

Storage and Handling of Drypacked Surface Mounted Devices (SMD)



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AND8003/D

INTRODUCTION

This information provides ON Semiconductor customers with the necessary packaging, storage and handling guidelines to preclude component package delamination, package cracking and other defects that could be induced during solder reflow procedures for Surface Mount Devices (SMDs).

This document applies to plastic encapsulated SMDs that ON Semiconductor identifies as moisture sensitive and delivers in a dry pack. Moisture sensitive devices include, but are not limited to small outline J pins (SOJs), plastic leaded chip carriers (PLCCs), quad flat packs (QFPs), plastic quad flat packs (PQFPs), thin quad flat packs (TQFPs), thin small outline packages (TSOPs), small outline integrated circuits (SOICs), plastic ball grid arrays (PBGA), shrink small outline packages (SSOPs) and thin shrink small outline packages (TSSOPs).

SMD PACKAGE LIMITATIONS

During reflow procedures, SMDs are exposed to very high temperatures and the internal moisture absorbed from the atmosphere will vaporize. The resulting vapor pressure can cause internal delamination or interfacial separation of the packaging material from the die, leadframe, substrate and damage to the bonding wires. This pressure, in the most severe case may also form cracks in the mold compound and possibly expose the die to the external environment. These damages may pose immediate and potential reliability problems.

By following the guidelines herein, ON Semiconductor customers will prevent the occurrence of these problems.

DRY PACK DESCRIPTION

Dry pack consists of a dessicant, and a Humidity Indicator Card (HIC), sealed inside a Moisture Barrier Bag (MBB) and a barcode label.

The MBB provides ESD protection and has the required mechanical strength and flexibility, is puncture-resistant and heat-sealable.

The desiccant packed in each bag will keep the internal relative humidity level below 10% at 25°C.

APPLICATION NOTE

The Humidity Indicator Card provides the customer with a simple and efficient means to verify the internal humidity level inside the package using color spots as well as detailed instructions for dry bake.

The Manufacturer Part Number (MPN) barcode label indicates the bag seal date, the qualified Moisture Sensitivity Level (MSL) of the SMD, and the floor life or allowable time out of the MBB. MSL of ON Semiconductor's SMDs were classified according to 12MSB17722C, Reliability Qualification Process, IPC/JEDEC J-STD-020, Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices and JEDEC A113, Preconditioning of Plastic Surface Mounted Devices Prior to Reliability Testing.

STORAGE REQUIREMENTS AND TIME LIMITS OUT OF DRY PACK

The MSL at which each SMD is classified determines the appropriate packaging, storage and handling requirements when the SMDs are out of dry pack. Table 1 provides the MSL and the floor life, packaging, storage conditions and floor life before the solder reflow process. If the floor life is exceeded, the affected SMDs must undergo bake prior to any reflow process.

Table 1. Bake Conditions for Mounted or Unmounted SMD Packages after Floor Life has expired or after exposure outside ≤60% RH (User Bake: Floor life begins counting at time = 0 after bake.)

MS Level	Dry pack	Storage TH	Floor Life (Out of Bag) at Factory Ambient ≤30°C/60% RH or as Stated
1	No	30°C / 90% RH	Unlimited at ≤30°C/85% RH
2	Yes	30°C / 60% RH	One Year
2a	Yes	30°C / 60% RH	4 Weeks
3	Yes	30°C / 60% RH	168 Hours Max
4	Yes	30°C / 60% RH	72 Hours Max
5	Yes	30°C / 60% RH	48 Hours Max
5a	Yes	30°C / 60% RH	24 Hours Max
6	Yes	30°C / 60% RH	Mandatory bake before use. Reflow within the limit specified on label after bake.

SAFE STORAGE REQUIREMENTS

If the customer cannot mount the SMDs within the specified time limit, or factory ambient conditions exceed the specified maximum temperature and/or humidity level, then the customer can abate moisture absorption by following any of the safe storage methods to maintain the floor life:

Dry Pack The calculated shelf life for dry packed SMD packages is a minimum of 12 months from the bag seal date, when stored in an environment maintained at < 40°C/90% RH.

Dry Atmosphere Cabinet Nitrogen or dry air-purged storage cabinets with low humidity maintained at 25 ± 5°C and capable of recovering to the required humidity within one hour from opening and/or closing cabinet door/s.

Dry Cabinet at 10% RH SMDs not sealed in a MBB may be placed in a dry atmosphere cabinet maintained at ≤10%

RH up to a maximum time specified in J-STD-033B.1. If the time limit is exceeded, bake is required to restore the floor life.

Dry Cabinet at 5% RH SMDs not sealed in a MBB may be placed in a dry atmosphere cabinet maintained at ≤5% RH for an unlimited shelf life equivalent to storage in a MBB.

DRYING PROCEDURES AND REQUIREMENTS

SMDs that are not handled or stored within required conditions must undergo bake for drying prior to reflow to reset floor life. Re-sealing in an MBB with a dessicant resets shelf life.

Moisture sensitive SMDs which have been exposed only to ambient conditions of ≤60% RH for any length of time may be adequately dried by baking according to Table 2 prior to reflow or Table 5 for drying prior to dry pack.

Table 2. Bake Conditions for Mounted or Unmounted SMD Packages after Floor Life has expired or after exposure outside ≤60% RH (User Bake: Floor life begins counting at time = 0 after bake.)

Package Body	Level	Bake at 125°C		Bake at 90°C, ≤5% RH		Bake at 40°C, ≤5% RH	
		Exceeding Floor Life by >72 h	Exceeding Floor Life by ≤72 h	Exceeding Floor Life by >72 h	Exceeding Floor Life by ≤72 h	Exceeding Floor Life by >72 h	Exceeding Floor Life by ≤72 h
Thickness ≤1.4 mm	2	5 hours	3 hours	17 hours	11 hours	8 days	5 days
	2a	7 hours	5 hours	23 hours	13 hours	9 days	7 days
	3	9 hours	7 hours	33 hours	23 hours	13 days	9 days
	4	11 hours	7 hours	37 hours	23 hours	15 days	9 days
	5	12 hours	7 hours	41 hours	24 hours	17 days	10 days
	5a	16 hours	10 hours	54 hours	24 hours	22 days	10 days
Thickness >1.4 mm ≤2.0 mm	2	18 hours	15 hours	63 hours	2 days	25 days	20 days
	2a	21 hours	16 hours	3 days	2 days	29 days	22 days
	3	27 hours	17 hours	4 days	2 days	37 days	23 days
	4	34 hours	20 hours	5 days	3 days	47 days	28 days
	5	40 hours	25 hours	6 days	4 days	57 days	35 days
	5a	48 hours	40 hours	8 days	6 days	79 days	56 days
Thickness >2.0 mm ≤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
Thickness >17 mm x 17 mm or any stacked die package	2-6	96 hours	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

AND8003/D

Table 3. Reference Conditions for Drying Mounted or unmounted SMD Packages (User Bake: Floor life begins counting at time = 0 after bake.)

Package Body	Level	Bake at 125°C, +10/-0°C		Bake at 90°C, +8/-0°C, ≤5% RH		Bake at 40°C, +5/-0°C, ≤5% RH	
		Exceeding Floor Life by >72 h	Exceeding Floor Life by ≤72 h	Exceeding Floor Life by >72 h	Exceeding Floor Life by ≤72 h	Exceeding Floor Life by >72 h	Exceeding Floor Life by ≤72 h
Thickness ≤1.4 mm	2	5 hours	3 hours	17 hours	11 hours	8 days	5 days
	2a	7 hours	5 hours	23 hours	13 hours	9 days	7 days
	3	9 hours	7 hours	33 hours	23 hours	13 days	9 days
	4	11 hours	7 hours	37 hours	23 hours	15 days	9 days
	5	12 hours	7 hours	41 hours	24 hours	17 days	10 days
	5a	16 hours	10 hours	54 hours	24 hours	22 days	10 days
Thickness >1.4 mm ≤2.0 mm	2	18 hours	15 hours	63 hours	2 days	25 days	20 days
	2a	21 hours	16 hours	3 days	2 days	29 days	22 days
	3	27 hours	17 hours	4 days	2 days	37 days	23 days
	4	34 hours	20 hours	5 days	3 days	47 days	28 days
	5	40 hours	25 hours	6 days	4 days	57 days	35 days
	5a	48 hours	40 hours	8 days	6 days	79 days	56 days
Thickness >2.0 mm ≤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 >17 mm x 17 mm or any stacked die package	2-5a	96 hours (See Note 2)	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

- Table 3 is based on worst-case molded lead frame SMD packages. Users may reduce the actual back time if technically justified (e.g., absorption/desorption data, etc.). In most cases it is applicable to other nonhermetic surface mount SMD packages. If parts have been exposed to >60% RH it may be necessary to increase the bake time by tracking desorption data to ensure parts are dry.
- For BGA packages >17 mm x 17 mm, that do not have internal planes that block the moisture diffusion path in the substrate, may use bake times based on the thickness/moisture level portion of the table.

AND8003/D

Table 4. Default Baking Times Used Prior to Dry Pack that were Exposed to Conditions $\leq 60\%$ RH (MET = 24h)

Pacakage Body Thickness	Level	Bake at 125°C, +10/-0°C	Bake at 150°C, +10/-0°C
≤ 1.4 mm	2	7 hours	3 hours
	2a	8 hours	4 hours
	3	16 hours	8 hours
	4	21 hours	10 hours
	5	24 hours	12 hours
	5a	28 hours	14 hours
> 1.4 mm ≤ 2.0 mm	2	18 hours	9 hours
	2a	23 hours	11 hours
	3	43 hours	21 hours
	4	48 hours	24 hours
	5	48 hours	24 hours
	5a	48 hours	24 hours
> 2.0 mm ≤ 4.5 mm	2	48 hours	24 hours
	2a	48 hours	24 hours
	3	48 hours	24 hours
	4	48 hours	24 hours
	5	48 hours	24 hours
	5a	48 hours	24 hours

- The bake times specified are conservative for packages without blocking planes or stacked die. For a stacked die or BGA package with internal planes that impede moisture diffusion the actual bake time may be longer than that required in Table 4 if packages have had extended exposure to factory ambient before bake. Also the actual bake time maybe reduced if technically justified. The increase or decrease in bake time shall be determined using the procedure in JEDEC JESD22-A120 (i.e., $< 0.002\%$ weight loss between successive readouts) or per critical interface concentration calculations.

Table 5. Bake Conditions for SMD Packages prior to Dry Pack after exposure to $\leq 60\%$ RH

Pacakage Body Thickness	Level	Bake at 125°C	Bake at 150°C
≤ 1.4 mm	2	7 hours	3 hours
	2a	8 hours	4 hours
	3	16 hours	8 hours
	4	21 hours	10 hours
	5	24 hours	12 hours
	5a	28 hours	14 hours
> 1.4 mm ≤ 2.0 mm	2	18 hours	9 hours
	2a	23 hours	11 hours
	3	43 hours	21 hours
	4	48 hours	24 hours
	5	48 hours	24 hours
	5a	48 hours	24 hours
> 2.0 mm ≤ 4.5 mm	2	48 hours	24 hours
	2a	48 hours	24 hours
	3	48 hours	24 hours
	4	48 hours	24 hours
	5	48 hours	24 hours
	5a	48 hours	24 hours

Room temperature desiccation using dry pack or a dry cabinet is also an option for previously dry SMDs exposed only to ambient conditions of $\leq 30^{\circ}\text{C}/60\%$ RH. If in a dry pack and the total desiccant exposure is ≤ 30 minutes, the original desiccant may be reused.

For MSL 2, 2a, and 3 classified packages with floor life exposure of ≤ 12 hours, a minimum desiccating period of 5X the exposure time is required to dry the SMD packages enough to reset the floor life. This can be accomplished by dry packing or storing in a dry cabinet maintained at $\leq 10\%$ RH. For parts with exposure time less than floor life, dry packing or storage in a dry cabinet with $\leq 10\%$ RH will pause the floor life clock as long as the cumulative floor life meets the conditions in Table 1.

For MSL 4, 5, and 5a classified packages with floor life exposure of ≤ 8 hours, a minimum desiccating period of 10X the exposure time is required to dry the SMD packages enough to reset the floor life. This can be accomplished by dry packing or storing in a dry cabinet maintained at $\leq 5\%$ RH.

Bake oven to be used shall have proper ventilation and capable of maintaining the required temperatures at $\leq 5\%$ RH.

Baking of SMDs at 125°C may be done using high temperature/shipping carriers unless otherwise indicated by manufacturer. If low temperature carriers are used, SMDs can only be baked in the carriers at $\leq 40^{\circ}\text{C}$. If higher bake temperatures are to be used, transfer SMDs to thermally safe carriers for the bake process. Remove any paper and plastic materials around the carriers prior to bake.

Exercise care in handling SMDs out of their shipping containers to maintain lead coplanarity and prevent inducing mechanical damage. Proper precautions in handling SMDs shall also be observed to avoid ESD damage per JESD625-A, Requirements for Handling Electrostatic-Discharge-Sensitive (ESDS) Devices.

When the floor life is reset after bake, Safe Storage Requirements shall be followed.

NOTE:

The customer must apply the same storage requirements and time limits specified in Storage Requirements to all dried SMDs.

SOLDER REFLOW GUIDELINES

The reflow process may be a single or multiple passes during assembly reflow and single component attach/removal for rework.

Upon opening of MBB, reflow process must be completed for all SMDs in the bag prior to the stated floor life, resealed in the MBB, or stored in a dry atmosphere cabinet per Safe

Storage Requirements. If the floor life or factory ambient conditions are exceeded, refer to Drying Procedures and Requirements.

Ensure that the rated maximum temperature for the SMDs as indicated on the barcode label is not exceeded during reflow process as this will affect product reliability.

NOTE:

During IR and IR/convection reflow processes, it is important to verify the component body temperature which may be different from lead or solder ball temperature.

If hot air attach processes requires heating to $>225^{\circ}\text{C}$ and the maximum safe temperature for the component is exceeded, the supplier should be consulted.

Thermal reflow profile parameters stated in JESD22-A113 should be complied with. Although the body temperature during reflow is the most critical parameter, other profile parameters may also influence component reliability.

If more than one reflow pass is required, ensure that the SMDs, mounted or unmounted, have not exceeded their floor life prior to the final pass. If any component on the board has exceeded its floor life the board needs to be baked prior to the next reflow according to Table 2.


NOTE:

The floor life is NOT reset by any reflow or rework process. For cavity packages in which water may be entrapped, water clean processes after the first reflow can be an additional source of moisture. This may present an additional risk, which should be evaluated.

Each component must go through a maximum of three reflow passes only. If more than three are required for any reason, the supplier must be consulted.

REFERENCE DOCUMENTS

IPC/JEDEC J-STD-033B.1, "Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices". IPC/JEDEC J-STD-020, "Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices". JEDEC Test Method A113, "Preconditioning of Plastic Surface Mounted Devices Prior to Reliability Testing." ON Semiconductor Specification 12MSB17722C, "Reliability Qualification Process". JESD625-A, Requirements for Handling Electrostatic-Discharge-Sensitive (ESDS) Devices.

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