DVD-41C
Through-Hole Rework

Below is a copy of the narration for DVD-41C. 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

The reliability of electronic products is becoming more important every day. International competition demands quality and reliability at the lowest possible cost. At the same time, there are significant changes within the electronics *assembly* industry - to *reduce* solder joint touch-up and rework. We normally think of touch-up and rework as *adding* to the overall quality of an assembly... since we're fixing or improving solder joints that are less than perfect. But that's where these changes come in.

The IPC/ J-STD-001 and the IPC-A-610 are *industry specifications* that many companies in the electronics industry use for *acceptance standards.* In the past, these specifications defined acceptance criteria using the terms: "preferred, acceptable, and rejectable". But the unspoken emphasis was always to obtain the *preferred* condition. Even when a solder joint was considered *minimally acceptable* it was often *reworked* to achieve the *"preferred"* status. In some cases this may have happened because people took the term "*preferred*" too literally... because they really wanted their products to be the best they could possibly be.

In the current revisions of these industry standards, these terms have been changed to: "Target - Acceptable - and Defect". The obvious differences are the changes from "Preferred" to "Target;" and from "Nonconforming" to "Defect." But there has also been an important change in the definition for *acceptable conditions.* The term "*acceptable*" is now being defined to mean *two* specific things.

First, if a solder joint meets the minimum acceptable conditions, it should be left alone. And second... if a solder joint meets the *minimum* acceptance criteria - but exhibits certain *cosmetic* imperfections that are *not detrimental* to the reliability of the solder joint... these types of conditions now fall into a category called "*Process Indicators*". The idea here is that the *process* that created these imperfections may need to be changed - rather than the cosmetic imperfection. This makes a lot of sense... since when you fix the *process,* the incidence of imperfections will be reduced or eliminated. These cosmetic imperfections include certain types of voids, pinholes, and other surface irregularities that are not considered to be harmful to the reliability of the solder connections.

This reduction of unnecessary rework has several advantages... first, it saves time... but it can also have a beneficial effect on the overall *reliability* of the assembly. To understand how this works, we'll need to look inside a plated-through hole - to understand what happens to the structure of the materials whenever heat is applied.

Let's begin by reviewing how the plated-through holes were originally created. After the holes are drilled in the circuit board, the walls of the holes are plated with copper to create an electrical connection between both sides of the board - and any internal layers of circuitry that may exist. The copper is often overplated with tin or tin lead during the electroplating operation.

Eventually the component leads will be inserted into these plated-through holes - and soldered - either by hand - in a *wave* soldering machine - or in a solder *reflow* process. The heat of the soldering operation is pretty intense... in fact, it's hot enough to cause the laminate material to *expand* in thickness.

Every material reacts to heat differently... and will also *expand* at different rates. There's actually a *numerical index* that exists called the *Coefficient of Thermal Expansion* - which measures how much a specific material will expand when it's heated. Notice the difference between these numbers for a typical epoxy laminate material and the copper plating on the walls of a plated through-hole.

What this means is that epoxy *laminate* will expand much faster than the copper - during solder rework. When the laminate grows - the copper can actually crack - if it's not soft or *ductile* enough to absorb this expansion. Most rework operations will require *two* heating cycles - one to remove and another to replace the solder. That's two extra chances to create internal cracks in the plated through-holes.

On multilayer boards that have internal connections to the innerlayer circuitry, even a *small* crack can cause an electrical open or intermittent failure. This type of internal damage will not even be *visible* to the rework technician. Also keep in mind that the laminate will also expand and shrink - to a lesser degree - whenever an electronic product is turned on and off. This can aggravate a small crack that might not show up during electrical test - into an eventual failure out in the field. And that translates - in any language - into unhappy customers.

There's another reason why we don't want to rework unless it's absolutely necessary. Every time heat is applied to the connection, it will increase the growth or *thickness* of the intermetallic layer. The intermetallic layer is a thin copper-tin compound that is created when the solder bonds to the copper land and the component lead or termination.

While the intermetallic layer is the critical and necessary part of the connection forming the bond – excessive intermetallic thickness will cause solder joint strength to be reduced. This is because the intermetallic portion of the solder joint is more *brittle* than the rest of the joint. Therefore, the *thicker* the intermetallic becomes, the more prone it is to a physical failure - such as cracking. This defect is also invisible to the eye. You won't even know the solder joint is degraded until it's too late – meaning a failure occurs.

The point of all this is to explain why it's very important to avoid *unnecessary* rework. The attempt to obtain *cosmetic perfection* in the past may have actually *decreased* the quality and reliability of some interconnections. The acceptance of a solder connection should *always* be based on the requirements of your company's workmanship standards -- and *not* on any individual's *personal expectations*. If you would like a detailed explanation of the acceptance criteria for through-hole solder joints, including process indicators, you can review the IPC DVD on *Through-Hole Solder Joint Evaluation.*

Another change in our industry has been the transition to *lead free* soldering processes. Section 8 will describe how lead free solder alloys can affect the through-hole rework process. The remainder of this program will concentrate on the tools and rework techniques for the most *common* defects found on through-hole assemblies.

Rework Tools and Materials

Let's examine the typical tools and materials used during through-hole 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 Celsius (or 600 degrees Fahrenheit) 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 - 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.

You'll find that any solder joint will melt faster if there is a coating of flux to help transfer the heat. You could think of it like a frying pan... if you were to quickly touch your fingers to a hot frying pan, you might feel the sensation of heat. But if that pan had a coating of hot oil on it, you would probably burn your fingers... don't try this heat transfer experiment at home, please.

The importance of efficient heat transfer is worth a little more discussion at this point... If you think of *time plus temperature* as the total amount of applied heat... then when you reduce either one of these variables, you have applied less *total heat*. And remember that the less heat you apply, the less likely you are to damage the circuit board. Of course there are many other factors that can affect the rate of heat transfer which always need to be considered.

There are also many different types of fluxes available. Some are very strong or *active*... and some are relatively weak - or *mildly activated*. Strong or *highly active* fluxes can be severely corrosive to metal unless they are removed after the soldering process. This cleaning process may require certain chemicals or solvents that create problems in our environment.

Some companies are changing to *less active fluxes* that may not require cleaning after the soldering process. These are sometimes referred to as *Low Residue or No-Clean fluxes*. Your soldering process may require slight modifications in order for these low residue fluxes to work properly.

If you would like more information on Hand Soldering with Low Residue fluxes, you may want to review the IPC training DVD on this subject. In any case, your company will decide which type of flux you'll be using. It should always be compatible with the flux used during the wave soldering operation.

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 - 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.

The final tool we'll be using 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.

There are also various tip sizes and shapes for different solder removal operations. We'll be discussing proper tip selection as we review specific rework procedures. Both the tips and the storage chamber will require periodic maintenance - as defined by the tool manufacturer or your company's *standard operating procedures*. It's important to perform this preventive maintenance in order to consistently obtain the best results. You'll need to empty the solder from the storage chamber *before* the tool becomes clogged. And be sure to always deposit the solder in the proper receptacle.

Vacuum Extraction – Straight-Through Leads

In this section we'll be discussing the *vacuum extraction process* for removing *round-leaded components*. Let's start with the *unclinched* or *straight-through leads*. *Axial leaded* components have *round* leads - extending out from *either side* of the component body.   They come in various sizes and shapes. *Radial-leaded* components have round leads extending *from the bottom* of the component. They also come in various sizes and types.

Now let's talk about tip selection for de-soldering *round leaded* components... On the *solder side* of the board, you should be able to see the outline or shape of the component lead *inside* the solder fillet. The width of the vacuum tip should be approximately the same as the land.   And the hole in the center of the tip should be slightly larger than the diameter of the component lead. This will allow the molten solder to flow past the lead into the solder storage chamber.

Now insert the selected tip into the tool, and tighten the setscrew. A general starting point is 315 degrees C - or 600 degrees F. This should be sufficient for most vacuum extraction operations. It's also cool enough that it won't burn the surface of the board - if you happen to touch it by accident.

We do have the option to apply a small amount of flux onto the joints to be de-soldered. There are a variety of different ways to apply flux. Some companies prefer *not* to use flux, to avoid cleaning the assembly after the rework operation. Always make sure to follow your company's recommended procedures for flux application and cleaning.

Now we're ready to position the board for the de-soldering operation. You can clamp the assembly in an *upright or vertical position* - in order to view both sides of the board at the same time... although most people prefer to work with the board secured in a flat or horizontal position. Now we should be ready to begin the vacuum de-soldering operation.

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.

The component lead will probably lean back against the edge of the hole wall. There may be a few small *beads* of residual solder inside the hole... If we didn't cool this residual solder with fast moving air, the lead could now reattach itself to the side of the hole. This is called a *sweat joint.* If you try to pull a *sweated lead* out of the hole, this could potentially rip some of the metal right off the *hole wall*. And a damaged hole wall can be difficult to repair.

Now we're ready to de-solder the remaining leads. 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.

If the component *doesn't* come out of the holes without resistance, you'll need to determine which lead is still attached to the hole wall. You can do this by attempting to move each lead with a *holding tool*. If one or both of the leads are stuck, you won't be able to move it freely.

In this case, we'll need to add fresh solder to the hole. It's always a good idea to allow the area to cool between each heat application. This can help prevent damage to the laminate surface, lifted lands, and cracks in the plated-through holes. After the solder cools, repeat the de-soldering operation until we obtain a sweat-free joint. Let's stop here to make sure that you understand the basic operation of the vacuum extractor - for the round-leaded component removal process.

Vacuum Extraction – Clinched Leads

Now let's discuss the removal of *clinched leads* - using the vacuum extractor. Some component leads are *bent over* - or *clinched* - during the automatic insertion process. This is done to hold the component in place prior to wave soldering. There are various degrees of clinching... ranging from *partially clinched* to *fully clinched*.

You can easily spot a clinched lead... since the outline of the lead should always be visible underneath the solder. There are several techniques for de-soldering clinched leads... let's begin with the *partially* clinched lead. We'll need to bend the lead *upright* before we can de-solder the entire joint properly. The vacuum extractor tip can be used -- whenever the lead is not clinched completely flat against the land.

Once again, you may want to start by applying flux - to help speed up the heat transfer process. Tip selection will be the same as before... We'll place the vacuum tip parallel to the clinched lead - right at the end of the lead. As the solder melts, slide the tip forward until the clinched portion of the lead is completely inside the tip.

Now you should be able to bend the lead upright. The component lead and the molten solder should transfer heat all the way through the hole. Move the lead around in a circular motion - then activate the vacuum. After you remove the tool - continue the vacuum for a few additional seconds. The entire operation should then be repeated on the second lead. This method will work for most partially clinched leads.

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. After the lead is straightened, the vacuum de-soldering tool will de-solder the connection. Let's look at this lead straightening process in more detail...

The heat setting for the thermal parting tool should be specified by the manufacturer - or your company's standard operating procedures. We always start by setting the correct temperature on the power supply. Then we position the tip against the *end* of the clinched lead. Next we activate the heat, typically with a foot pedal. The heat should ramp up within a few seconds - and begin to melt the solder. When the solder melts, slide the tip underneath the clinched lead and start to lift. At this point you should be able to bend the lead straight up.

It's a good idea to *unclinch* the other lead at the same time - so you aren't constantly shifting tools back and forth. After the second lead is straightened... Place the thermal parting tool back in the tool holder. The solder shouldn't stick to the tip, so there's no need to clean it.

You can also use a *chisel tip* on a *hand soldering iron* to perform this same un-clinching process. We begin by selecting a small double-sided *chisel tip*. Again we have the option of adding flux... Then we position the tip at the end of the lead. Once the solder melts, push the lead straight up. You need to be careful not to wedge the tip down *into the board* during this process. This can gouge the board or lift the land - along with the lead. After we've properly un-clinched the second lead, we're ready to de-solder both of the joints with the vacuum extractor - just like we did before.

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.

At this point, you'll need to decide if there's enough solder remaining inside the hole to transfer the heat properly. If the remaining solder fills the hole up to the top of the barrel, you can usually de-solder the connection as is. But if some of the solder in the barrel was removed during the un-clinching process... it may be necessary to add additional solder to the joint. This extra solder will help insure proper heat transfer during the vacuum de-soldering operation.

After the connection has cooled, we apply the heat... feel the tip drop... move the lead around... activate the vacuum... remove the tool... and stop the vacuum. That should cover the vacuum de-soldering process for *partial* and *fully clinched* - *round* leaded components. Let's take another break to make sure you understand these processes - before we discuss *flat-leaded* component removal.

Vacuum Extraction – Flat Leads (DIPs)

In this section, we're going to be removing *dual in-line packages* with the vacuum extractor. Notice that these DIP components have two rows of *flat leads.* Each of the leads will have either a tapered or flat *shoulder*. This is designed to hold the component away from the surface of the board - for cleaning purposes.

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. And like before, 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. Again, positioning of the board will be based on your personal preference.

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. If it 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. That covers the removal process for DIP's and other flat-leaded components - like D-Paks or power transistors.

Auxiliary Heat Techniques

In this section, we're going to be discussing some of the *auxiliary heat techniques* you might need to de-solder components on large *thermal mass* or multilayer boards... Whenever you find that you're having trouble melting the solder all the way through to the other side of the hole... you might find it advantageous to use an *auxiliary heat source* on the *opposite side* of the board.

There are several options - depending on the tools you have available. One method is to apply a *resistance tweezers* on the *component side* of the board. Be sure to use the recommended heat setting specified by the tool manufacturer. After you activate the auxiliary heat on the *component side*... wait a few seconds... then apply heat to the *solder side* - with the vacuum extractor. After the solder has melted all the way through the hole… apply the vacuum.

You can also use a standard *hand soldering iron* as an auxiliary heat source. This takes a little more *dexterity* - since you'll need to be able to work with both hands at the same time. The addition of external flux onto both sides of the board can also help in the de-soldering process. Again, this is *optional* - depending on your company policy.

We begin by preparing the *tip* of the soldering iron. Remember that a cleaned and properly tinned tip will transfer heat *much* faster than an *oxidized* tip. Position the soldering iron tip on the *component* side of the board - against the lead and the land. Now place the vacuum tip on the *solder* side - and wait until you feel it drop down onto the land. Then start to move the lead around –- and activate the vacuum. Withdraw the soldering iron – and continue the vacuum until any residual solder in the hole has *cooled down.*

Then remove the de-soldering tool, and continue the vacuum for a few additional seconds - to make sure that all of the solder reaches the storage chamber. Continue this same process until all of the leads have been de-soldered. Remember to *skip leads* on multi-leaded components - and to move flat leads *sideways*... Round leads are always moved in a *circle*.

These auxiliary heating techniques can be useful in a variety of situations. Just keep in mind that you *are* applying *a lot of heat*... so don't overdo it. It *is* possible to damage the board if you keep the heat applied for too long.

Another technique that can be helpful when you can't access the leads on the component side of the board - or during *multilayer* rework - is to *preheat* the assembly prior to the rework operation. This can be done in a *convection* oven - or on specially designed local area *preheaters*. It can take a few minutes to bring the temperature up to one hundred degrees C... but preheating does have some distinct benefits. First, it reduces the amount of *direct heat* required to melt the entire solder joint. This can reduce the chance of potential damage to the board. Preheating can be advantageous prior to many types of through-hole rework... but it does take time and specialized equipment. Your company policy on preheating will decide when to utilize a preheating process.

Rework of Solder Defects

Now we're going to show you how to fix *solder bridges* and *icicles* - as well as insufficient and excessive solder conditions. Remember that we *never* want to fix any solder joints that *meet* the minimum acceptance standards. Let's start with a condition that *always* needs to be corrected: solder bridges.

Some of the *smaller* solder bridges can be removed with the tip of a soldering iron. Chisel tips are usually preferred over conical tips... since they have more surface area to draw or wick the excess solder onto. We *will* need to use flux for this particular operation. If you've ever tried to reheat a solder joint without the aid of flux -- you'll understand why flux is required. The flux should be applied onto all of the affected joints - and over the solder bridge.

Next we'll select a *chisel tip* for the soldering iron. Now prepare the tip by wiping it on a damp sponge - to shock off any oxidation. Place the clean tip *on* the solder bridge - and reheat both joints completely. As you draw the tip away from the joint, the excess solder should flow toward the heat source.

If you don't reflow both of the joints *completely* - you take the chance of weakening the internal structure of the solder... It's kind of like melting wax onto a candle. The strength or *bond* of the freshly melted wax will never be as strong as the original candle. In this situation, you *will* need to go back and reflux the partially melted connection - then reflow the joint completely.

Another process for bridge removal uses *solder braid*... We begin by selecting the *braid width* for the particular bridge we need to remove. We'll be holding the braid across the solder bridge like this. The correct width of the solder braid is important. If the braid is too small… it can take several heat applications to remove the solder. If the braid is too wide… it may overhang the land and burn the surface of the board.

Now we install a *chisel tip* - and make sure the temperature is set to 315 degrees C. A chisel tip will usually transfer the heat much faster than a conical tip. The optional addition of external flux onto the solder braid - can improve the ability of the braid to wick the solder more thoroughly.

Place the solder braid over the first joint - then apply the heat. When the solder stops wicking up into the braid… remove the braid and the tip at the same time. Now we'll reposition a *clean* section of the braid over the second joint - and touch it with the tip. When you see the solder stop wicking into the braid… the operation is complete. We'll need to give these joints a few seconds to cool down... This time can also be used to *trim* the *used* portion of the solder braid.

Now we're ready to add some fresh solder to the joints that we just de-soldered... There should be enough flux in the core of the solder wire to reflow the entire joint properly. But we do have the *option* of adding flux if necessary. To re-solder the joint, place the tip of the iron against the intersection of the lead and the land. Then touch the tip of the solder wire to this junction to start the flow of solder. Now move the solder wire over to the *other side* of the joint - and remove it when you have formed a proper fillet. If you have any questions about proper soldering techniques, you can review the IPC DVD on *Hand Soldering Procedures.*

It's also possible to remove solder bridges with a *vacuum extractor...* We'll essentially be removing as much solder as possible from the joints that are *bridged* - then we'll replace it with fresh solder. Again, we have the option of adding flux.

On straight-through leads, always start *on top* of the lead - just like you were removing a component. Try to get as much solder out of the hole as possible. The excess solder from the bridge should also be attracted to the heat source. Repeat the same de-soldering operation on the next joint... and remember to give both connections a few seconds to cool down before re-soldering.

If the bridged leads are *clinched*, place the extractor tip in contact with the lead and the land until all the solder melts. Now vacuum away as much solder as possible from the first connection. Then move the vacuum tip over to the second land - at the junction of the land and the clinched lead - and repeat the de-soldering operation. It isn't necessary to straighten the clinched leads for this particular rework operation. That covers the removal of solder bridges - using all of the different techniques. You'll need to decide which technique to use for specific situations.

Now let's talk about solder *icicles.* In some cases, icicles *may* be acceptable - depending on their location, size, and the type of product being built. Remember that *whenever* possible, it's always best to *leave solder joints alone.* Having said that… there are some cases where icicles *will* need to be removed.

The easiest way is to use a hand soldering iron and a bit of flux. We always begin by preparing the soldering iron tip. Then we add a little bit of flux onto the joint. Now we apply the heat - and reflow the entire solder connection. As we pull the tip away from the joint, the excess solder should follow the heat source. The resulting solder joint should meet all of the workmanship standards for acceptability.

You can also use solder braid - or a vacuum extractor - to remove icicles... In both cases, we'll be trying to remove as much of the original solder from the joint as possible... Then we'll add fresh solder to create the proper fillet shape. Both of these operations will take longer than a hand soldering iron - and require *two* heating processes. For this reason it makes more sense to use a hand soldering iron - for icicle removal - whenever possible.

Now let's talk about reworking solder joints that have *excess solder*. After you have determined that the connection does *not* meet your company's workmanship standards, you'll need to decide how to remove the solder.

The simplest and fastest method is to add flux... Prepare the tip of your hand soldering iron... then reflow the entire joint *completely* - and remove the excess solder with the tip of the soldering iron. You can usually remove enough solder from the joint on the first try. Even if you have to perform this operation twice... it still takes the same amount of heat to remove the solder with solder braid - or a vacuum extractor - and then replace it with a hand soldering iron.

Another condition that may require rework is *insufficient solder.* After you have determined that the solder joint does *not* meet workmanship standards, the simplest fix is to heat up the entire joint with a hand soldering iron - then add enough solder to create a proper fillet. The flux inside the solder wire should be sufficient to reflow the existing solder all the way through the hole.

And finally, you may run across different kinds of *surface imperfections* that *may* have required rework in the past. As we discussed at the beginning of this program, these may now be classified as *Process Indicators.* We want to be very careful *not to* rework any solder joints that fall into this category.

Lead Free Rework

In this final section we're going to review what you'll need to be aware of - when touching up or reworking *lead free* solder joints. Again, touch up or rework of these connections should be performed *with discretion* to avoid causing additional problems. Engineering studies have indicated that lead free solder joints can be as reliable as tin-lead… and the criteria for rework is identical.

One important consideration for lead free rework is *cross contamination*. Cross contamination occurs when different solder alloys are *mixed*. Cross contamination *may* create unreliable solder connections. There have been studies that show that contaminated solder joints can develop cracks and other types of physical instabilities. 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.

It's harder to control cross contamination during rework and repair than it is during normal production. That's because we'll need to know which lead free alloy was used during the original soldering operation. You'd think this wouldn't be too difficult – if we're simply touching up solder joints that exhibit insufficient solder – since these connections were just soldered. But your company may be running leaded and lead free assemblies at the same time on different machines. Solder technicians need to know which assembly is which. That's why it's important to check the *traveler* before touching up any assembly.

It is *much* more difficult to track the type of solder used when assemblies are returned for repair from the *field*. It's also important to make sure that replacement *components* have lead free finishes. In an ideal world lead free components will be marked so that you'll know they're lead free.

For example… components may be marked with the lead free symbol; the words lead or PB free; or with the designation for the type of lead free finish on the component leads. It's important to follow your company's policy with regard to *mixing* any solder alloys. And make sure to use *tools* that are designated for *lead free only*.

The visual appearance of lead free solder connections may differ from tin-lead joints in two ways – they are typically grainier and duller, and they often have larger solder *contact angles*. These conditions are caused by the higher soldering temperatures required by the lead free alloys. As you probably know, tin-lead solder becomes liquid at 183 degrees C. The melting temperature for lead free alloys is often 40 degrees C higher than tin-lead.

The higher soldering temperature presents several *challenges* in the lead free soldering process. Lead free soldering presents several challenges. The components and the circuit boards need to be able to withstand the higher temperatures required to melt the solder. In addition, lead free alloys have greater *surface tension* -- which means that the melted solder won't spread over the connection as easily or as quickly as their tin lead counterparts. The slower spread of the solder can increase the dwell time -- or the time that the soldering iron is in contact with the connection -- compounding the heat problem.

Fluxes will need to prepare the surfaces *more aggressively* due to the reduced spreading of the lead free solder. The flux also needs to function properly at *higher soldering temperatures* – because there's more possibility of oxidation – and potentially longer soldering times at these higher temperatures. When we move to more *active* fluxes, they may require a more thorough cleaning process to remove the more aggressive – and possibly still active residues.

There are several types of cosmetic imperfections – such as *fillet lifting* and *tears* that are more likely to occur in a lead free process. It's important to understand that these types of conditions typically won't affect the strength of the mechanical and electrical connection of the solder joint.

At this point, let's watch as we touch up some of the same types of defective solder joints we fixed previously – using lead free solder.

Through-hole rework requires educated decisions... there are a number of factors to consider for each different situation. If you ever have a question - don't just reheat or replace the solder... *ask your supervisor.*   Asking shows that you *care* about what you do. Knowing *when* to rework is just as important as using the proper techniques - in order to do each job properly and safely.