% RH	168 +5/-0	85°C/85% RH	NA	NA	NA
2	1 year	≤ 30°C/60% RH	168 +5/-0	85°C/60% RH	NA	NA	NA
2a	4 weeks	≤ 30°C/60% RH	696(Note 2) +5/-0	30°C/60% RH	120 +1/-0	168 +1/-0	60°C/60% RH
3	168 hours	≤ 30°C/60% RH	192(Note 2) +5/-0	30°C/60% RH	40 +1/-0	52 +1/-0	60°C/60% RH
4	72 hours	≤ 30°C/60% RH	96(Note 2) +2/-0	30°C/60% RH	20 +0.5/-0	24 +0.5/-0	60°C/60% RH
5	48 hours	≤ 30°C/60% RH	72(Note 2) +2/ 0	30°C/60% RH	15 +0.5/-0	20 +0.5/-0	60°C/60% RH
5a	24 hours	≤ 30°C/60% RH	48(Note 2) +2/-0	30°C/60% RH	10 +0.5/-0	13 +0.5/-0	60°C/60% RH
6	Time on Label (TOL)	≤ 30°C/60% RH	TOL	30°C/60% RH	NA	NA	NA

NOTE 1 CAUTION – To use the "accelerated equivalent" soak conditions, correlation of damage response (including electrical, after soak and reflow), should be established with the "standard" soak conditions. Alternatively, if the known activation energy (eV) for moisture diffusion of the package materials is in the range of 0.40 eV - 0.48 eV or 0.30 eV – 0.39 eV, the "accelerated equivalent" may be used. Accelerated soak times may vary due to material properties (e.g., mold compound, encapsulant, etc.). JEDEC document JESD22-A120 provides a method for determining the eV.

NOTE 2 The standard soak time includes a default value of 24 hours for semiconductor device supplier's exposure time (MET) between bake and bag and includes the maximum time allowed out of the bag at the distributor's facility. If the actual MET is less than 24 hours, the soak time may be reduced. For soak conditions of 30°C/60% RH, the soak time is reduced by 1 hour for each hour the MET is < 24 hours. For soak conditions of 60°C/60% RH, the soak time is reduced by 1 hour for each 5 hours the MET is < 24 hours. If the actual MET is > 24 hours, the soak time must be increased. If soak conditions are 30°C/60% RH, the soak time is increased 1 hour for each hour that the actual MET exceeds 24 hours. If soak conditions are 60°C/60% RH, the soak time is increased 1 hour for each 5 hours that the actual MET exceeds 24 hours.

NOTE 3 Device supplier may extend the soak times at their own risk.

NOTE 4 "Floor Life" only relates to moisture/reflow related failures and does not take into consideration other failure mechanisms or "shelf life" issues due to long term storage.

NOTE 5 Table 4 accelerated soak requirements may not apply to mold compounds that do not contain fillers.

8.6 Reflow

Not sooner than 15 minutes and not longer than 4 hours after removal from the temperature/humidity chamber, subject the devices to 3 cycles of the appropriate reflow conditions as defined in Table 5 and in Figure 1. If the timing between removal from the temperature/humidity chamber and initial reflow cannot be met, then the devices must be rebaked and resoaked according to 8.4 and 8.5. The time between reflows shall be 5 minutes minimum and 60 minutes maximum.

All temperatures refer to the center of the package, measured on the package body surface that is facing up during assembly reflow (e.g., live-bug orientation). If devices are reflowed in other than the normal live-bug assembly reflow orientation (i.e., dead-bug), T_P shall be within ± 2°C of the live-bug T_P and still meet the T_C requirements, otherwise, the profile shall be adjusted to achieve the latter. To accurately measure actual peak package body temperatures, refer to JEP140 for recommended thermocouple use.

The oven should be loaded with the same configuration or verified equivalent thermal load when running devices or being profiled. All devices in the test load shall meet the classification profile requirements.

Reflow profiles in this document are for classification/preconditioning and are not meant to specify board assembly profiles. Actual board assembly profiles should be developed based on specific process needs and board designs and should not exceed the parameters in Table 5.

For example, if T_C is 260 °C and time t_P is 30 seconds, this means the following for the device supplier and the user:

- For a device supplier: The peak temperature must be at least 260 °C. The time above 255 °C must be at least 30 seconds
- For a user: The peak temperature must not exceed 260 °C. The time above 255 °C must not exceed 30 seconds.

All ramp rates (up or down) shall be calculated as an average rate over a five (5) second period, shall not be an instantaneous value, nor an overall average. The ramp up and down rates between T_P to T_L are the critical zones for the controlled heating and cooling rates. If the ramp rate needs to be controlled below T_L, the device supplier shall convey this limitation to the user per the requirements of J-STD-075.

SMDs classified to a given MSL by using Procedures or Criteria defined within any previous version of J-STD-020, JESD22-A112 (rescinded), IPC-SM-786 (rescinded) do not need to be reclassified to the current revision unless a change in classification level or a higher peak classification temperature is desired.

8.6 Reflow (cont'd)

Table 5 — Classification Profiles

Profile Feature	**Eutectic Assembly (SnPb)**	**Pb-free Assembly (SAC Alloys)**	**LTS Assembly (LTS Alloys)**
Preheat Soak • Temperature Min (Ts_{min}) • Temperature Max (Ts_{max}) • Time (Ts_{min} to Ts_{max}) (t_S)	100 °C 150 °C 60 seconds – 120 seconds	150 °C 200 °C 60 seconds – 120 seconds	100 °C 120 °C 30 seconds – 90 seconds
Ramp-up rate(T_L to T_P)	3°C/second max.	3°C/second max.	3°C/second max.
Time 25 °C to Peak Temperature (Device supplier Maximum)	6 minutes max.	8 minutes max.	4 minutes max.
• Liquidus temperature (T_L) • Time maintained above Liquidus temperature (t_L)	183°C 60 seconds – 150 seconds	217°C 60 seconds – 150 seconds	139°C 60 seconds – 150 seconds
Peak package body temperature (T_P)*	**For users:** T_P shall not exceed T_C in Table 1 **For device suppliers:** T_P shall equal or exceed T_C in Table 1*	**For users:** T_P shall not exceed T_C in Table 2 **For device suppliers:** T_P shall equal or exceed T_C in Table 2*	**For users:** T_P shall not exceed T_C in Table 3 **For device suppliers:** T_P shall equal or exceed T_C in Table 3*
Time (t_P) within 5°C of the specified (T_C), (see Figure 1)	20 seconds*	30 seconds*	20 seconds*
Ramp-down Rate (T_P to T_L)	6°C/second max.	6°C/second max.	6°C/second max.
NOTE Peak package body temperature is defined as a device supplier minimum and a user maximum.			

8.6 Reflow (cont'd)

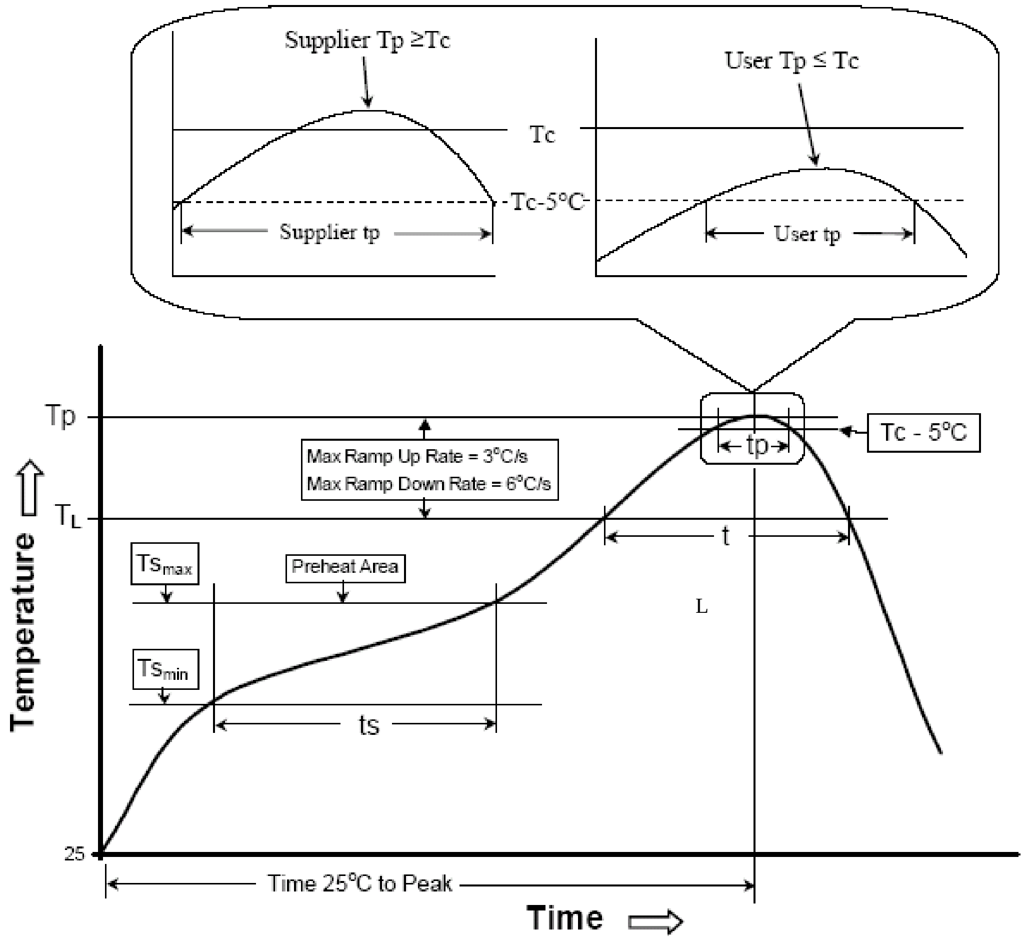

Figure 1 — Classification Profile (Not to scale)

8.7 Final External Visual

Examine the devices using an optical microscope (at 40X) to look for external cracks.

8.8 Final Electrical Test

Perform appropriate electrical testing on all devices, (e.g., data sheet values, in-house specifications, etc.).

NOTE Considerations should be taken for lead oxidation or other mechanisms due to baking that may affect the electrical testing of the devices.

8.9 Final Acoustic Microscopy

Perform acoustic microscope analysis on all devices.

9 Criteria

9.1 Failure Criteria after Reflow Simulation

If one or more devices in the test sample denoted in 8.1 fail, the SMD shall be considered to have failed the tested MSL.

A device is considered a failure if it exhibits any of the following characteristics:

a. External crack visible using 40X optical microscope. It is highly desired to use 100X optical magnification or low vacuum scanning electron microscopy (SEM) to better observe any cracks that could be precursors to problems during the stress of operational life.
b. Electrical test failure.
c. Internal crack that intersects a bond wire, ball bond, or wedge bond.
d. Internal crack extending from any lead finger to any other internal feature (lead finger, chip, die attach paddle).
e. Internal crack extending more than 2/3 the distance from any internal feature to the outside of the device.
f. Changes in package body flatness caused by warpage, swelling, or bulging not visible to the naked eye per JESD22-B101. If parts still meet co-planarity and standoff dimensions as measured at room temperature per JESD22-B108, they shall be considered passing.

If the device passes the requirements of 9.1, and there is no evidence of cracks observed by acoustic microscopy or other means, the device is then considered to pass that MSL. If internal mold compound cracks are indicated by acoustic microscopy, they must be considered a failure or verified that it has not failed the criteria above using polished cross sections through the identified site.

NOTE 1 For packages known to be sensitive to vertical cracks, it is recommended that polished cross sections be used to confirm the nonexistence of near vertical cracks within the mold compound or encapsulant.

NOTE 2 Failing SMDs must be evaluated to a higher numeric MSL (i.e., more susceptible) using a new set of samples.

9.2 Criteria Requiring Further Evaluation

Delamination is not necessarily a cause for rejection. To evaluate the impact of delamination on device reliability, the semiconductor device supplier may either meet the delamination requirements shown in 9.2.1 or perform reliability assessment using JESD22-A113 and JESD47 or the semiconductor device supplier's in-house procedures. The reliability assessment may consist of stress testing, historical generic data analysis, etc. Annex A shows the logic flow diagram for the implementation of these criteria.

If the SMDs pass electrical tests and there is delamination on the back side of the die paddle, heat spreader, or die back side (lead on chip only), but there is no evidence of cracking per 9.1 or other delamination and they still meet specified dimensional criteria, the SMDs are considered to pass that MSL.

9.2.1 Delamination

The percent delamination or delamination change is calculated in relation to the total area being evaluated. The following delamination change criteria for the specific device type are measured from pre-moisture soak to post reflow. A delamination change is the difference between pre- and post-reflow delamination.

9.2.1.1 Metal Leadframe Devices

a. No delamination on the active side of the die.

b. No delamination on any wire bonding surface of the leadframe:

   1. On the lead finger standard and LOC (lead on chip) package styles.
   2. On the downbond area (die paddle).

c. No delamination on any flip chip joining surface on the leadframe for COL (chip on lead) package styles.

d. No delamination change > 10% along any polymeric film bridging any metallic features that is designed to be isolated (verifiable by through transmission acoustic microscopy).

e. Die attach delamination criteria are summarized in Table 6:

Table 6 — Die Attach Delamination Criteria

Die Attach Critical Function	Delamination Criteria: Power Applications *For devices that require thermal and/or electrical contact to the backside of the die (e.g., such as power MOSFET, IGBT and diodes)*	Delamination Criteria: Other applications
Thermal conductivity	The acceptable delamination % change requirements for thermal die attach used in power applications should be determined between device suppliers and users as a function of potential thermal coupling efficiency loss.	No delamination / cracking > 50% of the die attach area
Electrical continuity	The acceptable delamination % change requirements for electrically conductive die attach used in power applications be determined between device suppliers and users as a function of potential electrical characteristic degradation (e.g., increase of RdsON).	No delamination/cracking > 50% of the die attach area
NOTE Delamination criteria are typically more critical for power devices than other devices with respect to their performance and reliability.		

f. No surface-breaking feature delaminated over its entire length. A surface-breaking feature includes lead fingers, tie bars, heat spreader alignment features, secondary leadframes, Cu clips, heat slugs, etc. Reliability assessment for this category of delamination should consider the detection and evaluation methods discussed in JESD22-A113, Annex B.

9.2.1.2 Laminate Based Devices (e.g., BGA, LGA, etc.)

a. No delamination on the active side of the die.
b. No delamination on any wire bonding surface of the laminate.
c. No delamination change >10% along the polymer potting or molding compound/laminate interface for cavity and overmolded packages.
d. No delamination change > 10% along the solder mask/laminate resin interface.
e. No delamination change > 10% within the laminate.
f. No delamination/cracking change > 10% through the die attach region.
g. No delamination/cracking between underfill material and chip or underfill material and laminate/solder mask.
h. No surface-breaking feature delaminated over its entire length. A surface-breaking feature includes lead fingers, tie bars, heat spreader alignment features, secondary leadframes, Cu clips, heat slugs, etc. Reliability assessment for this category of delamination should consider the detection and evaluation methods discussed in JESD22-A113, Annex B.

On laminate based devices, the C-mode acoustic image is not easy to interpret. Through Transmission Acoustic Imaging is recommended to supplement and verify the C-mode images because it is easier to interpret and more reliable. If it is necessary to verify results or determine at what level in the device the cracking/delamination is occurring, cross-sectional analysis should be used.

9.2.2 Moisture Induced Body Warpage during Board Assembly of Laminate Based Devices

Laminate based devices include BGA, LGA, etc. Moisture Induced warpage could result in solder bridging, open connections, or hot tear during board assembly solder attachment operations. It is known that ingressed moisture can either increase or decrease the total body warpage depending on the specific design of the device. Total body warpage can be a function of the moisture content and can be affected by the ramp rates and dwells used to measure the total warpage effect at elevated temperatures. Body warpage measured per JESD22-B112 should be characterized during device development and any time there are changes of the type denoted in 9.3. Ability to attach devices that exhibit warpage can be verified by using board assembly.

9.2.3 1st Level Interconnect Devices such as Flip Chip, WLP and Bare Die with Polymer Layers

Currently J-STD-020 does not provide failure criteria for 1st level interconnect devices such as Flip Chip, WLP and bare die with polymer layers. Any party choosing to use the procedures within this standard to determine a MSL rating for these types of devices is responsible for defining the appropriate failure criteria to ensure the long term reliability of the device.

If applicable, the following criteria should be considered:

a. No delamination on the active side of the die.
b. No delamination change > 10% along the polymer potting or molding compound/laminate interface for cavity and overmolded packages.
c. No delamination change > 10% within the laminate.
d. No delamination/cracking change > 10% through the back (nonactive) side of die.

9.2.3 1st Level Interconnect Devices (cont'd)

e. No delamination/cracking between underfill material and chip or underfill material and laminate.

f. No surface-breaking feature delaminated over its entire length. A surface-breaking feature includes laminate, laminate metallization, etc.

9.2.4 Non-IC Devices

Currently J-STD-020 does not provide failure criteria for non-IC devices. Any party choosing to use the procedure within this standard to determine the MSL rating for a non-IC package is responsible for defining the appropriate failure criteria to ensure the long term reliability of the device.

9.3 Failure Verification

All failures should be analyzed to confirm that the failure mechanism is associated with moisture sensitivity. If there are no reflow moisture-sensitive-induced failures in the level selected, the device meets the tested MSL.

If the acoustic microscope scans show failure to any of the criteria listed in 9.2.1, the SMDs shall be tested to a higher numeric MSL or subjected to a reliability assessment using JESD22-A113 and JESD47 or the semiconductor device supplier's in-house procedures.

10 Moisture/Reflow Sensitivity Classification

If a device passes MSL1, it is classified as not moisture sensitive and does not require dry pack. Other factors beyond MSL may need to be considered, such as those included in JEP160, for long term storage.

If a device fails MSL1 but passes a higher numerical MSL, it is classified as moisture sensitive and must be dry packed in accordance with J-STD-033, and, if required for long term storage, per the guidelines of JEP160.

If a device will pass only MSL6, it is classified as extremely moisture sensitive and dry pack will not provide adequate protection. If this product is shipped, the customer must be advised of its classification. The device supplier must also include a warning label with the device indicating that it either is socket mounted or baked dry within TOL before reflow soldering. The minimum bake time and temperature should be determined from desorption studies of the device under test (see 11.3).

11 Optional Weight Gain/Loss Analysis

11.1 Weight Gain

Weight gain analysis (absorption) can be very valuable in determining estimated floor life (the time from removal of a device from dry pack until it absorbs sufficient moisture to be at risk during reflow soldering). Weight loss analysis (desorption) is valuable in determining the bake time required to remove excess moisture from a device so that it will no longer be at risk during reflow soldering. Weight gain/loss is calculated using an average for the entire sample set. It is recommended that ten (10) devices be used in the sample set. Dependent on weight, devices may be weighed individually or in group(s).

11.1 Weight Gain (cont'd)

Final weight gain = (wet weight - dry weight)/dry weight.
Final weight loss = (wet weight - dry weight)/wet weight.
Interim weight gain = (present weight - dry weight)/dry weight.
Interim weight loss = (wet weight - present weight)/wet weight.

"Wet" is relative and means the device is exposed to moisture under specific temperature and humidity conditions.

"Dry" is specific and means no additional moisture can be removed from the device at 125°C as per 11.2.2.

11.2 Absorption Curve

11.2.1 Read Points for Plotting the Absorption Curve

The X-axis (time) read points should be selected for plotting the absorption curve. For the early readings, points should be relatively short (24 hours or less) because the curve will have a steep initial slope. Later readings may be spread out further (10 days or more) as the curve becomes asymptotic. The Y-axis (weight gain) should start with "0" and increase to the saturated weight gain. Most devices will reach saturation between 0.3% and 0.4% when stored at 85°C/85% RH. Use the formula in 11.1. Devices shall be kept at room ambient between removal from the oven or chamber and weighing and subsequent reinsertion into the oven or chamber.

11.2.2 Dry Weight

The dry weight of the device shall be determined first by baking the device for 24 hours at 125°C +5/-0°C; continued baking and weighing of the devices every 12 hours is recommended until no further weight loss is observed to ensure that the devices are dry. The dry weight is determined when no further weight loss is observed after two consecutive measurements with a minimum baking interval of 12 hours. Characterization outside recommended 12 hour intervals will possibly require more data points to determine weight loss stabilization and prolong this process.

Within 1 hour after removal from the oven, weigh the devices using the optional equipment in 6.7 and determine an average dry weight per 11.1. For small SMDs (less than 1.5 mm total height), devices should be weighed within 30 minutes after removal from oven.

If a bake time is interrupted for greater than 15 minutes; then the total time of the interruption shall be added to the bake time to ensure a minimum of 24 hours. The interruption time should be accounted and no greater than 1 hour. If greater than 1 hour the bake shall be restarted for a full 24 hours of bake time. For instance, if the interruption was 45 minutes, then the total bake test time would be 24 hours and 45 minutes.

11.2.3 Moisture Soak

Within 1 hour after weighing, place the devices in a clean, dry, shallow container so that the device bodies do not touch each other. Place the devices in the desired temperature/humidity condition for the desired length of time.

11.2.4 Readouts; Absorption

Upon removal of the devices from the temperature/humidity chamber, allow devices to cool for at least 15 minutes. Within 1 hour after removal from the chamber, weigh the devices. For small SMDs (less than 1.5 mm total height), devices should be weighed within 30 minutes after removal from the chamber. After the devices are weighed, follow the procedure in 11.2.3 for placing the devices back in the temperature/humidity chamber. No more than 2 hours total time should elapse between removal of devices from the temperature/humidity chamber and their return to the chamber.

Continue alternating between 11.2.3 and 11.2.4 until the devices reach saturation as indicated by no additional increase in moisture absorption or until soaked to the maximum time of interest.

11.3 Desorption Curve

A desorption curve can be plotted using devices that have reached saturation as determined in 11.2.

11.3.1 Read Points for Plotting the Desorption Curve

The suggested read points on the X-axis are 12 hour intervals. The Y-axis should run from “0” weight gain to the saturated value as determined in 11.2.

11.3.2 Baking

Within 1 hour (but not sooner than 15 minutes) after removal of the saturated devices from the temperature/humidity chamber, place the devices in a clean, dry, shallow container so that the device bodies do not touch each other. Place the devices in the bake oven at the desired temperature for the desired time.

11.3.3 Readouts; Desorption

At the desired read point; remove the devices from the bake oven. Within 1 hour after removal of the devices from the bake oven, remove the devices from the container and determine their average weight using the optional equipment in 5.7 and formula in 11.1.

Within 1 hour after weighing the devices, place them in a clean, dry, shallow container so that the device bodies do not touch each other. Return the devices to the bake oven for the desired time.

Continue until the devices have lost all their moisture as determined by the dry weight in 11.2.2.

12 Additions and Exceptions

The following details shall be specified in the applicable documentation:

a. Device selection criteria (if different from 8.1).

b. Test procedure sample size (if different from 8.1).

c. Device types to be evaluated.

d. Any reject criteria (including Acoustic Microscope criterion) in addition to those shown in 9.

e. Any preconditioning requirements beyond those shown in 8.

f. Conditions or frequency under which retest is required.

Annex A Classification Flow

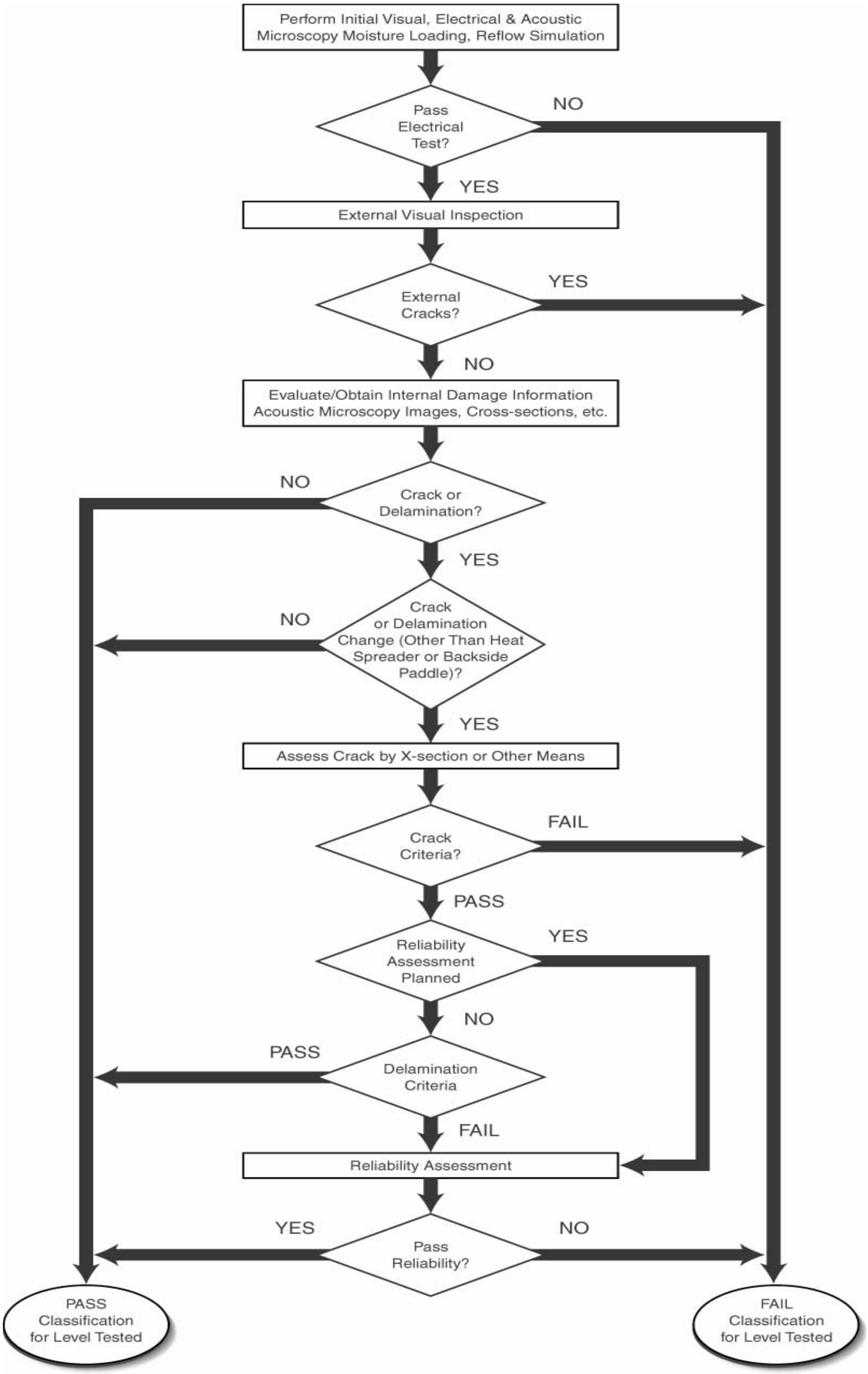

Figure 2 — Classification Flow

Annex B Differences Between Revisions

Revision E to Revision F

Clause	Description of change
General	JEDEC terminology alignment (devices), and document formatting alignment (Chapters and Headings re-numbered. Figures and Tables sequentially numbered).
2	Clarification on Vapor Phase reflow (SnPb only).
4	Pb-free and Low Temperature Solder (LTS) – definition update.
5.1	J-STD-075 purpose and name update.
5.3	RH guidance for bake oven consistent with J-STD-033.
6.1	Adding Table 3 (LTS classification temperature).
6.2	Rework compatibility update (Pb-free and LTS).
7.6	Reflow profile content relocation for improved flow and min/max understanding.
7.6	Table 5-1 renamed to Table 4. Table 5-2 renamed to Table 5 and updated with LTS reference conditions, ramp down rate and Pb-free (SAC).
8.2.1.x	Updates to delamination consideration (discrete or power modules and vertical interfaces).
8.2.4	Reframing of potential criteria (as applicable) on 1st level interconnect packages.

Revision D to Revision E

Clause	Description of change
1	Alignment to JESD22-A113 on preconditioning.
1	Update to J-STD-075 referencing for some devices.
1.3.x	Numbering for terms and definitions added.
1.3.10	Clarification for Shelf life consideration per JEP160 added.
5.4	Note 2 Clarification for bake time computation if test is interrupted added.
5.5	Clarification Note 4 and Note 5 added.
5.8	Clarification Note added.
6.2.4	Potential exclusion for bare die with polymer devices on J-STD-020 applicability.
6.2.5	Potential exclusion for non-IC packages on J-STD-020 applicability.
7	Consideration for long term storage requirements (JEP160).
8.2.2	Dry weight determination with time interval characterization.
8.2.2	Note added; Clarification for bake time computation if test is interrupted.

Standard Improvement Form **IPC/JEDEC J-STD-020F**

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

If you can provide input, please complete this form and return to:

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1. I recommend changes to the following:

☐ Requirement, clause number ____________

☐ Test method number ____________ Clause number ____________

The referenced clause number has proven to be:

☐ Unclear ☐ Too Rigid ☐ In Error

☐ Other ____

2. Recommendations for correction:

____

____

____

____

3. Other suggestions for document improvement:

____

____

____

____

Submitted by

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