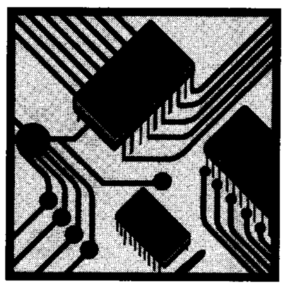
A Cooperative Project
between the
U.S. Environmental
Protection Agency
and PWB
Manufacturers
Nationwide

EPA 744-F-95-004

design FOR THE ENVIRONMENT

PRINTED WIRING BOARD
CASE STUDY 1



Pollution Prevention Work Practices

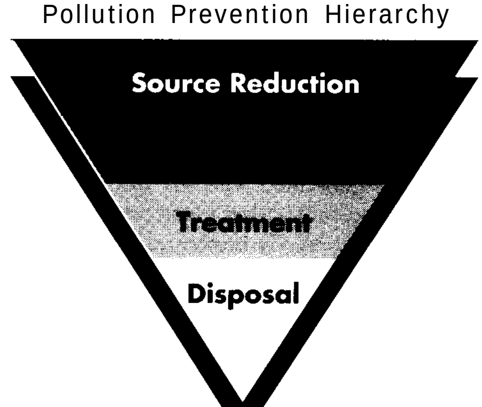
The Design for the Environment (DfE) Printed Wiring Board Project is a voluntary, cooperative effort between the printed wiring board (PWB) industry, the U.S. Environmental Protection Agency (EPA), and other stakeholders dedicated to helping PWB manufacturers find cost-effective ways to incorporate environmental concerns into business decisions. To help PWB manufacturers improve environmental performance, the DfE project is developing a series of case studies highlighting industry-specific pollution prevention information.

Successful pollution prevention focuses on reducing or eliminating pollution at the source through changes in materials, processes, practices, or products, Source reduction is at the top of the pollution prevention hierarchy, and is preferred by EPA over closed-loop recycling, treatment, and disposal. As specified in the Pollution Prevention Act, EPA prefers that companies investigate recycling and treatment only after every attempt has been made to implement source reduction options.

Implementing viable pollution prevention alternatives can result in economic as well as environmental benefits for your manufacturing operation. This case study, the first of a series, focuses on improved work practices and minor process changes that PWB manufacturers have found reduced their chemical and water use, lowered workplace chemical exposures, or reduced waste generation and resulting disposal and compliance costs. These changes have reduced the environmental impact of the facilities' manufacturing processes and have cut costs at the same time. For example, after implementing some simple water conservation measures, one PWB manufacturing plant with a throughput of 1,000 boards per week was able to save over 850,000 gallons of water per year. The $250 implementation cost of purchasing and installing the flow reducers used to achieve these savings led to an extremely short payback period of only two months.

As you think about the production processes and work practices in your plant, this case study may give you some new ideas for preventing pollution in your facility. There are many more techniques that PWB manufacturers have used to prevent pollution than space available in this publication allows. In addition, many manufacturers have invested

Pollution Prevention Hierarchy



in more capital intensive changes, such as on-site etchant regeneration (the focus of Case Study #2) or an ion exchange / electrowinning system for metals recovery from wastewater, which can significantly reduce waste generation.

Getting Started

The most successful pollution prevention programs are developed as an integral part of a facility's decision-making process, where the opportunities to prevent pollution are considered with each decision to install new equipment, to make process changes, or to purchase new chemicals.

> ***The Benefits of Preventing Pollution Include Reductions in:***
>
> - ***Raw materials use, exposures, and costs***
> - ***Waste generation and disposal costs***
> - ***Regulatory compliance costs***
> - ***Treatment costs***
> - ***Transportation** risks **and costs***

In planning a pollution prevention program, it is essential to first obtain the full support of management and to define the goals of the program. Next, examine each step of your manufacturing process and identify the raw materials used, wastes generated, potential occupational exposures, and environmental releases. This assessment will allow you to take a comprehensive look at your process and to prioritize and select areas where pollution prevention and cost savings are most feasible and most easily accomplished.

Once the most promising opportunities have been implemented, evaluations of the project engineering, equip ment design, and performance should be conducted.

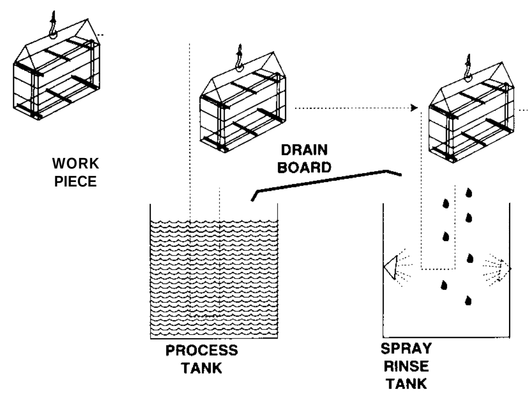
The process does not end after implementation of the selected opportunity. Pollution prevention is an efficient way of doing business because there is continuous evaluation of pollution prevention opportunities in working toward the goal of eliminating risk to workers and the environment, while maintaining or improving product quality and process efficiency.

Preventing Pollution

While the materials used, releases, exposures, and wastes generated will vary from one facility to another, the pollution prevention ideas presented in this case study have been successfully implemented under a variety of operating conditions. This case study concentrates on relatively simple changes that PWB manufacturers have found to be helpful in reducing chemical losses, increasing bath life, conserving water, reducing sludge volume, or recovering materials that otherwise would have been disposed.

By reducing dragout between the process baths and the rinsewater, both the amount of chemical removed from the bath and the amount of chemical added to the rinsewater can be reduced. The following options will help to reduce dragout:

- Withdraw racks at a slower rate: lengthen dragout time to allow more chemical to drip back to the process tank.
- Tilt racks at an angle to allow dragout chemicals to collect and drain back into the tank.
- Install drainboards between process and rinse tanks. Drainboards will minimize spillage between tanks. By sloping the drainboards away from rinse tanks, dragout chemicals drain back into the process tank.



- Using a cam, add a slight bump at the end of the rack withdrawal stroke to shake excess chemical back into the bath.
- Install an under-rack tray that travels with the rack from one tank to the next and empties dragout back into the tank.

In addition to reducing dragout, process bath chemicals and replenisher can be conserved by maximizing the useful life of process baths. Sludge generated from treatment of spent baths will also be reduced with the lengthening of bath life.

- Useful bath life can be maximized by understanding the bath conditions through monitoring. With some processes such as electroless lines, cupric chloride etching, and ammoniacal etching, continuous monitoring (pH, conductivity, specific gravity, calorimetric, or on-line titration) allows the operator to maintain consistent, optimum conditions, Other types of baths (e.g., copper plating and tin-lead plating) can be maintained through periodic monitoring.

- Facilities that currently send bath samples off-site for testing may find it cost-effective to test the bath chemistry on-site. This allows for improved control of process baths through shorter turnaround times between the bath measurement and the bath adjustment. The capital required for equipment and personnel may be justified through the savings associated with improved process control and reduced fees for laboratory testing.
- Baths that require dumping due to particle build-up, such as the resist build-up in the stripper for photoresist, can be filtered to increase the bath life.
- Use rinsewater as make-up to top off the bath.
- Using a "drain and fill" system as an alternative to a "feed and bleed" system for process bath replenishment can reduce chemical use while still allowing for in-process replenishment. The drain and fill system automatically removes a measured volume of the spent process solution (draining) by lowering the level slightly in the process tank and then replacing (filling) the removed solution with fresh chemical without interrupting production. Unlike a feed and bleed system where a portion of the fresh solution is bled with the spent solution, the drain and fill system does not waste fresh solution. This technology can be applied to the feed and bleed process in photoresist developing and photoresist stripping operations, electroless copper bath growth, and ammoniacal etchant replenishment, as well as to rinse tanks where water use can be reduced.

[illegible] Build-up on [illegible]

By taking steps to prevent copper build-up on your plating racks, you can reduce the amount of stripping solution needed, thereby reducing the amount of plating sludge generated.

One facility converted to polyethylene racks on their electrolytic plating lines and reduced the amount of stripping solution needed (and spent stripper) by 75%.

- Plating rack design and material choice can reduce copper build-up. Using polyethylene-coated plating racks in the electrolytic copper plating lines can significantly reduce copper build-up.
- Some facilities have found they can easily scrape the copper build-up from racks with a knife instead of chemically removing it. This option may only be feasible for smaller facilities.
- Check racks periodically for wear. Replace insulation where it has worn out and, when necessary, rebuild and recoat racks.

[illegible] Losses from [illegible]

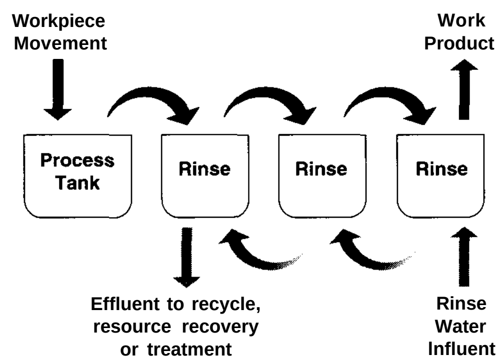
Process chemicals lost through evaporation contribute to your environmental releases and increase your raw material costs.

- Verify that your ventilation and air circulation system is engineered to achieve an optimal balance between increasing ventilation to reduce employee exposure and decreasing ventilation to reduce chemical losses and releases to the environment through evaporation.
- Float polypropylene balls on plating baths to reduce evaporation from process tanks. The success of this technique depends on the type of bath and the tank configuration.

[illegible]

Improvements in your rinsing efficiency can reduce the amount of water required for rinsing while reducing the amount of wastewater sent to treatment.

- Install flow controls. For example, use spray rinsing in the first rinse tank or use flow restrictors to reduce the quantity of water used. Additionally, installing contact switches automatically turns off the fresh water supply when the rinse is not in use.
- Use a countercurrent rinse configuration.
- Use an evaporator to concentrate the wastewater from the first tank after the copper plating tank and return the cop per to the plating tank as a make-up.
- Install a rinse tank controller to measure conductivity dynamically. As acidic rinsewater indicates contamination, a conductivity sensor provides information on the cleanliness of the rinsewater, and can be set to trigger the flow of fresh water only when necessary.
- Install turbulence devices, such as mixers or agitators to increase contact between the rinse water and the board Air agitation or workpiece agitation can also improve rinse efficiency.



- Reuse the acid rinse effluent as influent for the alkaline rinse tank. On the electroless line, rinse water used after the dilute sulfuric bath can be reused after the alkaline cleaner. This allows for reactive rinsing where the fresh water feed to the alkaline rinse tanks can be turned off.
- Other rinsewaters can also be rerouted to a previous rinse, provided the rinsewaters are compatible. For example, the rinsewater for rinsing boards removed from the catalyst bath can be reused for rinsing boards removed from the accelerator bath.

[illegible]

By using process chemicals in your manufacturing process that generate less sludge, both the volume of chemicals needed for waste treatment and the amount of waste generated are reduced.

- Examine your process chemicals and look for substitutes that generate less sludge. For example, using sodium borohydride or organometallic compounds (e.g., dithio carbamate) instead of ferrous sulfate in waste treatment will generate less sludge. Because sludge disposal costs vary regionally, it is important to perform a cost/benefit analysis to determine the possible savings from implementing this option.
- When possible, use non-chelated process chemistries rather than chelated chemistries to reduce sludge volume. Ask your supplier for a copy of the technical data sheet to determine if a product contains chelating agents (commonly used in stripper, etchant, and electroless copper chemistries). If the product is a chelator, see if an equivalent non-chelating substitute is available. If a substitute is not available, avoid mixing the chelator-containing waste stream with a metals waste stream, where the chelator will bind the metals so they cannot be easily removed from the waste.
- Maintaining good process control will result in fewer bath dumps and, consequently, less sludge.
- Thorough rinsing can reduce sludge. If the board is very clean before the next step, there will be less contamination and dragout, resulting in less sludge being generated.

[illegible] Materials

To further minimize the wastes from your manufacturing operation and to recover costs, look for opportunities to reclaim materials, especially metals.

*Use reusable polymer membrane filters instead of paper filters for filtering copper and zinc from the wastewater of the mechanical wet scrubbing operation (where a protective layer of zinc applied to prevent oxidation of the copper during shipment is removed). Filter the rinsewater containing the copper, zinc, and brush particles before sending it to the water treatment system, and scrape the particles off the filters for recycling.

- Send scrap boards to a reclaimer for recovery of metals.

The Design for the Environment (DfE) Approach

This case study describes a number of practices that many manufacturers have found prevent pollution and reduce employees' exposures to chemicals in their shops. These techniques may also reduce the total cost of your process (which includes equipment, labor, and waste disposal and compliance costs) with minimal capital expenditures.

The EPA's Design for the Environment Program encourages you to evaluate systematically the technologies, practices, and procedures in your facility that may impact the environment. Our goal in working with PWB manufacturers is to help you to make informed choices, now and in the future, by promoting the search for and evaluation of cleaner alternatives. With this case study and others like it, we hope to illustrate the application of this goal and the pursuit of continuous environmental improvement.

For More Information...

EPA's DfE Program would like to receive feedback on the effectiveness of this case study. If you successfully implement one or more of these pollution prevention ideas and would like to provide feedback to EPA, please send a brief description of your pollution prevention initiatives (or ideas for inclusion in future case studies) to the Design for the Environment Program, U.S. EPA (7406), 401 M St., SW Washington, DC, 20460, or fax: (202) 260-0981.

For additional PWB case studies, other publications specific to pollution prevention in the PWB industry, and more information on EPA's Design for the Environment Program or the DfE Printed Wiring Board Project, contact:

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