TECHNICALLY SPEAKING

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Why White Residue Forms on Printed Circuit Boards

The appearance of white residues, on circuit boards, is a recurring problem in the PCB manufacturing industry, and generates many questions and complaints for the Tech Support hotline. When contamination is found on the board, after it has passed through the cleaning step, the customer is likely to assume that the contamination has come from the cleaner they are using. Usually residues form on circuit boards due to problems inherent in the nature of the soldering and the cleaning process, and are not due to problems with the chemical cleaners that are used.

All ITW Chemtronics circuit board cleaners are filtered, to remove any insoluble particulate contamination that might be deposited on the board after cleaning. Most residues are the result of inadequate or partial cleaning and can be eliminated by simply repeating the cleaning step. There is another class of circuit board residue, that derives from more complex chemical reactions between the soldering flux, the cleaning solvents, the soldering process, the board laminate and certain process parameters, such a line speed, soldering temperature. These residues usually cannot be removed with conventional circuit board cleaners, and sometimes cannot be removed at all.

Circuit board residues, which are amenable to solvent cleaning, fall into two broad categories, ionic residues and organic residues. Ionic residues can cause corrosion, if left on the board. Organic residues spoil the appearance of the board and can lead to adhesion problems, if the board must be conformal coated. The nature of the soldering flux used, soldering process and cleaning parameters, and problems with the cleaning solvents used, can all lead to the formation of ionic residues. Organic residues can occur due to improper soldering or cleaning techniques or because of a mismatch between the flux and the specific flux remover employed.

It's easy to determine the type of contamination you have on the board. Test each patch of residue with drops of water or alcohol (IPA). If the drops of water dissolve the residue, its ionic; if dissolved by the alcohol, the residue is organic. This quickly tells you what it will take to clean the board (either a water-based cleaner or a solvent-based cleaner), and can give you some indication of what is causing the problem. In both cases, it's more likely to be improper techniques or incomplete cleaning that causes the contamination problem.

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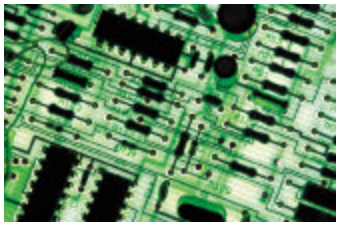
Ionic contamination often results from the type of soldering flux used. Rosin and rosin-based no clean fluxes and many water-soluble fluxes contain varying amounts of halide acid activators. These activators give the fluxes greater heat stability, and help promote the formation of good solder joints by dissolving the oxide films contaminating copper, lead and tin surfaces. The chemical reaction of chloride and bromide ions in these activators, with the lead in the solder, can cause the formation of white lead chloride and lead carbonate residue around the solder joints. If not completely removed during cleaning, these ions can establish a continuing corrosion cycle, producing more lead chloride and lead carbonate (white residue) and hydrochloric acid, which will attack the copper in the board laminate. The best solution to the formation of ionic contamination is the clean the board thoroughly, as soon as possible, after soldering. Ionic residues can also be removed from the board by cleaning with a water-based alkaline cleaner, such as Flux-Off® Aqueous. Process parameters such a pre-heat and soldering temperatures, along with the line speed can also lead to residue formation. If the line speed is too fast, it does not allow the board to cool sufficiently before it enters the cleaning process. The hot board surface can cause the cleaning solvent to evaporate too rapidly. If using a water-based saponifier like Flux-Off® Aqueous, the rapid loss of water can precipitate other cleaner ingredients, such as silicates and carbonates. This contamination appears as crusty patches on all areas of the board. Slowing the line speed down, to allow the boards to cool sufficiently before exposed to the cleaner, can eliminate this cause of contamination.

Organic rosin residues can arise from a number of circumstances. Using old solvent, that has been stored for some time, can lead to incomplete cleaning. Isopropyl alcohol is used extensively in the industry, as a flux remover and general circuit board cleaner. 70% IPA or “rubbing alcohol” already contains 30% water, and even 99% anhydrous alcohol is hydroscopic and will absorb water from the air during prolonged storage. Diluted IPA is a poor solvent for rosin-based fluxes, and will not dissolve heavy contamination without lengthy exposure time. Also the water in the solvent can react with no clean fluxes, leaving a white residue on the board.



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In hand soldering operations, there is a general tendency to use too much flux solution, leading to a heavy build-up of contamination, which is not easily removed with a single pass through the cleaning process. Repeated runs through the cleaning line will eventually remove this built-up residue. Using too much flux can also lead to flux solution being trapped underneath components. Cleaning must be performed in a manner that flushes this contamination from underneath the components; otherwise partial removal will result in rosin contaminant draining across the board after initial cleaning has been completed. Increasing the residence time of the board with the flux remover can prevent this from happening.

A general mismatch of the cleaner to the contamination type can be inferred by examining how the contamination coats the board. If the areas of residue are patchy in nature, then incomplete cleaning is indicated. Increase cleaning time and/or temperature. If the contamination appears as an even layer over the board surface, then you are not using the right cleaner for the residue present. Cleaners containing HCFCs, like Electro-Wash® PN and Flux-Off® No Clean, will not attack synthetic no clean fluxes, and may even react with the flux, causing the formation of white residue. Usually this type of residue can be removed by using an aggressive cleaner like Flux-Off® Heavy or Flux-Off® No Clean Plus.

Detergent saponifier cleaners, like the Flux-Off® Aqueous ES132, can attack the surface of the solder joints and form a layer of lead and tin oxide film, if the cleaner is used in concentrated form. This is why we recommend that the ES132 be diluted as much as 1:10 with water, for most applications. Flux-Off® Aqueous will also attack metals such as aluminum, and metal-plated surfaces that contain phosphorus, leading to residues of lead and tin oxide or a phosphorus/tin oxide film. These white residues can be transferred to the circuit board during the cleaning process. Masking such metal surfaces, prior to cleaning, will eliminate the formation of these residues.

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