JEDEC STANDARD

Evaluation Procedure for Determining Capability to Bottom Side Board Attach by Full Body Solder Immersion of Small Surface Mount Solid State Devices

JESD22-A111A

(Revision of JESD22-A111, May 2004)

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JEDEC SOLID STATE TECHNOLOGY ASSOCIATION

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EVALUATION PROCEDURE FOR DETERMINING CAPABILITY TO BOTTOM SIDE BOARD ATTACH BY FULL BODY SOLDER IMMERSION OF SMALL SURFACE MOUNT SOLID STATE DEVICES

Introduction

Frequently, small Surface Mount Devices (SMDs) are attached to the bottom side of a printed circuit board by passing them through a wave solder (full body immersion) while simultaneously soldering devices with pins on the top of the board (plated through hole attach). As a result, these small SMDs may be exposed to high temperatures as high as 265 °C during this type of board attach method.

If sufficient moisture exists in the package, exposure to the molten solder causes the moisture to turn to vapor, resulting in increased pressure within the package which in turn may cause quality and/or reliability degradation.

The test method in this document will address the issues related to the determination of the capability of a solid state device to withstand the stresses of full body wave solder immersion and subsequent field use.

EVALUATION PROCEDURE FOR DETERMINING CAPABILITY TO BOTTOM SIDE BOARD ATTACH BY FULL BODY SOLDER IMMERSION OF SMALL SURFACE MOUNT SOLID STATE DEVICES

(From JEDEC Board Ballot JCB-10-19, formulated under the cognizance of the JC-14.1 Subcommittee on Reliability Test Methods for Packaged Devices.)

1 Scope

This evaluation procedure is written to provide USER's of ICs of small surface mount packages with a method to evaluate the capability of a component to withstand full wave solder immersion.

Typically packages capable of full body solder immersion (wave solder immersion) board attach have pitch greater than 0.5 mm. There is only limited demonstrated capability to survive full body (wave solder) immersion attach for QFP and/or packages with bodies larger than 5.5 mm x 12.5 mm (or die paddle size greater than 2.5 mm x 3.5 mm). Packages with limited or no data for capability demonstration should not be wave soldered.

The capability of a package for full body immersion is strongly affected by structure. Large body packages may have reliability and quality problems induced by such a board attach method. Die and paddle sizes, as well as wavesolder conditions (board size, package profile, speed, part density, etc.), are some of the factors that modulate quality and reliability problems.

If wave solder immersion results in a different Moisture Sensitivity Level than the J-STD-020 solder reflow level specified by the supplier, the user must take appropriate precautions to ensure that new floor life is not exceeded during the user's manufacturing processes.

The purpose of this test method is to identify the potential wave solder classification level of small 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 wave solder attachment and/or repair operations. This test method also provides a reliability preconditioning sequence for small SMDs that are wave soldered using full body immersion.

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

2 Applicable documents

JESD625, *Requirements for handling Electrostatic Discharge Sensitive (ESD) Devices*

JESD47, *Stress Test Driven Qualification Specification*

J-STD-020, *Moisture/Reflow Sensitivity Classification for Non-Hermetic Solid State Surface Devices*

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

J-STD-035, *Acoustic Microscopy for Non-Hermetic Encapsulated Electronic Components*

JEP113, *Symbol and Labels for Moisture Sensitive Devices*

3 Apparatus

3.1 Bake oven

Ovens capable of operating at 125 °C +5/-0 °C, for use in drying(baking) the SMDs.

3.2 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%.

3.3 Wave Solder equipment

Wave solder equipment with preheat; capable of up to 260 °C (+5/-0 °C) solder temperature.

3.4 Solder dip machine

Solder dip machine capable of up to 260 °C (+5/-0 °C) solder temperature for full body immersion evaluation.

3.5 Optical microscope

Optical microscope should be capable of 40x magnification for external visual examination and 100X magnification for cross-section examination.

3.6 Electrical test equipment

Electrical test equipment should be capable of performing at least room temperature DC and functional tests.

3.7 Scanning Acoustic Microscope

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

NOTE 1 The scanning 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 scanning acoustic microscope.

4 Classification/reclassification

This test method provides four possible classifications with two solder temperature classifications (245 °C and 260 °C) and two dip conditions (single dip and dual dip). The test conditions must be reported with the classification results. Two types of solder procedures are allowed, wave solder and manual dip soldering.

Table 1 — Wave solder simulation conditions

Test conditions		Reflow method	
		Wave solder	Solder dip
Preheat Temperature		25 to 140 °C	145 °C
Preheat Time		80 seconds min	15 seconds min
Solder Temperature	245 °C Classification	245°C +5/-0 °C	245°C +5/-0 °C
	260 °C Classification	260°C +5/-0 °C	260°C +5/-0 °C
Solder Immersion Time	Single Wave Simulation	5 +/-1 seconds	5 +/-1 seconds
	Extended Single Wave Simulation	10 +/-1 seconds	10 +/-1 seconds
	Dual Wave Simulation	First Wave + Second Wave = 10 +/-1 seconds	10 +/-1 seconds

NOTE Bottom side board attach of small Surface Mount Devices by full immersion in wave solder requires special evaluation of the packages. The profile elements such as preheat, dwell and peak temperatures vary from process to process. Yet the ability of small packages to be exposed to such treatment depends on these parameters. Assessment by dipping in a solder pot usually exposes devices to higher stresses than the wave solder procedure, which results in induced failures. In summation packages that would be attached by wave solder immersion require special evaluations by the USER due to the wave solder process differences.

5 Moisture classification/reclassification procedure

5.1 Requirements for floor life

The recommended soak condition and soak time for determining the desired floor life is shown in Table 2.

5.1.1 Sample requirements

Select a minimum sample of 22 units for each moisture sensitivity level to be tested. Sample groups may be run concurrently on one or more moisture sensitivity levels.

5.2 Initial electrical test

Test appropriate electrical parameters (e.g., Data sheet values, in house specifications, etc.). Replace any devices that fail to meet tested parameters.

5 Moisture classification/reclassification procedure (cont'd)

5.3 Initial inspection

Perform an initial external visual and acoustic microscope examination to establish a baseline for the cracking/delamination criteria in 6.3.1.

NOTE This standard does not consider or establish any time zero requirements for delamination.

5.4 Bake requirements

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

NOTE 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 7c.

5.5 Moisture soak

Place devices in a clean, dry, shallow container so that the bodies of parts do not touch or overlap each other. Submit each sample to the appropriate soak requirements shown in Table 2. (At all times, parts should be handled using proper ESD procedures in accordance with JESD625.)

Table 2 — Moisture sensitivity levels

Level	Floor life		Soak requirements			
			Standard		Accelerated equivalent [1]	
	Time	Conditions	Time (hours)	Conditions	Time (hours)	Conditions
1	Unlimited	≤30 °C/85% RH	168	85 °C/85% RH		
2	1 Year	≤30 °C/60% RH	168	85 °C/60% RH		
2a	4 Weeks	≤30 °C/60% RH	696[2]	30 °C/60% RH	120	60°C/60% RH
3	168 Hours	≤30 °C/60% RH	192[2]	30 °C/60% RH	40	60°C/60% RH
4	72 Hours	≤30 °C/60% RH	96[2]	30 °C/60% RH	20	60°C/60% RH
5	48 Hours	≤30 °C/60% RH	72[2]	30 °C/60% RH	15	60°C/60% RH
5a	24 Hours	≤30 °C/60% RH	48[2]	30 °C/60% RH	10	60°C/60% RH
6	6 hours	≤30 °C/60% RH	Time on Label	30 °C/60% RH		

NOTE 1 To use the "Accelerated Equivalent" soak requirements; correlation of damage response, including electrical, after soak and reflow must be established with the "Standard" soak requirements. Accelerated soak times may vary due to material properties (e.g., Mold compound, encapsulant, etc.)

NOTE 2 Standard soak time includes default value for semiconductor Manufacturer's Exposure Time (MET) between bake and bag plus the maximum time allowed out of the bag at the distributor's facility is 24 hrs.

If the actual MET is less than 24 hrs the soak time may be reduced. For soak conditions of 30 °C/60% RH the soak time is reduced by 1 hr. for each hour the MET is less than 24 hrs. For soak conditions of 60 °C/60% RH the soak. Time is reduced by 1 hr. for each 5 hours the MET is less than 24 hrs.

5 Moisture classification/reclassification procedure (cont'd)

5.5 Moisture soak (cont'd)

NOTE 2 (cont'd)

If the actual MET is greater than 24 hrs the soak time must be increased. If soak conditions are 30 °C/60% RH, the soak time is increased 1 hr. for each hour that the actual MET exceeds 24 hrs. If soak conditions are 60 °C/60% RH, the soak time is increased 1 hr. for each 5 hrs that the actual MET exceeds 24 hrs

5.6 Reflow

Not sooner than fifteen (15) minutes and not longer than four (4) hours after removal from the temperature/humidity chamber, subject the sample to the reflow conditions per Table 1.

5.6.1 Wave solder procedure

Not sooner than fifteen (15) minutes and not longer than four (4) hours after removal from the temperature/humidity chamber, submit the devices to:

a) Preparation

The bottom surface of the device specimen shall be adhered to holder by adhesive agent specified in the relevant specification. Unless otherwise specified in the relevant specification, the flux shall not be applied to the specimen and holder at this point in the wavesolder procedure.

NOTE If flux is applied, vaporization of solvent in the flux hinders rising temperature of the specimen. Therefore the flux shall not be applied to the body of the specimen and should be applied to the lead pins as little as possible (if it is desirable that the effect of fluxing on reliability be evaluated, fluxing may be applied after the wave solder)

b) Preheating

Unless otherwise specified in the relevant specification, the specimen shall be preheated in such a way that so as the package temperature shall go from 25 °C to 140 °C in 80 seconds minimum.

c) Wave Solder (Heating)

Following preheating, the specimen shall be passed through the wave solder as appropriate per table 1

5.6 Reflow (cont'd)

5.6.2 Solder Dip procedure (alternative to wave solder)

NOTE When using this method care should be taken to insure that the package body temperature does not exceed the temperature the device would experience when using the wave solder method above (consideration for heat capacity of the solid state package).

Make sure that the solder (or other medium used to simulate the wave solder) temperature is 260 °C or 245 ° C (+5 °C/-0 °C). Not sooner than fifteen (15) minutes and not longer than four (4) hours after removal from the temperature/humidity chamber:

a) Use appropriate fixture to expose devices to molten solder (when using manual means exposing one device at a time make sure that variation is kept at a minimum)

b) Hold device(s) within one inch above the hot solder (or other medium used for the wave solder simulation) for 15 seconds to simulate preheat.

c) Submerge the device(s) in the hot solder for 5 +/-1 second (single wave simulation) or 10 +/- 1 second for double wave simulation. The immersion and emersion rates should be such so as to minimize gradients across the device being immersed. If automatic equipment is used, record the immersion and emersion rates.

5.7 Post reflow procedure

After the solder cycle(s) are completed, allow the devices to cool at room ambient for 15 minutes minimum.

a) If the test is for wave solder MSL classification then proceed to section 6.

b) If the test is for preconditioning before subsequent reliability testing then continue with 5.7 item (c) and (d) only.

c) Apply an activated water soluble flux to the devices by bulk immersion (entire device body) of the sample in flux at room ambient for 10 seconds minimum.

d) Clean devices externally using multiple agitated de ionized water rinses. No waiting time is required between flux application and cleaning. Devices should be dried at room ambient prior to submission the reliability testing.

6 Criteria

6.1 Failure criteria

If one or more devices in the test sample fail, the package shall be considered to have failed the tested level. A device is considered a failure if it exhibits any of the following:

a) External crack visible under 40X optical microscope

b) Electrical dc and/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

f) Changes in package body warpage or flatness (visible to the naked eye). If parts still meet coplanarity and standoff dimensions they shall be considered passing.

NOTE If internal cracks are indicated by acoustic microscopy, they must either be considered a failure or verified good using polished cross sections through the identified site. Failing components must be evaluated to the next level of moisture sensitivity.

6.2 Pass Criteria

If the components pass the requirements in 6.1, and there is no evidence of delamination change per 6.3.1 or cracks observed by acoustic microscopy or other means, the component is considered to pass that level of moisture sensitivity.

6.3 Criteria requiring further evaluation

To evaluate the impact of delamination on device reliability, the product must either meet the delamination change requirements shown in 6.3.1 or reliability assessment using JESD22-A113 and JESD47. The reliability assessment may consist of stress testing, historical generic data analysis, etc.

6.3 Criteria requiring further evaluation (cont'd)

6.3.1 Peripherally leaded IC components

The following delamination changes are measured from pre-moisture soak to post reflow. A measurable delamination change is defined as a 10% absolute change between pre and post reflows. The absolute percent (%) delamination change is calculated in relation to the total area being evaluated. For this criterion, the equipment must be capable of measuring a minimum absolute delamination change of 10 %.

a) No measurable delamination change on the top surface of the die

b) No measurable delamination change on any wire bonding surface of the die paddle (downbond area) or the leadframe of LOC (Lead on Chip) devices.

c) No measurable delamination change along any polymeric film bridging any metallic features that are designed to be isolated (verifiable by through transmission acoustic microscopy).

d) No measurable delamination/cracking change through the die attach region in thermally enhanced packages or devices that require backside electrical contact.

e) No surface-breaking feature delaminated over its entire length. A surface-breaking feature includes: lead fingers, tie bars, heat spreader alignment features, heat slugs, etc.

NOTE No data is available at present to indicate that Ball Grid Array packages are capable for wavesolder bottom side attach.

6.4 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 component meets the tested level of moisture sensitivity.

If the acoustic microscope scans show failure to any of the criteria listed in 6.3.1, the components shall be tested to the next level of moisture sensitivity or will perform reliability assessment using JESD22-A113 and JESD47 or the semiconductor manufacturer's in-house procedures.

6.5 Moisture sensitivity level

If the components pass electrical tests and there is delamination on back side die paddle, heat spreader, die back side (lead on chip only), and/or the top side periphery of the die paddle for die without downbonds, but there is no evidence of cracking, or other delamination, and still meet specified dimensional criteria, the components are considered to pass that level of moisture sensitivity.

7 Moisture/reflow sensitivity classification

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

b) If a device fails Level 1, but passes a higher level, it is classified as moisture sensitive and must be used in accordance with floor life in Table 2.

c) If a device will only pass Level 6, it is classified as extremely moisture sensitive and dry pack will not provide adequate protection. Level 6 devices must be baked dry before wave solder immersion. The minimum bake time and temperature should be determined from absorption studies of the device under test.

8 Summary

Documentation of the evaluation shall include as a minimum:

a) Device selection criteria if different than clause 1.

b) Test procedure if different than clause 5.

c) Sample size if different than 5.1.1.

d) Package types to be evaluated (specify size in x, y, z dimensions as well as die paddle size in x, y dimensions)

e) Any failure criteria (including scanning Microscope criteria) in addition to those specified in clause 6.

f) Any preconditioning requirements beyond those shown in clause 5.7.

g) Conditions or frequency under which retest is required.

Annex A (informative) Differences between JESD22-A11A and JESD22-A111

This table briefly describes most of the changes made to entries that appear in this standard, JESD22-A111A, compared to its predecessor, JESD22-A111 (May 2004). Some punctuation changes are not included.

Location	Changed from:	Changed to:
Table 1, Preheat Time	80 seconds	80 seconds min
Table 1, Solder Immersion Time	Does not exist	Extended Single Wave, 10+/-1 seconds, 10+/-1 seconds
Table 1, Dual Wave Simulation	First Wave - 5 +/-1 seconds Second Wave - 5 +/-1 seconds	First Wave + Second Wave = 10 +/-1 seconds
Section 5.7 (b) (Contained references that don't exist and were identified during the JEDEC ballot response.)	(b) If the…5.7.3 and 5.7.4 only.	(b) If the …5.7 item (c) and (d) only.

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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 _____

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