Manufacturing Considerations When Implementing VOC-Free Flux Technology

Our thanks to Kester Co. for allowing us to reprint the following article

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In 1990 the United States Environmental Protection Agency Issued the Clean Air Act. The Clean Air Act and subsequent amendments are designed to limit the use of chemicals that contain volatile organic compounds (VOCs). The document goes into great detail setting limits for allowable VOC emissions for different industries.

Manufacturers and assemblers of printed circuit boards fall into the category of manufactures which are allowed to emit up to 15 pounds of VOC emissions per day per manufacturing site. This limit considerably lower than most of the larger manufacturing cites emit at this time. 15 pounds is approximately equivalent to two gallons of flux or flux thinner.

Presently the US EPA does not have the resources to enforce these amendments, however that will change in time. As in the case of eliminating CFCs the US EPA acted swiftly and within a matter of a few years these materials have disappeared from the market completely. The same or a similar process will soon be used to eliminate VOC containing materials. Conscientious manufacturers are currently looking at VOC-free technology to replace their existing flux chemistries.

Solvent Characteristics

Manufactures who have looked at VOC-Free fluxes have discovered that VOC-free fluxes are not simply "drop in" replacements for the existing flux chemistries. Because VOC-free fluxes contain water as a solvent difficulties are encountered when soldering boards with these fluxes.

The difference between VOC-Free and alcohol based fluxes lies in the characteristics of the solvent (thinner).

The alcohol used in fluxes typically boils at 65-70°F. Existing wave solder machines were developed to quickly and efficiently flash off the alcohol from the flux.

Water on the other hand boils at 212°F. Most equipment was never designed to provide the amount of heat necessary to flash off water. Another characteristic of water evaporation is that a layer of air supersaturated with water forms over the surface of the water when it is heated (Fig. 1).

Because of the increased boiling temperature the solvent evaporation is considerably slower for VOC-free fluxes. As a result much of the solvent (water) is carried along to the solder pot. When water touches molten solder it vaporizes with explosive force. The vaporization causes noticeable spattering and splashing of both flux and solder across the board or assembly. This result in a multitude of defects on the finished assembly. The majority of defects include solder balls, solder webbing, incomplete fillets and icicles.

In order to minimize the spattering problem the manufacturer must find a way to drive off the water during the pre-heat stage of the soldering process.

At first, the task of driving off excess water seems like a simple one. Either by slowing down the convey or increasing the pre-heat or a manufacturer should be able to accomplish this goal. Unfortunately it is not that easy. Lets examine these two options.

First, slowing down the conveyor. Slowing down the conveyor will allow the board to see more heat and subsequently drive off more water but there is a problem. The problem is that fluxes work best at recommended conveyor belt speeds typically in the 4-1/2 to 6 feet per minute range. Slowing down the conveyor often results in the manufacturer seeing an increase in solder related defects such as bridging and the formation of icicles.

The second option is to increase pre-heat. Again this will allow the board to see more heat and subsequently drive off more water but here too there is a problem. As water is heated it does not simply go away. What happens is that a supersaturated layer of air is formed just over the surface of the water, or in this case flux, which acts to inhibit further evaporation.

What is needed is an increase of air flow across the surface of the circuit board to push the supersaturated layer of air away which will in turn allow more water (flux) to evaporate.

The following section is addressed at modifications that can be made to existing equipment in order to evaporate off as much water as possible which will in turn allow for fewer defects in the soldered assemblies.

A Process Modification Suggestion

VOC-Free fluxes can be applied to circuit boards by spray, dip or foaming equipment. Foaming fluxes will provide a uniform head of small bubbles. The flux level should be maintained at approximately 1-1.5 inch (2.5 - 3.8 cm) above the stone in the foam fluxer. Note that this height is twice as high as is normally required for non VOC-free fluxes. It may be necessary to decrease the width of the foam chimney to achieve the higher foam heights.

An air knife after the flux tank is recommended to remove excess flux from the circuit board and prevent dripping on the preheater surface. A warm gentle airflow is required so as not to blow the flux off the board.

The optimum preheat temperature for most circuit assemblies is 200 - 240°F (93 - 116°C) as measured on the top or component side of the printed circuit board.

The wave soldering speed should be adjusted to accomplish proper preheating and to evaporate the water to eliminate spattering. Typically, speeds of 4-1/2 to 6 feet per minute are used. The surface tension of the flux has been relieved to cause the flux to form a thin film on the board surface to allow flashing off of the water.

VOC-Free fluxes are water based and because of this, splattering is a problem. Splattering occurs when a board that is still wet comes in contact with molten solder. One way to drive off the water is by using forced air or convection in the pre-heat zone. Blowing hot air at 10-30 cubic feet per hour greatly assists in drying the water off the circuit boards. Copper or stainless steel tubing is placed down on the preheaters and several holes are drilled in the tubing, these holes act as air knives to evaporate the water. See figure 2. The holes closest to the fluxer are angled at 45° back to the fluxer. These air jets act like an air knife and help minimize the amount of flux that is carried by the board. The holes further away from the fluxer are angled at 90°. (Fig. 3). These air jets help dry the flux out from the through-holes.

Another potential problem area is in the area of the pallets for the boards. A pallet with fingers is preferred to a pallet that completely encloses the board or boards. The fingers are important to let the excess flux drain before the pallet hits the molten solder. Some manufacturers have found that drilling drain holes along the trailing edge of the pallet is enough to ensure good flux drainage.

Conclusion

The successful implementation of VOC-free flux technology requires some process modification for most of the existing wave soldering equipment. An increased air flow across the circuit boards is needed to drive off most of the water present in VOC-free fluxes. The purpose of this paper has been to present a modification that can be installed onto existing equipment to help drive off the excess water. The suggested network of tubing is easy to assemble and easy to retrofit onto existing equipment.

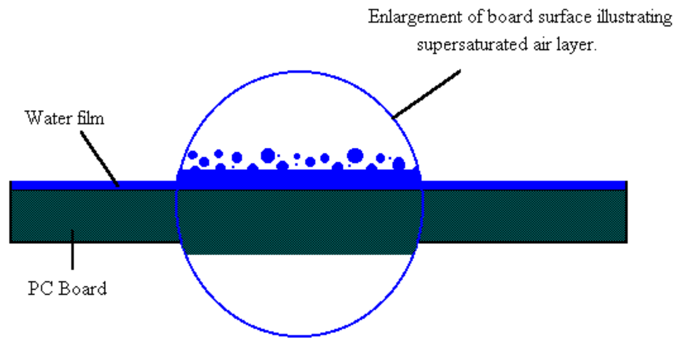

Fig. 1

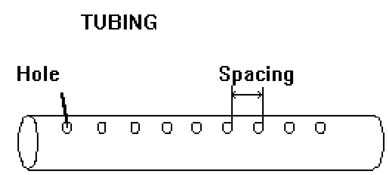

Fig. 2

Hot Air Circulation Apparatus and Method for Wave Soldering Machines Patent No. 5,379,943.

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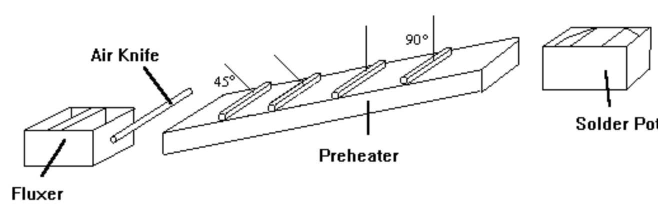

Fig. 3

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