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SURFACE MOUNT STENCIL CLEANING

By Nick J. Lester

Eliminating tradeoffs, improving throughput and protecting the environment.

Two drivers are dominating PCB manufacturing: the push for smaller, faster, more complex assemblies, and the demand for environmentally safe processes. The former is a function of advancing silicon technology - component size continues to decrease while functionality continues to increase. The later is driven by a real concern for air and water quality. While some may argue that the Greenhouse Effect is a figment of the bureaucratic imagination, signatories to the Montreal Protocol, the United Nations Environment Program (UNEP) and the U.S. Environmental Protection Agency (EPA) have, together and separately, worked to eliminate CFCs and other chemicals linked to ozone depletion.

Of course, there is a third driver - profitability. OEMs and contract manufacturers are reevaluating processes across the board to find those technologies that can minimize defects while increasing throughput and yield - thus pushing profitability...not an easy task.

What the industry has come to realize is that the balance between throughput/quality and environmental concerns results in tradeoffs, particularly in the area of cleaning. Many of the no-clean technologies may meet government limits for air and water pollution but may be too expensive to use or may not leave the assembly clean enough. On the other hand, cost-effective technologies may not meet government requirements - particularly in states like California where local restrictions are sometimes tougher than federal limits.

CAN STENCIL CLEANING MAKE THE DIFFERENCE?

Often, it's the processes that seem "simple" that yield a greater improvement in total efficiency and improved quality. Case in point - stencil printing and cleaning.

The "art and science" of stencil printing has moved from simple to complex as smaller components and less board real estate have become mainstream. Reduced lead pitches are demanding that stencil printing be more precise. In turn, today's stencil printing systems are sophisticated and expensive.

Regardless of how the solder paste is dispensed - and there is controversy concerning the most accurate way to do this - one key to performance is the stencil itself, and how thoroughly the stencil can be cleaned. A study, published in the Proceedings of the 1993 Surface Mount International Technical Program (Vol. 1, pp. 157-166), indicated that 51 to 72% of all solder defects were the result of screen-printing problems.1

Particularly when smaller components are required, a less than clean stencil spikes defects, raising ppm rates to untenable levels. Zero contamination is necessary in a tight margin, highly competitive world.

One way to assure consistent solder paste deposition is to guarantee the cleanliness of the stencil itself. If apertures are clogged (and there is an increased risk of clogging with today's fine pitch devices), or if solder paste remains on the bottom of the stencil, printing defects will result - shorts, opens, etc. At established intervals, stencils must be cleaned. How often depends upon the type of paste, the type of stencil, the size of the apertures, and the lead size. If not cleaned thoroughly, solder balls left inside apertures can dry like cement creating an obstruction and impeding paste transfer. Once dried, most stencil cleaners cannot remove it and the problem compounds itself.

In some cases, cleaning the surface of the stencil can be accomplished without the need for any type of chemistry - a roll of lint free paper simply wipes the stencil. However, total cleaning of the surface and apertures requires the use of a chemistry, and herein lies the problem.

To completely clean the stencil, a CFC-based solvent was the ideal choice - until, that is, environmental concerns eliminated the availability of CFCs. Replacement chemicals, alcohol- and terpene-based chemistries, have come online, but these require tradeoffs: some selectively clean a few pastes well, but are flammable or present health hazards; others clean well but can damage the stencil (or the substrate itself when chemistries are used to clean residue from misprinted PCBs); others are simply too expensive, while many aqueous-based products clean well in the post solder cleaning of PCBs where wash temperatures may reach 140 - 160o F, but fall short in the presolder cleaning of screens and stencils requiring ambient cleaning temperatures.

Because few stencil cleaner manufacturers will guarantee the performance or environmental soundness of their systems, PCB manufacturers are placed in the difficult position of evaluating stencil cleaners for efficacy, safety and health concerns, while balancing environmental restriction with cost and overall processing speed. In addition, as there are no industry standards for stencil cleanliness, it has been relatively easy for suppliers to claim that they have a safe and effective method of stencil cleaning without necessarily having the hard data to back these claims.

STENCIL CLEANING CHOICES

Cleaning stencils presents manufacturers with several decisions. For one, can under stencil wipes or individual stencil towels work effectively? For thorough cleaning, are solvents or aqueous detergents the preferred method? If solvents are used, which ones offer the best cleaning while meeting industrial safety and environmental requirements? Finally, do criteria exist by which aqueous cleaners can be judged?

In high-volume, fine-pitch surface-mount settings, wipes are not sufficient. The use of wipes is, at best, a semiautomatic process that requires time and patience. And, in applications requiring deep cleaning, wipes are not effective even when combined with a solvent. Granted, the environmental impact of wipes is minimal; yet, the combination of various types of paste and smaller, tighter tolerances makes them effective in basically "hand-held" applications.

Saponifiers have been used when cleaning PCBs themselves. For stencils, however, they present problems. Saponifiers require heat to work, which is not a problem for PCBs. However, it is a problem for stencils, which are manufactured using heat-cured adhesives. The temperatures required for saponifiers can delaminate the stencil. The hot water and hot drying air break down the stencil, which is obviously not cost-effective. Worse, the use of hot water and hot air causes metals used in the stencil to expand and contract. Since stencils are made with a combination of metals (aluminum, stainless steel, polyester and Metal foil), the differing rates of expansion and contraction destroy its accuracy.

Alcohol and terpene solvents are also used for cleaning stencils. Both have the advantage of working with ambient temperatures, thus, eliminating the problems encountered with saponifiers. However, both have drawbacks.

Citrus-based terpenes may be safe for the ozone layer, but they may affect workers with their smell. Terpenes are also slow to dry, slowing production. Contrary to common belief, terpenes are not environmentally safe. They leave a residue that must be rinsed away. The resulting wastewater is not at all safe for the environment. Finally, both terpenes and alcohols are flammable.

Even so, many used terpenes to clean stencils until no-clean solder pastes appeared. These new formula pastes could not be cleaned with either terpenes or alcohols. Now, add fine-pitch and ultra fine-pitch apertures, and the effectiveness of both cleaners was severely compromised.

AN EFFECTIVE ALTERNATIVE

If chlorinated solvents like 1,1,1-TCA and other CFCs can't be used to clean stencils - and the Montreal Protocol has eliminated this possibility by banning production as of January 1, 1996 - experts agree that the best cleaning chemistries for stencils are detergent-based. Not to be confused with saponifiers that require heat and clean by chemical reaction, detergents are surfactants (wetting agents) that can be formulated to perform certain cleaning tasks and achieve specific cleaning objectives. If formulated properly, detergents can offer a good level of cleaning while doing no environmental harm. A correctly formulated detergent would not deplete the ozone, would not contain volatile organic compounds (VOCs) or flammables, and would not damage the stencil.

With the exception of increased drying time (alcohol- and terpene-based cleaners dry quickly because they are VOCs), aqueous cleaners appear to be superior. However, there has been a problem: many aqueous cleaning chemistries require a certain amount of heat to work - and heat creates problems for stencils. The resulting expansion and contraction of the screen and its frame can alter the tension of the screen or cause detachment of the screen altogether because the adhesive bonding the screen to the frame and metal etched foil is heat-cured. The thermal shock of hot wash solutions and/or hot drying air can degrade the adhesive bond causing the screen to detach from the frame or etched foil. Once stainless steel expands, it is unlikely to contract back to the exact original position causing distortion of fine-pitch apertures. This all leads to misprints, slow throughput and increase defects.

The ideal cleaning system would feature a unique chemistry that addresses these problems, while at the same time delivers environmentally safe processing. It should eliminate the potential for damage that high-pressure spray can cause to the delicate land mass areas of a fine-pitch stencil and should contain no CFCs, VOCs, flammables or other hazardous ingredients. The system should operate at ambient temperature, conserving energy and maintaining stencil integrity over systems requiring heat; eliminate liquid hazardous waste disposal; and present no health, fire or explosion hazards.

Just as important, the chemistry should clean all types of solder paste, flux residue and surface-mount device adhesives faster and more effectively than CFCs or other solvents. The ideal chemistry would replace alcohols, terpenes and hot/corrosive saponifiers with a mild alkaline (<12.5 pH) detergent that cleans effectively at ambient temperature.

Because the ideal detergent should contain no VOCs, flammables or other hazardous ingredients, it can be safely evaporated to atmosphere in standard wastewater evaporating equipment. By evaporating the wastewater, liquid hazardous waste disposal would be eliminated. The non-hazardous liquid waste could go to atmosphere, reducing everything down to the original solder paste that can be recycled. Nothing would go to drain, and the customer would be completely removed from the associated liability.

ENTER ETV

In an effort to help speed the implementation of environmentally safe products and processes, and to help consumers verify the efficacy of these solutions, the US Environmental Protection Agency (EPA) began its ETV Program - Environmental Technology Verification Program. The ETV Program was created, according to EPA, "to substantially accelerate the entrance of new environmental technologies into the domestic and international marketplace. It supplies technology buyers and developers, consulting engineers, states, and U.S. EPA regions with high quality data on the performance of new technologies. This encourages more rapid protection of the environment with better and less expensive approaches."

Under the ETV Pilot, operated by the Cal/EPA's Department of Toxic Substances Control (DTSC), the program evaluates and verifies the efficacy of pollution prevention and waste management technologies. Evaluated products, if they are found to perform as required receive certification and a verification statement that gives users an unbiased appraisal and gives regulatory agencies a technical evaluation designed to facilitate local permitting and use.

HOW THE PROGRAM WORKS

Cal/EPA and the U.S. EPA look for companies with innovative environmental technologies (Sidebar). For those technologies selected for evaluation, Cal/EPA, under the auspices of the U.S. EPA, establishes multidisciplinary teams which, in consultation with the applicants, identify the specific performance claims and establish criteria for evaluating claims. The technology evaluation teams review and approve test plans, and review the results of the field tests in conjunction with other technical information submitted with the application. Proposed verification and certification decisions are published for public review.

The Cal/EPA program has been so successful, with 26 certifications approved since 1994, that the program itself is serving as a model for EPA's national technology verification plan. California officials are working with other states and Canada to establish reciprocity. In fact, the program being established in Canada is modeled after the California program.

"We don't just verify technologies, we certify technologies here in California, and that makes the ETV pilot program unique," says Project Manager Pat Bennett. "We are geared to test and evaluate technology to help with the commercialization. If the specific technology passes, it will receive a Certification from California's Secretary of Environmental Protection and the U.S. EPA."

What makes California certification so important is the fact that the state's environmental standards are, in many instances, more strict than many national and international standards. For example, industries large and small - from auto repair garages and printers to high tech PCB assemblers and aerospace manufacturers - must begin using water-based cleaning chemistries by the year 1999 under recently adopted California Air Quality Management District (AQMD) rules. Companies using clean air chemistries will be exempt from record-keeping requirements and emissions fees under AQMD regulations. Savings in emissions fees and recording keeping will help offset any cost associated with a new cleaning process.

NO MORE TRADEOFFS

Stencil cleaning CFC alternatives should require no tradeoffs. The ideal detergent should safely remove all types of solder paste and should deliver the ideal balance among cleaning effectiveness, environmental concerns and cost.

In high volume assembly, the ideal detergent should maintain stencil cleanliness while reducing misprints in the most advanced ultra fine-pitch and flip-chip applications. An ideal aqueous chemistry should also be nonflammable, present no health hazards, have no environmental impact and operate at ambient temperature. The result of cleaner stencils is higher throughput, fewer defects, and lower overall stencil cost and higher profitability.

REFERENCES

1. Proceedings of the 1993 Surface Mount International Technical Program (Vol. 1, pp. 157-166).

Nick Lester is a past editor of Printed Circuit Assembly (now Circuits Assembly). He is now U.S. director for Vertical Marketing, Wimborne, England; e-mail: njl@atlcom.net.

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Stencil Cleaner Selected for EPA Verification

As of press time, Smart Sonic's (Newbury Park, CA) stencil cleaner has been the only aqueous cleaning system of any type selected for verification and certification under the Environmental Protection Agency's (EPA) ETV program (Environmental Technology Verification Program). That process, now under the direction of Project Manager Pat Bennett and DTSC Assignment Manager Tony Luan, is well into the evaluation phase. DTSC engineers, with help from Lawrence Livermore National Laboratories and the U.S. EPA, have developed the criteria by which the company's aqueous cleaner is being evaluated. According to Bennett and Luan, the evaluation period began in early May of this year. If the stencil cleaning chemistry performs as expected, approval should be forthcoming.

"Part of the plan to verify the Smart Sonic process consists of analyzing their aqueous cleaner, doing surveys with users and on-site observations of their system, and verifying cleanliness by magnified inspection of the surface and inside apertures of the stencil after cleaning," says Luan. "We will also bring a hygienist to observe the system and those using it to make sure there are no health hazards."

The evaluation plan for Smart Sonic includes a laboratory analysis of the 440-R¨ SMT Detergent and performance evaluation of the Smart Sonic Cleaning System. Lab analysis will determine if the cleaner contains detectable heavy metals, mercury, pH, ozone depleting compounds (ODC), global warming compounds (GWC), volatile organic hazardous air pollutants (VOHAP), or other VOCs.

AQMD Certification Granted

Seeding the process is the fact that 440-R" SMT Detergent has already been lab tested by California's South Coast Air Quality Management District (SCAQMD). The cleaner has been certified (October 16, 1997) as a "Clean Air Chemistry" by SCAQMD and, as of press time, remains the only stencil cleaning chemistry to attain this certification. The ETV project team will validate the SCAQMD lab results as part of the ETV certification.