

EIA/JEDEC STANDARD

Test Method A112-A

Moisture-Induced Stress Sensitivity for Plastic Surface Mount Devices

EIA/JESD22-A112-A

(Revision of JESD22-A112)

NOVEMBER 1995

ELECTRONIC INDUSTRIES ASSOCIATION
ENGINEERING DEPARTMENT



TEST METHOD A112-A

MOISTURE-INDUCED STRESS SENSITIVITY FOR PLASTIC SURFACE MOUNT DEVICES

(From JEDEC Council Ballot JCB-95-37,
Formulated Under the Cognizance of JC-14.1,
Committee on Reliability Test Methods for Packaged Devices)

1. PURPOSE

The purpose of this test method is to identify the potential classification level of plastic Surface Mount Devices (SMDs) that are sensitive to moisture-induced stress so that they can be properly packaged, stored, and handled to avoid subsequent mechanical damage during the assembly solder reflow attachment and/or repair operation.

This test method may be used to determine what classification level should be used for initial reliability qualification.

If initial qualification exists and no major changes have been made, this method may be used for reclassification to an improved level (longer floor life up to level 2). The reclassification level cannot be improved by more than one level without additional reliability testing.

No components classified as moisture sensitive by any previous version of A112 may be reclassified as nonmoisture sensitive (Level 1) without additional reliability stress testing (i.e., JESD22 A113 and JESD47 or the semiconductor manufacturer's in-house procedures).

Passing the reject criteria in this test method is not sufficient by itself to provide assurance of long term reliability.

2. INTENT

Moisture inside a plastic package turns to steam and expands rapidly when the package is exposed to the high temperature of VPR (vapor phase reflow), IR (infrared) soldering, or, if the package is submerged in molten solder, wave soldering. Under certain conditions, the pressure from this expanding moisture can cause internal delamination of the plastic from the chip and/or leadframe, internal cracks that do not extend to the outside of the package, bond damage, wire necking, bond 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 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 device. For through-hole devices, the soldering operation occurs under the board, which shields the devices from the hot solder. Also, SMDs have a smaller minimum plastic thickness from the chip or mount

pad interface to the outside package surface, which has been identified as a critical factor in determining moisture sensitivity.

3. APPARATUS

This test method requires as a minimum access to the following equipment plus the capability for performing "polished" cross section analysis (not required if optional Scanning Acoustic Microscopy is used).

3.1 Moisture chamber(s), capable of operating at 85°C/85% RH, 85°C/60% RH, and 30°C/60% RH. Within the chamber working area, temperature tolerance must be $\pm 2^\circ\text{C}$ and the RH tolerance must be $\pm 3\%$ RH.

3.2 Solder Reflow Equipment

3.2.1 Infrared (IR)/Convection solder reflow equipment capable of maintaining the reflow profile outlined in 4.8.

3.2.2 VPR chamber capable of operating from 215-219(C. The chamber must be capable of heating the packages without collapsing the vapor blanket and recondensing the vapor to minimize loss of the vapor phase soldering liquid. The vapor phase soldering fluid must vaporize at $+215 \pm 4/0^\circ\text{C}$.

NOTE: The moisture sensitivity classification test results are dependent upon the package body temperature (rather than board or lead temperature) and VPR is known to be more controllable and repeatable than IR/Convection. As a result, when there are correlation problems between VPR and IR/Convection, the VPR results shall be considered as the standard.

3.3 Bake oven capable of operating at $125 \pm 5/0^\circ\text{C}$.

3.4 Optical Microscope (40X for external and 100X for cross-section exam).

3.5 DC electrical test equipment capable of performing room temperature dc and functional tests.

3.6 Optional weighing apparatus capable of weighing the package with accuracy of 0.001% to a resolution of 0.0003%. This apparatus must be maintained in a draft-free environment, such as a cabinet. It would be used to obtain absorption and desorption data on the devices under test (see Paragraph 7).

3.7 Optional Scanning Acoustic Microscope.

Refer to IPC-TM-650, Test Methods Manual, Number 2.6.22, for operation of the Scanning Acoustic Microscope.

NOTE: The Scanning Acoustic Microscope is a useful tool for helping determine the level of moisture sensitivity classification of packages. However, there is no "one-to-one" correlation between delamination and future electronic component failure or performance. There have been component failures traced to delamination at various sites. Some of these failures have been caused by faulty techniques used to remove components from the printed wiring board.

4. TEST PROCEDURE

- 4.1 There are six (6) moisture sensitivity levels as outlined in table I. Components classified by the manufacturer to the previous revision of this document need not be reclassified using the criteria of this revision provided the specified floor life out of the bag does not change from the previous classification. If it is desired to upgrade the product by extending the floor life out of the bag, then the product must be reclassified in accordance with the criteria of this document. 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). Samples may be run concurrently on one or more moisture sensitivity levels. Testing must be continued until a passing level is found. For each evaluation package consisting of an SMD package type (SOIC-small outline IC, PQFP-plastic quad flat pack, PLCC-plastic leaded chip carrier, etc.), number of pins, mold compound, and die pad area to be evaluated, select a sample of 10 units for each moisture sensitivity level to be tested. A minimum of two nonconsecutive assembly lots must be included in the sample with each date code having approximately the same representation. Sample units shall have completed all manufacturing processing required prior to shipment.
- 4.2 In order to minimize testing, the results from a given SMD package type, mold compound, and die pad area may be accepted to cover all other devices in the same SMD package, same mold compound, and same or smaller die pad area.
- 4.3 Perform a room temperature electrical dc and functional test to verify that the devices meet the room temperature data sheet specification. Replace any devices that fail to meet this requirement.
- 4.4 Perform an initial external visual and acoustic microscope examination to establish a baseline for delamination criteria in 5.3.1.
- 4.5 Bake the sample for 24 hours minimum at 125 +5/0°C. This step is intended to remove all moisture from the package so that it will be "dry."

NOTE: This time may be modified if desorption data on the particular Test Method A112-A

device under test shows that more or less time is required to obtain a "dry" package when starting in the wet condition for 85°C/85% RH. See 7.3.

- 4.6 Each sample of ten (10) units shall at all times be handled with adequate precautions to ensure that ESD damage does not occur. Place devices in a clean, dry, shallow container so that the parts do not touch each other. Submit each sample to the appropriate soak requirements shown in table I.
- 4.7 Remove the devices from the temperature/humidity chamber and allow them to dry for a minimum of fifteen (15) minutes.
- 4.8 Not sooner than fifteen (15) minutes and not longer than four (4) hours after removal from the temperature/humidity chamber, submit the sample to either three (3) cycles of VPR at 215-219°C for 60 seconds or three (3) cycles of IR/Convection that meet the following requirements.

Ramp-up rate+6°C/second max

Temperature maintained at 125(±25)°C120 seconds max

Temperature maintained above 180°C120-180 seconds

Time at maximum temperature10-40 seconds

Maximum temperature220+5/0°C

Ramp-down rate-6°C/second max

All temperatures refer to top side of the package, measured on the package body surface. The devices shall be allowed to cool down for five (5) minutes minimum between VPR or IR/Convection cycles.

- 4.9 Examine the devices from each sample under a microscope (40X) to look for external cracks.
 - 4.10 Perform electrical room temperature dc and functional tests on all devices.
5. CRITERIA
- 5.1 A device is considered a failure if it exhibits any of the following:
 - (a) external crack visible under 40X optical microscope
 - (b) electrical room temperature dc or functional 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 two-thirds (2/3) the distance from any internal feature to the outside of the package
 - 5.2 If internal cracks are suspected based on acoustic microscopy, polished cross sections should be made to verify the suspected

site(s). In lieu of evidence of suspected crack sites, section half the devices from each sample with a vertical section through the middle of the package (when viewed from either side or end). Section the other half of the devices from each sample with a vertical section through the middle of the package, along opposite corners of the device.

Note: If marks from the knockout pins are present on the device surface, one of the above sections should be located through at least one of these marks.

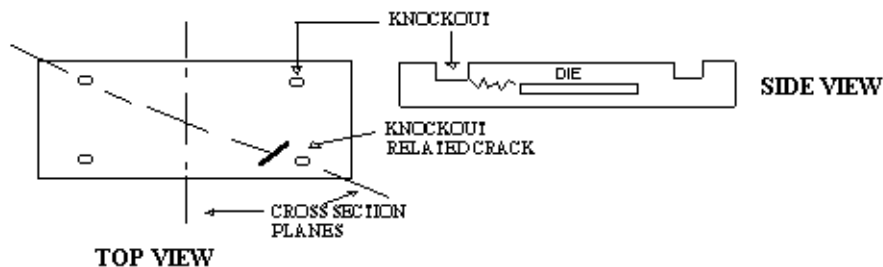


FIGURE 1 CROSS SECTIONING

5.3 To evaluate the impact of delamination on device reliability, the semiconductor manufacturer may either meet the delamination change requirements shown in 5.3.1 or perform reliability assessment using JESD22-A113 and JESD47 or the semiconductor manufacturer's in-house procedures. The reliability assessment may consist of stress testing, historical generic data analysis, etc. Specific methods including historical generic data should be agreed upon by the semiconductor manufacturer and the user.

NOTE: The Scanning Acoustic Microscope is a useful tool for helping determine the level of moisture sensitivity classification of packages. However, there is no "one-to-one" correlation between delamination and future electronic component failure or performance. There have been component failures traced to delamination at various sites. Some of these failures have been caused by faulty techniques used to remove components from the printed wiring board.

5.3.1 The following delamination changes are measured from pre-moisture soak to post VPR or IR/Convection reflow. A measurable (statistically significant) delamination change is defined as an absolute change. The absolute percent (%) delamination change is calculated in relation to the total

area being evaluated. The ability to see a "measurable" delamination change depends upon the amount of delamination present, the surface being scanned and the equipment capability. For this criterion, the equipment must be capable of measuring a minimum absolute delamination change of 10%.

- (a)measurable (statistically significant) delamination change on the top surface of the chip
- (b)measurable (statistically significant) delamination change on any wire bonding surface of the leadframe/die paddle
- (c)measurable (statistically significant) delamination change along any polymeric film bridging any metallic features that are designed to be isolated
- (d)measurable (statistically significant) delamination/cracking change through the die attach region
- (e)any surface-breaking feature delaminated over its entire length. A surface-breaking feature includes: lead fingers, tie bars, heat spreader alignment features, heat slugs, etc.

5.4 All failures from 5.3 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 option selected, the component meets the tested level of moisture sensitivity.

6. MOISTURE-INDUCED STRESS SENSITIVITY CLASSIFICATION

6.1 If a device passes Level 1, it is classified as not moisture sensitive and does not require dry pack.

6.2 If a device fails Level 1, but passes a higher level, it is classified as moisture sensitive and must be dry packed. Labeling should be in accordance with JEP113.

6.3 If a device will only pass Level 6, 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 and a special warning label must be included with the device indicating that it must be either (1) socket mounted, or (2) baked dry within six hours of reflow soldering. The minimum bake time and temperature should be determined from absorption studies of the device under test. See 7.2.

7. OPTIONAL WEIGHT GAIN/LOSS ANALYSIS

7.1 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

Test Method A112-A

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. It is recommended that ten (10) devices be used in the sample so that the average weight can be calculated by simply moving the decimal.

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 = (present weight - dry weight)/wet weight

"Wet" is relative and means the package is saturated with moisture under specific temperature and humidity conditions such as 85°C/85% RH or 30°C/60% RH.

"Dry" is specific and means no additional moisture can be removed from the package at 125°C.

7.2 ABSORPTION CURVE

7.2.1 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 7.1. Devices shall be kept at room ambient between removal from the oven or chamber and weighing and subsequent reinsertion into the oven or chamber.

7.2.2 The dry weight of the sample should be determined first. Bake the sample for 48_hours minimum at 125 +5/0°C to ensure that the devices are dry. Within one (1) hour after removal from the oven, weigh the devices using the optional equipment in 3.6 and determine an average dry weight per 7.1. For small SMDs (less than 1.5 mm total height), devices should be weighed within thirty (30) minutes after removal from oven.

7.2.3 Within one (1) hour after weighing, place the devices in a clean, dry, shallow container so that the parts do not touch each other and then place the devices in the desired non-biased temperature/humidity condition for the desired length of time.

7.2.4 Upon removal of the devices from the temperature/humidity

chamber, follow the procedure in 4.7. Within one (1) hour after removal from the oven, weigh the devices. For small SMDs (less than 1.5 mm total height), devices should be weighed within thirty (30) minutes after removal from oven. After the devices are weighed, follow the procedure in 7.2.3 for placing the devices back in the temperature/humidity chamber. No more than two (2) hours total time should elapse between removal of devices from the temperature/humidity chamber and their return to the chamber.

7.2.5 Continue alternating between 7.2.3 and 7.2.4 until the devices reach saturation as indicated by no additional increase in moisture absorption.

7.3 DESORPTION CURVE

7.3.1 The desorption curve is plotted using devices that have reached saturation as determined in 7.2. 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 7.2.

7.3.2 Within one (1) hour (but not sooner than fifteen (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 parts do not touch each other and then place the devices in the bake oven at the desired temperature and for the desired time. Use only containers rated to withstand the bake temperature.

7.3.3 At the desired read point, remove the devices from the bake oven. Within one (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 3.6 and formula in 7.1.

7.3.4 Within one (1) hour after weighing the devices, place them in a clean, dry, shallow container so that the parts do not touch each other and then place the devices in the bake oven at the desired temperature and for the desired time.

7.3.5 Continue alternating between 7.3.3 and 7.3.4 until the devices have lost all their moisture as determined by the dry weight in 7.2.2.

8. SUMMARY

The following details shall be specified in the applicable procurement document:

(a) Device selection criteria if different from 4.1.

- (b) Test procedure sample size if different from 10.
- (c) Package types to be evaluated.
- (d) Any reject criteria (including Scanning Acoustic Microscope criterion) in addition to those shown in Paragraph 5.
- (e) Any preconditioning requirements beyond those shown in Paragraph 4.
- (f) Conditions or frequency under which retest is required.

TABLE I
MOISTURE SENSITIVITY LEVELS

<u>LEVEL</u>	<u>FLOOR LIFE</u>		<u>SOAK REQUIREMENTS</u>			
	<u>CONDIT IONS</u>	<u>TIME</u>	<u>TIME (Hours)</u>			<u>CON DITI ONS</u>
1	≤30°C/ 90% RH	Unlimited	168			85°C/ 85% RH
2	≤30°C/ 60% RH	1 Year	168			85°C/ 60% RH
			<u>TIME (Hours)</u>			
			X + Y = Z			
3	≤30°C/ 60% RH	168 Hours	24	168	192	30°C/ 60% RH
4	≤30°C/ 60% RH	72 Hours	24	72	96	30°C/ 60% RH
5	≤30°C/ 60% RH	24 Hours	24	24/48	48/72	30°C/ 60% RH
6	≤30°C/ 60% RH	6 Hours	0	6	6	30°C/ 60% RH

X= Default value of semiconductor manufacturer's time between bake and bag plus the maximum time allowed out of the bag at the distributor's facility. The actual times may be used rather than the default times, but they must be used if they exceed the default times.

Y= Floor life of package after it is removed from dry pack bag.

Z= Total soak time for evaluation

NOTE: There are two possible floor lives and soak times in Level 5.
Test Method A112-A

The correct floor life will be determined by the manufacturer and will be noted on the dry pack bag label per JEP113, Symbol and Labels for Moisture Sensitive Devices.