# Cleaning Options for Degreasing & Surface Preparation

By Barbara Kanegsberg

**A number of cleaning options are available to platers and surface finishers. The best approach for selecting the right application depends on performance, economics, safety and environmental considerations.**

Some cleaning process problems faced by plating facilities include multiple types of metals, materials compatibility problems, corrosion, erosion, a variable product mix, variable product line, need for cleaning efficiency, streaking, surface finish, complex structure, incomplete cleaning caused by nesting of parts, rapid throughput, variable surface finish and, ultimately, unacceptable plating.

## Aqueous Cleaning

Solvent costs, development of precision aqueous cleaning systems, and regulations—ranging from the chlorinated solvents National Emission Standard for Hazardous Air Pollutants (NESHAP) to Rule 1122, recently enacted in Southern California—have prompted interest in aqueous cleaning systems.

There are many excellent aqueous cleaning chemistries on the market. Certainly, those cleaning agents that have been certified as "clean air solvents" provide the user with an extra measure of assurance, because they have been subjected to extensive analysis by an outside agency to exclude those products with ozone depleters, global warming agents, over 50 g/L of volatile organic compounds (VOCs) and hazardous materials.

Some aqueous cleaning agents contain significant amounts of water-soluble organics. This can lead to potential problems with both air and water pollution. Whether or not a clean air solvent is chosen, it is important to work with manufacturers with a record of good product support and a well-staffed and communicative applications laboratory.

Successful cleaning is a combination of cleaning agent and cleaning equipment. While this is true of all cleaning systems, it holds particularly true for aqueous systems. For some aqueous systems, a simple dip tank may be sufficient. Many high performance, precision aqueous systems, however, require fixturing, sample handling systems, agitation, adequate rinsing and efficient drying. The more sophisticated aqueous cleaning systems can require a significant capital investment (similar to the investment in an airless or airtight solvent system). Aqueous systems require a significant amount of floor space. There are many possibilities for systems configuration. It is, therefore, a good idea to perform some initial evaluations with the cleaning equipment manufacturer, to find the optimal system for your cleaning requirements.

While chlorinated, brominated and other organic solvents, such as esters, utilize solvency properties for effective cleaning, aqueous systems typically require heat and some sort of agitation. This agitation can consist of turbulation, spray in air, spray under immersion, rotation and ultrasonics. Ultrasonics are a particularly powerful tool with aqueous cleaning agents, because relatively mild aqueous cleaning agents may become so effective with ultrasonics that erosion and materials compatibility may develop. Materials compatibility is a potential problem with all cleaning agents—the more active the cleaning agent, the higher the potential to damage certain substrates. Aluminum and beryllium are particularly prone to compatibility issues. Controlling the power and selecting a higher-frequency ultrasonics can avoid damage to parts.

Immediate, thorough rinsing is crucial. Any delay in rinsing can result in an adherent layer of residual cleaning agent. There may even be component damage. In some cases, application of a rust-preventive is necessary, especially if parts are to be stored.

Many shops, in an effort to control costs, either ignore or skimp on the quality of drying equipment. If you need dry parts, and your cycle time is limited, be aware that the drying step is typically the rate-limiting step in the aqueous cleaning process.

Finally, there is the matter of jumping out of the frying pan into the fire. Many people have adopted aqueous cleaning in response to regulatory pressures based on air pollution. The new process may lead to problems with water pollution. Even if the cleaning agent itself can go directly down the drain, oils, polishing compounds and trace metals may be present in unacceptable levels in the spent cleaning agent and rinsewater. Closed-loop systems may be needed.

Some factors influencing the success of aqueous cleaning are indicated in Table 1.

## Solvent Cleaning

Aqueous cleaning is often, but not always acceptable. You have to evaluate your own situation. There is a point at which aqueous cleaning either does not perform acceptably, or may be exceedingly inefficient. In some instances, solvent cleaning may be your best option. Sometimes, the sheer variability of the product line makes it difficult to implement aqueous cleaning across the board.

The physical and chemical properties of the cleaning agent have to be considered. Table 2 indicates the wetting index, Kauri-Butanol (KB) number and boiling point of a few cleaning agents. The wetting index is the ratio of the density times one thousand to the product of the surface tension and the viscosity. The higher the wetting index, the better able the cleaning agent to get into closely spaced components. The KB number is a cloud point test for solvency. It is the volume of solvent needed to produce a defined degree of turbidity when added to standard solutions of Kauri resin in n-butyl alcohol. In general, the higher the KB number, the stronger the solvent for most soils of interest. The number is valid for hydrogenated cleaning agents, not for oxygenated solvents. There are more complex and more predictive solubility approaches, such as the Hansen solubility parameters. The KB value, however, provides a good preliminary indication of relative solvency. The boiling point is indicated, because the higher the boiling point, the more entropy and, therefore, the more efficient the cleaning that can go into the system. There are properties shown for two compounds that deplete stratospheric ozone—CFC 113 and 1,1,1-trichloroethane. Even though there has been a production phaseout, many companies are still (legally) using existing reserves of these.

Solvent cleaning can be particularly desirable with closely spaced components, or for very ornate parts with blind holes. As a rule of thumb, where the spacing is 5 mils or under, it may be difficult to achieve adequate cleaning and rinsing with an aqueous-based system, because of inefficient wetting. Picture a very ornate, complex part that needs to be cleaned prior to plating. An aqueous system is chosen for cleaning. Adding surfactants to the water to increase the wetability, and then using ultrasonics and power spraying can allow the cleaning agent to get into closely spaced components and blinds holes, removing embedded soils. The question must be asked: "How do I rinse?" How can the agent be removed (the surfactant that was added to get the liquid in there in the first place)? In an aqueous system, water—with all its physical properties—is used for rinsing. Adding ultrasonics and spraying may help, but if the part is really complex, soils and cleaning agent may remain trapped, leading to plating and coating problems. While VOC-exempt solvents are becoming increasingly available, solvency for the soils of interest, toxicity, and flammability may limit their utility. Acetone and the volatile methyl siloxanes, which are VOC-delisted at the federal level and in many local areas, must be used in specially designed low-flashpoint systems, if they are to be heated.

Table 1—Some Considerations in Aqueous Cleaning

| Factor | Comments |
|---|---|
| **Cleaning agent composition: organic** | Potential:<br>• Volatile organic compounds (VOCs)<br>• Hazardous air pollutants (HAPs)<br>• Toxics |
| **Cleaning agent composition: inorganic** | Potential:<br>• Undesirable residue<br>• Undesirable interaction with materials of construction |
| **Oil separation, cleaning agent** | • If miscible, potential disposal problems<br>• If two phases, sparging required to avoid redeposition of soil on parts |
| **Fixturing** | • Required for optimal orientation of components<br>• Must be convenient for operators<br>• Must be compatible with long-term exposure to cleaning agent |
| **Cleaning action: spray turbulation ultrasonics rotation** | • Crucial for adequate cleaning<br>• Potential for erosion, materials compatibility problems |
| **Temperature** | • Optimal temperature may vary with metal or soils<br>• High temperature may damage or deform parts |
| **Rinsing** | • Multiple tanks may be required<br>• Water quality may be crucial<br>• Rust inhibitor may be required |
| **Drying** | • Must be adequate to remove moisture<br>• Often the rate-limiting step in the process |
| **Robotics** | • Can assure smooth, rapid throughput<br>• Require space<br>• Parallel, overhead robotics with batch systems may provide process flexibility |
| **Wastewater treatment** | • Dependent on cleaning agent, soils, trace metals, fluxes, solders<br>• Check local requirements |
| **Floor space, money** | • Allow enough of both to meet cleaning needs |

Aggressiveness toward the soil of interest is also important. As with aqueous cleaning, the goal is to balance efficient removal of soil and compatibility with materials of construction. In addition, many of the costly, so-called designer solvents, such as the hydrofluorocarbons and hydrofluoroethers, are relatively weak solvents for many soils of interest. HCFC 225 has similar solvent strength to CFC 113. HCFC 123 is a somewhat less costly solvent with moderate solvency. The boiling point is relatively low—it can be used successfully in a well-functioning degreaser or airless system. While the neat, undiluted solvents may be VOC-exempt, the additives that boost cleaning power are typically VOCs. So, regulations that apply to VOCs typically apply to these blends.

Stabilized N-propyl bromide, a relatively new cleaning agent with moderate cost and solvency, and evaporative qualities similar to 1,1,1-trichloroethane, is still considered to be a VOC, but it does not fall under the federal NESHAP. Degreasing and cold-cleaning operations using classic chlorinated solvents are covered by the federal NESHAP. Perchloroethylene is VOC-exempt at the federal level. In may areas, chlorinated solvents, such as perchloroethylene and trichloroethylene, are regulated to minimize worker exposure, and to avoid potential impact of emissions on surrounding neighborhoods.

With volatile solvents, whether or not they are classified as VOCs in your area, liquid and vapor phase degreasing, in a new or upgraded well-functioning degreaser, is a better option than cold cleaning in terms of minimizing employee exposure to solvents, containing costly solvents, and minimizing emissions of HAPs and VOCs. When the final rinse consists of holding the part to be cleaned in the vapor phase, there is typically no concern about redeposition of soil, because you are effectively cleaning in freshly-distilled, uncontaminated solvent. Because many employees are not aware of the importance of proper degreasing operations, particularly maintenance of the vapor zone, automated systems are often a good investment.

The newer airless or airtight cleaning systems, including contained spray systems, can be particularly useful in achieving optimal cleaning with an array of solvents, including VOCs and HAPs with essentially no solvent loss. The initial capital investment is relatively high, and there is a period of employee education in learning to program the automated cleaning cycles. There can be, however, a rapid recoup in costs because of lower solvent usage, and worker and community exposure to solvents is minimal.

Table 2—Some Physical & Solvency Properties Of Cleaning Agents

| Cleaning Agent | Wetting Index | KB Number | Boiling Point, °C |
|---|---|---|---|
| CFC-113 | 121 | 32 | 48 |
| 1,1,1-trichloroethane | 65 | 124 | 74 |
| n-propylbromide | 105 | 125 | 71 |
| HCFC 225 | 145 | 31 | 54 |
| HFC 43-10 | 167 | 9 | 55 |
| Water | 14 | N/A | 100 |
| Water with 6% saponifier | 31 | N/A | 100 |

## Solvents for Cold Cleaning

Options for cold cleaning (cleaning below the boiling point of the solvent) are limited, particularly in areas where regulations do not provide for using VOC-containing solvents with very low vapor pressure. In California's south coast area, it will soon be a problem to use hydrocarbon blends, ester blends, and terpenes in cold cleaning operations, because they are all VOCs. Some manufacturers have attempted to perform cold cleaning with chlorinated solvents. This may be far from desirable, because it may be difficult to limit worker exposure.

Where aqueous options cannot be used for high-value applications, it may be expeditious to convert the cold-cleaning process to a vapor degreasing or contained-solvent system.

## Solvent-free Systems

Cleaning with $CO_2$ can involve snow, liquid, or supercritical fluids. $CO_2$ snow is probably the most accessible to platers in terms of cost. Throughput may be somewhat limited and, because $CO_2$ snow cleaning is a line-of-sight process, there can be limitations with very complex, intricate parts.

Plasma cleaning is especially useful for final removal of soils, rather than for heavy soil loading. Plasma is also used for surface modification.

Laser cleaning is a high capital investment with specific fixturing required. The possibility for use in plating operations has been demonstrated.

## Conclusions

There is no environmentally perfect cleaning agent or process—all have some baggage. Platers have varying requirements. No single approach is apt to suit everyone.

Often, it is possible to adopt an aqueous or solvent-free process. A properly installed aqueous system can be very successful and avoid certain regulatory problems.

The fact remains (local VOC regulations to the contrary), the only practical cleaning agent for the job may be a non-aqueous cleaning agent that is a VOC. In addition, what is considered to be a VOC can vary markedly from one region of the country to the next. VOCs are one of a number of important regulatory drivers. In some areas, all solvents must have permits for use, regardless of VOC status. Factors such as worker exposure and community exposure to HAPs must also be considered. Treatment of waste streams is becoming increasingly important.

Process change is a cooperative effort. Regulations can be confusing. It's important to develop a reasonable rapport with regulators. In terms of performance, there is no substitute for working with reliable cleaning agent suppliers, and equipment manufacturers with responsive applications chemists and engineers who have access to testing facilities. Whatever cleaning agent you choose, it is important to know with what you are working. If you don't know the nature of the cleaning agent, it's very difficult to optimize the process. I advise against using supposedly safe mystery mixes. Instead, sign a confidentiality agreement if necessary. If you are not supplied with the information you need, I suggest finding another supplier.

Often buried under the mountain of confusing (and perhaps conflicting) regulations is the requirement to produce a high-quality product in a practical manner. While regulations may be the driver for process change, if performance and cost requirements are kept in sight, it is often possible to meet regulatory requirements while actually improving the process. **P&SF**

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