A Cooperative Project between the U.S. Environmental Protection Agency and PWB Manufacturers Nationwide

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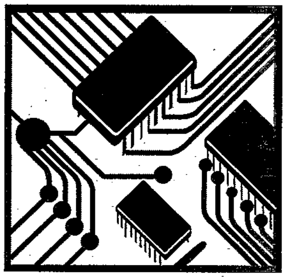
PRINTED WIRING BOARD PROJECT



Pollution Prevention Beyond Regulated Materials

The most successful pollution prevention programs involve looking for opportunities "beyond the barrels." Whereas pollution prevention most commonly takes the form of chemical use and waste reduction, by maintaining a chemical-specific focus you may overlook less obvious opportunities, such as in energy and water conservation. For one facility, Tri-Star Technologies, Inc., in Methuen, Massachusetts, broadening its view of pollution prevention led to energy and water use reductions that have resulted in significant cost savings. These energy and water reduction projects are the focus of this case study.

Getting Started

Tri-Star Technologies, Inc., is a manufacturer of double-sided and multilayer printed wiring boards, specializing in products for the electronics industry. With 220 employees at its 120,000 ft^2 facility, Tri-Star produces 1,000,000 surface square feet annually.

As Tri-Star implemented its pollution prevention program, this company discovered that demonstrating cost savings is the key to a successful program, especially when first getting started or when jump-starting a slow-moving program. Initially, Tri-Star implemented a few projects that required little capital investment. When it was able to show the cost savings achieved from these projects, the credibility of pollution prevention as a good business practice grew.

Today, with several successes to its credit, Tri-Star's pollution prevention team now is able to obtain funding for projects that do require larger capital investments. These projects also offer increased cost savings over the long term. For example, the facility is currently installing a cupric chloride regeneration system to recycle inner-layer etchant (see Printed Wiring Board Case Study 2 for more information on etchant regeneration). Such a system might require a capital investment of $150,000 or more, but the payback is expected to be less than 18 months by achieving dramatic reductions in spent etchant and virgin chemical purchases, and by selling the recovered copper by-product. Requiring a significant investment, this project has come about only after the pollution prevention concept gained credibility through the success of "low tech/no tech" projects.

By looking beyond regulated materials, Tri-Star found cost-saving opportunities in energy and water conservation. Such opportunities are a "cheap, easy, and often overlooked way to reduce your facility's environmental impact while saving money," says Ed Gomes, Safety and Environmental Support Operations Director for the facility. Energy reductions can lead to decreases in the by-products of energy use that cause global warming, acid rain, and smog—this is pollution prevention on a global scale. While not all of Tri-Star's projects are directly transferable to every facility, other manufacturers could use the information gained from Tri-Star's experience to examine their own energy and water use.

Utilizing the Utilities

Tri-Star has implemented several energy conservation projects. The two projects described in this case study both involved collaborative efforts with the electric and/or gas companies. Together, these two projects have resulted in savings of thousands of dollars per month, or about $51,800 annually.

◆ *Balancing air flow saved energy.*

Tri-Star's first energy conservation opportunity was identified in its fixed flow-rate air make-up units. The facility has several pieces of equipment that exhaust air, including wet scrubbers and an electrostatic precipitator. To balance the air flow, Tri-Star had been using two gas-fired air make-up units, each with a capacity of 40,000 cubic feet per minute (cfm). Since these operated at a fixed rate, they were on continuously, even during non-production hours.

In addition to the operating energy they consumed, the units also required the air conditioning and heating systems to work overtime. In the summer, the units blew hot, humid air into the facility. In the winter, the units heated the air that was blown in. This resulted in major temperature inconsistencies throughout the building, with the hot air in some areas shutting down the thermostats, making the cold areas even colder.

Working with the gas and electric companies, Tri-Star found state-of-the-art, variable speed controllers that could be retrofitted to the make-up air units. (With the variable speed controllers, the flow rate is based on the air exhaust rate from the exhausting equipment.) Significant savings in electric and gas bills were realized. A unique feature of this project is that it required no capital investment; *the electric and gas company paid for the new equipment.*

The facility estimates annual savings to be $22,900 on gas and $15,600 on electricity. Additionally, the project reduced air pollution through energy savings of 31,000 therms and 192,800 kilowatt-hours (kWh). This translates to annual reductions of:

- CO_2 (global warming) of 289,200 pounds
- SO_2 (acid rain) of 3,000 pounds
- NO_x (acid rain and smog) of 1,100 pounds

◆ *Replacing compressors improved efficiency.*

In another energy conservation project, Tri-Star examined its compressed air use. The facility had been using two 100 HP and two 50 HP compressors. These units had some trouble meeting the demand. With help from the "Energy Initiative" program run by the electric company (Mass Electric) and input from a consultant, the facility investigated its compressor situation. Based on the results, Tri-Star:

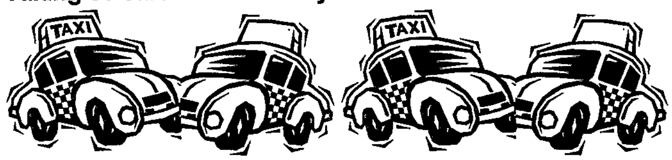
- ☑ added a reserve air tank
- ☑ replaced the four compressors of 300 HP combined capacity with three 50 HP energy efficient compressors (150 HP combined capacity)
- ☑ set up the units to cycle based on the compressed air demand in the facility

These changes have saved energy and eliminated the problems in meeting the facility's demand for compressed air. Annual energy cost savings from this project are estimated to be $13,300, based on a 164,800 kWh reduction in electricity use. This translates to annual reductions of:

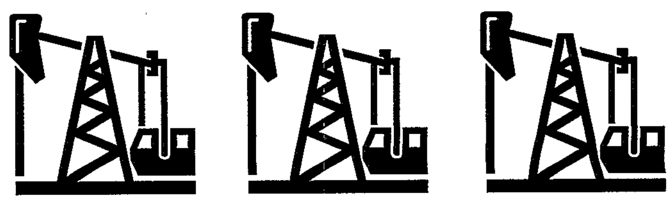
- CO_2 (global warming) of 247,200 pounds
- SO_2 (acid rain) of 2,500 pounds
- NO_x (acid rain and smog) of 900 pounds

Energy savings from the Tri-Star projects are equal to:

Taking 50 cars off the road/year. . .



. . . or saving 27,000 gallons of crude oil/year



These energy use reduction projects have improved plant operations, saved money, and reduced virgin oil consumption, waste oil (hazardous waste) generation, and air pollution in the community.

Conserving Water Pays Off

Water conservation has been another focus area of Tri-Star's pollution prevention efforts that goes beyond regulated materials.

◆ *Using DI water avoided chemical cleaners.*

When Tri-Star expanded its fabrication business to add assembly operations, the facility considered the different types of systems it could use to clean flux residue from the wave soldering unit. It looked into the options available in vapor degreasing and semi-aqueous cleaning. With further investigation, Tri-Star discovered that hot deionized (DI) water could clean the boards just as effectively as the chemical-based cleaning systems. Then Tri-Star went one step further and purchased a closed-loop DI water generation system that delivers 5 to 7 gallons per minute (gpm). The closed-loop system both generates DI water and recycles it through the cleaning process.

One problem Tri-Star initially experienced with the system was that solder paste was degrading the system's resin columns. In normal production this is not an issue; however, when a board requires rework, the operator runs it through the closed-loop cleaning system to remove the solder paste before reapplication. To solve this problem, Tri-Star installed a sink on the side cleaning unit where the operator could manually clean the reject boards with hot DI water instead of placing them on the system conveyor. The effluent from the sink is plumbed through a filter and sent directly to waste treatment. With this simple installation, the solder paste from the rejected boards never enters the closed-loop system, extending the life of the resin columns.

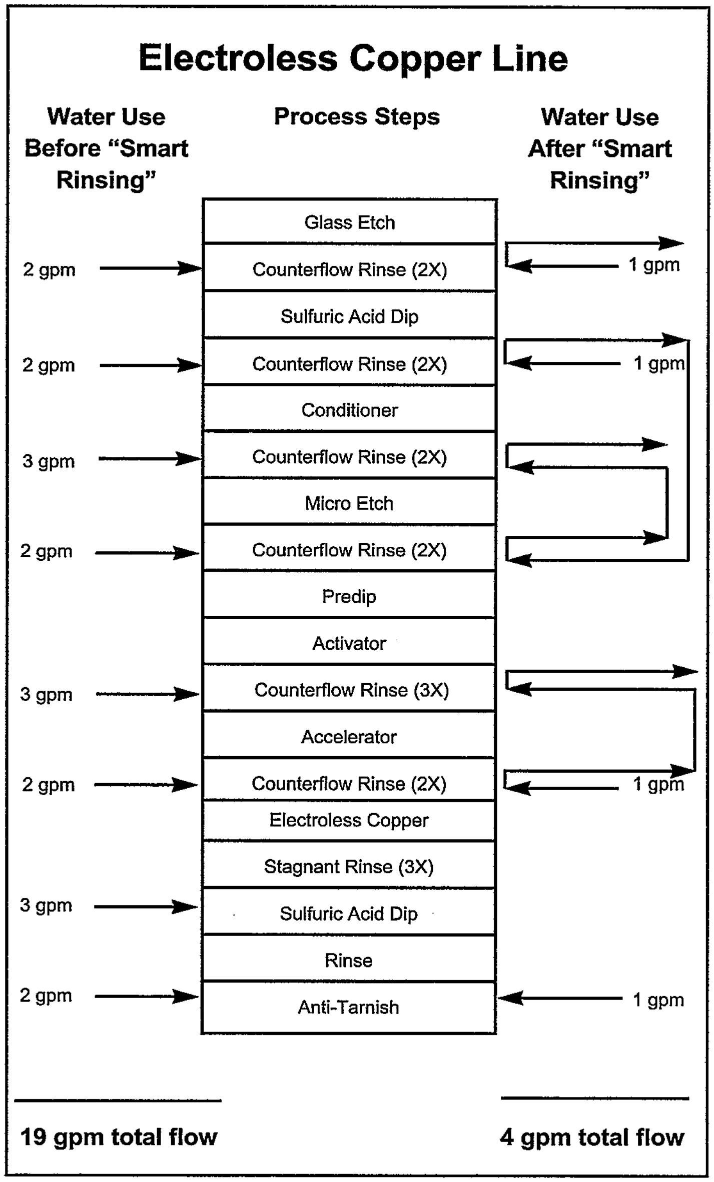
Because this closed-loop system was installed for a new operation, benefits compared to other technologies could not be quantified. Compared to other flux residue cleaning systems, the qualitative benefits are that it:

- conserves water
- does not use solvents
- does not use any chemicals

◆ *Smarter rinsing reduced water use by 79%.*

In another water conservation project, Tri-Star installed flow controls on rinses, increased counterflow rinsing, and implemented other "smart rinsing" techniques on its electroless copper plating line. By re-routing rinse water from one set of counterflow rinse tanks to another, Tri-Star cut the incoming water sources from seven to four, and reduced water usage on the line from 19 gpm to 4 gpm, as shown in the chart below.

Although Tri-Star made these changes on the deposition line, these water use reduction ideas may be applied to other processes that use multiple rinses. To make these changes in any process, cross-contamination issues must be carefully considered. To



design the rinse water reuse for this line, Tri-Star set up criteria, flagging "Do not contaminate" items.

Do not contaminate:

- ☑ electroless copper bath with palladium from the catalyst
- ☑ catalyst with cleaner/conditioner
- ☑ accelerator with electroless copper
- ☑ electroless copper with microetch or acids
- ☑ microetch with cleaner/conditioner

In addition to water savings, these changes also reduced the amount of chemicals needed to maintain the process baths. With the "smart rinsing" set-up, the chemistry is eventually dragged back into the tank from which it was dragged out (i.e., rinse water flows back and becomes the rinse of the previous step). This has reduced the chemicals needed for drag-out replenishment additions by 25% for the affected baths (microetch and accelerator).

Overall, Tri-Star estimates that "smart rinsing" has reduced its water usage by 2.5 million gallons per year, resulting in cost savings of approximately $15,000. This is based on operating the electroless copper line for 10 to 12 hours per day, 5 days per week. The combined water and sewer fees in the facility's area are $4.69/100 ft^3 (or $6.26/1,000 gal). Additionally, Tri-Star saved on chemical purchases resulting from reduced chemical use.

The Design for the Environment Printed Wiring Board Project

Through the Design for the Environment (DfE) Printed Wiring Board (PWB) Project, representatives of the printed wiring board industry and other stakeholders have formed a partnership with the U.S. Environmental Protection Agency (EPA). This project is a cooperative, non-regulatory effort in which EPA, industry, and other interested parties are working together to develop technical information on pollution prevention technologies specific to the PWB industry. This information includes comparative data on the risks, performance, and cost of other manufacturing options.

To date, the DfE PWB Project has focused on conducting a comprehensive evaluation of alternative technologies for making through-holes conductive. The Project is also beginning to evaluate alternatives to the hot-air-solder-leveling process. By publishing the results of these evaluations, DfE is able to provide PWB manufacturers with the information they need to make informed business decisions that take human health and environmental risk into consideration, in addition to performance and cost. The Project is also identifying and publicizing other pollution prevention opportunities in the industry through the development of PWB case studies such as this one.

Acknowledgments

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Additional Pollution Prevention Resources for the PWB Industry

In addition to this case study, the DfE PWB Project has prepared other case studies that examine pollution prevention opportunities for the PWB industry. All case studies are based on the experiences and successes of facilities in implementing pollution prevention projects. The other case study topics available include:

Pollution Prevention Work Practices
On-site Etchant Regeneration
Opportunities for Acid Recovery and Management
Plasma Desmear
A Continuous-flow System for Reusing Microetchant

These case studies and other documents published by the DfE Project are available from:

Pollution Prevention Information Clearinghouse (PPIC)
U.S. EPA
401 M Street, SW (7409)
Washington, D.C. 20460
Phone: 202-260-1023 Fax: 202-260-4659
E-mail: PPIC@epamail.epa.gov

These documents are also available via Internet at:
http://www.ipc.org/html/ehstypes.htm#design

The DfE Program welcomes your feedback. If you have implemented any of the ideas in this series of PWB case studies, please tell us about it by calling the DfE Program, at 202-260-1678 or by sending e-mail to:
oppt.dfe@epamail.epa.gov