Effective use of aqueous cleaners for electronics and metals hinges on the orchestration of basic variables of cleaning agents and procedures.

Variables and Vitals of Metal and Electronics Aqueous Cleaning

BY MALCOLM McLAUGHLIN

Today, the terms *precision* or *critical* cleaning apply whenever residue can cause a failure in the performance or function of the surface being cleaned. In general industry this includes electronic component cleaning, and surface preparation of metals prior to coating or bonding.

Current practice for critical cleaning includes the use of volatile solvents, corrosive chemicals, and aqueous detergents. In today's hazard-sensitive workplace, however, many companies are re-examining their use of volatile-solvent and corrosive-chemical cleaners.

By switching to the right aqueous cleaning technologies now, it's possible to minimize hazards without sacrificing critical cleaning performance. Many aqueous cleaners now offer cleaning performance comparable to — or better than — solvent cleaning systems.

Photos courtesy of Alconox

Critical jet engine components, such as a fuel nozzle, are thoroughly cleaned during both their manufacture and scheduled maintenance using an aqueous ultrasonic detergent.

Qualities for Quality

The major requirement in cleaning electronic parts, assemblies, precision parts and metal surfaces is that there be no residues that interfere with further use or processing of the cleaned surfaces. The cleaning method should be noncorrosive to the component.

For electronic components this can mean that the cleaning method and detergent used should not have the potential to leave conductive residues. For metal cleaning, no trace organics, oxides or particulates can be left on the surface to interfere with further surface-treating operations.

The detergent chosen should exhibit exceptional free-rinsing qualities. For electronics cleaning in particular, the formulation should be free of metallic cation ingredients to avoid conductive residues from improper rinsing.

In practice, you need to be able to choose from a range of detergents to find one that performs well with the cleaning method you wish to use and is suitable for the soils and surfaces you need to clean. (See Table 1.)

Before testing aqueous cleaners as a replacement for electronics or metals cleaning, it is important to understand a few basic procedures regarding their use. The major variables in precision-equipment cleaning using aqueous methods include:

1. Detergent
2. Agitation
3. Temperature
4. Cleaning time
5. Rinse used

Detergent/Method Matchup

The detergent used should be matched to the desired cleaning method, and the surface and types of soils being cleaned. For instance, a low-foaming detergent should be used for spray cleaning, a good anti-redeposition detergent for soak and ultrasonic cleaning, a high emulsifying and wetting detergent for manual cleaning.

The detergent, temperature and degree of agitation should be strong enough to remove the soil to the desired level of cleanliness without harming the substrate being cleaned.

It is critical that the detergent be formulated to clean

effectively and to rinse away without leaving interfering residues. These qualities are attributable to appropriate surfactant ingredients and nondepositing rinse aids.

The surfactants should be chosen to be effective on the types of soils the detergent is intended for. It also should have sufficient surface tension lowering properties to assist in proper rinsing. A surface tension below 35 dynes per centimeter for the cleaning solution as used is typically sufficient for the surfactant to contribute to good rinsing.

Nondepositing rinse aids can help complete a formulation to meet the rinsing requirements of critical cleaning. Found in free-rinsing detergent formulations, this ingredient inhibits spot formation and promotes sheeting and rinsing action to maximize residue removal.

Agitation

Agitation can be characterized as non-agitation (soaking), manual (cloth, sponge, brush), ultrasonic, flow-through clean-in-place (for pipes, tanks and tubes), spray cleaning (a dishwasher, for example), and high-pressure spray cleaning. In general, the more agitation, the more effective the cleaning on bulk soils.

Cleaning often can be enhanced by pre-soaking, particularly if soils are dried or baked onto a part to be cleaned. It is always desirable, whenever possible, to clean prior to soils becoming dried or baked onto surfaces.

Different agitation methods are often chosen with time required and number of parts being cleaned as the major considerations. If large numbers of parts must be cleaned quickly, then a fast, high-agitation method such as spray washing often is used with an aggressive detergent. For smaller numbers of batch or batch-continuous quantities of parts, ultrasonic soak cleaning with a milder detergent may be used.

Temperature

In general, higher-temperature cleaning solutions result in better cleaning. In practice, there is typically an optimum temperature for a given combination of cleaning variables.

When used in an ultrasonic bath, aqueous detergents provide the aggressive cleaning action of Freon — but with none of its ozone-depleting side effects when cleaning nickel-plated wire structure mount frames for metal-halide bulbs.

Many soak, manual and ultrasonic cleaning methods work best, for example, at 50°C to 55°C. Many spray washing techniques work best at 60°C to 70°C. Waxy or oily soils are more easily cleaned at somewhat higher temperatures. Particulate soils tend to be more easily cleaned at slightly lower temperatures.

These are, of course, broad generalizations. It is not always necessary or practical to clean at the optimum temperature. You may have both waxy and particulate soils present, or the part being cleaned may not be able to withstand the optimum temperature.

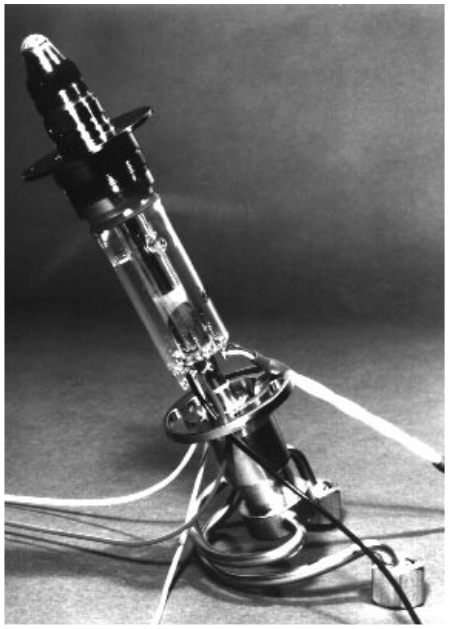
Cleaning Time

In general, the longer the cleaning time, the more thorough the cleaning. Many cleaning mechanisms such as emulsifying, dissolving, suspending and penetrating are time

Table 1
Detergent Cleaning Applications and Methods

APPLICATION, KEY CONCERNS	ARTICLES CLEANED/SOIL REMOVED	CLEANING METHODS
Metalworking and Precision Manufacturing Clean parts, avoid volatile solvents, strong acids and other hazardous chemicals	Glass, ceramic, porcelain, steel, stainless, specialty steel,aluminum, brass, copper, other metal parts and surfaces, plastic, rubber, fiberglass, personal safety equipment. Oils, chemicals, solvents, particulates.	Manual, ultrasonic, soak, C-I-P*, machine wash, power wash
	Inorganics, metallic complexes, trace metals and oxides, scale, salts, buffing compounds.	
	Silicone oils, mold-release agents, buffing compounds.	Manual, ultrasonic, soak, C-I-P*, machine wash, pressure spray
	Metallic complexes, metal oxides, scale, trace metals, salts. Metal brightening.	Manual, ultrasonic, soak, C-I-P*
Electronics Avoid conductive residues, avoid CFCs, pass cleaning criteria	Circuit boards, surface-mount assemblies, components, ceramic insulators, conductive residues, resins, rosins, fluxes, particulates, salts.	Manual, ultrasonic, soak, machine wash, power spray

*Clean-in-Place



Mild alkaline aqueous detergents facilitate the thorough cleaning action required of vacuum dewars for electronic sensors without leaving vacuum-degrading residues, or damaging fragile components such as fused connectors.

dependent. Up to the point where cleaning has been completed, the longer they're employed, the more cleaning is accomplished.

Cleaning time can be accelerated by increased agitation, more aggressive detergents, and by increasing temperature. If you cannot increase agitation, detergent, or temperature — perhaps because your substrate is too delicate or you do not have the equipment available — then you must be prepared to use longer cleaning times to achieve the desired cleanliness. In order to reach similar levels of cleaning, you may soak for hours or even overnight, while manual cleaning may take minutes, and spray cleaning might even take seconds.

There are some instances when long cleaning times may promote substrate corrosion, weakening or swelling. The optimum cleaning time should be chosen relative to the specific substrate, temperature, cleaning method and detergent.

Rinse

For critical cleaning, the rinse is an important part of the process. By the nature of the manufacturing and use conditions, precision electronic and metal parts are usually not that badly soiled to begin with. The objective is to remove whatever contamination or residues are present down to levels that will not interfere with part or equipment performance.

With aqueous cleaning, the last thing to come into contact with the cleaned surface is the rinse water. A thorough rinse will remove soils which have been cleaned from the surface and any residue from the detergent itself. What-

Cleaning Procedures, Residue Precautions

Any detergent cleaning procedure begins with developing a solution. The detergent concentration should be diluted according to the manufacturer's instructions.

Typically, warm (about 50°C) or hot (about 60°C) water is used. Water of ambient temperature may be acceptable, especially for presoaking. For difficult soils, very hot water (over 65°C) should be used, and the recommended detergent concentration doubled.

Following are common cleaning procedures, along with guidelines for eliminating interfering residues.

Soaking

For cleaning small items and the insides of larger vessels.

This should serve as a pretreatment to prevent soils from drying onto a part. Soiled parts can be placed in a soak tank until such time that they can be washed. Soaking is also effective to clean or pretreat stubborn dried-on residues.

To clean by soaking, a detergent recommended for soaking should be used, and a detergent soak solution made up according to the directions.

The article should be completely submerged to prevent any deposits or etching at the air/solution interface. Soils should be soaked until they are removed, which may take several hours. Some soils may require additional agitation or wiping for removal. A thorough rinse follows.

Manual Cleaning

For cleaning small batches of parts and surface.

The article to be cleaned should be wet either by immersion in the detergent solution, or with a soaking cloth or sponge. For nonabrasive scouring, undiluted detergent should be poured onto a wet cloth or sponge for scrubbing. A cloth, sponge, brush, or pad can be used for cleaning. A thorough rinse follows.

Protective gloves and eye protection should be worn if recommended or required.

Ultrasonic Cleaning

For larger numbers and repetitive batches of parts.

A solution is made up in a separate container, the ultrasonic tank filled, and the machine run for several minutes to degas the solution and allow the heater to reach the correct temperature.

Small articles should be placed in racks or baskets; irregularly shaped articles aligned so that the long axis faces the ultrasonic transducer (usually the bottom); and the machine run two to 10 minutes until parts are clean. A thorough rinse follows.

Machine Washing

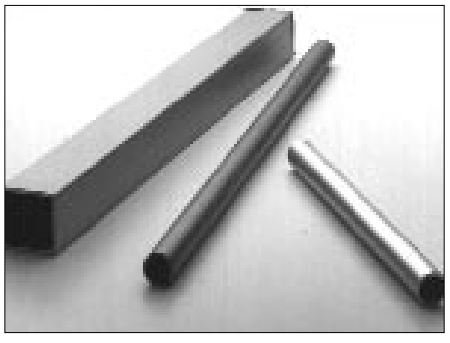
For cleaning large quantities of components.

The machine's directions should be consulted for details on proper use. Only low-foam detergents designed for these machines should be used. Typically, 10 g or 10 mL of detergent per liter of hot, wash-cycle water (approximately 60°C) is used.

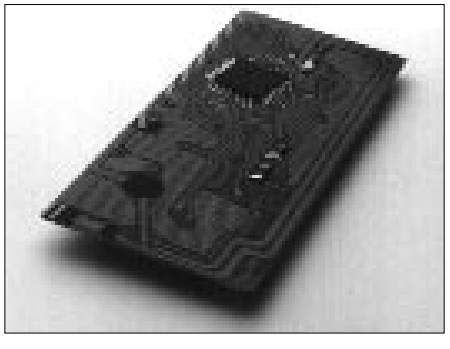
In general, the parts are loaded on racks with open ends facing the spray nozzles. Narrow-necked parts should be placed in the center of the racks, preferably on specifically designed spindles with spray nozzles directed into the necks. Small articles should be grouped in baskets to prevent dislodging by spray.

Aqueous acid detergents have proven ideal for degreasing and brightening brass as well as other non-ferrous machine parts.

A manual cleaning aqueous detergent can safely remove interfering residues in high-fidelity, research-quality medical devices such as Doppler flow catheter transducers, avoiding use of harsh chemicals.



When descaling copper, stainless and nickel alloy tubing, an aqueous acid detergent cleans effectively without leaving post-rinse detergent residues.



After soldering, an aqueous detergent can effectively remove ionic and nonionic contaminants and saponify flux residues.

ever contaminants are present in the rinse water to begin with will be present after rinsing. Therefore, the more stringent the cleaning requirement, the greater the need for rinse water purity.

For standard critical cleaning, a thorough tap water rinse followed by a deionized water or distilled water rinse is usually sufficient. In general, a thorough rinse means rinsing with at least three times the amount of rinse water as the cleaning solution used. A spray washing cycle of five minutes, for example, should be followed by three rinse cycles of five minutes each in a spray washing machine.

With soak or ultrasonically agitated rinsing, it is desirable to have two counterflow-cascade rinse tanks with dripping "over the tank" to reduce dragout. In all cases, running water or otherwise agitated rinse is better than a static soak-tank rinse.

Higher levels of cleaning may require the exclusive use of deionized or distilled water and in some cases more than three times the volume of rinse water.

For most cleanroom, electronic component and circuit board cleaning, deionized water is preferred over either tap or distilled water because of its lesser potential for metallic cation deposition on sensitive electronic components, leaving conductive residues. On metal parts, the use of deionized rinse water reduces the likelihood of depositing calciums, magnesium or other water-spotting salts.

Critical Choices

Many detergents strong enough to remove fingerprints can remove oils from skin, potentially dry it out and cause "dishpan hands." This is especially true of detergents designed for machine spray washing which, in order to perform in the limited contact time afforded during spray cleaning, are considered to be aggressive cleaners.

Protective gloves are recommended for any extensive manual cleaning operation. In addition, many detergents are potential eye irritants, and should not be used without eye protection.

Critical cleaning requires careful selection of cleaning chemistry and methods to ensure optimum performance without jeopardizing worker safety or environmental welfare. PC

About the Author

Malcolm McLaughlin is director of marketing for Alconox (New York, NY), a leading manufacturer of aqueous detergent cleaners for healthcare, laboratory and industrial manufacturing and processing applications. A longtime consultant in detergent research and development, he holds an M.A. in Chemistry from Columbia University.

Key Questions to Determine Detergent

In choosing an appropriate detergent, one must consider the item it is intended to clean; the required level of cleanliness and residue removal; the cleaning method to be used; and the detergent's performance. Following are key questions to determine a detergent's appropriateness:

1. Does it have good detergency on the types of soils that need to be removed?

A broad range of organic and inorganic soils are readily removed by mild alkaline cleaners that contain a blend of surfactants and sequestering agents. Metallic and inorganic soils are often readily solubilized by acid cleaners. Proteinaceous soils are effectively digested by protease enzyme cleaners. Radioactive residues are often readily removed by detergents with high chelating capacity.

2. Is it free-rinsing? Will it rinse away without leaving interfering detergent residue?

3. Is the detergent recommended for the desired cleaning method?

4. How hazardous is it?

For example, is it highly alkaline or acidic, presenting a personal health hazard? Is it corrosive? Does it present a reactivity hazard with soils? Is it a flammable or volatile solvent?

These considerations can be evaluated by reviewing a Material Safety Data Sheet for the agent. Preferably, it should not contain any hazardous ingredients listed on the OSHA standard and Hazardous Substance List 29CFR 1910 subpart Z.

5. Can it be disposed of easily?

Any detergent chosen should be readily disposable and biodegradable, containing no RCRA Hazard Classification or EPA Priority Pollutants designation. Otherwise, the use of hazardous cleaners may require special, expensive waste-handling treatment.

6. Is it "environmentally friendly"?

Considerations concern ozone depletion potential and volatile organic compound (VOC) content regulated by the Clean Air Act Amendments. Approval under anticipated future restrictions should be weighed as well.

7. How economical is it?

The detergent should be widely available and affordable. For optimal economy, a concentrated detergent is typically used at 1:100 to 2:100 dilutions.

Reprinted from *Precision Cleaning* magazine January 1994 © 1994 Witter Publishing Co., Inc.