

Technical Note

Moisture Sensitivity of Plastic Packages

Introduction

All plastic integrated-circuit packages tend to absorb moisture. During surface-mount assembly, this moisture can vaporize when subjected to the heat associated with solder reflow operations. Vaporization creates internal stresses that can cause the plastic molding compound to crack. This cracking process is commonly referred to as the “popcorn effect.”

Cracks in the plastic molding may cause broken bond wires or may allow contamination to penetrate to the die, which can reduce the reliability of the semiconductor device.

Since plastic packages absorb moisture, care must be taken to prevent exposure to humid conditions greater than 10% RH for extended periods of time prior to surface-mount reflow processing. If exposed to excessive moisture, the devices should be baked to remove moisture prior to solder reflow operations.

This technical note describes the shipping procedures that can ensure Micron customers receive memory devices that do not exhibit the popcorn effect. It also discusses Micron’s recommendations for baking the devices if they are exposed to excessive moisture.

Standards referenced in this discussion are available for download at the JEDEC Web site at www.jedec.org.

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Absorption Characteristics

Micron's extensive testing empirically characterizes the moisture absorption characteristics of plastic packages. As the plastic takes on moisture, the weight of the device increases. Micron employs a standard procedure for weighing the device before and after it is exposed to moisture. We calculate the percentage of weight gain to determine the relative efficiency of different packaging techniques used for shipping devices.

Shelf Life Requirements

Micron has reduced the chance of having popcorn failures with surface-mount packages by shipping all material that is not level one (as defined in Table 1 on page 4) in sealed moisture barrier bags containing a desiccant. Devices stored in these bags show no measurable weight gain when subjected to a high-humidity environment for extended periods. Hence, devices stored in unopened, sealed bags at lower than 40°C and 90% RH have a shelf life of 36 months. Before shipping product, Micron will ensure that the package seal date is within the 36 month window. If not, the product will be backed out of finished goods and the condition of the humidity indicator card (HIC) will be inspected. If the HIC indicates an elevated level of moisture, the parts will be baked dry, repackaged with a new moisture barrier bag, desiccant, and HIC. The package seal date on the label will be updated accordingly. If the HIC does not indicate an elevated level of moisture, the parts will be repackaged as above without the baking step. The date code on the product will not change, but the customer can be assured that the product shelf life with respect to moisture absorption extends to 36 months from the package seal date. Electrical functionality of the devices is not affected by the extended storage times.

Moisture absorption can be eliminated by storing the devices at the recommended floor life conditions specified in Table 1.

There is no shelf life for module-level products. The memory components are humidity sensitive, which can affect their performance and reliability during mounting. When mounted, these components are no longer moisture sensitive.

Moisture Sensitivity Level

IPC/JEDEC Test Method J-STD-020 (see the latest revision) provides a means of testing and classifying devices for a certain level of moisture sensitivity. The eight moisture sensitivity levels, according to this IPC/JEDEC standard, are described in Table 1, along with the associated floor life and soak requirements. Micron characterizes its devices to J-STD-020 levels; results are available upon request.

Table 1: Moisture Sensitivity Levels

Level	Floor Life		Soak Requirements				
			Standard		Accelerated Equivalent ¹		
	Time	Conditions	Time (Hours)	Condition	Time (Hours) 0.40–0.48eV	Time (Hours) 0.30–0.39eV	Condition
1	Unlimited	≤30°C/85% RH	168 +5/-0	85°C/85% RH	N/A	N/A	N/A
2	1 year	≤30°C/60% RH	168 +5/-0	85°C/60% RH	N/A	N/A	N/A
2a	4 weeks	≤30°C/60% RH	696 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 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 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 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 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	N/A	N/A	N/A

- Notes:
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 for moisture diffusion of the package materials is in the range of 0.40–0.48eV or 0.30–0.39eV, 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 diffusion coefficient.
 2. The standard soak time includes a default value of 24 hours for semiconductor manufacturer'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 less than 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 less than 24 hours.
If the actual MET is greater than 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.

Device Baking

If the seal on the shipping container has been broken or if the devices have been removed from their shipping containers and exposed to high levels of moisture, Micron recommends a device bake-out procedure before surface mounting.

Devices not stored in sealed moisture barrier bags require baking before mounting if any one of the following statements is true:

1. Devices have been stored at >20% RH.
2. The humidity indicator card is >20% RH when read at 23°C (+5°C).
3. The product floor life has expired (specified on the packaging label).

Table 2 outlines the bake-out requirements specified in IPC/JEDEC standard J-STD-033 (see the latest revision) and recommended by Micron. These are listed by package thickness and moisture sensitivity level. Devices may be baked at 125°C for high-temperature device containers. Additional bake-out conditions are provided in Table 2 for cases where the device containers cannot be subjected to high temperature, or shorter bake times are desired.

In the cases of mNAND and SSD products, baking is not allowed on units already programmed at customer side. In the cases where a bake is needed on units already programmed, the units must be reprogrammed after baking.

Table 2: Baking Component Conditions

Package Thickness	Level	Bake at 125°C +10/-0°C ≤5% RH		Bake at 90°C +8/-0°C ≤5% RH		Bake at 40°C +5/-0°C ≤5% RH	
		Exceeding Floor Life by >72 hours	Exceeding Floor Life by ≤72 hours	Exceeding Floor Life by >72 hours	Exceeding Floor Life by ≤72 hours	Exceeding Floor Life by >72 hours	Exceeding Floor Life by ≤72 hours
<0.5mm (See Note 4)	2	Not required (See Note 3)	Not required (See Note 3)	Not required (See Note 3)	Not required (See Note 3)	Not required (See Note 3)	Not required (See Note 3)
	2a	1 hour	1 hour	2 hours	1 hour	12 hours	8 hours
	3	1 hour	1 hour	3 hours	1 hour	22 hours	8 hours
	4	1 hour	1 hour	3 hours	1 hour	22 hours	8 hours
	5	1 hour	1 hour	3 hours	1 hour	23 hours	8 hours
	5a	1 hour	1 hour	4 hours	1 hour	26 hours	8 hours
>0.5mm ≤0.8mm (See Note 4)	2	Not required (See Note 3)	Not required (See Note 3)	Not required (See Note 3)	Not required (See Note 3)	Not required (See Note 3)	Not required (See Note 3)
	2a	4 hours	3 hours	15 hours	13 hours	4 days	3 days
	3	4 hours	3 hours	15 hours	13 hours	4 days	3 days
	4	4 hours	3 hours	16 hours	13 hours	4 days	3 days
	5	4 hours	3 hours	16 hours	13 hours	4 days	3 days
	5a	4 hours	3 hours	16 hours	13 hours	4 days	3 days
>0.8mm ≤1.4mm (See Note 4)	2	Not required (See Note 3)	Not required (See Note 3)	Not required (See Note 3)	Not required (See Note 3)	Not required (See Note 3)	Not required (See Note 3)
	2a	8 hours	6 hours	25 hours	20 hours	8 days	7 days
	3	8 hours	6 hours	25 hours	20 hours	8 days	7 days
	4	9 hours	6 hours	27 hours	20 hours	10 days	7 days
	5	10 hours	6 hours	28 hours	20 hours	11 days	7 days
	5a	11 hours	6 hours	30 hours	20 hours	12 days	7 days
>1.4mm ≤2.0mm (See Note 4)	2	18 hours	15 hours	10 days	2 days	25 days	67 days
	2a	21 hours	16 hours	63 hours	2 days	29 days	20 days
	3	27 hours	17 hours	3 days	2 days	37 days	22 days
	4	34 hours	20 hours	4 days	3 days	47 days	23 days
	5	40 hours	25 hours	5 days	4 days	57 days	28 days
	5a	48 hours	40 hours	8 days	6 days	79 days	35 days
>2.0mm ≤4.5mm	2	48 hours	48 hours	10 days	7 days	79 days	67 days
	2a	48 hours	48 hours	10 days	7 days	79 days	67 days
	3	48 hours	48 hours	10 days	8 days	79 days	67 days
	4	48 hours	48 hours	10 days	10 days	79 days	67 days
	5	48 hours	48 hours	10 days	10 days	79 days	67 days
	5a	48 hours	48 hours	10 days	10 days	79 days	67 days
BGA package >17mm x 17mm (See Note 2)	2-5a	96 hours See Note 2 and Note 4)	As above per package thickness and moisture level	Not applicable	As above per package thickness and moisture level	Not applicable	As above per package thickness and moisture level

- Notes:
1. This table provides conditions recommended by JEDEC for drying components.
 2. BGA packages greater than 17mm x 17mm (and 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.

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

Repetitive Baking

If packages need to be baked more than once, Micron recommends the following maximum limits, which are measured by the total bake time of each package. These limits represent ~2% of the proven product lifetime, which is based on 1008 hours of HTOL being equivalent to the proven product lifetime. These recommendations can be exceeded, but this results in more of the proven product life being consumed.

Repetitive baking is not allowed for mNAND and SSD. The maximum limits are the ones reported in table 2.

Table 3: Baking Maximum Limits

Condition	Bake at 125°C	Bake at 90°C
Total maximum bake time	72 hours or 3 days	480 hours or 20 days
Maximum cycles with 24-hour bake	3 times	20 times
Maximum cycles with 12-hour bake	6 times	40 times

- Notes:
1. Calculations per the Arrhenius equation.
 2. Ea assumed to be 0.7eV.

8000 S. Federal Way, P.O. Box 6, Boise, ID 83707-0006, Tel: 208-368-3900
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Revision History

Rev. J	08/2023
<ul style="list-style-type: none">• Changed shelf life from 24 months to 36 months• Updated Table 2	
Rev. I	10/2022
<ul style="list-style-type: none">• Updated Baking Component Conditions table	
Rev. H.....	07/2020
<ul style="list-style-type: none">• Added Repetitive Baking section	
Rev. G.....	10/18
<ul style="list-style-type: none">• Updated Shelf Life Requirements section	
Rev. F	2/13
<ul style="list-style-type: none">• Updated Shelf Life Requirements (previously Storage Conditions) section	
Rev. E.....	2/10
<ul style="list-style-type: none">• Updated template• Minor grammatical and textual changes• Table 1: Moisture Sensitivity Levels: Updated table and notes to match JEDEC Standard J-STD-020D.1, "Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices," except note 3 (not included; applies to supplier)• Table 2: Baking Component Conditions: Updated note 1	
Rev. D.....	3/07
<ul style="list-style-type: none">• Updated template• Changed shelf life from 12 months to 24 months• Updated Table 2	
Rev. C.....	9/04
Rev. B.....	
Rev. A.....	2002
<ul style="list-style-type: none">• Initial release	