Corporations assembling printed circuit boards no longer need to depend upon CFCs for cleaning. A method of cleaning exists that can completely eliminate their use. This system has the added benefit that it imposes no harm to the environment and is very cost-effective.
This closed-loop system opens new possibilities for eliminating CFC usage.

By Frank Grano and Bryan Neumann

Cleaning Investigation

Like many other electronic manufacturers, Data Switch (Stamford, CT) was using Freon TMS as its cleaning medium. With the acceptance of the Montreal Protocol, along with many international conferences calling for accelerated CFC elimination, Data Switch realized it needed to investigate other methods of cleaning circuit boards.

Before beginning our investigation, we developed a set of requirements for the cleaning system. Above all, it had to impose no harm to the environment, as we did not want to substitute one problem for another. We needed to choose a system that employed presently available materials to avoid selecting a chemical that was not yet fully developed with future supplies uncertain. The boards had to be cosmetically as well as functionally clean, for both the through-hole boards we currently assemble as well as any surface-mount boards we may assemble in the future. The system had to be cost-effective, and finally, the fluxes used in the assembly process had to offer excellent solderability.

Several alternatives were investigated before a decision was made. HCFCs, although not yet developed, could still pose an environmental problem, and would be at least as expensive as the chemicals they replaced. Terpene cleaning was examined, but it involved a twostep process. Water rinsing was required after the wash, and it did not offer the economic advantage needed.

We experimented with several no-clean fluxes; none proved to be very promising. Either the board had residue with good (but not excellent) solderability, or little residue with inferior solderability. Water cleaning was given a thorough investigation, as it seemed to meet all of our requirements.

Water Cleaning

The investigation into water cleaning began in the spring of 1988. We contacted and evaluated several equipment manufacturers. Ultimately, the Treiber TRL-SMD2 cleaner was chosen for a number of reasons, including its cleaning and drying ability along with its ease of use and maintenance. This cleaner also incorporates technology for cleaning surface-mount product.

Cleaning tests were performed on our most difficult-to-clean board, which contains ten 64-pin PLCC sockets and two DIN connectors along one edge. The cleaner was tested for cleaning as well as drying ability. Two fluxes were tested, both organic neutral and water-soluble. These fluxes are extremely aggressive and provide excellent solderability. Flux was applied by a foam fluxer.

Conveyor speed was set at seven feet per minute (the same speed used for wave soldering). Water temperature was set at 100°F. It was important to keep the water temperature down to a level that would not pose a danger to the operator when changing filters. All boards tested showed contamination levels under 4 µg/in² NaCl.

Closed-Loop System

After deciding that water was the method of choice, it was still unclear what to do with the wastewater. The rinsewater would contain residual metals and flux, which required monitor-

![Diagram of system block diagram](image)
Anbn of a closed-loop becomes very carbon had to be consumed, but the credits or carbon dioxide is produced at each stage of the process. The tank must be cleaned periodically to prevent the build-up of contaminants and to maintain the efficiency of the cleaning process.

The closed-loop water system consists of several components, as outlined in Figure 2. The system is designed to supply clean, DI water to the aqueous cleaner.

**Initial Installation**

During the initial few months of operation, several problems did occur. All of these were solved by working with the vendors. The problems involved modifying the pumping system to prevent air lock in the piping, changing the flux to eliminate foaming in the high-pressure wash, and increasing the size of the holding tank to prevent overfilling. The type of carbon used had to be changed, and the carbon had to be replaced at each tank regeneration.

**With the use of a closed-loop system, the selection of production chemistry becomes very critical.**

With the use of a closed-loop system, the selection of production chemistry becomes very critical. Anything that is put on the board and subsequently removed by the cleaner must be cycled through the filtering system. Any incompatible chemistry will foul the DI tanks very quickly.

**System Operation**

Daily operation of the closed-loop system begins by filling the cleaner with water previously retained in the holding tank. Water is pumped from the tank, through the DI system, and into the cleaner. From this point the closed-loop system is transparent to the operator and the cleaner.

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1. 30-micron (&#955;) cartridge filters are used to eliminate large contaminants such as solder balls or latex solder mask that are removed from the board during cleaning.
2. The 150-gallon water holding tank is designed to hold the water required for cleaning. The tank also contains a float valve for automatic addition of "makeup" water.
3. The circulation pump supplies water to the cleaning module at ten gallons per minute.
4. Carbon filtration removes organics from the water.
5. Cations remove the positively charged ions from the water.
6. Anions remove the negatively charged ions from the water.
7. The mixed-bed tanks are identical in makeup and are designed to remove both positively and negatively charged ions from the water.
8. A 1-M indicator light measures the resistivity of the water at the output of the first mixed-bed tank.
9. The resistivity meter measures the resistivity of the water at the output of the second mixed-bed tank prior to delivery to the cleaner.

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The following is reprinted from the Lonco Z-100 Manual:

For military testing purposes (MIL-STD-2000 & MIL-P-55110), the Z-100 has an EQUIVALENCE FACTOR of 3.7, which corresponds to a PASS/FAIL LIMIT of 37.0 μg/in² (5.7 μg/cm²).

The Belcore telecommunications specification (TA-TSY-000078) requires that the contamination level must be 1.00 SOD or less (1 SOD = 1.0 μg/cm²), referenced to the EQUIVALENCE FACTOR accepted by the military specifications. In this instance, a PASS/FAIL LEVEL of 3.7 μg/cm² (23.9 μg/in²) would apply.

Current Assembly Process

Our current assembly process consists of inserting as many parts as possible prior to wave solder. The board is then wave soldered and cleaned with water. For any major board repairs, we use a water-soluble core solder and rework the board in the cleaner. For simple touch-up work we use a no-clean core solder, eliminating the need to rework the board. The solder leaves just a trace of flux residue and normally does not violate our requirements. Any parts that are not compatible with the washing process (for example, unsealed switches) are soldered with the no-wash core solder as well. This is primarily a problem with older products for which a direct replacement sealed part is not available. It is not a problem due to water cleaning; the same problems existed before Freon.

New designs involve components that are compatible with the new cleaning...
process. With these two processes in place, water washing after wave soldering
and the use of no-clean core solder, Data Switch has completely eliminated its
need for CFCs.

Cleanliness testing was recently performed using a Lancro 21-100 ionic con-
sumption test system. All boards tested
met the military as well as the Bellcore
telecommunication specifications for
tonic contamination (Figure 3).

However, we did find that the solder
mask present on the board had the grea-
est effect on the cleanliness testing.

New designs
involve
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with the
new
cleaning
process.

On product containing a wet-film
mask, there was no measurable level of
ionic contamination. On boards contain-
ing dry-film solder masks, the ionic con-
tamination levels ranged from 12 to
20 μg/in² of NaCl.

Cleaning Costs

Use of this system has proven to be
extremely cost-effective. Regeneration
of the deionized system is the primary
cost contributor, and particle filters are
the other. Together they average about
$300 a month.

There has been no increase in elec-
tricity or water costs as a result of the
installation. Water usage is about 15
gallons a day, mainly due to evapo-
tion losses, compared to the five gal-

lons per minute the cleaner requires if no
closed-loop system is installed.

Conclusions

Our system has been installed since
February of 1989, and except for the
initial installation problems which oc-
curred over the first few months, it has
been trouble-free. This system offers
proof that in a commercial environment,
CFCs can be eliminated. Aside from the
closed-loop system eliminating the need
to dump wastewater, it also makes it
possible to use water cleaning where
restrictions on water consumption exist.

From an economic aspect, Data
Switch will save over $100,000 this year
on Freon costs.

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