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ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Manufacturer of Finished Metal Components

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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. 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). The WMAC team at Colorado State University performed an assessment at a plant manufacturing finished metal components — approximately 260,000 sq ft/yr. Customer-specified coatings and surface treatments are applied to prefabricated aluminum and stainless steel parts. Aluminum parts may be finished by hard-coat or soft-coat anodizing, and chromate conversion coating. Stainless steel parts are finished by surface passivation. Parts are also processed for surface inspection using a fluorescent dye and ultraviolet light. The team's report, detailing findings and recommendations, indicated that most waste was generated in the aluminum anodizing process, and that the greatest savings could be obtained by using hot deionized water instead of nickel acetate solution to seal pores in the aluminum oxide coating applied by anodizing.

This Research Brief was developed by the principal investigators and EPA's Risk Reduction Engineering 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.

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 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 formation of hazardous waste but who lack the inhouse expertise to do so. Under agreement with EPA's Risk Reduction Engineering 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 waste minimization 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 inhouse expertise in waste minimization.

The potential benefits of the pilot project include minimization of the amount of waste generated by manufacturers, reduced waste treatment and disposal costs for participating plants, 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 waste minimization 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

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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

The plant is a metal-finishing job shop that applies coatings and surface treatments to prefabricated metal parts. The plant operates 2,448 hr/yr to produce approximately 280,000 sq ft of finished metal parts.

Manufacturing Process

This plant does hard-coat and soft-coat anodizing, chromate conversion coating, and surface inspection of aluminum parts. Processing of stainless steel parts involves surface passivation, surface inspection, or both. The raw materials used include aluminum cleaner, NaOH aluminum etch, nitric/hydrofluoric (HF) acid deoxidizer, sulfuric acid, dyes, nickel acetate, sodium dichromate, chromate conversion coatings, nitric acid, hydrofluoric acid, oil-base penetrant, developer, water washable penetrant, and hydrophilic emulsifier.

The following steps are carried out in the surface finishing operations:

- The aluminum anodizing line involves alkaline cleaning and etching, acidic deoxidizing to remove smut left after etching, anodizing in an electrolytic solution of sulfuric acid, dyeing, and sealing the aluminum oxide layer with aqueous nickel acetate.
- Chromate conversion coating of aluminum involves alkaline cleaning and etching, acidic deoxidizing, clear or gold-colored chromate conversion coating, and rinsing in deionized water.
- For stainless steel passivation, parts are degreased, etched, and immersed in a passivating acid solution.
- For surface inspection, parts are first degreased and etched. A fluorescent dye is then applied and the surface is illuminated with ultraviolet light to reveal surface flaws.

An abbreviated process flow diagram is shown in Figure 1.

Existing Waste Management Practices

- Two-stage and three-stage counterflow rinses in the anodizing and chromate conversion lines reduce water consumption and waste generation.
- Process solutions are made up with deionized water to reduce sludge formation.
- Drain boards are used between solution tanks to reduce dragout.
- Spent etching solution is used for adjusting the Ph of spent rinse water.

Waste Minimization Opportunities

The type of waste currently generated by the plant, the source of the waste, the quantity of the waste, and the annual management costs are given in Table 1.

Table 2 shows the opportunities for waste minimization that the WMAC team recommended for the plant. The type of waste, the minimization opportunity, the possible waste reduction and associated savings, and the implementation cost along with the payback time are given in the table. The quantities of hazardous 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 minimization opportunities result from the need for less raw material and from reduced present and future costs associated with hazardous 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 should also be noted that the savings given for each opportunity reflect the savings achievable when implementing each waste minimization 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.

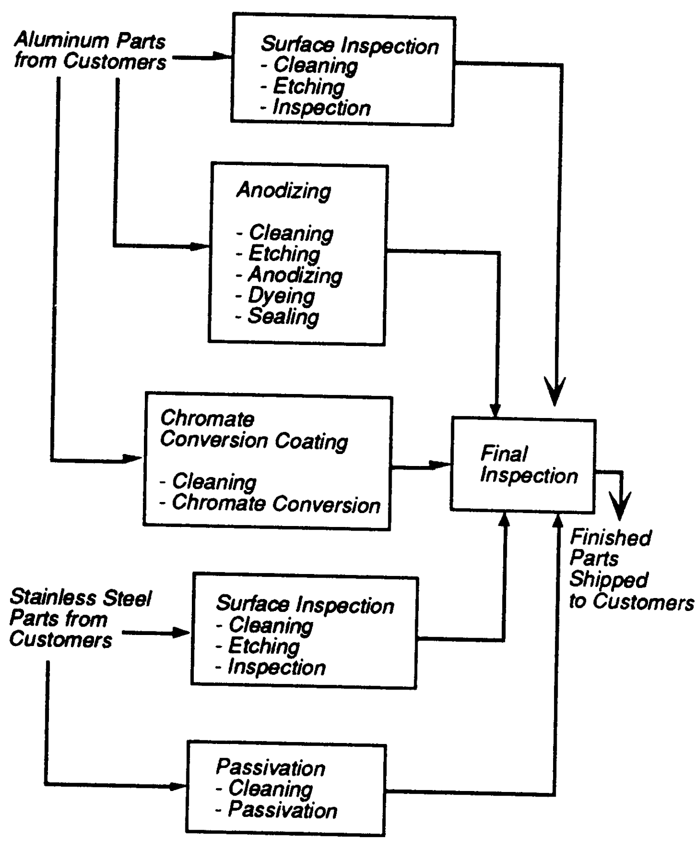

Figure 1. Abbreviated process flow diagram.

Table 1. Summary of Current Waste Generation

Waste Generated	Source of Waste	Annual Quantity Generated (gal)	Annual Waste Management Cost
Spent rinse water	Rinse waters from anodizing, chromate conversion coating, and surface inspection are Ph adjusted and discarded as industrial wastewater.	1,547,734	$19,963
Spent anodizing solutions	Aluminum cleaner, alkaline etch bath, acidic deoxidizer solution, anodizing reagent solution, and dyeing and nickel acetate seal solutions are batch treated (Ph adjusted) and discarded with rinse water as industrial wastewater.	5,000	8,589
Spent chromate conversion coating solutions	Hexavalent chromate solutions are reduced with sodium metabisulfite; then, with aluminum cleaner, alkaline etch bath, and acidic deoxidizer solution, are batch treated (Ph adjusted) and discarded with rinse water as industrial wastewater.	641	759
Spent passivation solutions	Hexavalent chromium solutions are reduced with sodium metabisulfite and, with nitric acid solutions, are batch treated (Ph adjusted) and discarded with rinse water as industrial wastewater.	125	306
Spent acidic etchant solution	Spent acidic etchant from surface inspection is batch treated to adjust Ph and precipitate dissolved metals then discarded as industrial wastewater.	40	123
Spent penetrants	Spent dyes, developer, and emulsifier from surface inspection are shipped as hazardous waste for use as cement kiln fuel.	20	985
Batch treatment sludge	Sludge (metal hydroxides and trivalent chromium compounds) from treatment of spent process solutions and rinse waters is disposed of as hazardous waste.	150	5,191

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Table 2. Summary of Recommended Waste Minimization Opportunities

Waste Generated	*Minimization Opportunity*	*Annual Waste Reduction*		*Net Annual Savings*	*Implementation Costs*	*Payback Years*
		Quantity (gal)	*Percent*			
Spent nickel acetate seal solution	*Use hot deionized water instead of nickel acetate as a seal after anodizing.*	*2,275*	*100*	*$ 3,094*	*$ 1,020*	*0.3*
Nickel hydroxide sludge from treatment of spent nickel acetate solution	*Use hot deionized water instead of nickel acetate as a seal after anodizing.*	*104*	*100*	*1,109*	*0*	*0*
Spent anodizing solutions	*Neutralize the spent solutions with 50% aqueous caustic instead of sodium hydroxide pellets. Use automated metering equipment to reduce raw material and labor costs.*	-	-	*2,933*	*1,140*	*0.4*
Spent reagent solutions from chromate conversion coating	*Allow increased drainage time above the chromate conversion coating line reagent baths. Increased solution life will result in waste reduction and cost savings.*	*1,292*	*20*	*2,498*	*0*	*0*
Anodizing and chromate conversion coating water rinses	*Eliminate the soft-coat anodizing rinse (use the hard-coat rinses for both treatments), and install timer switches to shut off all flowing rinses when not in use.*	*651,346*	*42*	*2,351*	*2,081*	*0.9*
Alkaline etch water rinses	*Use spent acidic deoxidizer rinse water instead of tap water for the anodizing and chromate conversion coating alkaline etch rinses.*	*259,820*	*17*	*756*	*260*	*0.3*
Anodizing and chromate conversion coating water rinses	*Install flow reducers and flow meters on flowing water rinses in the anodizing and chromate conversion coating lines to avoid excessive use of rinse water.*	*144,015*	*10*	*419*	*1,210*	*2.9*

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