

Moisture Sensitive Devices Technical Note

1. Background

The vapor pressure of moisture inside a nonhermetic package increases greatly when the package is exposed to the high temperature of solder. Under certain conditions, this pressure can cause internal delamination of the packaging materials from the die and/or lead-frame/substrate, internal cracks that do 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 crack with an audible “pop”. SMDs are more susceptible to this problem than through-hole parts because they are exposed to higher temperatures during soldering.

2. Definitions

(1) Dry Pack

Description Dry pack consists of desiccant material and a humidity indicator card (HIC) sealed with the SMD packages inside a moisture barrier bag (MBB).

(2) Floor Life

The allowable time period between removal of moisture-sensitive devices from a moisture-barrier bag, dry storage, or dry bake and the solder process.

3. Dry Packing

- (1) Requirements Dry-packing requirements for the various moisture sensitivity levels are shown in Table 1 below.

Table 1 – Dry Packing Requirements

MSL Level	Dry Before Bag	MBB With HIC	Desiccant	MSID Label	Caution Label
1	Optional	Optional	Optional	Not Required	Not Required if classified at 220 - 225 °C [428 - 437 °F] Required* if classified at other than 220 - 225 °C [428 - 437 °F]
2	Optional	Required	Required	Required	Required
2a-5a	Required	Required	Required	Required	Required
6	Optional	Optional	Optional	Required	Required

*A “Caution” label is not required if level and reflow temperature are given, in human readable form, on the barcode label attached to the lowest level shipping container.

- (2) The floor life of SMDs per Table 2 below will be modified by environmental conditions other than 30 °C/60% RH. If partial lots are used, the remaining SMD packages must be resealed or placed in safe storage within one hour of bag opening.

Table 2 – Moisture Classification Level and Floor Life

Moisture Sensitivity Level	Floor Life (out of bag) at factory ambient ≤ 30 °C/60% RH or as stated
1	Unlimited at ≤ 30 °C/85% RH
2	1 year
2a	4 weeks
3	168 hours
4	72 hours
5	48 hours
5a	24 hours
6	Mandatory bake before use. After bake, must be reflowed within the time limit specified on the label.

- (3) Any Duration Exposure Moisture sensitive SMD packages that have been exposed only to ambient conditions of $\leq 60\%$ RH for any length of time may be adequately dried by high or low temperature baking according to Table 3 for re-bake prior to reflow or Table 4 for drying prior to dry pack.

**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 @ 125 °C +10/-0 °C		Bake @ 90 °C +8/-0 °C $\leq 5\%$ RH		Bake @ 40 °C +5/-0 °C $\leq 5\%$ 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 ≤ 4.5 mm	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	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
		(See Note 2)					

Table 4 – Default Baking Times Used Prior to Dry-Pack that were Exposed to Conditions ≤60% RH (MET = 24 h)

Package Body Thickness	Level	Bake @ 125°C +10/-0°C	Bake @ 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

Note 1: If baking of packages >4.5 mm thick is required, see appendix B in IPC/JEDEC J-SDT-033.

Note 2: 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.

4. Reflow Temperature Profile

Usually, SMDs is soldered using reflow soldering. Use the appropriate reflow conditions as defined in Table 5 and Figure 1.

Table 5 – Classification Profiles

Profile Feature	Pb-Free Assembly
Preheat/Soak Temperature Min (T_{smin}) Temperature Max (T_{smax}) Time (t_s) from (T_{smin} to T_{smax})	150 °C 200 °C 60-120 seconds
Ramp-up rate (T_L to T_p)	3 °C/second max.
Liquidous temperature (T_L) Time (t_L) maintained above T_L	217 °C 60-150 seconds

Peak package body temperature (T_p)	For users T_p must not exceed the Classification temp in Table 6. For suppliers T_p must equal or exceed the Classification temp in Table 6.
Time (t_p)* within 5 °C of the specified classification temperature (T_c), see Figure 5-1.	30* seconds
Ramp-down rate (T_p to T_L)	6 °C/second max.
Time 25 °C to peak temperature	8 minutes max.

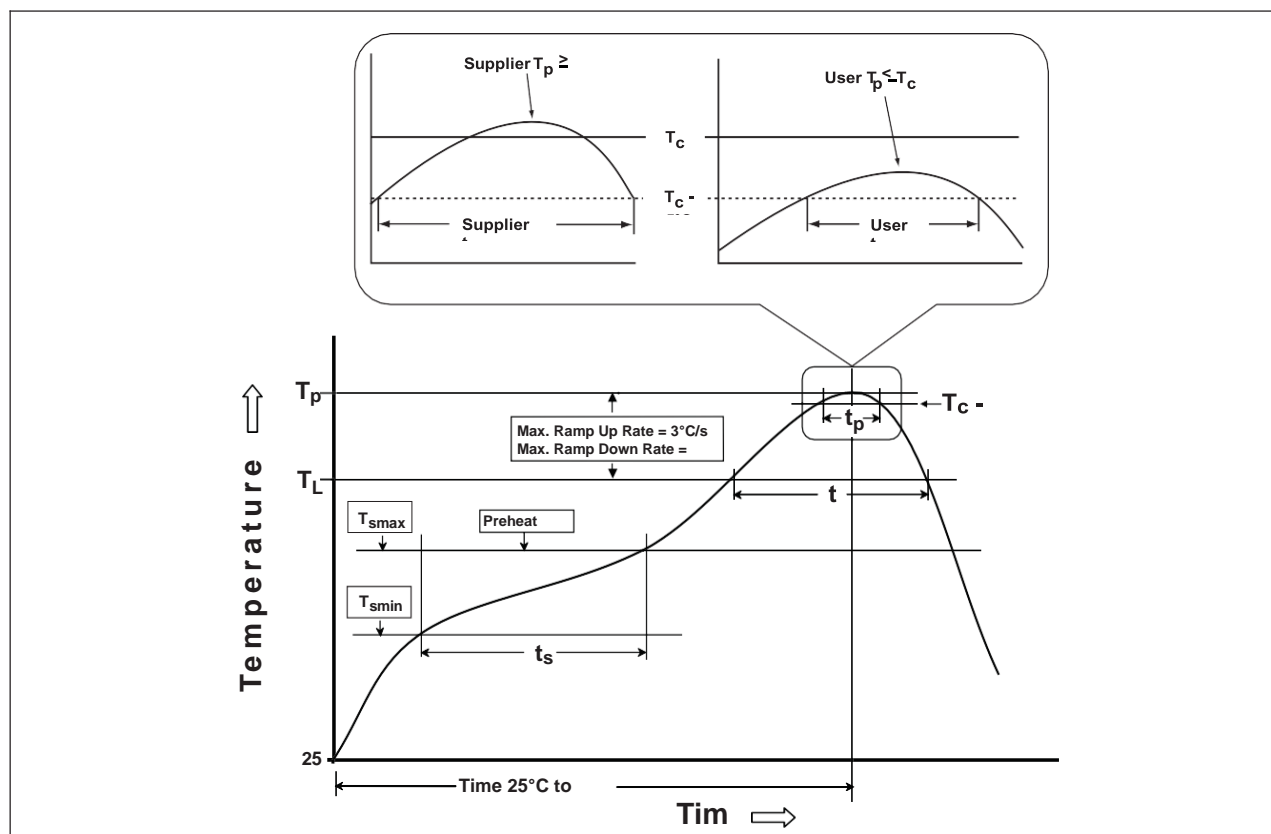


Figure 1 Classification Profile (Not to scale)

Table 6 – Pb-Free Process – Classification Temperatures (T_c)

Package Thickness	Volume mm ³ <350	Volume mm ³ 350 - 2000	Volume mm ³ >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

5. Wave solder Temperature Profile

(1) Applicability

Small 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).

Typically packages capable of full body solder immersion (wave solder immersion) board attach have a lead pitch greater than 0.5 mm. There is only limited demonstrated capability to survive full body (wave solder) immersion attach for QFPs and packages with bodies larger than 5.5 mm x 12.5

mm (or die paddle sizes greater than 2.5 mm x 3.5 mm). Devices in packages with limited or no data for capability demonstration should not be wave soldered.

The capability of a device for full body immersion is strongly affected by its package structure. Devices with large body packages may have reliability and/or 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. Package styles with bottom terminations, such as Ball Grid Array (BGA), Land Grid Array (LGA), and Quad/Dual Flatpack No lead (QFN/DFN) are not suitable for full body solder immersion board attach.

- (2) Use the appropriate test conditions as defined in Table 7 and Figure 2,3, 4.

Table 7 – Wave solder simulation conditions

Test conditions		Reflow method	
		Wave solder	Solder dip
Preheat Temperature (device body temperature)		25 to 140 °C	145 °C
Preheat Time		80 seconds min	40 seconds min
Ramp-up Rate (preheat only)		3 °C/second max	3 °C/second max
Solder Temperature (wave or pot)	260 °C Classification (SnPb and Pb-free solder)	260 °C +5/-0 °C	260 °C +5/-0 °C
Solder Immersion Time	Single Wave Simulation	5 +2/-01 seconds	5 +2/-0 seconds
	Extended Single Wave Simulation	10 +2/-0 seconds	10 +2/-0 seconds
Preheat Temperature	Dual Wave Simulation	First Wave + Second Wave = 10 +2/-0 seconds	10 +2/-0 seconds
Ramp-down Rate		6 °C/second max	6 °C/second max

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.

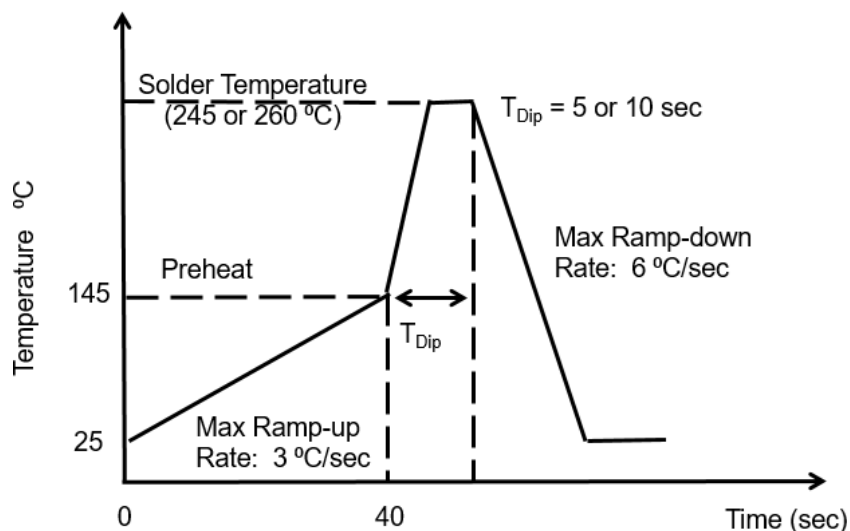


Figure 2 Classification profile for solder dip

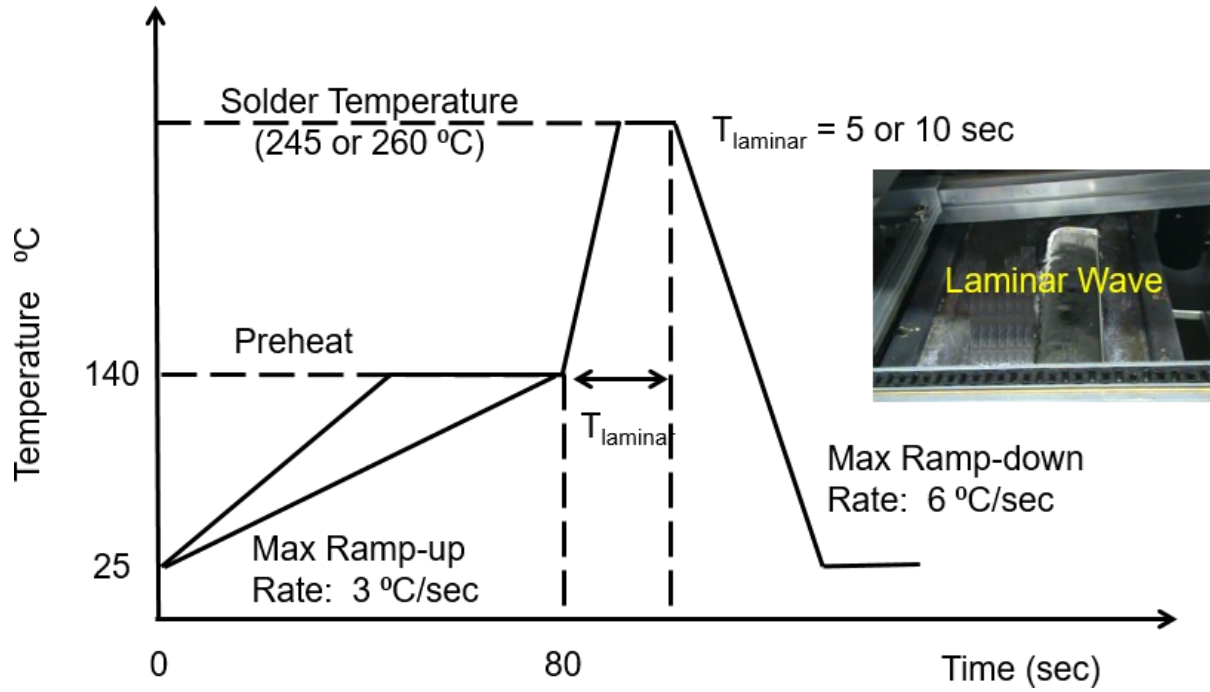


Figure 3 Classification profile for single wave

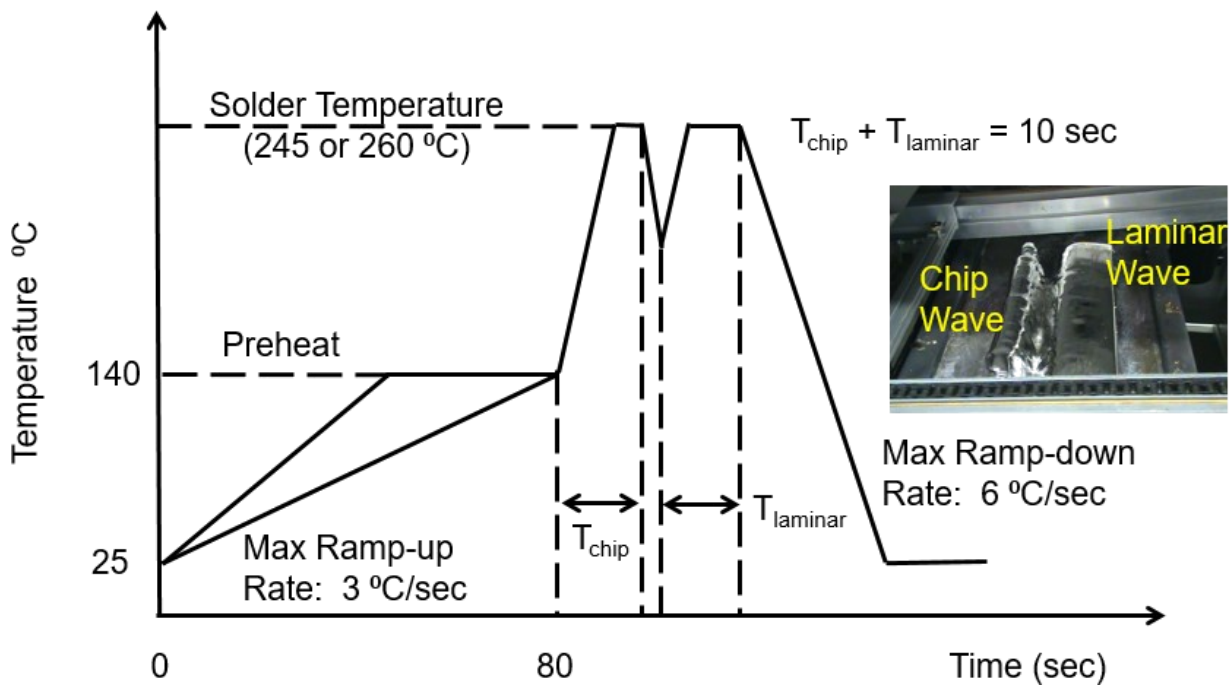


Figure 4 Classification profile for dual wave

6. Reference Document

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

IPC/JEDEC J-STD-020 Moisture/Reflow Sensitivity Classification for Nonhermetic Surface Mount Devices

JESD22-A111 Evaluation Procedure for Determining Capability to Bottom Side Board Attach by Full Body Solder Immersion of Small Surface Mount Solid State Devices