DVD-79C
Handling Moisture Sensitive Devices

Below is a copy of the narration for DVD-79C. The contents for this script were developed by a review group of industry experts and were based on the best available knowledge at the time of development. The narration may be helpful for translation and technical reference.

Introduction

Many companies focus on training their operators and other production personnel in proper ESD control. There needs to be a similar focus and commitment when dealing with MSDs. MSD stands for *Moisture Sensitive Device*. These types of surface mount components need to be protected from the humidity that occurs in a factory environment.

A component that has accumulated moisture can become a major issue in surface mount assembly – specifically during reflow soldering and certain rework operations. Engineering studies show that the rate of failure for many individual moisture sensitive devices is already at an intolerable level because of ongoing changes in packaging technology. And more problems will be encountered with the higher temperatures required for lead free soldering. That's why it's so important to be vigilant when working with these types of components.

In this program, we'll be describing the proper handling of moisture sensitive devices. We'll be explaining what is meant by "moisture sensitive" – and why this can be a problem during surface mount reflow soldering operations.

We'll also be examining the materials and techniques used to protect MSDs. Finally, we'll be taking a look at what needs to be done to prevent problems from occurring during surface mount production.

What is a moisture sensitive device? "Moisture sensitive" refers to electronic components or devices encapsulated with plastic compounds and other organic materials that allow moisture from the atmosphere to enter the permeable package. What this means is that the package is like a sponge – there is *not* a perfect seal between the integrated circuit die and other internal interfaces, and the package that surrounds it.

There are two industry standards that deal with the classification and use of MSDs. IPC/JEDEC J-STD-020 "MOISTURE/REFLOW SENSITIVITY CLASSIFICATION FOR NONHERMETIC SOLID STATE SURFACE-MOUNT DEVICES" is used to determine the moisture sensitivity level of components. The second is IPC/JEDEC J-STD-033 "HANDLING, PACKING,

SHIPPING AND USE OF MOISTURE/REFLOW SENSITIVE SURFACE-MOUNT DEVICES" covers the logistics and use aspects of MSDs.

Many common surface mount plastic packages are at risk – including small outline integrated circuits, or SOICs; quad flat packs, or QFPs; plastic leaded chip carriers, or PLCCs; and ball grid arrays, or BGAs.

When these types of packages are exposed to a typical factory environment, moisture will accumulate inside the package. The level to which this moisture accumulates is based on four variables: the *relative humidity* in the environment, the *temperature* and *time* of exposure, and the *physical properties* of the package materials.

The reason moisture accumulation is a problem is that the *vapor pressure* of the moisture inside the package greatly increases when the device is exposed to high temperatures during reflow soldering operations. Moisture sensitive devices are even *more* at risk in lead free reflow soldering operations because of the higher soldering temperatures required to melt lead free solder.

The exposure to these high temperatures can result in package *cracking* or the delamination of *internal interfaces* within the package. Examples of internal interfaces include the integrated circuit die, bonding wires and ball or stitch bonds. These interfaces are internal to the component package – and contain circuitry and interconnecting points within the device.

When the vapor pressure causes an external crack in the component, it is called *popcorning*. You can actually hear a "popping" sound when the package cracks. When the internal interfaces are damaged or degraded from the vapor pressure, you won't be able to see the result since it's inside the package.

Hopefully, this problem will be discovered during electrical test. However, sometimes the damage won't immediately result in a failure – and the compromised assembly will be installed in an electronic product. And at some point the degradation may result in equipment failure. This usually happens at a most inconvenient time, creating unhappy, frustrated customers.

Now that you understand the problem, let's take a look at the most common materials and techniques we can use to help protect moisture sensitive devices. The first level of protection is to store MSDs in a *moisture barrier bag*. When properly sealed, these bags restrict the transmission of water vapor.

There are three tools that should be used with the moisture barrier bag for increased MSD control. The first is active *desiccant.* Desiccant is a moisture absorbent material that is used to absorb the moisture that penetrates the bag or is sealed in the bag. Additional desiccant may need to be included to absorb moisture contained in *component carrier materials* -- such as trays, tubes, reels or other packing materials that are not baked dry.

The second item is a *humidity indicator card or HIC*. This card contains moisture-sensitive spots that will change color to indicate the level of relative humidity inside the moisture barrier bag. Depending on the level of humidity indicated various actions may need to be taken.

Finally, there is the *moisture sensitive caution label*. This label provides information on the moisture sensitivity level or MSL; the classification temperature; shelf life; floor life; baking requirements; and the bag seal date. Some of this information can also be included on the bar code label.

Another important tool is the *bake oven*. When MSDs inside a moisture barrier bag have absorbed excess humidity based on the color change on the humidity indicator card, the components will need to be placed in an oven for a specific time period at a specific temperature so that the moisture can be baked out slowly to dry them out.

Not all MSDs require moisture protection. For example, components that are installed in sockets are not exposed to the high reflow soldering temperatures that can cause problems. Similarly, MSDs that are hand soldered using point-to-point soldering techniques are also not at risk.

Your company will provide you with specific procedures for the proper handling of moisture sensitive devices. The current revision of J-STD-033 is the industry standard – providing important guidelines on dry packing, baking and using MSDs with a variety of moisture sensitivity levels.

Preventing Moisture Damage

Now that you've been introduced to moisture sensitive devices, and have taken a look at the materials and tools used to protect them, let's examine how we can prevent moisture absorption from occurring in the stockroom and on the production floor.

We'll begin with receiving and incoming inspection. The purpose of incoming inspection is to verify that what has been received is – in fact – what was ordered. Incoming inspection may be very detailed, or may be bypassed altogether. Many companies are using a system of certified suppliers to minimize incoming inspection. The supplier takes responsibility for the quality of the materials. This system is sometimes called "dock to stock." The certified materials are left in their packaging and are simply checked by a bar code reader for correct part number and revision level. Dock to stock receiving procedures are preferable for MSDs because the packaging does not need to be opened in order to verify component quantities. Some companies perform more detailed inspections on the materials they receive.

Regardless of the method used, moisture sensitive components have some special requirements. For example, it's important to check the moisture barrier bags for holes, gouges, tears, punctures or openings. If any irregularities are discovered, we'll need to check the humidity indicator card to see whether the maximum humidity has been exceeded. If this is the case, the components will need to undergo a baking operation. Under these circumstances, we'll need to place the MSDs in a new moisture barrier bag with the proper labeling, along with fresh active desiccant and a humidity indicator card.

When a detailed inspection is called for, components are removed from the packaging so that the quantity and part number can be verified. Once this verification occurs, the MSDs should be sealed in a moisture barrier bag, along with active desiccant and a humidity indicator card. The parts inspected might have to be handled differently depending on the length of time that the components were exposed to the factory environment. If the moisture barrier bag is open for more than a few hours, the parts will need to be baked. With shorter exposures, it's important to wait a specified amount of time after sealing before use.

After incoming inspection, the moisture sensitive devices will need to be stored. A critical element of a company's storage and distribution system is the practice of *first in-first out*, or what we called FIFO – especially in the case of MSDs. What this means is that older parts should be used before newer parts. We do this to minimize moisture accumulation, and to minimize oxidation and degradation of the solderability of stored components. We also perform FIFO to prevent older parts from exceeding their warranty before use.

In this system, all newly received components and circuit boards should be placed in the back, or on the bottom of the storage bin – and the older devices moved forward. When the moisture barrier bag is opened, the humidity indicator card needs to be inspected immediately to see whether the allowed relative humidity has been exceeded. If this is the case, these components should undergo a baking operation before use.

Some companies provide added protection for MSDs by storing them in dry cabinets. These cabinets maintain a low relative humidity environment. It's important to keep the doors to the cabinets closed when you're not in the process of storing or removing components.

Now, let's discuss the distribution of the materials we just stored. Distribution of these production materials is essential to a smooth manufacturing operation. Again, you'll want to observe the FIFO rule -- pulling components from the front or top of the bin first. A more accurate way of doing this is to check the date code on the packaging. The earliest date codes should be removed first. Your company should have a standard operating procedure on the removal and distribution of components. It's important to follow this procedure exactly.

As you know, the process of preparing components and transferring them to the production floor is called *kitting*. When kitting moisture sensitive devices, it's important to leave them sealed in their original packaging until they're ready to be loaded into the placement machines.

When a small quantity of MSDs are required for a job, they'll need to be removed from the packaging. Make sure to cut open the bag as close as possible to the original seal so that the bag can easily be re-sealed. Before kitting them, it's important to check the humidity indicator card to ensure that the allowable relative humidity has been exceeded.

Then place the MSDs that you've removed into a moisture barrier bag, along with desiccant and a humidity indicator card – and seal the bag. A moisture sensitive label should also be placed on the new packaging. The original packaging should also be resealed after returning the components, active desiccant and the humidity indicator card.

During kitting, if the shelf life or the relative humidity on the humidity indicator card has been exceeded, the components will need to be baked until the moisture is removed – before being placed into the production environment.

Once the moisture sensitive devices arrive at the surface mount production line, the critical concern is the *floor life* of the component. Floor life is the allowable time period for an MSD to be exposed to a factory ambient environment not exceeding 30 degrees C and 60% relative humidity. This time period begins after removal from the moisture barrier bag and ends just prior to the solder reflow process.

Again, the moisture sensitive caution label will specify the floor life for a specific component. Depending on the moisture sensitivity level of the component, the floor life ranges from 6 hours to 1 year. This is usually enough time for the components to be loaded onto the placement

machines, be placed onto the lands of the circuit board, and to go through the reflow soldering process. In fact, there may be enough floor life remaining for components that require hot air rework following a visual inspection.

Where floor life becomes an issue for MSDs is when *another* hot job is needed – and reels, trays and tubes have to be switched out to run the new job. If the exposure to the factory ambient environment exceeds the specified time, then the MSDs will need to go through a baking operation – often 48 hours – before they can be safely reflow soldered, or be returned to the stockroom. Check J-STD-033, or your company's standard for proper baking times and temperatures. If we forget to keep track of how long any moisture sensitive devices are exposed to the environment, then we run the risk of undetected damage to the components when they are reflow soldered.

Another floor life consideration has to do with double-sided assemblies – which take longer to process because there are components on both sides of the board. Again, the key is to be aware of how long the components are exposed to the relative humidity of the factory.

Our final consideration for protecting moisture sensitive components is during hot air rework or repair operations. It's important to bake the populated boards, prior to performing this type of rework. The maximum bake temperature for populated boards is limited by the capability of the various components on the board and may require very long times at low temperatures.

This program has described proper techniques and considerations for handling moisture sensitive devices. We discussed why MSDs are at risk during surface mount reflow operations and we examined the materials and techniques used to protect these components from moisture accumulation.

Then we explained how to prevent problems from occurring in surface mount operations. Let's review some of the key points. Moisture sensitive devices need to be stored in moisture barrier bags, along with active desiccant and a humidity indicator card. When the humidity indicator card reveals that the allowed relative humidity has been exceeded, the components will need to be baked per the tables in J-STD-033 – or your company's standard operating procedure.

Carrier materials such as trays, tubes and reels can also affect the moisture level in the moisture barrier bag – and if not baked will require extra desiccant to be added. MSD exposure to the factory environment should be kept to a minimum during the surface mount assembly process.

Protecting moisture sensitive devices is critical to the quality and reliability of the circuit board assemblies we're manufacturing. That's why you are so important to this process.

"Raindrops Keep Fallin' on My Head" Spoof

Moisture keeps messin' with my head
Temperature's rising, my components are turning red
You can hear them pop!
Thooooose MSDs keep poppin as we reflow the solderrrrr...

So here's what we're doing to protect
MBBs, desiccant and humidity detect
No sleepin' on the job
Cuz... moisture keeps falling on my head, it keeps falling

But there's one thing I know
When floor life is exceeded, baking's needed
It won't be long til all these defects are defeated

Moisture keeps messin’ with my head
It don't really matter if it's lead free or tin-lead
Precaution is the rule
success never comes to anyone by complainin'
Because I'm free
Moisture doesn't worry me

[trumpet solo]
It won't be long until all these defects are defeated

Moisture keeps messin’ with my head
It don't really matter if it's lead free or tin-lead
Precaution is the rule
success never comes to anyone by complainin'
Because I'm free
Moisture doesn't worry me