Commentary

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How Clean is Clean?
The Case Against Bulk Resistivity Testing

In a recent trade journal article, the question was posed - "why do we need different or more expensive cleanliness tests with made-up methods, and cleanliness levels?"

And, in response I ask, "Why doesn't the industry trade association state the limits for traditional ROSE (Resistivity of Solvent Extract) in J-STD-001 for all fluxes like it does for R0 and R1 (rosin) type fluxes? Does using the J-STD-001 value rosin fluxes of 10 ug/in2 (1.56 ug/cm^2) sodium chloride (NaCl) equivalents allow all assemblies to perform well in the field? Since fluxes are oxide removing residues, should they act the same chemically?

Ion Chromatography (IC), a sophisticated analytical method that separates and speciates the ionic and organic residues remaining on the board assembly, comes under fire in the article. The author suggests that higher limits of weak organic acids allowed for IC testing are unrealistic and cause confusion when applied to the ROSE test. It is my opinion that the two tests are unrelated and un-correlateable, but may, periodically, trend in the same direction.

Let's review a few important points about the little changed, more than 30-year old ROSE test method. A PCB assembly of any size is immersed in a 3-5 gallon *bucket* of a solution of isopropyl alcohol and DI water (IPA 75% / DI 25%). The board, in slightly heated or ambient conditions, is allowed to sit in contact with the solution for at least 6 minutes or up to 60 minutes and then the measurement is made. The measurement is a general assessment of the IPA/DI solution's conductivity before and after sample exposure. Once complete it is then compared to a sodium chloride (NaCl) standard to determine the solution's conductivity. This tool does not measure the amount of NaCl on an assembly surface, but the gross conductance of any ionizable residue that goes into solution.

Once the initial test is complete, the board is never rerun to determine if any additional residues have leached from under components, edges of circuits or from within the board material.

Can You Dig It
What I've found interesting is that PCB assemblies built with rosin fluxes and cleaned in solvents as far back as the 60s have all exhibited the same effect – excellent field performance. Back then, cleanliness was not a problem for through-hole and mixed-technology assemblies.

As I analyzed product from this era using Ion Chromatography (IC), an interesting data point emerged. A typical 18-25% solids flux left 9,000 ug/in^2 of abeatic acid (rosin) on the surface before cleaning. After cleaning, the abeatic acid level had dropped to 2,800 ug/in^2. Visually, the boards did not appear to have a residue, but if you looked hard enough or with the proper tools, the residual flux was very visible. The flux formed a layer of varnish on the surface of the assemblies. This varnish locked up flux activators (halides) and PCB fabrication contaminants. IC analysis also resolved chloride levels as high as 25 ug/in^2 with no detrimental effects noted in system performance (under-hood automotive, military avionics).

I'm Down Wit Dat
Later, as the industry moved to new flux technology and new processing techniques, it became the best practice to use non-rosin based fluxes on smaller and increasingly circuit sensitive assemblies and not clean the assembly. In many cases, no-clean technology has worked. In many it hasn't – why?

When this product is tested with the ROSE process test, test data results of 0.1 ug/in^2 or 147 ug/in^2 result in field failures not due to the conductivity, but to residual contaminants creating electrochemical migration problems. How come? Doesn't a ROSE result of 10 ug/in^2 or less indicate an acceptable board assembly – a clean assembly?

As circuit sensitivity and spacing become more critical, judging the cleanliness of an assembly using a cleanliness value derived from a measurement taken from entire surface of an immersed assembly is ludicrous.

The ROSE testers are gross process indicators for the production floor, but are a poor gauge of cleanliness in terms of predicting product performance.

Today, the cleanliness of specific areas of the board is much more critical than the normalized effect of examining an entire surface area. With no-clean fluxes and cleaning processes, pockets of contamination can

be present pad-to-pad, circuit-to-circuit or entrapped beneath a low stand-off component. Because of this, it becomes absolutely critical to understand the contamination effects in specific areas.

New tools are being developed to assess residues using localized extraction and are capable of providing understanding of residue effects while a board is still on the production floor. Laboratory testing, ion chromatography, can be reserved for process qualification and failure analysis instead of process control. These industry developments and subsequent specifications are necessary to provide electronics manufacturers with meaningful process control and monitoring data right on the production floor.

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