DVD-48C

The Seven Sins of Surface Mount Assembly

Below is a copy of the narration for DVD-48C. 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

MANAGER (v.o.)

We've got problems in surface mount. Big, big problems. There's too much rework. In fact, we're having to rework almost everything.

SUPERVISOR

I don't understand it. Everyone's working harder and faster – our people are more productive. I'm trying to get a handle on the situation. I need help.

VOICE WITH HEAVY REVERB

Obviously, faster isn't better. Haven't you heard about the 7 deadly sins of surface mount assembly?

SUPERVISOR (V.O.)

What???

In the beginning we're taught the correct procedures and techniques used in surface mount production. But after a while we get comfortable with our jobs and start doing tasks automatically. That makes it easy to develop some bad habits. Let's begin by reviewing the basic surface mount assembly process – which consists of three steps: solder paste application, component placement and reflow soldering.

Solder paste application is commonly done using a stencil printing process. Solder paste is pressed through openings in a metal stencil onto the corresponding circuit board lands – with a squeegee. The squeegee may be made of hard rubber or stainless steel.

Once solder paste has been applied to the lands, the board is moved to one or more automatic pick and place machines for component placement.

After components are positioned, the surface mount assemblies are transferred to a reflow soldering machine. The heat from this machine comes from a combination of infrared panels and forced convection air. The equipment contains heating zones that first activate the flux in the solder paste to clean oxides from the lands, then cause the solder to reflow and wet properly.

As you can see, surface mount assembly is pretty much an automated process. We start relying on the machines, but these machines need people to monitor them – to make sure they are set up correctly and functioning properly – in order to manufacture reliable assemblies.

That brings us to the seven deadly sins – the most common problem areas of surface mount production. Let's take a look. We have old solder paste; unclean stencils; improper squeegee operation; misalignment; component issues; feeder issues; and improper temperature profile.

Problems in any one of these areas can ultimately cause an entire electronic system to fail. In this program we'll be examining each of these conditions – explaining the problem, how it causes an undesirable result and what needs to be changed to control the situation.

Sin number one – Old Solder Paste

Let's begin by reviewing some of the important features of solder paste. Solder paste consists of solder particles in flux – with additives that control the *viscosity* of the paste. Viscosity refers to the *resistance* to flow of the paste. If the additives dry up and evaporate, the performance of the paste changes and becomes unacceptable.

Sometimes, in the course of a busy day, we may forget to check what's going on with the solder paste in the stencil printer. Our minds may be elsewhere. The solder paste that is applied to the stencil may have dried out – and won't behave the same as fresh paste. The results of using old solder paste can be incomplete coverage; solder skips; missing deposits; and loss of tack – meaning the component won't stick to the paste after placement.

Solder paste ages and changes with temperature and the flow of air. Solder paste viscosity also changes based upon the amount of kneading and the speed of the squeegee. One way to prevent dry paste is to control temperature and humidity so that the solder paste has less exposure to dry air. For example, if the stencil printer is located below an air vent, the problem is compounded.

If solder paste has been sitting for ten minutes, it's a good practice to increase the amount of paste on the stencil and to knead the paste before starting a printing cycle. Then verify that the solder paste is rolling properly during printing. This is an example of a good paste roll – compared to what the roll looks like when the paste is dried out.

Sometimes operators get into the habit of scooping up paste at the end of their shift and returning it to the storage container to be reused. It's quite likely that this paste is degraded and will cause problems.

It's also important to change solder paste on a regular basis. That's because it's much cheaper to change paste frequently than to fix problems later. Ask you supervisor for your company's policy on dispensing and replacing solder paste.

Sin number 2 – Unclean Stencil

When you're trying to get product out as quickly as possible, there is the tendency to use a stencil again and again – ignoring the recommended cleaning schedule. What will occur when you use a stencil that needs cleaning is there will be incomplete or missing deposits. That's because the stencil apertures will become clogged with old paste over a period of time. Also, a dirty stencil tends to leave solder paste in unwanted areas on the circuit board. After the solder reflows, there may be solder shorts and solder balls.

A clean stencil is critical for a good solder paste deposit. Let's look at the different methods of cleaning. To manually clean the stencil, wipe it with a lint free cloth and an appropriate solvent. The solvent you'll need to use will be determined by the type of solder paste you are using.

For automatic printers, you can activate the stencil wiper that will wipe and vacuum the underside of the stencil. There are also dedicated washers that can clean a number of stencils at the same time. Dedicated washers can also be used to clean misprinted boards along with the stencils – assuming that process parameters will allow it.

Sin number 3 – Improper Squeegee Operation

By monitoring solder paste deposits, you'll be able to tell whether the squeegees are operating properly. When there is a problem, you'll notice apertures on the stencil that aren't getting filled – and there will be an inadequate quantity of paste on the land. or too much solder deposited causing bleed out on the contact side of the stencil and/or too much solder volume on lands.

The reasons for a squeegee not operating properly include a nick on the blade; a poor edge; the blade not being parallel, or level; and the speed and pressure not being properly set. To resolve the problem of a nick or poor edge, you'll need to replace a *stainless steel* squeegee. You may be able to sharpen a dull edge using the squeegee guides.

If the blade is made of *rubber*, you can flip it over to get a new edge. There are also squeegee sharpeners. If the squeegee is not parallel to the stencil, you'll need to make a level adjustment.

Squeegee pressure should be increased if there is an excessive volume of solder paste deposited. It's a good practice to vary the pressure adjustment in increments of ten percent of the current setting. If you need to change the speed, it should be done in increments of two tenths of an inch per second.

Sin number 4 – Misalignment

Occasionally the printer or a component placement machine can go out of alignment. Misalignment can create solder bridging or short circuits – especially on fine pitch components where proper positioning is extremely critical.

When the stencil printer is out of alignment, the stencil apertures won't be in exact relationship to the land patterns on the circuit board. This will cause improper solder paste deposits. When a placement machine is out of alignment, the solder joint geometry won't be optimized. This will create unreliable connections and solder shorts.

The causes of misalignment can include illegible *fiducials*, or optical registration points on the circuit board, the vision camera not operating properly, rails positioned incorrectly, placement nozzles out of alignment and worn belts on the equipment.

Misalignment is usually a machine issue and a maintenance technician will need to be called to fix the problem. What's really important is that you are able to catch these problems early so that there aren't a large number of misassembled boards – meaning lots of expensive rework or scrap. The sooner the problem can be detected and resolved, the sooner the surface mount line will be back in operation making functioning assemblies.

Sin number 5 – Component Issues

Component issues include incorrect polarity and orientation; loading the wrong component; and utilizing the incorrect *form factor* – such as a tube instead of a tray – to load the correct component. When components are loaded with incorrect *polarity*, or they are not *oriented* properly, the result is a non-functional assembly. The assembly will fail electrical test and expensive rework will be required.

Components that have a positive and negative connection are said to have polarity. The correct termination point – positive or negative – must be placed on the correct land. You'll need to verify the marking on the component that lets you know which side is positive and which side is negative. That way you can make sure the components are oriented correctly when placed in the feeders.

This principle is also true for components that must be placed on the assembly in a specific position based upon pin locations. Pin 1 is usually designated by a marking such as a dimple or a stripe. You'll need to verify correct orientation of these components before loading them onto the placement machine.

The next component issue occurs when the incorrect component is loaded. This will also cause the assembly to malfunction and fail electrical test. Sometimes it's not so easy to determine the correct component. That's because many chip components look identical and are too small to have a part number written on the component. To make matters worse, there may be only a slight variation in the part number displayed on the reel. That's why it's important to verify to part number *before* loading components onto the feeders.

Our last component issue involves the *form factor* of the component. Sometimes the same component is available on tape and reel, in tubes *and* in matrix trays. If the job calls for a component to be placed from matrix trays and you've loaded a tube containing the same component, the component simply won't get placed on the assembly.

The solution to the problem is to make sure you're loading the component from the correct form factor for the specific set-up you're running. Taking the time to verify proper polarity and orientation, correct components and the appropriate form factor in the beginning saves time and money in the end.

Sin number 6 – Feeder Issues

Feeder issues include loading feeders in the incorrect feeder locations and the feeder not feeding the components. Sometimes in your hurry to get the placement machines up and running, you might accidentally load a feeder into the wrong slot. For example, if components are loaded into a feeder location not being used by the placement program, they won't get assembled onto the circuit board. Or if components are loaded into the wrong feeder location, the wrong components will be placed.

The solution to loading feeders into incorrect locations is verification. It's helpful to work with a partner during the set up process. This will ensure that the correct components are being loaded into the correct feeder locations.

The other feeder issue involves components not being fed into the placement machine. A sensor typically causes the machine to stop. This can be due to the *feeder advance* not being set correctly. Feeder advance refers to how much a component is moved before it is available for pick-up. If the advance is set incorrectly, the component on the tape reel won't move far enough, or will move too far – and the component will not be picked up.

To set the feeder advance correctly, verify the tape size for the particular tape reel, then loosen the feeder advance mechanism. Now, move this set pin to the corresponding number on the feeder. Finally, tighten the feeder advance mechanism for the new setting.

Tape jams can also cause the placement machine to stop. You'll need to remove excess tape from the jammed feeder, making sure the tape is still threaded properly.

Sin number 7 – Improper Temperature Profile

Our last mortal transgression in surface mount assembly deals with the reflow soldering operation. Circuit board assemblies need to be preheated to activate the flux in the solder paste. Then they need to be heated at a higher temperature to reflow the solder. A cooling step follows that allows the solder to solidify. The preheating, heating and cool down cycles in the reflow machine are defined by the *thermal profile.* A specific profile for a particular board may also be known as a *recipe.*

If this recipe is set incorrectly, the result will be unacceptable solder connections. For example, if the temperature is not hot enough, there will be unreflowed solder paste – resulting in open circuits. Too hot a temperature can cause damage to plastic components and the circuit board.

The first thing to check if there is an incorrect temperature cycle is to verify that the correct thermal recipe is being used for the specific assembly you're running.

There may also be a problem with the reflow machine. A reflow soldering test utilizing a thermocouple attached to the assembly may be performed to make sure the correct thermal profile actually result from the settings of the reflow machine.

You've just taken a refresher course in how to avoid the most common pitfalls in surface mount assembly. Remember, the seven sins include old solder paste; unclean stencils; improper squeegee operation; misalignment; component issues; feeder issues; and improper temperature profile.

Most of the processes in surface mount production are automated. That’s why you need to continually monitor the process and make sure that machines are set up properly – and that the correct circuit boards and components are being used.

You’re now armed with the information to defeat the seven heinous sins of surface mount assembly. Fighting the good fight will result in more reliable products and a contented feeling of accomplishment.