
DVD-49C

The Seven Sins of Hand Soldering

Below is a copy of the narration for the DVD-49C videotape. 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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RAY (v.o.)

I woke up this morning with a shortness of breath and the shape of dread hovering above me. There's an evil that lurks among us. Some say it's just bad habits. But it jeopardizes our reputation and product quality. The perpetrators seem to be possessed. Yet they're not aware of the treacherous evil that's crept into their daily lives. My name's Ray. I call this evil "The Seven Deadly Sins of Hand Soldering."

NARRATOR

In the beginning we're taught the right way to solder. But when we solder every day, it's easy to start doing things without thinking - and pretty soon we develop some bad habits. And we don't even know we're doing anything wrong. Ray mentioned we have seven bad habits. There are probably others, but these are the most common. Let's take a look at the list. There's excessive pressure; improper solder heat bridge; wrong tip size; excessive temperature; improper use of flux; transfer soldering; and unnecessary touch up or rework. Any one of these sins can cause an entire electronic system to fail. This program will examine each of these bad habits - to explain why it's a problem; how it causes an undesirable result; and what needs to be changed so the habit can be broken.

RAY (v.o. - with reverb)

Sin number one - Excessive Pressure

NARRATOR

Many operators, when confronted by a difficult connection, feel the need to press down in order to transfer more heat to complete the connection. But pressing harder doesn't make the connection heat up any faster. In fact, it has nothing to do with how quickly the heat transfers from the soldering iron to the connection.

Excessive pressure causes some pretty nasty results - like lifted and deformed lands, or measles. These connections may initially pass an electrical test, but the weakness may lead to intermittent failures, or even an entire system failure. It's important to realize that excessive pressure is not

needed to make successful solder connections. The proper technique is a light, relaxed touch with good contact. That's what creates a good solder joint.

Let's observe the difference between a proper light, relaxed touch and excessive pressure - and the way each solder joint looks. Notice how excessive pressure has caused a dent under the solder and the outside edges of the land to lift up.

Operators often use excessive pressure because of reduced heat transfer from an oxidized tip. Tinning the tip of the soldering iron will reduce the formation of oxides, or contamination on the tip itself. Oxidation acts as a barrier or an insulator - which mean it slows down the transfer of heat.

Tinning the tip with solder enables the heat to transfer from the tip to the connection faster. Now let's take a look at the second heinous sin.

RAY (v.o.)

Sin number two - Improper Solder Heat Bridge.

NARRATOR

Here's what an improper solder heat bridge looks like. It's applying the soldering iron first to the connection, and then feeding the solder in. This action will burn off any flux that is present before the solder contacts the connection area. This may also cause the solder on the tip to become overheated and grainy. In other words, an improper solder heat bridge can cause poor heat transfer.

Improper heat transfer may result in incomplete solder flow, or overheated solder connections. Cold solder connections may also result from improper heat transfer and too short a dwell time. Excessive dwell time coupled with too much applied pressure will frequently lift the land. The formation of a proper solder heat bridge is essential for the rapid heating of the solder connection. The bridge increases the contact area which helps heat the connection faster. The proper heat bridge is accomplished by placing the flux cored solder adjacent to the lead and land - then bringing the soldering iron tip in contact with the solder to establish a bridge for efficient heat transfer. Once the heat bridge is established, the solder wire should be applied on the surfaces to be soldered - not on the soldering iron tip. This will ensure adequate solder coverage of the connection area.

RAY (v.o.)

Sin number three - Wrong Tip Size

NARRATOR

Having the wrong tip size on your soldering iron can cause problems. For example, if the tip is too small, there may be incomplete solder flow, or a cold solder joint. Too small a tip will also increase the dwell time, or the time the soldering iron is in contact with the connection. Increased dwell time is due to poor heat transfer which happens when you use a conical tip on a large surface area. Increased dwell time may lead to component, conductor or circuit board damage.

If the tip is too large, it can overhang the connection area and cause thermal damage to the circuit board substrate. That's why tip selection is a critical issue in the hand soldering process. The three variables for selecting a tip include contact area, thermal mass and tip length and shape.

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 you want is the maximum tip-to-land contact area to heat the connection quickly.

Think of the tip-to-land contact area as a plumbing pipe-to-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 faster.

The second variable for tip selection is thermal mass. Thermal mass relates to the size of the tip and the amount of heat it can hold. The thermal mass of the tip may be important for connections that dissipate heat quickly. In other words, the solder connection should be completed as quickly as possible, while allowing for adequate solder wetting.

For some soldering irons, a tip that does not have enough thermal mass will require the iron's heating element to work hard to keep up with the thermal draw of the connection. An iron with low output capability, or an oxidized tip can also reduce the heat transfer capability. These situations can result in incomplete solder flow, or solder that appears dull and grainy.

To overcome this problem, many operators will increase the temperature setting. However, this may result in damage to the circuit board material and/or a lifted land caused by high temperature for an extended period of time.

Our final variable for tip selection is tip length and shape. Proper tip length and shape can allow us easy access to the area to be soldered. Some connections on very densely populated circuit board assemblies may be hard to access with certain tips. Using the wrong tip on a densely populated assembly may result in damage to adjacent components on the assembly. Many operators get very comfortable soldering with one style of tip and become reluctant to try other tips. Maybe it's just laziness - like not wanting to take the time to switch. They figure it's okay because time is more important than quality. Remember, it's important to let the connection area dictate the type of tip you'll use. Let's stop for a moment and review the material we just covered

RAY (v.o.)

Sin number four - Excessive Temperature.

NARRATOR Many trained solder technicians believe that if they are not getting the connection area up to solder melt temperature quickly, then they must increase the soldering iron temperature to compensate. Increasing the tip temperature to overcome slow heating of the connection area can cause localized overheating of the connection area and result in lifted lands, overheated solder and board damage.

The truth is that a more efficient method of transferring heat must be employed. Proper tip selection is an example of this. Increasing the contact area allows the connection to heat more rapidly without increasing temperature.

Another possibility is to use auxiliary heating to preheat the area to be soldered. Preheating makes it easier to solder a connection that requires a lot of heat. Basically, you 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 solder to melt and wet all connection elements.

RAY (v.o)

Sin number 5 - Improper Use of Flux.

NARRATOR

Using excessive flux heads the list of flux problems. Adding more flux does not necessarily result in a better solder joint. Excessive flux is often used as a crutch for the real problem - which may be bad design, poor solderability, wrong flux type, or improper tool or technique.

Excessive quantities of flux used during soldering may introduce long term reliability problems such as corrosion and electromigration. Corrosion breaks down the metal. This is caused by the acid in the flux, or other by-products of the residue. Electromigration is the growth of metal dendrites in the presence of flux residues. These dendrites can grow from one circuit trace to another and cause short circuits.

Using too much flux can also create problems with the bed-of-nails fixture on in-circuit testers. Excessive hard flux residues can prevent probe contact. Unreacted flux residues may create short circuits. These flux residues may result in false readings and increase the need for more frequent cleaning of the probes.

It's important to realize the hand soldering process itself fosters excessive use of flux - since there's less control of the flux application. It's not unusual to see a large increase in the amount of flux residue when compared to modern, efficient flux applicators for wave soldering. As you can imagine, using too much flux will increase the burden on the post soldering cleaning process.

In addition, as more and more companies utilize a no-clean soldering process, the importance of controlling the flux application becomes critical. That's because no-clean fluxes tend to flow out further than fluxes designed for cleaning. When this happens, more of the flux will be too far away to be thoroughly heated by the soldering iron. These unreacted flux residues may be both corrosive and electrically conductive. It's important to match the soldering iron temperature to the flux manufacturer's recommendations.

The best way of reducing the use of excessive flux is to only use the flux contained in the solder wire. If additional flux is required, then it should be applied with either a flux pen or needle dispenser - adding no more flux that is absolutely necessary.

RAY (v.o.)

Sin number six - Transfer Soldering.

NARRATOR

Transfer soldering is a common bad habit for operators to slip into. It happens when you apply what you think is an appropriate amount of solder to the hot soldering iron tip, and then transport it to the connection. Transfer soldering consumes the flux on the tip and does not allow the flux to activate the surface to be soldered. It also causes the solder to be exposed to prolonged dwell times for the entire soldering operation.

Improper transfer soldering relates primarily to through-hole connections. Many companies use a technique on surface mount components called multi-lead soldering which is a reliable soldering method. Improper transfer soldering can result in incorrect heating of the connection and cause poor wetting onto the lead and land. Again, it's important to make a proper solder heat bridge whenever soldering a through-hole connection. Last, but not least, let's take a look at the seventh treacherous sin.

RAY (v.o.)

Sin number seven - Unnecessary Touch-Up and Rework.

NARRATOR

Unnecessary touch-up and rework may be the worst sin of all. The cosmetic appearance of the solder joint should not be used as the sole criteria to start a rework or repair operation. For example, ANSI-J-STD-001 and IPC-A-610 do not classify a connection as a defect unless there is a risk of failure. Never perform any rework operation that is not required by your company's documented process controls.

Every time heat is applied to the connection, it will increase the growth of the intermetallic layer. The intermetallic layer is a thin copper-tin compound created when the solder bonds to the copper conductor and the compound termination. While the intermetallic layer is the critical and necessary part of the connection forming the bond -- excessive intermetallics 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 invisible to the eye. You don't know the solder joint is degrading until it's too late - meaning a failure occurs.

This program has provided a refresher course in how to break bad soldering habits. The seven sins are the most common habits we get into. A properly applied soldering iron and solder heat bridge, along with a documented process, goes a long way to ensuring that you produce consistent, quality work.

Let's review the list one more time. We have excessive pressure, wrong tip size, excessive temperature, improper use of flux, improper solder heat bridge, transfer soldering and unnecessary touch up or rework. Lots of people depend on the quality of the work we perform. Even one bad solder connection can cause an entire electronic system to fail, either completely or occasionally.

RAY (v.o.)

You now have the information and techniques to defeat the seven dastardly sins of hand soldering. The good soldering habits you develop result in quality electrical connections.