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New Solvents Simplify "No-Clean" Soldering on the Benchtop

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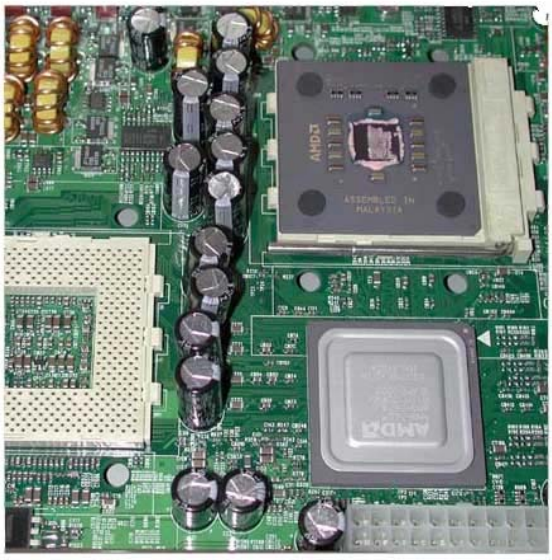
In the electronics industry, circuit cleaning has become the pariah everyone seeks to avoid. Cleaning with CFCs has been blamed for many environmental problems; water cleaning has been attacked for being energy-intensive; semi-aqueous cleaning creates waste disposal problems. Today's technical literature delivers the impression that anyone who still cleans must have rocks between their ears; all the smart money is on "no clean" fluxes and pastes.

But across the globe, people are still cleaning and "no clean" technologies are not meeting their promise. Here is the simple truth: many of today's new assembly processes have increased the demand for post-assembly manual soldering; what used to be called "rework and repair." This trend been exacerbated by the enthusiasm of many companies in their switch to "no clean" fluxes. But hand soldering almost always means hand cleaning, so thousands of companies are cleaning their "no-cleans."

The Unexpected Emphasis on Manual Soldering



There are three reasons for the remaining prominence of hand soldering:

- **The Market.** The electronics industry is suffering through an abbreviation of product life cycles. Manufacturers, striving for the thinnest competitive advantage, demand newer, high performance component designs. In turn, these require faster, cheaper, more accurate manufacturing technologies. When these technologies are in their formative stages - and they all are new when you're changing designs every eight months - errors increase, so manual soldering increases.

- **The Technology.** Cleaning was often the single greatest source of latitude in the soldering process. Today's finely-tuned systems have virtually no latitude for assembly variation. Switching preheaters, timers, conveyor speeds, fluxes or solders can knock automated manufacturing processes askew. This forces product back into the rework environment.

- **The Investment.** Customers often find there is one awkward component or connector that needs to be soldered, such as a power supply or a large capacitor, that the auto-insertion systems could not handle. The capital required to handle unusual sizes and shapes is huge. Therefore, many customers end up sending many of their boards to the technician's bench for a quick change/add.

Manual soldering is here to stay: it is the most cost-effective technique to solve minor production irregularities. Given that hand soldering is required, can engineers dispense with cleaning? Probably not. In theory, substantial savings could result if the cleaning step could be avoided. But it's hard - very hard - to implement on the rework bench. Soldering with "no clean" fluxes is like tying to solder without any flux. Weak solder joints, uneven solder joints, solder balls and solder bridges are very common, especially on fine-pitch devices.

The biggest problem lies with speed: "no clean" fluxes slow operators down. Technicians are tempted to short-cut the soldering process. Suddenly tip temperatures jump. Pre-tinning tips and tip cleaning is skipped. Extra spool solder is used to add more flux to the joint. Add to this the very human aspects of fatigue, illness, a hangover, or boredom and erratic results become the norm, not the exception. In short, it has been the authors' experience that "no clean" fluxes work best (a) in high volume automated soldering systems or (b) when used with low-cost cleaning systems on the rework bench.

The best choice out of this dilemma is to make cleaning on the workbench simple, safe and cost-effective. Many companies use modern, inexpensive benchtop cleaning systems with advanced solvents designed for today's electronics. Available from a wide variety of vendors, these systems will allow techs to clean quickly and conveniently at the benchtop. Long-term, the techs will solder better, the products will last longer, and the environmental issues will have been avoided while overall unit production costs are reduced. Here are some choices to handle this unloved-task.

Alcohol-Based Cleaning Choices Are Economical to Buy But More Expensive to Use

Many "no clean" fluxes are thinned with alcohol; some are thinned with water. Any material that will thin the flux will also clean it. The trick, of course, is to be sure the cleaners do not leave more residues behind than they remove.

Traditional alcohols are mild, proven circuit cleaners. They are both cheap and safe. As cleaners, they will be effective on most fluxes,

light oils and light grease and are compatible with nearly types of plastics and elastomers. Their toxicity is well-known and there are few handling problems with these cleaners.

Problems with alcohol are more likely to come from contaminants than the alcohol itself. Alcohols are frequently diluted with water to lower their cost. Savvy customers always specify the grade of alcohol they require because alcohols are hygroscopic, which means they absorb water out of the air. Sloppy storage and handling will result in this self-contaminating process degrading the quality of the cleaning job.

Another major concern is the aroma, flammability and handling. Open trays of alcohol are simply not safe; the re-filling of pump bottles creates the risks of spills and handling hazards. In areas of poor ventilation, the risk of dizziness, blurred vision and drowsiness is quite severe, so safety training will be a key issue. Engineers must be careful to design and implement new procedures for handling and using these flammable solvents. Periodically it also is wise to review compliance with those procedures, particularly among new employees.

Lastly, alcohols are ozone-safe but are volatile organic compounds (VOCs). VOCs contribute to low-altitude smog, just like gasoline and paint. VOCs are going to be more strictly regulated in the years ahead, as the State of California has shown, so developing a critical process based upon a vulnerable solvent may not be wise.

Hydrocarbon Cleaners Offer Good Economics and Moderate Cleaning Power

Axarel® 2200 is an ozone-safe defluxer specifically designed for "hand-wipe applications" by Petroferm Inc. of Fernandina Beach, Fla. Blended from petroleum products, this aliphatic hydrocarbon solvent offers great cleaning and versatility. It is very distantly related to mineral spirits or Stoddard solvents and also are known as "oxygenated solvents" by British Petroleum, which markets a related family of products under the brand name "Prozone." Other hydrocarbon-based choices include the RossTech family of cleaners, from Rossi Technologies in New York, and the Zestron family of cleaners from Germany.

The fastest-drying hydrocarbon formulation is Axarel® 2200. It was originally formulated to meet the demanding requirements of hybrid circuit manufacturers. Engineers appreciate the versatility of Axarel® 2200. It works well on rosin fluxes, synthetic fluxes, water-soluble fluxes and even "no-cleans." It easily dissolves both organic and inorganic (ionic) deposits, light oils, grease, some conformal coatings and even some inks. Non-corrosive Axarel® products are suitable for all types of electronics including surface mount boards, hybrids and connectors. Axarel® 2200 has received IPC approval for MIL-STD-2000.

With modestly low flashpoints, it is combustible and the usual precautions are required, including specific training for users on the safe and efficient handling of this material.

None of the ingredients are known or suspected carcinogens.

Terpene Cleaners Are Versatile, But Have Handling Problems

A radical innovation when they were introduced into the electronics industry, terpenes are now a well-known, proven technology. Terpenes are a type of chemical - distantly related to turpentine and fluxes - that are produced by every green plant. Years of experience have shown them to be non-toxic, highly effective cleaners that work on every type of flux. Terpenes also are very safe for people: terpenes are often found in ice cream and chewing gum, and many popular household cleaners use a terpene base. For cleaning "no cleans," however, terpenes are far stronger than most applications require.

For use in the electronics industry, terpenes come in pine and citrus types. For use on the workbench, special "no-rinse" citrus terpenes such as Bioact® EC7M have been developed and widely used for years. For technical reasons there are no pine terpenes which are residue free (they must always be rinsed) so they are rarely used in manual cleaning applications. Citrus terpenes are fairly aggressive cleaners so compatibility testing is strongly suggested. Good ventilation is required because the characteristic citrus aroma of the cleaner can be quite annoying to some techs.

Siloxanes Are Powerful, Easy to Use, and Low VOC Cleaners

In the search for an environmentally perfect cleaner, volatile methyl siloxane (VMS) cleaners are an unexpected answer. Widely used in the cosmetics industry, the VMS chemistries are powerful cleaners that quickly and easily remove standard contaminates from PCBs. Engineers and operators both like VMS solvents because they are easy to use, aroma-free and generally non-toxic. In short, for benchtop applications where skin contact is likely, the VMS materials are a great choice.

Importantly, siloxanes leap ahead of the competition with an exceptionally strong environmental pedigree. The VMS chemistries are produced from widely available natural resources, are exempt from VOC regulations and will not cause global warming. This superior environmental record leads some industry pundits to predict that the VMS cleaners may be the only product on the market today that will still be available twenty years from now.

Siloxanes are available as defluxers and as degreasers from Dow Corning, the giant U.S. chemical company. Extensive beta testing of Dow Corning's OS-120 has shown it to be a superior defluxer that can remove all types of fluxes, including no-cleans. Preliminary tests show excellent results on both organic and inorganic deposits. Completely volatile, OS-120 out-cleans CFCs and even the aggressive HCFCs without the need to be rinsed. Completely plastic-safe, it is suitable for use on surface mount boards, hybrids and connectors. Importantly, it dries quickly - almost as quickly as 1,1,1-TCA. OS-120 will be commercially available in the EU late

in 1995.

The cleaner is flammable, so careful handling (like IPA) is required. No rinsing is required. This cleaner has the best materials compatibility of any ozone-safe alternative on the market today. Overall, it is an excellent choice for repair depots where the widest variety of materials are found.

Other Choices May Emerge in the Years Ahead

Non-linear Alcohols. These solvents are very aggressive cleaners only distantly related to traditional alcohols. Most prominently marketed by Kyzen Corp., these materials are much more active cleaners: they will remove fluxes, oils, grease, soot, conformal coatings, inks and even some paints. The have an unfamiliar, musky aroma. They definitely will attack many types of soft plastics, so compatibility testing is mandatory. They are very slow to dry and will leave a slippery feel on the components for a few hours, after which no residues remain. They are most frequently used to remove inks and clean stencils.

Their most compelling advantage is their safety: they have flashpoints typically higher than 80°C/180°F, which minimizes the hazard most commonly associated with alcohols. These materials also have very acceptable toxicity ratings. However, the difficulties in cleaning with slow-drying materials makes them an unpopular choice except for stencil cleaning and in the most demanding defluxing applications.

Deionized Water/Alcohol Blends. Except for use with OA fluxes and water-based pastes, DI water is generally too mild to remove fluxes, organics, light grease or oils without some assistance from other additives. For benchtop cleaning, alcohol is added to DI water which improves the cleaning but makes the blend flammable. For best results, DI water must be kept pure and uncontaminated in sealed containers before dispensing. The good news about DI water is that it is cheap, nontoxic and not a VOC (volatile organic compound) so it does not contribute to low-level smog.

NMP Blends: N-Methylpyrrolidone (NMP) is used in wafer fabrication and is an aggressive cleaner offering exceptional solvency. Related to chemicals used in cosmetics and medicines, the material is relatively non-toxic. Special blends have been formulated to minimize component compatibility problems and have been available worldwide from International Specialty Products (ISP) for a number of years.

Perfluorinateds: While most of the alternative solvents are fairly active cleaners, the perfluorinated family of solvents ("PFCs") from 3M Corp. may find a niche because they are ultra-mild. These ozone-safe chemicals are exceptionally safe for people and components. They dry almost instantly and are completely nonflammable. Heavy enough to float a golf ball, they easily displace oils, fluxes and grime. Nonetheless, at roughly US$40/liter they are too expensive for widespread use and the global warming issue will further dampen enthusiasm for the product.

The Future: More Challenges, More Choices

While it is not widely acknowledged, the ozone issue is fundamentally solved. The world-wide production of CFCs will end within a few months. Computer models show the ozone layer should start to rebuild early in the next century and perhaps be completely restored by the end of that century. However, new environmental issues are looming on the horizon.

Engineers looking for a long-term solution to the clean needs would do well to keep an eye on the future environmental issues. Issues that will affect the electronics industry include water quality issues, smog caused by Volatile Organic Compounds (VOCs), climatic change from Global Warming (GWP), recycling and solid waste disposal. Solving these problems will make the ozone issue seem like a walk in the park.

In order of importance, the most critical operational issues are evaporation rate, odor/ventilation, and cost, followed by flammability, toxicity, and broad-based materials compatibility. Price naturally must be factored also. In our opinion, isopropyl alcohol is an inexpensive choice, but it will have a finite life, at best, and perhaps a short one in many regions. Therefore, better (long-term) options include the siloxane-based alternatives which offer superior cleaning and simplified handling, and the hydrocarbons which are probably the most versatile solvent choice. Newer, more radical innovations from DuPont and 3M Corp. promise even better performance. Engineers will need to consider all of these factors when evaluating their manual soldering processes.

Whichever alternative solvent is selected, good chemical management will be a mandatory requirement. Spills, fumes, skin contact and drag-out losses are signs of sloppy housekeeping. Engineers should search for the cleaning and dispensing technologies which will minimize costs, improve personnel safety and maximize production efficiencies. Good chemical management will minimize those risks and increase cleaning effectiveness. As a general rule, switching to alternative chemistries and implementing improved handling procedures result in a 40%-75% reduction in cleaning costs per-part-cleaned.

EDITORS NOTE: While this article was up-to-date when it was written, the technology has improved over the years (as predicted, above). Today, MicroCare offers the industry's widest array of cleaning choices, from the HFC and HFE solvents which were barely mentioned in the article above, to stronger choices like those based on nPB. In particular, there are today many good replacements for PFC-based cleaners. For more details, contact MicroCare.

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MicroCare specializes in ozone-safe cleaning alternatives for rework and touch-up applications.

Related Information:

- For additional information about the ozone-safe DuPont HFC solvents, check out the Vertrel® solvents web site.
- For other information about the Bromothane™ brand of nPB solvents, check out the Bromothane™ web site.
- For additional help, use the *Solvent Selection Guide* in this Site to help determine the optimal recommendation.
- A simplified PDF version of the same Selection Guide also is available.

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