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STANDARDS

From Maintenance to Precision: The Value of a Stencil Cleaning Handbook

During the infancy of surface mount technology, cleaning 50 mil-pitch brass stencils and emulsion wire screens was a fairly straightforward task for a third-shift maintenance crew using a CFC solvent vapor degreaser. The past 30 years have produced changes driven by environmental regulations and the "faster, smaller, cheaper" technology syndrome: brass to stainless to nickel, chem-etch to laser to E-fab, solvent to semi-aqueous to aqueous, vapor to spray to ultrasonics, RMA to water washable, to no-clean and now lead free. What will be the standard tomorrow? The only thing for certain is change. IPC is providing help with the new IPC-7526 *Stencil and Misprinted Board Cleaning Handbook*.

As little as 10 years ago, stencil cleaning was considered just a maintenance job; just clean it before returning to inventory. However, now knowing that more than 70 percent of assembly defects originate from the printing process, concern over stencil cleanliness has heightened and stencil-cleaning technologies are scrutinized. But committing to a stencil-cleaning process was not dissimilar to committing to a video system — VHS or Beta, VCR or laser disc, CD or DVD? Plus, video systems did not have environmental repercussions associated with them as do stencil cleaners. Many assemblers found themselves going through three or more different stencil cleaning methods to remove solder paste (Figure 1) in an attempt to keep up with technology and environmental regulatory changes.

Face it. In 1989, everyone was happy with their stencil cleaning process before researchers discovered that gaping ozone hole over Antarctica and got most of the industrial world to agree to eliminate CFCs (chlorofluorocarbons). It's one thing to have to research a new cleaning process because you're not happy with the current one. But, it is nothing short of aggravating to have to change a perfectly good process just because the government says it's necessary to save the Earth as we know it. After all, we are paid to make PCBs faster, smaller and cheaper, not to replace a perfectly good cleaning process.


Figure 1 — Solder paste build up

Where there's change, there's opportunity, and the 1990s certainly provided opportunities for stencil cleaner manufacturers. CFCs had to be eliminated. Almost everyone was using an RMA (rosin mildly activated) flux. Saponifiers proved capable of converting the RMA flux to a water-soluble soap so DI water could be used to remove the soap residue. Simple, just switch to aqueous saponifiers, spend about $100K on new board and stencil cleaning equipment, and get on with the business of making faster, smaller, cheaper PCBs.

Saponifiers could have been the end of the story if it wasn't for the fact that saponification typically requires temperatures in excess of 140 degrees F (60°C).

From day one, solder paste screens and stencils were cleaned using CFC solvents at low temperatures. By switching to saponifiers it was soon discovered that stencils were heat-sensitive. The metal-etched foil was attached to an aluminum frame and polyester screen using a heat-cured epoxy adhesive. Plus, the expansion coefficients of aluminum, stainless steel and polyester are significantly different causing additional stress on the adhesive bond when exposed to hot wash solutions or hot drying air. Epoxy debonding quickly became an issue when stencil cleaner manufacturers adopted the use of hot saponifier chemistries.

Ah, change — more opportunity. After selling hundreds of stencil cleaners to use hot saponifiers, the industry was forced to adopt another chemistry. Unfortunately, the "deep pockets" necessary to perform the research rested with the PCB cleaning companies. The small companies that made stencil cleaners were accustomed to just "spraying" whatever chemistry was used to clean PCBs. This concept was sound for using CFC solvents because the solvent could be used at ambient temperature. When saponifiers proved to be incompatible with SMT screens and stencils, the only other chemistry commonly used to clean flux was isopropyl alcohol (IPA). Enter the era of IPA stencil cleaners.

IPA cleaned RMA solder paste fairly well and stencil cleaner manufacturers were quick to begin making IPA stencil cleaners. IPA stencil cleaners were manufactured with appropriate safeguards to reduce the potential for ignition spark. Unfortunately, it was later discovered that an ignition could originate from other sources such as a mechanical spark of metal spray nozzles hitting a metal stencil, an unsuspected static discharge or from other electrical equipment in the area.

On a separate front, the solder paste manufacturers were busy developing “no-clean” and “water washable” solder paste. Stencil cleaner manufacturers focused their efforts on water washable solder pastes because the chemistry was readily available — water. However, process engineers had a basic choice to make — adopt a water washable process and spend lots of dollars on cleaning and wastewater equipment or adopt a no-clean process and not clean at all.

Those that went water washable usually had equipment that could be converted or retrofitted from IPA to H2O. Those that went no-clean thought that they would save the cleaning costs and proceeded to remove their inline cleaning machines. Unfortunately, even with no-clean assembly, the stencils still had to be cleaned. More change, yet more opportunity.

Stencil cleaner machines now need to clean no-clean solder paste and, in some cases, water washable and RMA pastes too. Many users moved away from alcohol and saponifiers in favor of a chemistry that could clean this broad spectrum of fluxes. Other solvents had inherent VOC (volatile organic compound) and health/safety hazards associated with them. Semi-aqueous technologies were briefly introduced for cleaning stencils but it was reasoned that if water was to be introduced into the process, why not just use water and eliminate the solvents completely? Special water additives (surfactants) were needed to clean solder paste at low temperatures.

Surfactants are wetting agents that can be formulated into detergents to clean specific contaminants using designed process conditions and various cleaning machines. Finally, it looked like there was an environmentally safe aqueous answer to the problem, but wait, why are the pallets becoming so dirty? Oh, that’s right, the inline cleaner went away as PCBs are no longer cleaned and now the pallets are no longer cleaned either. This sounds like another opportunity for the stencil cleaner.

Now, all that needs to be done is to formulate a detergent that will clean solder paste and post solder flux residue. Oh, while you’re at it, you may as well make it clean component mounting adhesives too.

Okay, detergents are the way to go and the last stencil cleaner ever needed could finally be purchased … if it wasn’t for fine-pitch.

The fine-pitch apertures of a stencil created the next opportunity. To the naked eye, the stencils appeared to be clean, but misprints mysteriously increased. It seemed that the surface of the stencil was getting cleaned, but many of the smaller apertures remained contaminated. A small amount of solder paste left in the aperture would “dry like cement” and resulted in a “snowball” effect. The dry paste would attract more paste and soon the aperture became blocked and insufficient paste deposition resulted. If the existing machine and chemistry could not clean the fresh paste, dry solder paste would prove impossible.

The need for an alternative stencil cleaner was once again evident. The microscopic cleaning action (cavitation) of ultrasonic technology could deliver the cleaning solution into ultra fine-pitch apertures. But if someone tried to use ultrasonic stencil cleaners with PCB technologies would there be compatibility issues? In the 1950s, the U.S. military tried to clean boards using ultrasonics, but circuit boards at that time were very delicate and the ultrasonic technology was very aggressive and uncontrollable. Today’s ultrasonic technology is the most controllable precision cleaning technology available and the SMT boards are very durable making the two technologies very compatible, given the proper frequency and power density parameters.

What’s an assembler to do? If you are a survivor of this debacle, you have probably learned about stencil cleaning technology the hard and expensive way. For everyone else, IPC has published IPC-7526 *Stencil and Misprinted Board Cleaning Handbook*. This wealth of information is a concerted effort by industry experts to help guide the reader through the pros and cons of stencil and misprinted board cleaning chemistry and machine and waste management technologies that are currently available to meet today’s cleaning needs and environmental restrictions.

The handbook is available as a free download from the IPC Web site at www.IPC.org/onlinestore
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