DVD-13C
Ray's Rework Secrets

Below is a copy of the narration for DVD-13C. 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

Do you ever wonder why rework can seem so difficult – and frustrating – and tedious. Do you ever think, "there must be a better way." Well, our good friend Ray has some interesting secrets to pass on that will make reworking through-hole and surface mount solder joints a whole lot easier.

Probably the most important secret for solder rework technicians is to avoid reworking solder joints unless it is absolutely necessary. That's because there can be potential damage to the component, the circuit board – and any *adjacent* solder joints. Every time the assembly is subjected to heat, its physical properties can be degraded. The adhesion between the resin in the laminate and the copper lands on the surface of the board can be weakened by heat.

Excessive heat and unnecessary force – caused by pushing with a soldering iron – or by attempting to remove a component before the solder is completely melted – can cause the land to separate and *lift* off from the board. A lifted land can be very difficult to fix. Your customers may not even accept this type of rework – which means the entire assembly may be scrapped.

Of course, we will need to fix the obvious problems that keep the product from functioning, but we definitely want to avoid any cosmetic or unnecessary touch up operations that can create more serious problems than they cover up.

At this point, let's review the typical tools and materials used during rework. We'll begin with the hand soldering iron. There are a variety of *temperature-controlled* soldering irons – maybe even within your own company. Perhaps the most important thing to remember is to always keep the temperature at a safe, controllable level during any type of rework operation. 315 degrees C is a reasonable starting temperature for most hand soldering operations.

Cleaning and tinning the tip of your soldering iron is equally important – for proper heat transfer and tip life. Always remember to wipe the tip on a *clean* damp sponge or brass sponge – and then apply a light coating of solder – before you begin any rework operations.

Now let's talk about soldering *flux*. Flux is an essential ingredient in the soldering process. Its purpose is to *remove oxidation* – which can prevent proper wetting or bonding of the solder. It can also be helpful in transferring heat between the tip of the iron and the component lead and land.

The next rework material is *Solder Braid*. Solder braid comes in different sizes or widths... for various solder removal operations. The braid is made up of copper strands – which can be unfluxed, or with a powdered or *dried* flux inside. When the braid is heated by the soldering iron tip, the molten solder will be drawn up into these copper strands. Once again, your company will supply you with a solder braid that's compatible with your soldering and cleaning processes.

Another tool that serves the same function is the *Vacuum Extractor*. This tool has a heated tip - with a hollow orifice or *hole* in the center. Attached to the back of the tool is a *flexible hose* - which vacuums the liquid solder into the storage chamber - inside the tool.

For surface mount rework, the more sophisticated removal tools include thermal tweezers, hot air pencils, pulse heat tools and complex rework stations.

This video will examine some alternative methods that make through-hole and surface mount rework even safer and easier. Ray's secret topics include destructive removal of axial or radial components; removal of DIP components with thermal tweezers; using a solder fountain to remove multi-pin connectors; using a low technology rework station to safely remove surface mount components; and tips for reworking ultra small surface mount components.

During these topics, we'll show the correct way of performing the more difficult "normal" method of component removal. Then we'll explain all the bad things that can happen during the conventional process. Finally, we'll show how fast and simple Ray's technique is.

Removal of Axial Components

The biggest risk when performing through-hole rework is damage to the *barrel* of the plated through hole – or damage to the *laminate*. The IPC 7711 – *process goals and guidelines* -- specifies that rework operations should be a *non-destructive* procedure – meaning that the component should not be damaged during the removal process. That's because there are many times when a replacement part is *extremely* expensive or can't be obtained. In these situations, the original part needs to be used again.

However, when replacing something like an axial leaded through-hole resistor, there are usually new replacement parts readily available that virtually cost pennies. The replacement of these components does not justify the additional time and risk to the circuit board assembly that occur when using the 7711 process.

Ray's secret is that destructive removal is bad for the component being removed, but much safer for the circuit board assembly – and faster than non-destructive removal.

Let's begin by examining the proper method of doing non-destructive removal of an axial component with fully clinched leads. There are several techniques for de-soldering clinched leads. We'll need to bend the lead *upright* before we can de-solder the entire joint properly. On *fully* clinched leads, you *may* have a problem getting the tip of the de-soldering tool underneath or around the lead – without damaging the land or the board. There are three alternate techniques for de-soldering fully clinched leads.

The first method uses a *thermal parting tool* - with a flat end tip. The tip of the parting tool can be used to melt the solder and then bend the lead upwards. It's a good idea to *un-clinch* the other lead at the same time - so you aren't constantly shifting tools back and forth.

Now, we're ready to use the vacuum extractor to de-solder the component. When you apply heat onto the first connection, the solder should melt rather quickly. At that point you'll feel the tip *drop down* onto the land. Now move the lead around in a circle - without applying pressure onto the land. As the solder melts, the lead will move more freely.

Upon complete solder melt, press the vacuum switch to draw the molten solder up into the handpiece. After the solder is removed, continue to move the lead around in a circle - with the vacuum still on. The *fast moving air* will now *cool* the metals inside the hole. This will also make sure that the liquid solder is drawn all the way into the vacuum chamber - rather than stopping inside the tip. After one or two seconds, you can remove the tip - then stop the vacuum.

You can also use a *chisel tip* on a *hand soldering iron* to perform the un-clinching process. We begin by selecting a small double-sided *chisel tip*. Then we position the tip at the end of the lead. Once the solder melts, push the lead straight up.

The third technique uses the vacuum extractor and a *pliers* to straighten a fully clinched lead. We begin this process by placing the tip of the vacuum de-soldering tool against the junction of the lead and the land. When the solder melts, activate the vacuum. At the moment, we're only trying to remove the solder that connects the clinched lead to the land. There may be a slight solder-bridge remaining between the land and the lead after this de-soldering process. If this bridge is relatively small, we'll take a flat-nosed pliers and gently twist the lead to one side. You should be able to feel when the lead is completely free from the land. Then bend the lead *upright* in preparation for the vacuum de-soldering operation.

Now we're ready to de-solder the remaining lead. Let's do it in real time – to demonstrate the proper sequence and timing of the operation. First, we apply heat... feel the tip drop down... move the lead around... activate the vacuum... remove the tip, and stop the vacuum. The component should now be ready to remove. It should offer no resistance at all. As you can see, non-destructive axial component removal is a fairly complex process, even when everything works perfectly.

Now, let's look at some of the problems that can happen during this process. Regardless of the technique you use to un-clinch the lead, you can easily tear the land away from the board. This is not a desired result. Improper use of the vacuum extractor to de-solder the lead can also cause problems. For example, staying on the connection too long to remove the solder can create measles, burns and delamination.

In addition, during the solder removal process, some residual solder may remain in the barrel and the lead can reattach to the side of the hole. This is called *a sweat joint*. If you try to pull the sweated lead out of the hole, some of the metal can be ripped right off the barrel wall. A damaged barrel can be difficult to repair and the entire assembly may need to be scrapped. As you can see, it takes a highly skilled solder technician to remove an axial component using these non-destructive methods.

Now, let's see why Ray's technique of destructive removal is safer and takes less time. The first thing we do is to simply cut the leads of this axial resistor. Next, we turn the board to the solder side and use a soldering iron to heat the connection area. Then we remove the remainder of the lead with tweezers. Let's watch that technique one more time on the second lead.

The last step is to use solder braid and a soldering iron to wick any remaining solder from the holes. And that's all there is to it. The resistor can now be replaced. The vacuum extractor can also be used to remove any remaining solder from the holes. As you can see, this secret deserves to be shared.

Removal of Multi-Leaded Components

Now let's check out the way Ray prefers to remove multi-lead devices – such as dual in line packages, or DIPs. The secret is that there are other non-destructive removal methods that are much safer for the substrate and much faster than conventional non-destructive removal.

We'll begin by reviewing the conventional DIP removal technique – using a vacuum extractor. Remember, DIP components have two rows of *flat* leads. For *flat* leads, the vacuum tip needs to be *sized* so that the *width* of the component lead will fit *inside* the de-soldering tip. The tip should not hang over the *edge* of the land - whenever possible. We can perform an *optional flux application* onto the component leads - on the *solder* side of the board.

We're ready to start at one of the corners. You'll often find that *two* of the corner leads will be partially clinched - to hold the DIP in place prior to soldering. Typically these partial clinches can be de-soldered with the vacuum extractor. Starting on the clinched corner lead, we'll angle the vacuum tip parallel to the lead, and then push the lead inside the tip as the solder melts. When the solder joint is molten, we can bend the lead upright and position the tip squarely onto the land.

After the entire joint is melted, we'll move *these* leads *back and forth* - rather than *around in a circle*. Then activate the vacuum - and continue drawing air through the hole - to cool any residual solder. After we remove the tip, continue the vacuum in order to draw the solder all the way into the storage chamber.

In order to avoid potential heat damage to the board - we'll need to skip around - rather than de-solder in a continuous line. Some people prefer to de-solder the corners first. Then they proceed to alternate back and forth in this same pattern. Others simply skip every other joint and work their way around twice until the job is completed.

Either way, keep repeating the operation until all of the joints are de-soldered. Hopefully the component should come out of the board without any difficulty. Remember *never* to pull it with any force. As you can see, this process can take a while – and the same damage can happen similar to axial components – except there are a lot more opportunities for things to go wrong. That's because this DIP component has 14 leads, whereas an axial component has only two.

When un-clinching the leads, you can inadvertently tear the land away from the board, or gouge the board. Staying on the connection too long can result in measles, burns and delamination. And there can be the dreaded sweat joints. If you try to remove the component with force, you can damage the hole wall.

So when the component doesn't come out easily – you'll need to figure out which leads have sweat joints. You can do this by gently moving each lead - until you find the one that doesn't move back and forth. Then we'll add solder to that particular joint – in order to transfer heat all the way through the hole. Always give the joint a few seconds to cool off after you add solder – to avoid overheating the hole. Now you can de-solder the hole once again - and the DIP should be ready to come out. You can see how time consuming this process can be, along with the possibility of causing damage to the circuit board assembly.

Now, we'll examine Ray's secret. In the same manner as the process we've just seen, the first step is to straighten the clinched corner leads. Again, this needs to be done carefully.

Next, we add solder to the leads. Then we use these thermal tweezers to heat the solder and remove the component. Pretty simple, isn't it? Now we complete the process by cleaning the holes with the vacuum extractor.

At this point you're probably wondering why we didn't just cut the DIP leads the way we do for axial components. Let's try it and see what happens. It's not so easy, is it? And there's a good possibility you'll destroy some lands in the process.

Removal of Through-Hole Connectors

Through-hole connectors are similar to DIPs in that they are multi-lead devices, often having as many as several hundred leads. Many of these connectors are not configured to allow the use of Ray's heat and tweeze method that you observed for DIP components. For large connectors we can use the solder fountain. It has the same advantages as the previous secrets – but on a much larger scale.

The conventional method of removing these components is the same as we saw for DIPs. It can really take a long time to remove one of these high pin count connectors. And there are even more opportunities for things to go wrong.

Now, let's examine Ray's technique of using the solder fountain. Once the fountain is running, all you have to do is heat up the connection area until the solder melts, then remove the connector with a set of pliers. It's really that simple. Then we finish the job by clearing the holes with a vacuum extractor.

The solder fountain technique does have some risk. There can be *copper dissolution* caused by the flowing solder bath. Copper dissolution is caused when the tin in the solder dissolves the copper on the land areas. This means that the longer the area is left in contact with the flowing solder, the more copper will be dissolved into the solder bath – causing the copper on the lands to become thinner, or to disappear completely. Lead-free solders, with their high tin percentages, are even more aggressive when it comes to copper dissolution.

Obviously, *minimizing* the exposure time to the flowing solder will reduce the copper dissolution. This can be accomplished by *preheating*. Preheating can be done as a separate step – or as an integral part of the solder fountain component removal process. In this manner, the flowing solder is being used to remove the part and not to heat the assembly. When preheating *tin-lead* assemblies, a topside temperature of 100 degrees C is recommended. When preheating *lead free* assemblies, the recommended topside preheat temperature is 150 degrees C. It should be noted that it is much easier to control copper dissolution through the use of preheating than it is to control a technician trying to manually desolder 100 or more individual solder connections.

Removal of Surface Mount Components

The biggest risk when doing surface mount rework is lifting a land. In many cases, surface mount rework results not only in land lifting, but in complete removal of the land from the board. The reason that this type of damage occurs more frequently on surface mount versus through-hole rework is that surface mount lands are typically much smaller. This means they have a much smaller area of contact for each lead – compared to a through-hole land. The failure occurs when the application of heat causes the material that bonds the copper to the board to become *soft*, or *over cured*, and loses its adhesive strength. That condition, coupled with the pressure and slight movement of the soldering iron tip can cause the land to break free of the substrate.

We'll start by examining the removal of *low thermal mass* surface mount devices – such as a multi-lead QFP. The traditional method for removing these components is to use a special tip that heats up all the leads at once. This method works great if the technician is very skilled, but can result in lifted lands if performed by less skilled rework technicians. Ray's secret is to use *convective*, or hot air removal techniques – which are much safer when performed correctly.

Let's begin by reviewing the typical technique for removing a QFP – using the Thermal Tweezers. We always begin by making sure that the tips match the size of the component. Remember that we want the tips to rest on the feet of all four sides of the leads. After the proper tips are selected, we install them in the hand piece. Squeeze the tips together to insure alignment, then tighten the set screws. The larger tips will require a special alignment tool.

For the larger QFP's, we may want to use a thermal enhancement technique - other than flux - to further speed up the removal process. The solder wrap - or solder preform process is designed to help improve the heat transfer. We begin by tacking one end of a solder wire to one of the corner leads. Then we wrap the solder tightly around the component - right at the heel of the leads. You'll have to experiment with the size of the solder wire to find out what works best for each component. After you've selected the correct sized tip - and cleaned and tinned it properly - you may also want to add external flux - all the way around the component. This will help improve the heat transfer.

Now you're ready to position the tips on top of the solder prefill. Gently tweeze the component with the tips. Then after you see that all of the connections have melted, lift the tool straight up. Then place the component onto a heat resistant surface.

Next, let’s examine the problems that can happen when a less skilled technician uses this technique. As you can see, applying too much pressure – and rocking the tip around to melt the solder –can result in lifted lands or bent leads.

Now, we’ll take a look at what Ray recommends. A *rework station* is the safest convective, or hot air removal method. Some rework stations are very sophisticated – removing and installing components using “full blown” thermal profiles and automated vision systems. Medium technology stations also provide for safe component removal and are much more common in facilities. A much lower tech process is using a hot air gun. However, it does require a rework technician who is able to stay alert and avoid distractions.

When it comes to high thermal mass surface mount components, Ray also recommends convective removal methods. That’s because it’s difficult to apply enough heat to the connection area without increasing the tip temperature and taking the risk of burning the board.

The only way to properly use conventional techniques is to *preheat* the assembly – especially when reworking lead free assemblies due to the higher solder melt temperatures. Here’s what happens when you *don’t* preheat the assembly. Now, let’s watch how fast and simple Ray’s method is.

Our final topic for surface mount rework involves ultra small surface mount devices. The difference in reworking these ultra small SMT devices – is that they are a lot smaller! This means we'll need greater magnification to see the soldering operation clearly, and we'll need tools that are appropriate for the size of the devices being soldered.

You can see that removing or replacing a multi-lead fine pitch QFP is the same if we use proper magnification and very small soldering iron tips. When removing or replacing chip style components, the old *tweezer tips* are too large. With magnification and soldering iron tips with very fine points, it is not that difficult.

Summary

This video has presented Ray's Rework Secrets. We've examined the removal of through-hole components such as axial resistors; DIPs; and multi-pin connectors – and surface mount components using convective methods. We also explained what's required to rework ultra small components.

Effective rework requires educated decisions. There are many different factors to consider for each different situation. If you have any questions about whether to rework, or which rework technique to employ, don't hesitate to ask your supervisor. Asking shows that you really *care* about what you do. And Ray's secrets should make your job safer and easier.