
DVD-99C

Lead Free Conversion in Electronics Assembly

Below is a copy of the narration for DVD-99C. 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.

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NEWSBOY

Extra, extra --Lead Free solder is creating a buzz in Electronics Assembly.

NARRATOR

But no worries – no need for concern. There *will* be some precautions to take, some *new* techniques to learn. That’s what keeps life exciting, right?

As you probably know, our industry is transitioning from tin-lead to lead free soldering. And almost everyone in manufacturing is going to be affected. The degree to which the conversion to lead free will affect us depends on our particular job.

For example, surface mount assembly operators will need to be aware of the differences in lead free solder paste characteristics for stencil printing, along with how the thermal profile will change for lead free reflow soldering. On the other hand, assembly inspectors will need to become knowledgeable about lead free solder joint acceptance criteria based on the differences in visual appearance.

This program will provide an overview of what’s involved in making the switch to lead free electronics assembly. We’ll be examining the affect that lead free alloys have on soldering; on visual inspection; on safety and the environment; and on moisture sensitive surface mount devices.

Let’s begin by taking a look at lead free solder alloys. As you probably know, tin-lead solder contains 63% tin and 37% lead. This alloy becomes liquid at 183 degrees centigrade. The lead free solder alloys require a higher temperature to become liquid – often 40 degrees C higher than tin-lead. The higher temperatures represent the most significant difference between the tin-lead and lead free processes.

The most common lead free solder is tin-silver-copper. It comes in paste form for reflow soldering, and in the solder wire we use for hand soldering applications. A common formulation consists of 96.5% tin, 3% silver and .5% copper.

Another common lead free alloy is tin-copper – used in wave soldering operations. The melting point of this alloy is a little higher at 227 degrees C.

As you can see, we'll be using lead free solders during reflow soldering, wave soldering and in hand soldering applications. We'll also be using these alloys when reworking both through hole and surface mount connections. It's important to understand that lead free solder joints are just as reliable as the tin-lead solder joints we're used to seeing. There have been numerous engineering studies that confirm this assertion.

However, the higher temperatures do present a number of challenges to the soldering process. For starters, components and circuit boards need to be able to withstand the increased heat. That's because the lead free alloys tend to have a higher surface tension – meaning they don't spread along the surface of the connection as easily as their tin-lead counterparts. This often results in increased dwell times, or the time that the soldering iron is in contact with the connection.

Another temperature issue relates to moisture sensitive surface mount devices. These components will need to be handled with even greater care in a lead free process. That's because when there is moisture retained in the component packaging *and* the device is exposed to higher soldering temperatures, there's even greater potential for board or component delamination. We'll be discussing the handling of moisture sensitive devices in more detail later.

Another issue in lead free soldering involves flux. There is a need for *higher activity fluxes* in order to clean the surfaces to be soldered more aggressively. This is due to reduced spreading of the lead free solder, along with operating at the elevated temperatures and potentially longer soldering times.

Also, when we move to the more active fluxes, the solder connections may require a more thorough cleaning process to remove the more aggressive, and potentially still active fluxes.

And it's important to understand that in a lead free process the bare printed circuit boards and components will also need to have lead free finishes. We'll need to know that tin-lead and lead free solders cannot be mixed. Mixing can create cross contamination – which could result in unreliable solder connections.

At this point, let's take a look at the visual inspection of the lead free solder joints. As we stated earlier, lead free connections may have a different appearance – depending on the specific alloy used.

As you can see, lead free solder joints appear a little *grainier* than their tin-lead counterparts. However, the same basic standards apply for target, acceptable and unacceptable solder joints. Let's examine a sampling of target solder joints – comparing lead free to tin-lead – for both plated through-hole and surface mount connections.

Notice how the lead free solder *feathers* onto the land... and up onto the lead or termination. The solder fillet is curved inward - or *concave*. The solder *covers* all of the land, and the lead or termination. The *texture* is a little bit grainy. The outline of the lead or termination is visible beneath the solder. The amount of solder here is just about perfect.

Now let's look at some solder joints that are *less than ideal*. Here are examples of *non-wetting*. Notice that the solder has not adhered to either the termination or land. Non-wetting will occur if the reflow or wave soldering temperature is too low, or there is poor flux activity.

These solder joints have *excessive solder*. The fillets are not concave, and there is solder flowing over the edge of the land. You can see that too much solder has been used. Finally, let's look at some connections that have *solder bridges*. A bridge is an *electrical path*, or *short circuit* that was not intended.

Now that you've been introduced to the characteristics of the lead free solders and have become familiar with their appearance, let's discuss why our industry is switching to lead free processes, and how this conversion can offer potential benefits for job safety and for the environment.

In the 1970s lead had become commonly recognized as a potential health hazard – and was eliminated from gasoline and paint. In addition, household plumbing has been changing from lead to no-lead.

As part of the continuing effort to reduce the potential for environmental issues with the lead contained in tin solders, there is now momentum for using lead free solder in the electronics industry. The main reason for this momentum is that European countries initiated a legal mandate converting to lead free soldering processes by July 1, 2006. Japan is also committed to this timetable. Given the global market commitment to lead free electronics, the United States is preparing to do the same.

The question isn't *whether* the switch will be made to lead free solder throughout our industry, but *when*. Everyone agrees that it's just a matter of time when lead will be *banned* and *removed* from all electronic products. The switch to lead free solder will allow us to do our part in keeping lead out of our landfills – and from being burned in our incinerators – which has a potential benefit for our environment.

Lead is toxic and can severely affect our central nervous systems. Ingestion is the most likely route of entry while performing electronics assembly.

Using proper precautions, we've learned how to minimize the potential hazards of tin-lead solder. We already know that lead can be ingested by touching food, cigarettes, chewing tobacco or make up after handling tin-lead solder, solder paste or soldered boards without hand protection.

And we also know that the hazard can be avoided by washing our hands with soap and water before touching any item that will come into contact with our mouths. What this means is that we *can* protect ourselves in the workplace.

But the situation involving lead is not so clear when we discard our old electronic products. Our landfills contain tons of electronic components and circuit boards that were manufactured and assembled using tin-lead solder. There is concern that the lead in the landfills will eventually end up in the water table through leaching.

At this point, let's return to our discussion on the effect of a lead free process on moisture sensitive devices. A moisture sensitive device, or MSD, is an electronic component that is encapsulated with plastic compounds and other organic materials that allows moisture from atmospheric humidity to enter that permeable packaging. An imperfect seal between the integrated circuit die and the package that surrounds it puts many plastic surface mount packages at risk.

When these types of packages are exposed to a typical factory environment with at least 30% humidity, moisture can accumulate inside the package. Moisture accumulation is a problem because the *vapor pressure* of the moisture inside the package greatly increases when the device is exposed to reflow soldering temperatures. The exposure to high temperatures can result in the package *cracking*, and/or the delamination of *internal interfaces* within the package. The higher soldering temperatures associated with a lead free process makes moisture accumulation in these types of surface mount components even more dangerous.

The proper handling of MSDs in a lead free process goes a long way in protecting these components. When possible, MSDs should be kept in their original packaging until used. This packaging consists of a sealed moisture barrier bag that restricts the transmission of water vapor; a moisture sensitive caution / identification label that specifies information such as classification level, shelf life, peak temperature, floor life, baking requirements and bag seal date; active desiccant, which is a moisture absorbent material; and a humidity indicator card that changes color when the specified relative humidity values are exceeded inside the moisture barrier bag.

There are situations during incoming inspection where we may be required to open the packaging to verify component part numbers and quantity. When this is the case, it's best to open the bag near the top so it can be easily resealed. Also, the desiccant and humidity card should be returned to the packaging.

When MSDs are stored in the stockroom, we'll need to store them so that the older devices can be removed and used before the newer components. This system of storage is called first in – first out, or FIFO. FIFO ensures that the older components are put into production before the newer ones - so shelf life is minimized.

Kitting MSDs for use on the production floor also requires some precaution. For example, all expiration dates should be checked on the packaging, along with verifying that the humidity indicator card has not exceeded 10% relative humidity. If the card *has* exceeded 10%, the devices will need to go through a baking operation to remove the accumulated moisture before being soldered onto a circuit board assembly.

Floor life is also an issue for MSDs. If the exposure to the factory environment exceeds a specified time, then the MSDs will need to go through a baking operation – often 48 hours long – before being safe to be reflow soldered, or to be returned to the stockroom for storage.

This program has presented an overview of what is involved to convert from tin-lead to a lead free soldering process. We examined how the lead free alloys affect the soldering process, and how the visual appearance of lead free solder joints may differ from the tin-lead connections we're used to seeing.

Then we discussed why our industry has decided to switch to lead free soldering, and how that can have a positive benefit for our personal safety and for the environment. We concluded with a description of how the higher lead free soldering temperatures make the proper handling of moisture sensitive surface mount components even more critical than with tin-lead.

The key element in the conversion to lead free processes is the higher soldering temperatures. This is what presents the majority of challenges in the assembly process. But with familiarization and practice, working with the lead free solders will become like second *nature*.

End with *Lead Free* song

Lead Free -- we solder without it
There's no need to doubt it
The conversion is here

Lead Free -- the temperature's rising
The grainy look is surprising
When inspecting the joints

Lead Free -- the flux is more active
The residue's unattractive
So clean more vigorously

And those moisture -- sensitive devices
You can prevent a crisis
With careful handling

Lead Free -- the earth's feeling happy
This song's getting sappy
But you know that it's true

Lead Free -- we solder without it
There's no need to doubt it
When we switch to lead free