HANDLING OF MOISTURE SENSITIVE PLASTIC PACKAGES

APPLICATION NOTE

ISSUE 3: SEPTEMBER 1997

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 OVERVIEW

"Popcorn" is an industry phenomenon affecting small plastic packages which got its name due to the distinctive popping sound made when a molded package cracks. Plastic packaged chips that have been exposed to humid environments may be damaged during board assembly. The plastic can absorb moisture that, upon heating during solder reflow operations, will cause it to delaminate from the die or leadframe. This delamination may cause the packages to crack and/ or wirebonds to break resulting in a non-functional circuit.

The objective of this document is to outline the process that must be followed, by PMC-Sierra and its customers to ensure that the moisture content of the plastic packages is at a safe level before board assembly.

2 BACKGROUND

2.1 Package Construction and Delamination

Figure 1 shows the cross section of a Plastic Surface Mount Device (PSMD). The molding compound (or plastic) encapsulates the device giving mechanical and environmental protection.

Figure 1 - Plastic Surface Mount Device (PSMD)

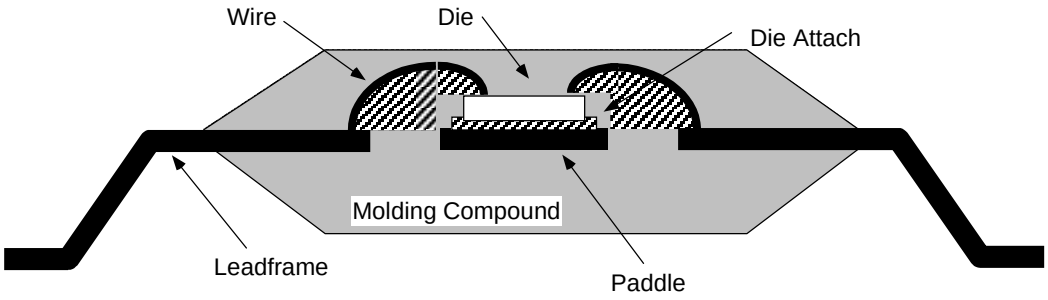
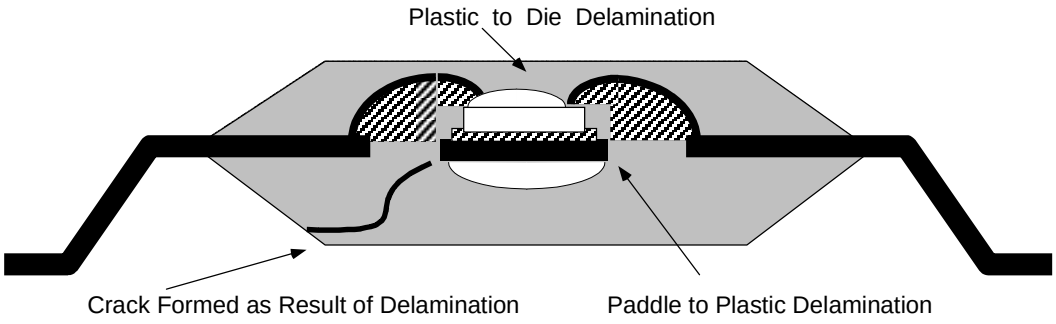


Figure 2 shows a device which has delaminated. For delamination to occur there must be moisture in the package and this moisture must be vaporized causing pressure build up in the package. Moisture may be absorbed when the parts are exposed to humid air. The level of humidity in the air required is discussed below, in general, the humidity in a normal room is high enough to cause the package to absorb water. The moisture may be vaporized during board assembly. The rate of heating and highest Temperature achieved during reflow are as important as the water level in the package.

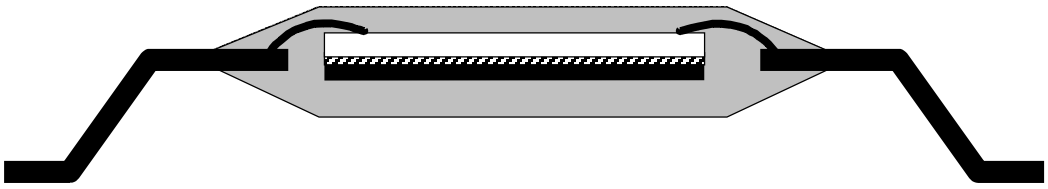
Figure 2 - Delamination Sites



2.2 Maximum Allowable Concentration of Water

The level of diffused water, as a percentage of total weight (% wt.), at which popcorn damage may occur will depend on the plastic (molding compound) , die attach material used, die attach coverage, lead frame design, thickness of plastic over the die and the die size. Figure 3 shows a more popcorn sensitive device - a large die in a small thin package. In this case water diffuses quicker to the bulk of the plastic and there is less partial pressure of vapor required to cause a rupture. There is clearly a trade-off between density and popcorn potential. Board Assemblers who can control the humidity present in devices have a competitive advantage over those who don't as they can create denser boards.

Figure 3 - Large Die / Thinner Package



2.3 Absorption Rates

The rate of water absorption is a function of the environment and the initial humidity For parts exposed in the PMC-Sierra clean room, (25 deg C/50% RH) absorption measurements show that the moisture content rises from 0.05% wt. to approximately 0.1% wt. in approximately 72 hours. Table 1 below (ANSI/IPC-SM-768) shows industry data for similar experiments. It can be seen that the PMC-Sierra data predicts a 20% shorter absorption time than the ANSI/IPC data but is probably within experimental error.

Table 1 - Absorption Rates

Environment (°C/%RH)	Initial Moisture Content	Time to 0.11% (hours)
25/50	0.05	100
25/85	0.05	75
30/60	0.05	92
25/50	0.08	60
25/85	0.08	30
30/60	0.08	48

2.4 Desorption Rates

When the plastic packages are baked in air at 125C, desorption measurements indicate that half the moisture content is removed every 12 hours. The Saturated Water Level a package can support is less than 0.30 %, therefore, when the moisture content of a plastic package is not known, it is safe to assume, that a bake of 24 hours at 125 deg C will ensure that the moisture content is below 0.075%, which ensures safe assembly for all PMC-Sierra Parts.

3 DRY BAGS AND BOXES

3.1 Dry Bags

Dry Bagging and Dry Bags are discussed in PMC-931210 "Procedure for Dry Bagging Moisture Sensitive Plastic IC Packages". The specifications for the bags and their labels and desiccants are stated there. A Dry Bag or Moisture Barrier Bag does not let external water vapor enter. If sufficient desiccant is in the bag the ambient will always have low humidity eliminating any water absorption while the devices are bagged.

3.2 Dry Boxes

Environments with relative humidities below 20% will cause the devices to lose or maintain their moisture level. Therefore storage in a suitable "dry box" with humidity less than 20% is acceptable. The dry box may be fed by Clean Dry Air or Dry Nitrogen. The dry box must be monitored with a hygrometer and flow meter to ensure compliance to the humidity requirement.

4 QUALIFICATION STANDARDS

The standard method used to specify the allowable device time out of bag is to qualify the package using the method of JEDEC - A113 "Preconditioning of Plastic Surface Mount Devices Prior to Reliability Testing". In this technique devices are pre-loaded (soaked) with moisture for a specified period of time as shown in Table 2 and then subjected to three simulated solder reflow profiles as shown in Table 3.

Table 2 - JEDEC - A113 Standards

LEVEL	Soak Time (hours)	Humidity (deg C / %RH)
1	168	85/85
2	168	85/60
3	168*	30/60
4	72*	30/60
5	24/48*	30/60
6	6	30/60

* In actual fact the soak time is increased by 24 hours to allow for IC Manufacturers out of bag time.

Following this the devices are subjected to standard endurance testing (HTOL, T/C, and THB). All PMC-Sierra devices pass Level 3 (168 hours or 1 week out of the bag).

Table 3 - JEDEC - A113 Reflow Simulation

Process	Duration / Temperature
Ramp Up Rate	Maximum 6 Deg C / Second
Temperature Maintained at 125 Deg C	120 Seconds max.
Temperature Maintained above 183 Deg C	120-180 Seconds
Time at Maximum Temperature	10-40 seconds
Maximum Temperature	220 +/- 5 Deg C
Ramp Down Rate	Maximum -6 Deg C / Second

5 THE HUMIDITY BUDGET

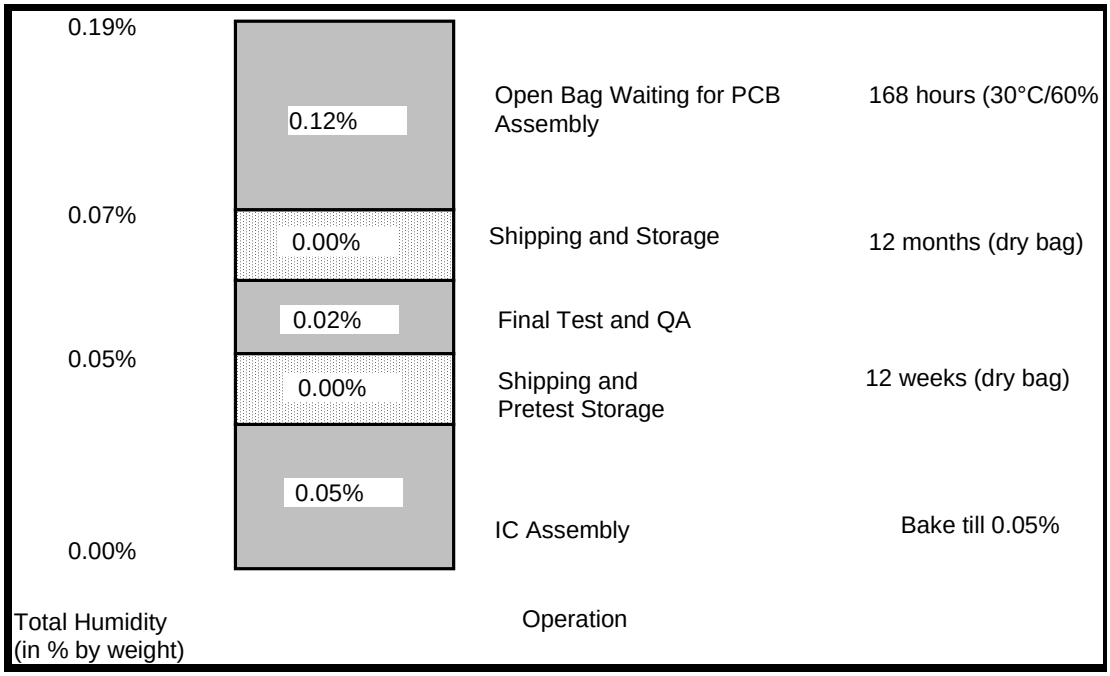
Figure 4 shows a typical humidity budget for PSMDs as they flow from IC assembly to PCB assembly. The actual water absorbed may be more or less as previously discussed. The flow is arranged so that customers will have a minimum 168 hours out of the bag shelf life under 30 deg C and 60% RH conditions.

PSMDs are specified to have less than 0.05% water weight when leaving assembly. This is achieved by baking and sealing in a moisture barrier bag containing sufficient desiccant and a humidity indicator card as specified in PMC-931210 Procedure for Dry Bagging of Moisture Sensitive Devices.

The production test procedures are controlled such that no more than 0.02% is added during these steps. This is done by limiting the exposure to 30/60 environment to no more than 20 hours. At all other times the parts are sealed in dry bags or stored in dry boxes.

At the end of production test the devices are re-sealed in an ESD shielded bag containing sufficient desiccant and a humidity indicator card as specified in PMC-931210 Procedure for Dry Bagging of Moisture Sensitive Devices. If at any point the parts have been exposed for more than the allotted 20 hours, or, a puncture in the bag has been noted the parts are re-baked for 24 hours at 125 deg C as per PMC-940101 Procedure for the Bake Out of Moisture Sensitive Plastic IC Packaged Devices.

Figure 4 - Typical Humidity Budget



6 CUSTOMER SITE REQUIREMENTS

6.1 General

Production Areas should have Temperature less than 30 deg C and relative humidity less than 60%.

Any Dry Boxes used must have relative humidity below 20% and temperature less than 30 deg C.

If at any point the conditions of this procedure are not met the devices must be baked at 24 hours for 125 deg C as per PMC-940101.

"ANSI/IPC-SM-786A Procedures for Characterizing and Handling of Moisture/Reflow Sensitive ICs" provides excellent guidelines to supplement the above information.

6.2 Incoming Inspection

Before opening a sealed bag check for bag integrity. No holes, gouges, tears, or puncture of any kind are allowed. The seal date should be checked and if it has expired the devices must be re-baked. The bag should be opened by cutting a slit as near as possible to the seal. Upon opening a sealed bag, note the condition of the humidity indicator card. If the 20% RH dot has turned pink and the 30% RH dot is not blue the devices must be re-baked as per PMC-940101. If the bag is intact and the humidity indicator card is in the correct state, the devices may be released to board assembly. See Appendix B for photographs of an intact bag and a bag which has been punctured. Bags which have been punctured will typically have a slightly inflated look to them.

6.3 Storage of Unused Components

The PSMDs may be stored, unbagged, in a dry box or re-sealed dry bag for up to 1 year depending on the date of original sealing as indicated on the bag label.

The devices may be left UN-sealed for a period of time as specified in the label (usually 48 or 168 hours). If the environment of the room is better than 30 deg C and 60% Relative Humidity the devices may be left unsealed slightly longer.

If a dry bag sealer is not available it is best to fold the end of the bag over for temporary storage.

6.4 Symptoms of Popcorning

A visible crack on the package (usually visible with a 10X lens) is a sure sign of popcorning. Since the crack may not always be visible or even extend to the surface of the package other indicators are useful. A good indicator is "open circuited" pins which can be checked for by removing a device from the board and "beeping" signal pins with respect to ground pins - a diode should be present on all signal pins. Often open circuit output pins show up on board test to be apparently stuck at "zero" - so it is a good idea to assume that stuck at "zero" pins may be in fact open circuit.

6.5 What to do if popcorning is suspected

If popcorning is suspected, it is important to stop assembly as devices cannot be recovered after they have been popcorned but they can be saved by baking before assembly. If some of the symptoms noted above are present a good test is to hand solder a device from the same batch onto the board - hand soldering does not in general generate enough heat to popcorn the device. If the hand soldered device functions try baking the rest of the batch and doing a limited assembly run. If the failures persist they are probably not the result of popcorning.

7 REFERENCES AND FURTHER READING

PMC-931210 Procedure for Dry Bagging Moisture Sensitive Plastic IC Packages

PMC-940101 Procedure for the Bake Out of Moisture Sensitive Plastic IC Packaged Devices

ANSI/IPC-SM-786A Procedures for Characterizing and Handling of Moisture/Reflow Sensitive ICs

Contact: IPC
7380 N. Lincoln Ave.
Lincolnwood, Illinois
60646-1705

Tel 708 677 2850

Fax 708 677 9570

JESD22 - A113-A Preconditioning of Plastic Surface Mount Devices Prior to Reliability Testing

Contact: Global Engineering Documents
15 Inverness Way East
Englewood, CO 80112-5074

Tel 1-800-854-7179 or 303-397-7956

8 APPENDIX A - BAKE OUT WORK INSTRUCTIONS

8.1 Objective

The objective of this procedure is to ensure that the moisture content of the plastic packages has been lowered to a safe level (0.08 % by weight) by baking.

8.2 Equipment

1. Blue M Convection Oven (Other ovens capable of 125 deg C may be used)
2. Anti-static gloves and strap
3. Vacuum pick-up tool (non-bakeable trays/tubes only)
4. Metal tray (non-bakeable trays/tubes only)

8.3 Materials

1. Plastic parts for baking
2. Bakeable plastic shipping trays

8.4 Devices in Bakeable Trays

1. Consult the oven schedule to make sure it is available to use for 24 hours.
2. Set the temperature set point to read 125°C
3. Verify that the trays holding the parts can be baked to a maximum temperature exceeding 125°C. If the tray is bakeable, the maximum temperature will be written on the tray. If the tray is not bakeable use the procedure in the next section.
4. Remove the nylon straps holding the trays together. Care must be taken that the trays do not separate to prevent the parts from moving, causing the leads to be damaged.
5. Keep the trays grouped by part and assembly lot.
6. Place the trays in the oven for 24 hours.

7. On completion of the bake cycle remove the trays from the oven using the oven mitts. Allow the parts to cool for one hour.

8. Re-strap the trays securely. For PQFPs, PMC-Sierra boxing allows for 5 full height trays with an empty tray as a cover and 10 half height trays with an empty tray as a cover per box. Except for special requests or at the end of a lot, the number of parts in a box will be the maximum that may be contained in the trays.

8.5 Devices in tubes, tape and reel, or non-bakeable trays

1. Consult the oven schedule to make sure it is available to use for 24 hours.

2. Set the temperature set point to read 125°C

3. Remove the parts from the anti static tubes, tape, or non-bakeable tray and place them on metal trays using proper ESD precautions. Trays may be foil lined to prevent lead wear.

4. Keep the trays grouped by part and assembly lot.

5. Place the trays in the oven for 24 hours.

6. On completion of the bake cycle remove the trays from the oven using the oven mitts. Allow the parts to cool for one hour.

7. Load the parts back into the anti static tubes, using proper ESD precautions, keeping them grouped by part and assembly lot. For PLCCs, PMC-Sierra boxing allows for 25 tubes per box. Except for special requests or at the end of a lot, the number of parts in a box will be the maximum that may be contained in the 25 tubes.

9 APPENDIX B - PUNCTURED BAG VS NORMAL BAG

9.1 Normal Bag

In a normal bag the ribs of the internal tray are clearly visible. If the expiry date hasn't been reached on this bag and the HIC reading is satisfactory then the parts are usable without baking.

9.2 Punctured Bag

A punctured bag has a slightly inflated look - the parts in this bag should be baked before use.

NOTES

CONTACTING PMC-SIERRA, INC.

PMC-Sierra, Inc.
105-8555 Baxter Place Burnaby, BC
Canada V5A 4V7

Tel: (604) 415-6000

Fax: (604) 415-6200

Document Information: document@pmc-sierra.com
Corporate Information: info@pmc-sierra.com
Application Information: apps@pmc-sierra.com
Web Site: http://www.pmc-sierra.com

PMC-951041 (R3) Issue date: September 1997