DVD-51C
Adhesive Application For Surface Mount

Below is a copy of the narration for DVD-51C. 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.

Section 1

Adhesive – a viscous material with a tendency to stick or adhere. The primary purpose of adhesive application is to keep surface mount components from falling off the board during the wave soldering operation. In many of today's circuit board designs, surface mount chip components are attached to the bottom side of the board. Through-hole components, as well as the larger surface mount components are attached to the top side of the board. When surface mount and through hole components are combined like this, we call the board a mixed technology assembly. When there are just surface mount components on both sides of the board, we have a surface mount assembly.

With mixed technology assemblies, bottom side surface mount components require adhesive application so they don't fall off during the wave soldering operation. For double sided surface mount assemblies, the surface tension of the solder is enough to hold on bottom side chip components during top side reflow. But if there are larger components on the bottom side, there won't be enough surface tension from the solder to hold them on during top side reflow. These types of components will also require adhesive application.

This video will examine the surface mount adhesive application process. You'll be introduced to the two primary methods of adhesive application – dispensing and stencil printing – and we'll take a look at the characteristics of the adhesive itself. During the remainder of the program, we'll provide details on common set-up procedures, system operation, troubleshooting and preventive maintenance for both dispensing and printing of adhesives.

Before we start, let's review a typical assembly process for double sided mixed technology boards. We begin with the bottom of the circuit board. The first step is to apply the adhesive dots in the precise locations where the surface mount chip components will be placed. Notice how these dots of adhesive are dispensed between the lands rather than on the land itself. If the

glue were placed on the land, the component wouldn't be able to be reliably soldered to the land. That's because the adhesive would block the solder. After all of the adhesive dots are applied, the components are positioned – typically using a high speed chip shooter. The next step is to cure the adhesive in an oven. Curing allows the glue to achieve its full strength. After this step is completed, the components are securely attached to the bottom of the board.

Now, the larger surface mount components can be added to the top side of the board. Here's how that happens. First, solder paste is printed onto the lands of the circuit board using a stencil and squeegee. Next, the components are automatically placed on the board so that the leads are accurately aligned to the solder paste covered lands. Then, the heat from the reflow oven activates the flux in the solder paste and melts the paste – to join the lands and the component leads. Notice how our adhesive has held the bottom side components in place during all this top side processing.

At this point, we begin the through hole component assembly sequence. Automatic insertion equipment is used to insert the through hole component leads through the corresponding holes on the top side of the board. These leads are automatically cut and clinched from the bottom side. Next, through hole components requiring hand insertion are added to the board. The fully assembled board is now passed over a wave of molten solder. The solder wicks up the holes to solder the leads of the through hole components. The chip components that are glued to the bottom of the board are also soldered at this time. Wave soldering completes the assembly process for this double-sided mixed technology assembly.

Now that you understand why it is essential to use adhesive on bottom side surface mount components, let's take a look at the two primary methods for applying the adhesive. Most manufacturers apply adhesive by dispensing. In this method, adhesive is applied to a circuit board by a nozzle mounted on an X-Y positioning system. For each component on the board, an appropriate adhesive dot pattern is dispensed according to the component's size and "land pattern" – or where it will be placed.

There are many different types of mechanisms used to force the adhesive through the nozzle and onto the circuit board. The three most common are time-pressure, or "air over" dispensing, the Archimedes pump and the piston pump.

In time pressure dispensing, the nozzle is connected to the adhesive syringe either directly, or by a short cylindrical channel. High pressure air, typically 20 to 40 pounds per square inch, or PSI, is pulsed on the back of the syringe for a programmable length of the time. This air pressure forces the adhesive through the nozzle and onto the circuit board. These dispensers use a *vision system* to provide dot size control. This is done by comparing the measured dot size with a reference dot size and adjusting the air pressure accordingly. The vision system is required because the dot size varies as the amount of adhesive remaining in the supply syringe changes. As the syringe empties, more air pressure is required to compress the increasing volume of air in the syringe.

The Archimedes pump uses an Archimedes screw to meter the adhesive onto the circuit board. A constant low pressure air supply of 10 to 20 PSI feeds the adhesive from the supply syringe into

the screw. The screw rotates for a programmable length of time, forcing the adhesive through the nozzle.

The last type of pump we'll discuss is the piston pump. In this system, adhesive is displaced by the action of a reciprocating piston. The adhesive is fed into the piston by a low pressure air supply. The volume of adhesive is dependent only on the piston stroke length and diameter. The stroke length can be changed through a mechanical adjustment on the pump. Also, the frequency of piston cycles is not dependent on stroke lengths. This means that dots of small and large volumes are dispensed in the same amount of time.

Your company may have one or more of these different types of dispensing systems. The important thing to understand are the general principles of adhesive dispensing. All of these dispensing systems share the same basic set of parameters that determine their performance. These include nozzle size, air pressure and quantity of adhesive dispensed. Each system has advantages and disadvantages. For example, one type of system may be easier to clean and another type may have better repeatability of dot size.

Now, let's examine the other primary method of applying adhesive. In the past few years, more and more companies have been investigating stencil printing of adhesives – especially in high throughput situations. The big advantage of stencil printing over dispensing is speed. Today's ultra high speed dispensers have a maximum rate of 70,000 dots per hour under ideal conditions. Stencil printers can well exceed 100,000 dots per hour.

One disadvantage of adhesive printing is flexibility. Every time a board population is changed, a new stencil is required. Another disadvantage is that cleaning small stencil apertures is more difficult than cleaning nozzles.

When stencils are used to print solder paste, the height of the paste is roughly equal to the stencil's thickness. With adhesives, the viscosity, or thickness of the material; and the size of the aperture, or opening in the stencil, determines the shape of the glue dot being printed. This is because the adhesive normally doesn't release completely from the stencil aperture. Since the thickness of the stencil is uniform, the size of the dot is determined by the size of the stencil aperture.

Any stencil printer capable of printing solder paste for fine pitch surface mount components can be used for adhesive printing. The most important aspect of the printer is its ability to form a programmable "snap-off" or printing gap between the board and stencil. The printer should also have a programmable, controlled separation of stencil and substrate after the printing stroke.

Our final topic for this introductory section is the adhesive. Different types of adhesives will be used depending on whether you're dispensing or stencil printing. Some adhesives designed for dispensing are sensitive to moisture in the environment and tend to have a much lower viscosity than printable adhesives. To be suitable for printing, an adhesive should be capable of being printed on a stencil for three to five days with no adverse effects.

Regardless of whether you're dispensing or printing adhesives, companies look to the adhesives for specific characteristics and criteria. There should be minimal volume variation from dot to dot. The bond strength of the adhesive to the components should be measured at room temperature and elevated temperature to simulate the conditions encountered during soldering. The green strength is the shear strength of the adhesive in the uncured state. High green strength is important to reduce component skewing during part placement. The adhesive bond should weaken at elevated temperatures to facilitate rework operations. The adhesive should also be easy to remove from misprinted boards in the uncured state. Finally, the choice for high or low viscosity adhesive is based on the types of components populating the board. For example, lower viscosity adhesive may be suitable if only chip components will be on the board. Gull wing and J-leaded components have higher stand-off – and therefore require a higher viscosity adhesive.

Section 2

In this section we'll examine some typical set up and operation procedures for dispensing the adhesive. Then we'll take a look at what's involved with troubleshooting errors and performing preventive maintenance. We'll assume you've come to work and there are boards requiring adhesive dispensing. These boards are usually accompanied by documentation that specifies the part number and revision letter of the assembly; the nozzle sizes and their spindle locations; the type of adhesive; board supports if required; and the program number to be loaded. The first step is to load the computer program.

Next, we check that the tubes of adhesive, as well as the correct size nozzles are properly located in the spindle locations. Make sure that all the nozzles are clean. You may need to change the adhesive and the nozzle sizes for a new run of assemblies. And sometimes the spindle may be empty. If this is the case, you'll need to drop in the tubes of adhesive and the correct size dispensing nozzles. Also, verify that the air pressure is set correctly and that the climate control is within proper limits. This is especially true on time pressure dispensing systems.

At this point, we press the purge button. The pump will start to operate. Check that adhesive flows out the nozzles and that there's no blockage. Now, set the rails to the size of the circuit board that will enter the machine. On some dispensers this adjustment is done automatically. Then, add appropriate board supports as required. This completes the dispenser set-up procedures.

In many companies, test dots are dispensed before starting production. Three to five test dots can be dispensed on a section of the board that doesn't contain circuitry – usually on the edge of the board. If the adhesive is flowing properly, the dots will have the correct size and shape.

Now that everything is set up and working properly, let's watch the adhesive dispensing operation. First, a vision system verifies the proper position of the board within the machine using alignment marks, or what we call "fiducials." Regardless of the type of dispensing system utilized, the adhesive is then pumped from the glue tube using air pressure. The computer controls the air pressure, the amount of adhesive dispensed and the precise locations where the drops of adhesive are applied. As you can see, this process happens really fast. Now, we'll look at it in slow motion so you can see it more clearly.

Once the adhesive has been dispensed, the circuit board needs to be inspected. Your company should have their own inspection criteria that you will follow. An assembly drawing is used to verify that the dots are correctly placed between the lands and that they are the correct size. The adhesive should never be dispensed across the lands. When adhesive gets on a land, there is likely to be an unreliable solder connection. Also, make sure you handle the boards only by the edges. It's very easy to smear the adhesive. If this happens, you'll have to clean the board and start the dispensing operation once again.

If the dispensing has been done accurately, then the process is continued until all of the boards requiring adhesive application are completed. While the machine is dispensing the glue dots, it's important to stay alert for indications of nozzles clogging, and the need for replenishing tubes of adhesive. To replace adhesive, simply remove the old tube and insert a new one. Make sure you're using the same type of adhesive and the nozzle is still the correct size. It's also important to inspect every circuit board. Errors can be detected quickly – and their causes remedied.

At the conclusion of each job it's critical that you clean the nozzles with an approved solvent. If the adhesive is allowed to dry, the nozzle will clog and probably will have to be thrown away.

As you have seen, once a dispensing machine is properly set-up, adhesive application pretty much happens automatically – until something goes wrong. What do you do when the dots don't look the way they're supposed to? Let's examine some of the common problems and defects, along with the underlying causes and suggested remedies.

Stringing or tailing dots are by far the most common defect. Stringing and tailing simply means that the dot isn't formed perfectly. The dot either strings from dot to dot, or droops into a tail. It was once believed that stringing or tailing was caused by poor viscosity of the adhesive. Of course, this is a possible cause, but there's more likely to be another reason. For example, the nozzle may not be coming down far enough, causing a larger nozzle to board gap than desired. This can be caused by improperly positioned board supports, or it may indicate that the dispenser's Z-axis zero position needs to be calibrated. All machine calibration should be performed by highly trained maintenance technicians.

Another possible cause of stringing or tailing dots occurs when the shot size is too small. This means the adhesive may not be filling the nozzle to board gap. The nozzle will pull away almost the entire dot. This results in poorly formed dots. One solution to this problem is to move the nozzle to board stand-off distance closer. On machines using time-pressure dispensing, you could increase the air pressure or the dispense time. On machines with a piston pump, you could increase the stroke on the piston pump.

When the shot size is too large, the adhesive may surround the tip of the nozzle and then get pulled away by the nozzle. The result – a stringing or tailing dot. The possible remedies to this problem are the opposite of when the shot size is too small. You can set the stand-off between the board and nozzle further; you can decrease the air pressure or the dispense time; or you can decrease the stroke on the piston pump.

Stringing and tailing aren't always caused by machine related parameters. Sometimes the surface condition of the circuit board, as well as the condition of the solder mask can be the culprit.

Another common defect in adhesive application is missing or inconsistent dots. This type of defect can be caused by a number of situations. The first things to check are whether the adhesive syringe is empty, or whether the nozzle is clogged. If these are okay, there's the possibility the adhesive contains air pockets. Try purging the system of all air, then see if the problem is still occurring.

The last cause of missing or inconsistent dots is that the air pressure feeding the pumps is insufficient. This would mean that the pump starves intermittently and misses putting down a dot of glue. Increase the air pressure. Then see if the problem is still there.

Not all problems are detected after the adhesive is dispensed. Sometimes later inspections will reveal missing components or insufficient solder that will relate back to problems with the adhesive. For example, when parts are missing and there is sufficient adhesive, the cause may be voids in the adhesive which has reduced the area for component bonding. Voids occur when absorbed water is bubbled out of the adhesive during the curing process. A slow temperature ramp rate during curing can remedy this.

Insufficient solder can be caused when an adhesive dot is inaccurately placed onto a land. That's why it's so important to carefully inspect the board prior to components being placed and soldered. Imagine all the rework that will be required if just one or two components on every board are missing or inadequately soldered.

Our final topic for this section is clean-up and preventive maintenance. At the end of every shift it's necessary to wipe down the surfaces of the dispensing machine with a lint free cloth and an appropriate solvent such as isopropyl alcohol. You'll want to remove any excess adhesive that is in contact with the surfaces of the machine. Also, it's critical to clean all of the nozzles so the adhesive doesn't harden and make them impossible to clean.

Pumps are generally cleaned on a weekly basis. Your company and/or the machine manufacturer will have a specific schedule and procedure for cleaning the pumps.

The remaining preventive maintenance is generally done by maintenance technicians. This includes performing periodic calibrations, checking and replacing air filters and air hoses and greasing the bearings.

Section 3

Now, let's take a look at what's involved in setting up a stencil printer for the application of adhesive. The variables for stencil printing of adhesives include the circuit board, the stencil, the adhesive and the squeegee. Your documentation will specify the boards to be run, the program to be loaded – as well as the stencil, adhesive and squeegees to be used.

Before we go into the actual machine set-up, let's briefly look at the stencil, adhesive and squeegees. Stencils for adhesive printing are usually stainless steel or plastic. Stainless steel stencils have been used for years in solder paste printing. The openings are typically cut out by a laser. Recently, plastic stencils have been developed – specifically for adhesive printing. The advantages of plastic stencils reportedly include better "gasketing" due to their flexibility. This minimizes "squeeze out" of adhesive on the underside of the stencil and reduces the need for periodic cleaning of the stencil. The flexibility also enhances stencil release during "snap-off" or "off contact" printing. The disadvantages of plastic stencils include only round apertures since the openings are drilled and that metal squeegee blades can't be used since they'll damage the stencil. This means plastic stencils aren't as durable as their stainless steel counterparts.

The next variable is the adhesive. As we said earlier, the main characteristic in an adhesive designed for stencil printing is that it must be designed for exposure to room temperature and ambient humidity. Beyond that, the requirements of the specific assembly will determine the adhesive that's selected.

In terms of squeegee selection, the best adhesive printing results are typically seen with a hard polyurethane squeegee. The polyurethane pushes the adhesive down into the apertures and ensures full aperture fill and contact to the board. Polycarbonate works best with plastic stencils.

Now that you have an understanding of the variables involved in adhesive printing, let's take a look at a typical set-up procedure. The first step is to use your documentation to load the correct computer program. The program contains the profile of the circuit board. It consists of the size of the board and all of the other parameters required for adhesive printing. These include squeegee speed, pressure, downstop, board separation speed and snap-off distance. We'll discuss these parameters in a little while.

Once the computer program is loaded, use your documentation to select, install and level the squeegees. Next, load the stencil. Although many stencil printers have automatic dispensers for solder paste, adhesives are normally spread onto the side of the stencil manually with a spatula. Printable adhesives are substantially thicker than solder paste and may be difficult to push out of the container automatically. Remember to verify that you're using the correct adhesive. At this time, add board supports if required. The board needs to remain flat during the printing process.

Now, let's watch how the adhesive is printed. After the board is transported into the printer, the vision system reads the fiducials on both the circuit board and stencil. The system performs a series of calculations, and makes necessary movements to position the stencil over the board in the best possible location for printing. The squeegee then strokes across the stencil, applying adhesive into the stencil openings onto the correct locations on the circuit board below. The amount of adhesive should be controlled so that it "rolls" in front of the squeegee.

At this point, depending on the sophistication of the printer, the vision system performs verification of the placement and sizes of the adhesive dots. The adhesive application is then inspected by the operator. That's all there is to it. When the printing process has been implemented correctly, minimal "process management" is necessary. Basically, boards are loaded, the printer does its thing and the adhesive application is inspected.

As we said earlier, the plastic stencils reportedly require very little cleaning. In contrast, stainless steel stencils require wiping periodically during the printing operation. "Squeezing out" of adhesive onto the underside of the stencil happens faster on metal stencils than plastic stencils. Also, the adhesive on the stencil needs to be replenished periodically. But, as with any machinery – things do go wrong, meaning defective adhesive dots are produced and parameters need to be adjusted.

Let's go back to the key printing parameters and examine how they can affect the printing. Snap-off is usually set between at about 40 thousandths of an inch. Larger snap-off can help eliminate voids in adhesive application due to trapped air in the apertures. For lower viscosity adhesives that are similar in consistency to solder paste, contact printing, or no snap off can be used.

The speed of the squeegee is also dependent on the viscosity of the adhesive. The lower the viscosity, the faster the printing. For example, a low viscosity adhesive may be printed at eight inches per second and a high viscosity adhesive is printed at a half inch per second. Quite a difference! Printing the adhesive too slow or too fast can produce inconsistent dots.

In terms of squeegee pressure, the higher the viscosity of the adhesive, the more pressure required to print properly. A rule of thumb is to have sufficient pressure so that the stencil is wiped clean of adhesive with each printing stroke.

Squeegee downstop is generally set the same as it would be for solder paste printing. If the downstop is too low, the ability of the squeegee to wipe the stencil clean will be impaired. If the downstop is set too high, a "coining" – or lifting of the stencil will be seen at the edge of the circuit board after several squeegee strokes.

The separation of the board and stencil after the print stroke is a critical parameter. This is also dependent on adhesive viscosity. If this parameter is not set up correctly, stringing and/or inconsistent dot heights will result.

Our last topic for adhesive printing is clean up and preventive maintenance. When a production run comes to an end, the inevitable must happen – clean up. It's important to note that common cleaning solvents, such as isopropyl alcohol, are <u>not</u> compatible with printable adhesives. Your adhesive supply company will advise you on an appropriate solvent to use.

The first step after a job is completed is to remove and properly dispose of all unconsumed materials. Next, clean and remove adhesive from the squeegees. It's important to check the squeegee blades for edge nicks. Then, thoroughly wipe down the stencil, making sure there is no adhesive left in the apertures. The adhesive will eventually cure at room temperature, making it more difficult to remove later.

Now, check the tooling pins and board supports for any debris or adhesive. Clean these if necessary. Finally, wipe down the entire machine, removing any adhesive that may have gotten onto a surface. It's important to look inside the printer and see if any tools or materials have

fallen inside during the job. While you're looking, check for frayed wire and worn belts. Any problems should be reported to maintenance.

This program has presented the details of the adhesive application process for surface mount. We discussed the purpose of adhesive application and saw how it fits into the assembly process for double sided mixed technology and surface mount circuit boards. You were also introduced to the two primary methods of adhesive application, and we took a look at the characteristics of the adhesive itself. Then we examined the details on set-up, operation, troubleshooting and preventive maintenance for both dispensing and printing of adhesives.

Adhesive application is a critical step in surface mount assembly. If it's not done correctly, there can be missing components and/or unreliable solder joints. Both situations require expensive rework to remedy. Your careful attention to adhesive application makes a big difference in producing quality assemblies.