DVD-69C
Ray's Lead Free Hand Soldering Secrets

Below is a copy of the narration for DVD-69C. 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

FEMALE OP 1 (voice over)
Lead free's not so easy.

FEMALE OP2 (voice over)

I know. It can really be a drag.

NARRATOR (voice over)

Drag soldering doesn't have to be a drag when it comes to lead free. We have some secrets that'll make hand soldering with lead free alloys a lot less frustrating.

OP1 (voice over)

Like what?

NARRATOR (voice over)

Well, if we told you they wouldn't be secrets any more, would they? Just kidding – just kidding.

This video training program will explain all our secrets for successful lead free hand soldering. The areas we'll be examining include extending soldering iron tip life; effective heat transfer; better wetting; improved drag soldering techniques; and how to avoid cross contamination.

Soldering Iron Tip Life

Let's begin with the soldering iron tip. One of the biggest complaints about soldering with a lead free alloy is the negative effect it has on soldering iron tip life. The villain in this drama is the high tin content in lead free solder alloys.

For example, tin-lead solder contains 63% tin and 37% lead. In contrast, the tin-silver-copper solder common to lead free hand soldering consists of 96.5% tin, 3% silver and .5% copper.

Tin is a very aggressive metal. At the 96.5% concentration, it will eventually eat through the plating on the tip of the soldering iron – reducing the life of the tip. That's because as the tin dissolves the plating, the tip becomes pitted and eventually cannot hold the solder. This phenomenon is similar to when a soldering iron tip becomes oxidized and will no longer hold the solder, or transfer the necessary heat.

To better understand the problem, let's look more closely at soldering iron tips. In general, most soldering iron tips are similar in composition, with the exception of the heating method, or element.

The tip is made of copper with a plating of iron. The sides of the tip usually have additional nickel plating followed by chrome. The chrome prevents solder from wicking up away from the working area of the tip. The soldering iron tip manufacturers then apply a coating of solder to the tip.

There are many factors that will affect tip life – in particular, plating failure of the iron coating. The increased tin content of lead-free solders, along with the more aggressive nature of the lead free fluxes, may cause a plating failure to occur *more* rapidly.

Most tip manufacturers have now increased the iron plating thickness – in the hope that this will prolong tip life with the more aggressive high tin content of the lead free solders. In addition to the increased iron plating, the final solder coating of the tip is done with lead free solder. This tip will then be acceptable for use on either a tin-lead process or a lead free process.

The tin in both the tin-lead solder and the lead free solder will form *intermetallics* with many other metals. This formation of tin *intermetallics* allows the solder to "stick" to the surface being soldered. What this means is that the tin in the solder is *mixing* with other metals – in particular, the iron plating on the tip. Every time the solder is wiped from the tip, it takes a little bit of the iron plating with it. Eventually it will remove enough iron plating to expose the copper of the tip.

Another example of the aggressive nature of tin occurs in lead free wave soldering. The old solder pots that were made from copper, iron and nickel plating, were dissolved by the high tin content of the lead free solder. Wave solder machines now use solder pots made from titanium to avoid this problem.

Now that you understand the lead free tip life issue, we'll let you in on some secrets to make soldering a little easier. The most important tip life secret is to use technology that will reduce the tip temperature while the iron is not actually used for soldering.

An example of this type of technology is the tip holder. Some tip holders that are available will automatically drop the temperature to 300 degrees Fahrenheit, or about 149 degrees C – well below the melting temperature of the lead free solder – which becomes liquid at about 220 degrees C. By turning the heat down automatically when you're not using the iron, the solder on the tip will not be in a molten form that will eat away at the tip.

Another secret to extend tip life is to avoid or reduce the use of aggressive tip tinners, or anything else that's abrasive on the soldering iron tip – such as scrubber pads. Infrequent use of these materials can be quite helpful for removing oxidation on the tip. However, frequent or excessive use will result in tip plating erosion and pitting of the tip. It is important to clean the tip with a damp sponge – and to keep the tip tinned with lead free solder wire when not using it.

Effective Heat Transfer

Now, let's turn our attention to effective heat transfer using lead free solder. As you know, tin-lead solder becomes liquid at 183 degrees C. Lead free alloys have a melting temperature of about 40 degrees C higher than tin lead solder. Therefore one would assume that lead free soldering temperatures should be 40 degrees C *higher* – ranging from about 355 to 410 degrees C. The problem is that these higher temperatures have the potential of damaging sensitive components and possibly even the circuit board.

Our secret is that effective heat transfer – rather than higher soldering temperatures – can result in perfectly acceptable lead free solder joints with minimum risk. Here's how it works. Effective heat transfer is accomplished through proper tip selection. This has to do with the contact area and the thermal mass.

When selecting a tip, always select a tip that has the greatest contact area without overhanging the joint area. A chisel tip with a flat surface has a much greater contact area than a conical tip. What we're looking for is the maximum tip to land contact area to heat the connection quickly.

Imagine the tip to land contact area as a plumbing pipe in a swimming pool. A one inch pipe will take fifteen minutes to fill a three hundred gallon pool. A fifteen inch pipe will only take one minute to fill the same pool.

Using a soldering iron tip with the greatest area of contact with the land will allow the tip to transfer its available energy into the connection much faster.

The *thermal mass* of the tip is also important for effective heat transfer. Thermal mass relates to the *size* of the tip and the amount of heat it can hold. For example, a tip with a weight of one ounce heated to 600 degrees Fahrenheit may be able to heat seven grams of copper to 600 degrees before the heating element has to energize and restore the tip temperature.

A tip with a weight of three ounces heated to 600 degrees Fahrenheit may be able to heat 21 grams of copper without the heating element energizing to restore the tip temperature, even if the contact areas are identical. This means the soldering operation can be done faster.

The thermal mass of the tip is important for connections that dissipate heat quickly. What this means is the solder connection needs to be completed as quickly as possible, while allowing for adequate solder wetting.

When a tip doesn't have enough thermal mass, the tendency is to increase the soldering temperature. However, this practice may result in damage to the circuit board material – or a lifted land – caused by high temperature over an extended period of time.

Let's do a comparison of the heat transfer capabilities of a small conical tip and a blade tip. Looking at the meter, we can tell that the tip with the greatest contact area is more effective at transferring heat.

Let's do another comparison that examines the effect of thermal mass of the tip on the heat transfer. As we can see from the meter, the tip with the *greatest thermal mass* is more effective at transferring heat.

Another secret for effective heat transfer is to use *auxiliary heating* to preheat the area to be soldered. Preheating makes it a lot easier to solder a connection that requires a lot of heat – especially with the lead free alloys.

We always want to use the lowest soldering temperature possible to avoid damaging the assembly. Yet the temperature of the iron must be sufficient to adequately heat all elements of the solder connection and to allow the lead free solder to melt and wet all connection elements.

When using auxiliary heating, we'll want to attain a board temperature of 100°C to 150°C. By preheating the board, the iron does not have to heat the connection area up from room temperature. It will be using its heating capacity for the actual solder connection.

Here's another useful secret. A quick way to check the board temperature without any equipment is to use your finger. You will not be able to leave your finger in place on the board if the temperature is above 100°C. Try dipping your finger in boiling water if you don't believe it! If the board is too hot to leave your finger in place, it is at least 100°C.

Now let's do another comparison of the heat transfer – with and without auxiliary heating.

Better Wetting

Next, let's take a look at some of the secrets for *better wetting*. Wetting is defined as the formation of a relatively uniform, smooth, unbroken and adherent film of solder to a basis metal. But before we talk about wetting, we should review the purpose of flux – and what we'll need to consider for lead free soldering.

Flux is an essential ingredient in the soldering process. Its primary purpose is to *remove oxidation* -- which can prevent proper wetting or bonding of the solder.

Lead free alloys tend to have higher *surface tension* – meaning they won't *spread* as well as tin-lead solder. Because of the reduced spreading, fluxes will need to be more robust and clean surfaces more aggressively – thereby facilitating better wetting.

But our *secret* for better wetting actually involves the surface finish on the land. If we are soldering a *new* board and parts, the surface finish may be electroless nickel immersion gold, immersion tin, immersion silver or some other metal. If we coat the land with our lead free alloy *before* we perform the hand soldering operation, the solder *wetting results* are often much better than if we solder *directly* on some of these other surface finishes. Remember the old saying “nothing solders like solder”.

Let’s compare the wetting characteristics for a nickel gold finish and a nickel gold finish that has been *tinned* with lead free solder.

Drag Soldering

Drag soldering is a fast and efficient technique for performing tin-lead solder rework on surface mount gull wing components.

When reworking lead free connections, drag soldering tends to produce multiple solder bridges that will need to be fixed individually. Preheating the assembly *improves* this situation, but there will typically be one or two solder bridges that result.

The secret here is to use a slightly *different* drag solder technique. As always, a liberal flux application is necessary to perform *lead free* drag soldering – just as it was for *tin lead* drag soldering.

As we discussed earlier… tinning the lands with lead free solder will provide better wetting and help with the drag soldering process. In many cases, the amount of solder that is already on the lands from the tinning operation will be sufficient to form good solder joints during the lead free drag soldering operation.

Even so, there is still a greater chance of creating solder bridges with lead free drag soldering – unless the *placement* of the soldering iron tip is adjusted. It is usually better to have the tip glide down the *end* of the lands – with the tip just *barely* touching the *very end of the toes* of the leads.

Placing the soldering iron tip further up *across* the feet of the leads will usually result in solder bridges.

Cross Contamination

Cross contamination occurs when different solder alloys are *mixed* – specifically tin-lead and lead free solders. Cross contamination can create *unreliable* solder connections. There have been studies that show that certain lead free and tin-lead *mixed* solder joints can develop cracks and other types of physical instabilities. There is also evidence that cross contamination can even become a *reliability issue* when *different lead free* alloys are mixed.

But the biggest problem with mixing tin-lead and lead free solders is that it will make our electronic assemblies and electronic products non-compliant with European Union standards. Companies that are found non-compliant will not have their products accepted. As you can imagine, this situation would be financially crippling.

During rework and repair, it can be difficult to control cross contamination. That’s because we’ll need to know which lead free alloy was used during the soldering operation.

When it is necessary to process both tin lead and lead free products, many companies have opted to set up separate, segregated areas for each type of solder. This can be very effective, but it may not be the best utilization of resources. Some smaller facilities may lack the money or space to create duplicate areas. This can be very effective, but it may not be the best utilization of resources. Some smaller facilities may lack the money or space to create duplicate areas.

Of course, solder pots and wave solder machines *must* be separate – as well as screen or stencil print machines.

For hand soldering operations it *may be possible* – with the right controls in place – to use the *same* soldering iron and tip to perform both tin lead and lead free soldering – *without* cross contamination. This secret is called "*rinsing*". To use a soldering iron for lead free that was previously used for tin- lead, we will have to *rinse the tip* to remove all of the lead from the tip.

The concept is similar to using hot water to "rinse" soap from a car after a car wash. The soap does not form a molecular bond with the surface of the car and the water is very good at dissolving the soap. This allows the water to "rinse" the soap off the car.

Similarly, *tip rinsing* can be accomplished by flooding the tip with lead free solder – and then *wiping* the tip. It should be noted that during the rinsing operation, a *separate* sponge should be used… *not* the same sponge that will be used for lead free soldering.

This rinsing step should be completed *at least* three times. Each time that the high tin content of the lead free solder wets the tip – it will remove *some* of the residual lead from the previous tin lead process.

Once the tip has been rinsed several times, the solder on the tip will only contain *trace* amounts of lead – comparable to the lead content of the lead free solder. Remember that regardless of what system and controls you have in place, they are only as good as the people performing the operations.

Summary

This program has provided a number of *secrets* for obtaining better results during the lead free hand soldering process. We've examined soldering iron tip life, effective heat transfer, better wetting, improved drag soldering techniques and how to avoid cross contamination.

It's important to realize that your abilities and determination make the difference in a successful lead free hand soldering program. You'll find that lead free hand soldering is not that difficult – once you know the secrets!