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New Developments In Ozone-Friendly Electronics Cleaning

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Inflammable, invisible and odorless, its hard to believe that CFCs are a global pollution problem. But while companies that use ozone-depleting materials may not suffer the eye-catching stigma of belching smokestacks, the public's patience is wearing thin. Like it or not, this is the only planet we have and the time to change is now.

For companies still cleaning with ozone-depleting solvents, the pressures are building. The final phase-out dates for CFCs and methyl chloroform are now established. Production levels are restricted. Prices are climbing. After May 15, 1993 new restrictions in the U.S. will virtually stop all products sales if the products have been manufactured with ozone-depleting solvents. Clearly, this is the time to migrate to environmentally sustainable materials.

But manufacturing engineers face tough challenges in the implementation of viable non-CFC cleaners. This review compares many of the most popular CFC replacements and highlights the factors that are important in selecting the viable alternatives.

Change Is Inevitable as Old Solvents Are Phased Out

While engineers and technicians will be most affected, every department in a factory will feel the impact of changing from old-style solvents. All of the alternative cleaning chemistries force compromises that ripple through every department: purchasing, safety, waste disposal, product design, marketing, quality control and training. This is because no single CFC replacement combines all of the features of the older solvents.

Typically the trade-offs are between evaporation rate, toxicity, odor, flammability and broad-based materials compatibility. On the positive side, many alternatives offer superior cleaning and lower cleaning costs. The challenge is to understand the strengths and weaknesses of each choice so one can find the best fit with the manufacturing process. For example, many companies

are looking to "no clean" fluxes to solve their solderability, environmental and waste disposal problems but, like all the other choices, "no cleans" have their own strengths and weaknesses.

Whichever alternative 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 best available technology ("BAT") for each chemical process under their control. BAT technologies will minimize costs, improve personnel safety and maximize production efficiencies.

Particular attention should be paid to benchtop cleaning applications. During cleaning technicians face the greatest risk of exposure to fumes and direct solvent skin contact. Good chemical management and BAT implementations will minimize those risks and, again, increase cleaning effectiveness.

Many Good Solvent Selections for Electronics Cleaning

In the not-too-distant past it would have been fair to say that there were no proven, cost-effective replacements for CFCs. That is no longer true, and the rate of new introductions is accelerating. Engineers now have a wide variety of different technologies to consider. All of these new chemicals have been introduced in just the past three or four years.

The products fit into four basic categories: Alcohol blends, CFC-Workalikes, terpenes, and a cluster of emerging chemistries. The best new products have fully-developed performance characteristics, so users no longer pioneer their conversions. Most alternatives work in cleaning systems from several manufacturers and are generally available in most parts of the world (although local restrictions may vary).

But as good as these new chemistries may be, they are not "drop-in" replacements for CFCs. As a general rule, switching to alternative chemistries and BAT handling result in a 40%-75% reduction in unit cleaning costs, but not without some growing pains. A few helpful hints:

- The testing/qualification program should be thorough and defined in advance.
- Only the most likely alternatives should be subjected to the entire testing process.
- Typical evaluations include the obvious chemical and conversion costs plus less obvious factors: labor costs, training costs, waste disposal costs, insurance costs, warranty repair costs, reject/rework costs, and so on.
- The result of the testing must be expressed as a total-cost-per-board comparison.

Alcohol Blends Are Affordable But Limited

There are three types of alcohol blends used today. The first are blends of the tried-and-true alcohols: the isopropals, ethanols, butyls and methanols. The second group includes the new "non-linear alcohols." Lastly, deionized water and alcohols blends provide excellent cleaning on some types of fluxes.

Traditional Blends. Traditional alcohols are mild circuit cleaners; proven, cheap and safe. They are effective on fluxes, oils and light grease. Except for methanol, alcohols are compatible with nearly all materials of construction and may be used as light contact cleaners. If sufficiently pure the materials will leave no residues and rinsing is not required. Alcohols are moderately slow drying materials, however, and may attract water from the air (hygroscopic) which may promote corrosion or possibly leave water marks on boards.

Obviously, flammability is a major concern when using these low-flashpoint materials. Engineers must implement appropriate handling processes and safety training. Equally important, only isopropyl and ethyl alcohols have acceptable toxicity levels if skin contact may occur; methanol and the butyl alcohols are significantly more toxic. Alcohols are completely ozone safe but may be classified as Volatile Organic Compounds (VOCs) which contribute to low-altitude smog and global warming.

Non-linear Alcohols. These products are much more active cleaners than traditional alcohols. In fact, non-linear solvents not only remove fluxes but oils, conformal coatings, paints and grease. These cleaners are unusual in their handy ability to clean "no-clean" fluxes and dissolve epoxies under surface mounted components. Non-linear alcohols can attack soft plastics - mainly polycarbonates - so compatibility testing will be required. Some blends of non-linear alcohols include surfactants for faster cleaning so water rinsing may be required.

Non-linear alcohols tend to have relatively high 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. In some communities they may not be classified as VOCs. Non-linear alcohols are completely ozone safe and generally less tightly regulated than other candidates.

Deionized Water and Blends. Water is the universal solvent. "Deionized" water is filtered to remove conductive minerals and salts. Since water naturally wants to retain these salts the separation leaves DI water hungrily trying to re-ionize itself. This aggressive search is the reason DI water is such a good cleaner and yet so hard to handle: DI water in an open container quickly recontaminates itself simply from atmospheric impurities. To be effective on the rework bench, DI water must be kept pure and uncontaminated in sealed containers with controlled dispensing.

DI water is generally too mild to remove fluxes, organics, light grease or oils unassisted. For benchtop cleaning alcohol is usually added; surfactants and/or saponifiers are added for bulk cleaning systems. They also may make the material more flammable, plus compound waste disposal problems.

For best results, water usually is heated, which makes water cleaning more energy-intensive than other types of cleaners. Water also is slow to evaporate. However, with BAT technology DI water can be an extremely safe and cost-effective choice in bulk systems and at the workbench.

Terpene Solvents Are Environmentally Perfect, But Hard to Use

Commonly used in consumer products, terpenes are a radical new cleaning technology for electronics. They are produced by all green plants and are found in every natural fruit beverage and food, including ice cream. In the electronics industry, terpenes have proven to be a non-toxic, highly effective cleaner that works on every type of flux.

Terpenes are ozone-safe and natural, biodegradable product. Most terpene cleaners require rinsing, but special "no-rinse" terpenes have been developed for benchtop cleaning. They are generally not conductive and could be used as contact cleaners. They will not mix with water so waste handling is simplified.

Not all terpenes are created equal. There are different evaporation rates, flashpoints and aromas. Pine terpenes are prone to rapid polymerization which can cause spontaneous combustion in solvent-soaked rags and wipes. Terpenes also are fairly aggressive cleaners so compatibility testing is strongly suggested.

CFC-Workalikes Are Quickly Coming to Market

Many companies have attempted to make cleaners which combine the handling of CFCs with improved environmental performance. While these complicated chemistries can take ten years to develop and commercialize, a few candidates have trickled in.

HCFC-141b is the cleaner that looks and feels most like CFC-113. Unique in that it is the only alternative that permits CFC-style cleaning in today's vapor degreasers, it offers small companies an environmentally acceptable choice without budget-busting capital expense. HCFC-141b removes rosin-based fluxes and is an excellent contact cleaner. Fairly aggressive, compatibility testing is strongly suggested. Although the final toxicity testing is not complete, a PEL/TLV of about 500 ppm is likely.

In terms of handling and ease of conversion, HCFC-141b is the best of the non-CFC alternatives. However, it has a slight ozone depletion factor. Many companies have decided it shall be used only where nothing else will work. Examples include (a) cleaning of "hot" circuits for maintenance purposes, (b) precision cleaning of high-power components, optics, hybrids and similar ultra-precise components, and (c) limited defluxing applications while making the change to ozone-safe alternatives.

Other Choices Are Coming Out of the Lab

After a fairly slow start, other alternatives are becoming available. A quick summary of likely candidates includes:

- ***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 should be available in the European Community by early 1993.

- ***Perfluorinateds:*** Most of the alternative solvents are fairly active cleaners, but the perfluorinated family may find a niche because they are ultra-mild. Heavy enough to float a golf ball, these chemicals are exceptionally safe on components but are relatively poor solvents; their most likely application will be as ozone-safe contact cleaners. They are extremely expensive (roughly £25/liter) and may have a significant negative global warming impact.

- ***Other Hydrocarbon Entries:*** British Petroleum is introducing a family of cleaners based on the family of oxygenated solvents. DuPont Corporation, the U.S. chemical giant, is marketing a family of petroleum distillates under the "Axarel" brand name. Both companies have versions for electronics cleaning, metal cleaning and most recently for hybrid circuits.

The Choice Is Yours

The good news is obvious: companies no longer have to pollute with CFCs and other ozone-depleters. Today, unlike five years ago, engineers need not risk their careers with unproven technologies. Safe, simple and relatively inexpensive alternatives now are available. The supporting hardware systems are available off-the-shelf, and the configurations can be tailored to fit budgets of all sizes.

One important fact bears repeating: all of these alternatives will reduce production costs. Because they will improve product quality, switching to environmentally progressive cleaners may even make products more reliable. With the costs of CFCs continuing to climb, it makes good sense to switch now and avoid the last minute rush. CFC pollution is everybody's problem, and that means that every business has to be part of the answer.

EDITORS NOTE: While the information in this article was accurate when it was written, today many new choices have come to market. HCFC-141b (marketed under the brand-names of "Genesolv", "Forane" and others) has been phased-out because it is an ozone-depleter in favor of HFC and HFE solvents, such as SuprClean, above. Despite a promising start, NMP was never widely accepted in electronics but nPB has become quite common. The PFC solvents have been phased-out for due to their global warming impact while numerous hydrocarbon solvents have earned wide acceptance. But today, as then, the biggest favorites are the CFC-workalikes. Today those are best represented by the HFC solvents from MicroCare, such as PowerClean(tm) and Flux Remover C.

Related Information:

- For additional information about flammability and how it is measured, see this Technical Note.
- This web site features a list of nonflammable solvents from MicroCare.
- 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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