DVD-36C
Hand Soldering With Low Residue Fluxes

Below is a copy of the narration for DVD-36C. 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

Changes are occurring in the electronics manufacturing industry as a result of increased requirements from federal, state and local agencies. Safety, health and environmental issues have been the driving force. In addition, our shifting economy has brought on increased competition and smaller profit margins.

In an attempt to become more competitive and lessen the effect of stricter regulations by government agencies, many alternative processing technologies are being initiated. One of these methods involves the use of low residue fluxes for soldering electronic assemblies.

Low residue fluxes are designed to be left on the board after soldering without affecting the reliability of the assembly. It is possible to totally eliminate the post solder defluxing operation if the parts, board, equipment and processes do not contribute undesirable contaminants that have a negative impact on performance and reliability. The elimination of the post soldering cleaning step and the overall simplification of the assembly process can have a beneficial impact on the cost and cycle time of the manufacturing process as well as on the environment.

This video will present what a low residue flux is; how it compares to most rosin-based fluxes; what changes have to be made to existing processes; hand soldering theory with an emphasis on effective hand soldering with low residue fluxes; and visual inspection for assemblies produced with low residue fluxes.

First, let's take a look at some of the differences between a low residue flux and traditional rosin based fluxes such as R, or rosin; RMA, or rosin, mildly activated; and RA, or rosin, activated. Although the terms no-clean and low residue are used interchangeably throughout the industry, they actually can be quite different. The term low residue is associated with the composition of the flux. No-clean is a term associated with the assembly process. No-clean refers to the elimination of the cleaning operation designed to remove flux residues.

A no-clean process includes the use of a low residue flux. In order to eliminate the defluxing process, the flux residues remaining after soldering must not affect the electrical performance or conformal coating adhesion.

The composition of a typical RMA liquid flux includes approximately 35% rosin and 5% activators and other additives for a total of about 40% solids. The amount of solids in a low residue flux may only total .5 to 4%. The reduced solids in a low residue flux can have a significant effect on the hand soldering process.

The reduced solids will leave less residue on the assembly after soldering. This is very beneficial as part of a no-clean process, but it will make it more difficult to solder parts with poor solderability. This may result in the need for improved handling and storage of materials to ensure adequate solderability.

The type and amount of activators are very important in determining if a flux can be used in a no-clean process. RA and some RMA fluxes typically use amine-halide activators which are very effective at removing oxides and improving wetting on parts with degraded solderability. However, when the residues from halide activated fluxes are exposed to water in the form of humidity, vapor or liquid, they can form corrosive acids that will attack the metals on the board and reduce reliability. These residues can also become electrically conductive and affect the electrical performance of the assembly. Consequently, halide residues need to be cleaned off the board to prevent these problems.

Low residue fluxes must be halide-free to reduce the corrosion problems. Low residue fluxes typically utilize low amounts of weak organic acids as activators. The residues from these fluxes are harmless if left in place on the assembly.

Here are some suggestions to reduce the possibility of contamination when hand soldering with low residue fluxes. The critical issue is to receive materials with a known cleanliness and solderability -- and to maintain that cleanliness and solderability throughout the various processes.

Although some facilities require the use of gloves or finger cots when working on the assemblies, they too can be a source of contamination. Handling the boards by the edges and avoiding contact with solderable surfaces are very effective means of reducing the possibility of contamination. Good hygiene habits like washing hands after eating can also help maintain cleanliness. In addition, make sure all storage containers are clean prior to use.

Another aspect to the no-clean process is that the final inspection criteria may have to be changed. Some flux residue will remain on the board after soldering. Decisions have to be made about how much residue will be acceptable. The critical issue is not whether residue is present, but what the effects of the residue will be on the long-term reliability of the board. Engineering staffs at your facility should be testing and evaluating this issue.

When using a low residue flux it is also possible to see some subtle differences in the appearance of the solder joint. The solder joints may appear to be duller than solder joints from the previous process. There may also be a difference in the degree of wetting present on the soldered areas. This difference in appearance is generally unrelated to the solder joint reliability characteristics. Rework or touch-up of a connection for appearance sake should be avoided to reduce the possibility of damage during the rework operation.

Hand Soldering Using Low Residue Fluxes

Now, let's take a look at what's involved with hand soldering using low residue fluxes. All the same soldering steps and theories still hold true. The only requirements for producing acceptable solder joints with a low residue flux is the ability to modify the current technique to compensate for some of the performance capabilities of the flux.

The main areas of concern for operators performing the soldering operations are odor and performance. The odors of low residue fluxes vary with the composition. You'll find that some of the odors are, if not pleasant, at least acceptable. Methods that address the issue of flux fumes include improving ventilation or installing fume extraction systems.

In terms of performance, when operators try a low residue flux for the first time, they may feel that the flux doesn't work as well as the old RMA flux. In reality, the low residue flux may produce quality product -- but requires certain changes in the soldering technique.

When hand soldering, it's important to remember that this is a very different process as compared to a machine soldering system. In wave soldering, the flux is applied in a controlled manner and then the assembly enters a pre-heat stage. During pre-heating the entire board is slowly heated to a temperature that will activate the flux and condition the metals for the actual soldering operation. At this point the assembly enters the wave of molten solder where the soldering operation takes place. The assembly then exits the wave and begins the cool down stage to complete the process.

In hand soldering, flux may be applied in the form of an external liquid or in the core of a solder wire. There is no pre-heat stage to slowly condition the area and begin the flux activation. The hot soldering iron tip will immediately come into contact with the connection area and transfer heat into the connection through a very localized contact point.

When using a low residue flux, the volatiles, or non-solids portion of the flux, will evaporate very quickly and the flux solids are also rapidly consumed. This means there is less time available to form the connection.

Tip selection has always been a critical issue, but when using low residue fluxes it's an even more important method of controlling the heat application. The three variables for tip selection include contact area, tip length and thermal mass.

When selecting a tip, always select a tip that has the greatest contact area. A chisel tip with a flat surface has a much greater surface area than a conical tip. There is, however, a danger in selecting a tip with a contact area that is too large because it may overhang the termination area and cause thermal damage to the board.

It is common for operators to get very comfortable with a particular style of tip and then become reluctant to try other tips. When they encounter a connection that will not solder easily, the tendency is to increase the tip temperature. This method may work -- but it can also result in thermal damage to the board because the heat is applied at a higher temperature in a localized area. A safer method would be to increase the tip contact area. This would allow the connection to heat more rapidly to soldering temperature while utilizing a lower temperature.

In terms of tip length, this will vary based on the particular application. It is important to be aware of the advantages and disadvantages of each type of tip. For example, it is advantageous to have a long, narrow tip for working on very densely populated assemblies. But it also means that the actual tip temperature at the very end of that tip may be different than the desired soldering temperature.

The thermal mass of the tip becomes important when soldering to connection areas that will dissipate the applied heat. If other items such as tip length and contact area have been considered and still cannot compensate for the need for increased heat to the connection area, a tip with a greater thermal mass may prove to be effective. This will increase the ability to transfer heat without raising the temperature.

For example, a tip with a weight of one ounce heated to 600 degrees Fahrenheit may be able to heat seven grams of copper to 600 degrees before the heating element has to energize and restore the tip temperature. A tip with a weight of three ounces heated to 600 degrees Fahrenheit may be able to heat 21 grams of copper without the heating element energizing to restore the tip temperature, even if the contact areas are identical. This means the soldering operation can be done faster which is important when using low residue fluxes.

The thing to keep in mind is that you should always use the lowest temperature possible for the soldering operation to avoid the potential of damaging the assembly. The temperature of the soldering iron must be sufficient to adequately heat all the elements of the solder connection and to allow the solder to melt and wet all the connection elements. Some low residue fluxes have optimum temperatures that may be higher or lower than RMA fluxes.

The dwell time, or how long the soldering temperatures are applied, is an important consideration when hand soldering with any flux. The dwell time should be long enough to allow adequate wetting, but short enough to prevent thermal damage or excessive growth of intermetallics. Intermetallic is an alloy that is formed when the tin in the solder and the copper conductors on the board interact during the soldering operation.

Since low residue fluxes have a reduced activity period compared to RMA fluxes, the dwell time should be minimized to coincide with the reduced activity of the flux. Compared to high solids fluxes such as RMA, low residue fluxes have less activators and will not remain viable for as long as a high solids flux when exposed to soldering temperatures. This may also be of benefit by minimizing the formation of intermetallics.

Here we see a comparison of the same connection being soldered with a low solids flux and an RMA flux. Notice the difference in dwell times.

The feed rate is how fast a given amount of solder is fed into the connection during the soldering operation. If the solder is fed too quickly, more of the tip's thermal energy will be used to melt the solder instead of heating the connection area. This results in improper flow and wetting. An ideal feed rate will allow the solder to be flowed into the connection continuously during the soldering operation. This will ensure flux is being supplied throughout the process.
One variable that affects the feed rate is the solder diameter. Of course, a larger diameter will feed solder into the connection quicker. Many operators use what is referred to as a pulse feed. With a pulse feed, very small quantities of solder and flux are pulsed into the connection at regular intervals during the dwell time of the solder connection.

Tip Maintenance and Soldering Tips

This final section deals with tip maintenance and the soldering operation itself. Tip maintenance becomes more critical when using a low residue flux. Proper tip maintenance will reduce tip oxidation, increase tip life and improve the performance of the iron. With the cost of soldering iron tips starting around $1.50 and ending in excess of one hundred dollars per tip, maintenance becomes very important to give a company a competitive edge.

Oxidation occurs as a result of the interaction between oxygen and other materials. Oxygen is a very reactive element. Whenever it comes in contact with other metals it creates oxides. When oxides form on a soldering iron tip, the tip performance is degraded. Oxides create a barrier which decreases heat transfer from the tip to the connection. If no tip maintenance is performed, the oxides can build up and render the tip unusable. The tip must then be scrapped or reconditioned.

Tinning the tip of the soldering iron is the best way to combat oxidation. The tinning process begins with the application of solder to the working surface of the hot soldering iron tip. The solder coats the plated working surface of the tip forming a barrier that prevents oxygen from reacting with the tip. The flux in RMA cored solder improves this tinning process by breaking down any oxides already present on the tip and allowing oxides to float to the surface of the solder. Because of the reduced solids and lower activity of low residue flux cored solder, it is not as effective at tinning the tip as an RMA flux cored solder. If you use a low residue flux cored solder for tinning, the tinning must be done more often.

Proper tip maintenance involves first wiping the tip on a wet sponge. With low residue fluxes the sponge wipe is more effective at removing oxides and residues when the sponge is very wet. After wiping the tip, always apply a fresh coating of solder to the tip before placing the iron in the holder.

There are several methods of reconditioning an abused tip. One method is to utilize a tip scrubber. This method uses an abrasive material to remove oxides and any other build-up from the tip. Another method is to use a tip tinner, usually a mixture of solder alloy and flux, to condition the tip. A method that is very effective but may require some carefully applied controls is the use of cored wire solder with a more active flux. This method works well, but may result in the inadvertent use of the more active flux onto the assembly being soldered. The best method of reconditioning the tip is to never let it degrade. Never rely on frequent reconditioning to overcome poor maintenance habits. The surface of a tip is plated and frequent reconditioning will degrade the plating and reduce the tip life.

Now, let's take a look at making a typical solder connection. The soldering iron tip should be applied to the connection in a way that allows contact with the pad and the component lead at the same time. This will ensure that all areas of the solder connection are heated at the same time and will allow the solder to flow over all the areas of the connection.

To improve the transfer of heat even more, a solder heat bridge should always be used. A small quantity of solder is applied to the junction of the soldering iron tip and the land. This can be accomplished by several different methods. One method has cored solder positioned on the area to be soldered prior to iron placement. Another method applies some solder to the tip prior to iron placement. The final method applies some solder to the junction of the soldering iron tip and the pad once the iron is in place.

The solder that forms the heat bridge is now an integral part of the tip and covers a much greater area than the tip alone. This allows the heat to flow into the connection more rapidly. This is important when using a low residue flux because it allows the connection to be completed sooner. Remember, the time that low residue flux remains active is shorter than the active time of an RMA flux.

After the solder heat bridge has been established, solder should be applied to the connection at the furthest point away from the soldering iron tip. The solder will tend to flow toward the heat source. This will help ensure good solder coverage.

Let's watch what occurs during the soldering operation in more detail. The solder will slowly flow down the plated through hole and coat the areas of the connection on the opposite side of the board.

Let's watch that again with a surface mount connection. The solder will flow over the termination area and wet to both the lead and the land.

When the correct amount of solder is present in the connection, the iron and solder should be removed at the same time. Failure to remove the iron and solder at the same time may result in solder peaks or a disturbed surface appearance.

Now let's watch how we apply these techniques to several different types of connections. We will still use the same steps we just covered, but the iron placement will be different.

On a gull wing device we still form a heat bridge, then flow the solder in and remove the solder and iron simultaneously. On a J-lead device, again we form a solder heat bridge, flow the solder in, and then remove the solder and iron simultaneously. On a turret terminal with a wire attached, form a solder heat bridge, flow the solder in and then remove the solder and iron simultaneously.

Some soldering irons have an integrated system that provides heated air or nitrogen to the connection area during the soldering process. When using a low residue flux, this heated air can more effectively remove the volatiles, leaving a reduced volume of residues. If nitrogen is used with the same system, it will still remove more of the residues than a standard soldering iron. It may also have the benefit of improving the wetting performance by eliminating or reducing the effects of oxygen during the soldering process.

The residues left on the assembly after hand soldering can vary greatly.
This is caused by the lack of control inherent in the hand soldering process and the amount of flux applied. The quantity of flux that remains after soldering is directly related to the applied quantity. This is why the flux application method is important when hand soldering.

If the assembly exhibits good wetting characteristics, the use of external flux should be avoided in favor of the use of flux cored solder. If, however, the wetting is less than satisfactory, the use of external flux should be considered.

Typical manual applications of external flux have not changed. Flux dispenser bottles and flux pens are still used. Flux dispenser bottles can be used with good results if the needle diameter is small enough to limit the flux application to a very small area. Brush bottles may require more skill to apply the flux precisely to the area being soldered. The use of flux pens with fine tips can be very effective at limiting the application of flux to the areas being soldered.

In terms of performing rework, always try to use the same flux that was used for the initial soldering process. There have been cases where flux incompatibilities have resulted in degraded electrical performance of the assembly. When it's not possible to use the same flux, use a flux that has been recommended by your company as being the best alternative.

Finally, let's examine the requirements for visually inspecting solder joints where low residue fluxes were used. Most inspectors are concerned over the presence of visible flux residue on the assembly. However, the appearance of residue from low residue flux doesn't necessarily mean that reliability of the assembly will be degraded.

The quantity of visible flux residues will vary with the type of flux and method of soldering. Some companies have inspection guidelines that specify how much visible flux residues are allowed and under what conditions. For example, some companies allow no flux residues when inspected visually, but allow residues to be visible with magnification. Other companies have tested their materials, processes and products and established that any amount of residue is acceptable.

Another area of concern when inspecting assemblies that have been soldered with low residue flux is the degree of wetting. In most cases, wetting won't be affected by low residue fluxes. Only when parts have marginal solderability, or when the soldering process is not optimized will the solder wetting be affected. And in most of these cases it will still be acceptable.

This program has provided information on what is required for hand soldering using low residue fluxes. You've seen that it is very similar to soldering with an RMA flux. It may help to review the areas where additional attention may be helpful.

Low residue fluxes have less solids and the activity ratio may be reduced. This means that the ability of low residue fluxes to break down oxides is less than RMA fluxes.

More attention may be needed with the handling and storage of solderable materials when using low residue fluxes.

The odor from low residue flux fumes may be different from that of RMA flux.

Tip selection is important to reduce dwell time. A tip with greater thermal mass is preferable when soldering.

Dwell time may have to be reduced for optimum performance with a low residue flux. This means the soldering operation must occur faster.

Tip maintenance needs to be accomplished more frequently when tinning with a low residue flux to increase tip life.

A good solder heat bridge is essential for soldering with a low residue flux since the heat needs to be transferred faster.

A pulse feed with flux cored solder may provide better results because the flux is constantly being fed.
Limiting flux application will minimize flux residues.

Always try to use the same flux for rework that was used for the initial soldering.

Visible residues from a no-clean soldering process may not be rejectable. Each company will have their own criteria for how much visible flux residues are allowed.

The use of low residue flux can provide solder connections that are as good as those produced using an RMA flux. The only requirements are knowledge of some of the differences and a slight change in your soldering technique.