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# ENVIRONMENTAL RESEARCH BRIEF

## Pollution Prevention Assessment for a Metal Parts Coater

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### Abstract

The U.S. Environmental Protection Agency (EPA) has funded a pilot project to assist small and medium-size manufacturers who want to minimize their generation of waste but who lack the expertise to do so. In an effort to assist these manufacturers Waste Minimization Assessment Centers (WMACs) were established at selected universities and procedures were adapted from the EPA *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003, July 1988). That document has been superseded by the *Facility Pollution Prevention Guide* (EPA/600/R-92/088, May 1992). The WMAC team at Colorado State University performed an assessment at a plant that applies corrosion resistant coatings to metal parts. Aluminum parts received from customers may be anodized or may receive a chromate conversion coating. Brass, copper, steel, and aluminum parts from customers are nickel plated—either by electrolytic or electroless plating. The assessment team's report, detailing findings and recommendations, indicated that large quantities of wastewater and metal sludge are generated by the plant and that significant cost savings could be achieved through replacement of Freon used for degreasing.

This Research Brief was developed by the principal investigators and EPA's National Risk Management Research Laboratory, Cincinnati, OH, to announce key findings of an ongoing research project that is fully documented in a separate report of the same title available from University City Science Center.

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### Introduction

The amount of waste generated by industrial plants has become an increasingly costly problem for manufacturers and an additional stress on the environment. One solution to the problem of waste generation is to reduce or eliminate the waste at its source.

University City Science Center (Philadelphia, PA) has begun a pilot project to assist small and medium-size manufacturers who want to minimize their generation of waste but who lack the in-house expertise to do so. Under agreement with EPA's National Risk Management Research Laboratory, the Science Center has established three WMACs. This assessment was done by engineering faculty and students at Colorado State University's (Fort Collins) WMAC. The assessment teams have considerable direct experience with process operations in manufacturing plants and also have the knowledge and skills needed to minimize waste generation.

The pollution prevention opportunity assessments are done for small and medium-size manufacturers at no out-of-pocket cost to the client. To qualify for the assessment, each client must fall within Standard Industrial Classification Code 20-39, have gross annual sales not exceeding $75 million, employ no more than 500 persons, and lack in-house expertise in pollution prevention.

The potential benefits of the pilot project include minimization of the amount of waste generated by manufacturers, and reduction of waste treatment and disposal costs for participating plants. In addition, the project provides valuable experience for graduate and undergraduate students who participate in the program, and a cleaner environment without more regulations and higher costs for manufacturers.

## Methodology of Assessments

The pollution prevention opportunity assessments require several site visits to each client served. In general, the WMACs follow the procedures outlined in the EPA *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003, July 1988). The WMAC staff locate the sources of waste in the plant and identify the current disposal or treatment methods and their associated costs. They then identify and analyze a variety of ways to reduce or eliminate the waste. Specific measures to achieve that goal are recommended and the essential supporting technological and economic information is developed. Finally, a confidential report that details the WMAC's findings and recommendations (including cost savings, implementation costs, and payback times) is prepared for each client.

## Plant Background

This plant applies corrosion resistant coatings to metal parts. It operates as a job shop and produces approximately 200,000 coated parts annually during 4550 hr/yr of operation.

### *Manufacturing Process*

Coatings to provide protection or to enhance appearance are applied to parts received from the plant's customers. Coating processes used by this plant include anodizing, chromate conversion coating, electrolytic nickel plating, and electroless nickel plating. Each of these coating procedures is described below.

#### Anodizing

Anodizing is performed on aluminum parts only. Parts received from customers are racked in aluminum or titanium racks. The racks are immersed in a series of chemical solutions and rinse water baths to generate an aluminum oxide coating on the part's surfaces.

Three steps-- cleaning, anodizing, and dyeing-- make up the anodizing process. The cleaning process sequence consists of an alkaline cleaner, a two-tank counterflow rinse, a caustic etch, a second two-tank counterflow rinse, a desmut rinse, a third two-tank counterflow rinse, and a final acid rinse. After the cleaning process, the parts are soft- or hard-coat anodized in sulfuric acid. Following anodizing, the parts either proceed to a dyeing process or remain uncolored (clear). The baths that make up the dyeing process are an agitated deionized water rinse, a two-tank counterflow deionized rinse, a dye tank, and another two-tank counterflow deionized rinse.

Both the dyed parts and the clear parts are then immersed in a sealing solution and rinsed in a two-tank counterflow rinse and a heated deionized water rinse. The racks containing the parts are then hung on bars to allow the parts to air dry. Dried parts are removed from the racks, inspected, packaged, and returned to the customer.

#### Chromate Conversion Coating

Only aluminum parts receive chromate conversion coatings. The chemical solutions and rinses for chromating are integrated with the anodizing solutions, and, therefore the chromating process uses many of the same baths as the anodizing process. The sequence of baths used for chromate conversion is: alkaline cleaner, two-tank counterflow rinse, caustic etch, two-tank counterflow rinse, tri-acid etch or desmut (determined by the part and customer specifications), two-tank counterflow rinse, yellow or clear chromic acid solution, two-tank counterflow rinse, and deionized water rinse. Following processing, the parts are allowed to dry and are removed from the racks, inspected, packaged, and shipped back to the customer.

#### Electrolytic Nickel Plating

Electrolytic nickel plating is performed on brass, copper, aluminum, and steel parts. However, this line is not used very often and as a result generates very little waste. The treatment baths used in the electrolytic nickel line are: caustic cleaner, electrosoap, two-tank counterflow rinse, desmut, desmut dragout, two-tank counterflow rinse, acid salt, hydrochloric acid, nickel strike, three-tank counterflow rinse, nickel plating, nickel dragout, two-tank counterflow rinse, and heated deionized water rinse. The parts are allowed to air dry, inspected, packaged, and shipped.

#### Electroless Nickel Plating

Most of the production in this plant is electroless nickel plating of steel and aluminum parts. Five lines are used for nickel plating: a hand-operated barrel plating line, a second line with an overhead hoist, a third line dedicated to aluminum parts, a fourth line dedicated to plating ice cube trays, and a crane-operated line for large parts.

The process solutions used in each line are similar, but different prep solutions are required for the different base metals that are plated. In general, the sequence of preparation tanks is: alkaline cleaner, electrolytic soap, two-tank counterflow rinse, desmut, desmut dragout tank, two-tank counterflow rinse, acid dip, two-tank counterflow rinse, acid salt, and a two-tank counterflow rinse.

An abbreviated process flow diagram for the processes used in this plant is shown in Figure 1.

### *Existing Waste Management Practices*

This plant already has implemented the following techniques to manage and minimize its wastes.

- Electrowinning is used to generate reusable nickel prior to precipitation, thereby reducing the generation of nickel hydroxide sludge.
- Flow reducers are used on all flowing rinses to reduce water consumption.
- Staged counter-flowing rinse tanks are used for more effective rinsing and to reduce water consumption.

## Pollution Prevention Opportunities

The type of waste currently generated by the plant, the source of the waste, the waste management method, the quantity of the waste, and the annual waste management cost for each waste stream identified are given in Table 1.

Table 2 shows the opportunities for pollution prevention that the WMAC team recommended for the plant. The opportunity, the type of waste, the possible waste reduction and associated savings, and the implementation cost along with the simple payback time are given in the table. The quantities of waste currently generated by the plant and possible waste reduction depend on the production level of the plant. All values should be considered in that context.

It should be noted that, in most cases, the economic savings of the opportunities result from the need for less raw material and from reduced present and future costs associated with waste treatment and disposal. Other savings not quantifiable by this study include a wide variety of possible future costs related to changing emissions standards, liability, and employee health. It also should be noted that the savings given for each opportunity reflect the savings achievable when implementing each opportunity independently and do not reflect duplication of savings that would result when the opportunities are implemented in a package.

This research brief summarizes a part of the work done under Cooperative Agreement No. CR-814903 by the University City Science Center under the sponsorship of the U.S. Environmental Protection Agency. The EPA Project Officer was **Emma Lou George**.

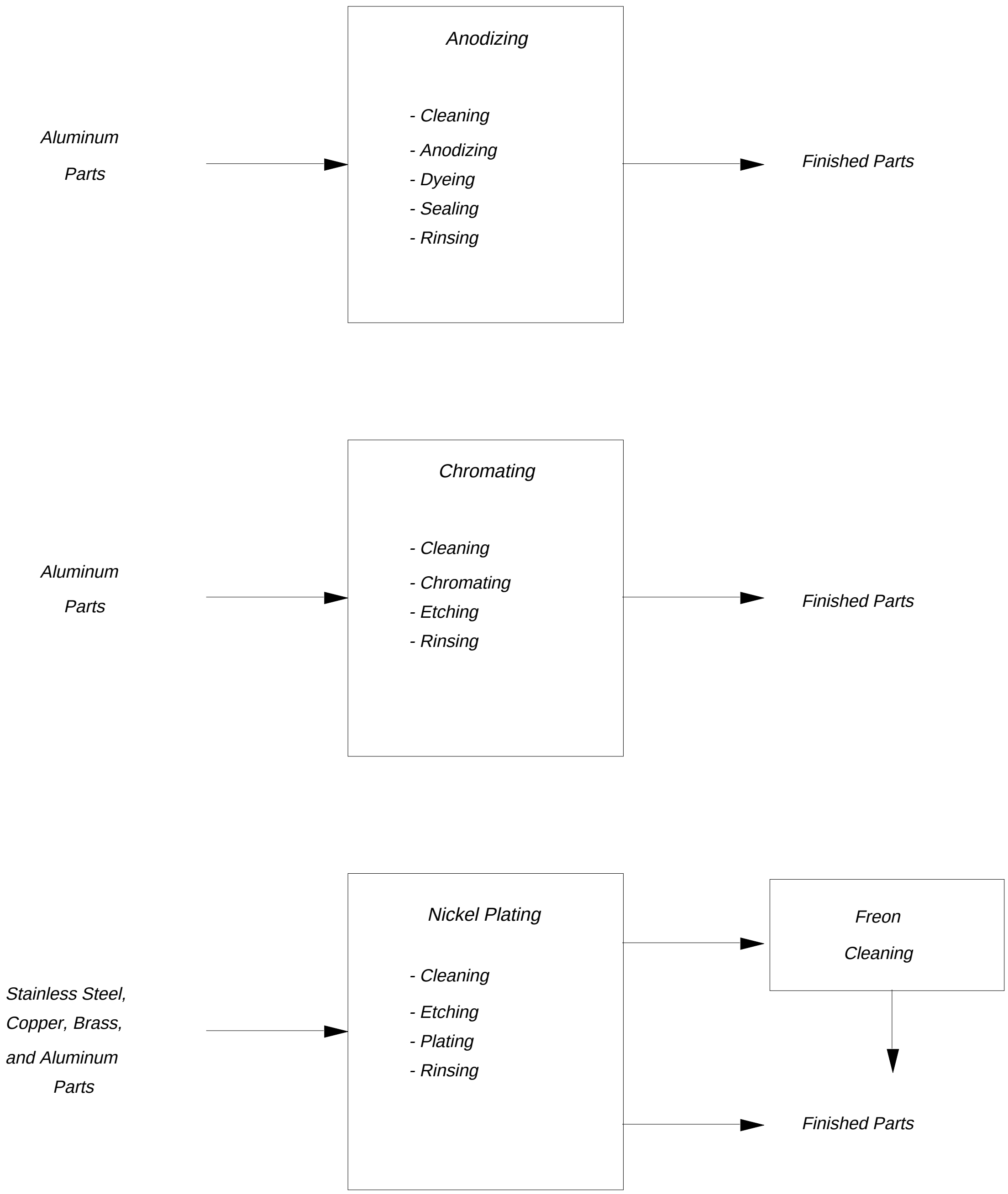


***Figure1.*** *Abbreviated process flow diagram for metal parts coating.*

*Table 1. Summary of Current Waste Generation*

| Waste Generated | Source of Waste | Waste Management Method | Annual Quantity Generated (lb/yr) | Annual Waste Management Cost* |
|---|---|---|---|---|
| Rinse water | All process lines | pH adjusted; sewered | 62,700,00 | $10,500 |
| Chromium-containing wastewater | Chromating and anodizing lines | Chromium removed by ion exchange; pH adjusted; sewered | 2,590,000 | 1,330 |
| Chromium-containing sludge | Pretreatment of chromium-containing wastewater | Shipped offsite to reclaimer | 1,470 | 2,930 |
| Nickel-containing wastewater | Nickel plating | Nickel removed by ion exchange; pH adjusted; sewered | 3,070,000 | 510 |
| Nickel-containing sludge | Pretreatment of nickel-containing wastewater | Shipped offsite to reclaimer | 1,730 | 3,470 |
| Waste Freon TF™ | Vapor degreasing of parts | Allowed to evaporate onsite | 8,630 | 28,500 |
| Waste 1,1,1-trichloroethane | Miscellaneous cleaning jobs | Shipped offsite for incineration | 2,090 | 2,250 |

*Includes waste treatment, disposal, and handling costs and applicable raw material costs.

*Table 2. Summary of Recommended Pollution Prevention Opportunities*

| Pollution Prevention Opportunity | Waste Reduced | Annual Waste Reduction: Quantity (lb/yr) | Annual Waste Reduction: Per Cent | Net Annual Savings | Implementation Cost | Simple Payback (yr) |
|---|---|---|---|---|---|---|
| Replace Freon TF™ used in the vapor degreaser with a nonhazardous cleaner and post-clean rinse. The spent cleaner can be regenerated onsite through vacuum distillation and the waste post-clean rinse can be sewered. | Waste Freon TF™ | 8,630 | 100 | $26,200[1] | $4,900 | 0.2 |
| Replace the chromic acid cleaner in the electroless-plating hoist line with a less hazardous cleaner such as a phosphoric acid cleaner. The current use of chromic acid results in the generation of a chromium-containing sludge. The replacement cleaner can be pH-adjusted onsite. | Chromium-containing sludge | 1,180 | 80 | 2,940 | 0 | 0 |

[1] Total annual savings have been reduced by an annual operating cost required for implementation.

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