

DETECTING FLUX RESIDUE

How Can There be *any* Flux Residue When the Ionograph Reads 0.00?

An acceptable ionograph measurement does not mean a circuit board is acceptably clean. It means that the operational limits of the ionograph machine have been reached, and its chemistry and method of application cannot penetrate further into areas of entrapped flux to detect additional amounts. Substantial flux deposits may exist beyond the detection capability of the measurement system. In order to measure total residual contamination, the ionograph fluid must penetrate and solubilize flux residue better than the cleaning system. According to Mr. Terry Munson, President of Contamination Studies Laboratory, “a bulk resistivity meter... is a gross detection method of *surface* residues... The meter has the ability to measure large changes in the cleanliness of a *manufacturing process*. It is primarily used as a *trending tool* and *not* to determine specific levels of cleanliness” (emphasis added).¹

Even if the ionograph *were* able to measure total flux residue, its computation algorithm calculates a ratio of contamination as though it were a film uniformly spread over the entire surface area of the product. Even minimally effective cleaning processes result in *exposed areas* which are virtually 100% free of visibility and ionic contamination. But where entrapped flux residue remains, *usually near conductors*, the flux coated surfaces *at that site* are 100% contaminated. Even with products of only nominal life expectancy, field reliability problems occur, not because the entire board surface gradually becomes conductive or corrodes, but because localized current leakage or blockage occurs at isolated sites. Without adequate cleaning, flux residue is found at one or more, often many, isolated sites.

Isolated sites may include the entire space between the board surface and the facing surface of large packages, forming a flux sandwich. Densely populated PWAs multiply the volume of entrapped flux by the number of packages on the board. The ionograph detection method has access solely to the exposed edge of the sandwiched flux, which may be only a few mils thick, and obscured by fine pitch leads. But depending upon package types, *the flux layer at each site may be one inch square* or more. Other isolated sites may include connectors, sockets, housings and stacking arrangements having cavities into which large amounts of flux residue flow through a narrow opening during the soldering process. Isolated sites may also be the inner solder fillets of chip capacitors, a difficult cleaning site in many instances, and multiplies by the number of chip capacitors present. A single board may possess many isolated sites. The simplest, most common and only sure method of flux residue detection is magnified visual examination at probable sites with the components removed. From this criteria for cleanliness, an effective cleaning process can be developed, and repeatability and uniformity can be monitored.

What Difference Does a Little Flux Make?

During the soldering step, flux residues combine with other heat-released agents from the materials of the substrate and components. These are known to be various combinations of “metallic dendrites, (such as) tin, lead, and/or copper containing compounds...sulfates, chlorides, bromides, sulfonates, hydrofluoric acid, sodium ion and ammonium iron.”² The source of these contaminants is “board processing-fluids, laminate flame retardant degradation, solder mask residues, plating bath residues and handling contaminants. (The) cumulative effect of the board level, component level and handling contaminants can combine to create the conditions for a corrosion cell or electrochemical migration”.¹

Mr. Tim Crawford, of the U.S. Navy Center of Excellence states “Ionic residues conduct electrical current and in the presence of moisture, can cause short circuits and corrosion of solder joints. Nonionic residues act as insulators and ..can inhibit current flow across edge connectors or some other communications port.”³ Textbook author/editor Mr. Les Hymes writes—“Postsolder cleaning is needed to:

- Remove residue which could contribute to electromigration and result in current leakage between circuitry.
- Eliminate the possibility of corrosion of circuitry and component packages as a result of flux residues.
- Provide for reliable adherence of correctly applied protective coatings by removal of materials which might result in porosity or reduce the bond strength between the coating and the substrate or components.”⁴

When flux residues remain entrapped due to inadequate or non-existent cleaning, the product’s long term reliability risk worsens. The responsible engineer must determine a balance between the manufacturing costs associated with total flux removal and the *total cost* of field failures attributed to the alternative. For many, the application demands scrupulous cleanliness: as in biomedical, aerospace, avionics, communications, military, automotive and advanced interconnect products. For others, product life expectancy may not merit the expense; such as inexpensive consumer products. For all, the consequences of misjudging the need for total flux removal should be fully understood before accepting anything less.

References:

¹ Munson T, and Ford M, “Component Cleanliness,” *Circuits Assembly Asia*, pp 34-38, (Summer 1993)

² Hwang J, “Case Study assessed No-Clean Reliability,” *SMT*, p 20, (May, 1994)

³ Crawford T, “Why the Military Will Never Accept a No-Clean Flux,” *Circuits Assembly*, (Sept, 1992)

⁴ Hymes L, *Cleaning Printed Wiring Assemblies*, Van Nostrand Reinhold, New York (1991)