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ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Manufacturer of Sheet Metal Cabinets and Precision Metal Parts

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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 hazardous 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 for a plant that manufactures sheet metal cabinets and precision metal parts. To make the cabinets, sheet metal is cut to size, bent, welded, and polished. The metal parts are then surface treated and painted. The machined parts are produced from bar stock which is cut, drilled, milled, and ground as needed. The team's report, detailing findings and recommendations, indicated that the most waste was generated by the chromate conversion and iron phosphate coating processes that prepare the parts for painting. The plant could achieve the greatest cost savings by replacing solvent-based painting with powder-based painting.

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, which is available from the authors.

Introduction

The amount of hazardous 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 hazardous 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 in-house 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 hazardous 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 $50 million, employ no more than 500 persons, and lack in-house 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 proce-

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dures outlined in the EPA *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003, July 1988). The WMAC staff locates the sources of hazardous waste in the plant and identifies 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 manufactures sheet metal cabinets and precision metal parts. Approximately 1.15 million parts are produced annually by 140 employees who operate the plant 2,210 hr/yr.

Manufacturing Process

Sheet Metal Parts

Sheets of aluminum and steel are cut to the proper size and shape. Holes are punched into the metal that is then bent as needed. Some pieces are welded together. Rough edges and surfaces are polished with power sanders and buffers. Metal scrap is shipped to a scrap metal dealer for recycling. Spent cutting fluid and waste hydraulic oil are combined and shipped offsite for recycle or incineration.

Before painting, metal parts are surface treated to improve paint bonding and provide corrosion protection. Aluminum parts receive a chromate conversion coating while steel parts receive an iron phosphate coating.

Aluminum parts are first dipped in a caustic cleaning solution that is followed by a continuous-flow tap-water rinse. A third tank contains a desmut solution and is followed by another continuous-flow tap-water rinse tank. A fifth tank contains the chromic acid-based chromate conversion solution. A sixth tank is a continuous-flow tap-water rinse and a final tank is a heated dead rinse of tap water. The caustic cleaner, desmut, and first rinse tanks are dumped monthly; the chromic acid tank is dumped every three to four years; and the remaining solutions are dumped every five months. In addition, sludge accumulates in the caustic cleaner tank and is disposed of monthly.

In iron phosphate coating of steel parts, the first stage involves a caustic cleaning tank followed by a continuous-flow tap-water rinse. A third tank contains the iron phosphating solution and is followed by another continuous-flow tap-water rinse. A final tank contains a deoxidizing solution. All of these baths are dumped and replenished on a monthly basis. Combined wastewaters from the iron phosphate and chromate conversion lines drain to an overflow tank and are then drained to the sewer as industrial wastewater. Typically, pretreatment before discharge is not required because the wastewater meets discharge limits set by the publicly owned treatment works (POTW). Sludge accumulates in the caustic cleaner and iron phosphate tanks and is disposed of monthly.

Solvent-based paint is applied to metal parts in dry paint booths. Waste paint that is generated when the paint mixture becomes too thick to be used is shipped to a hazardous waste treatment, storage, and disposal facility (TSDF). Spent paint thinner is also shipped offsite. Painted parts are dried and cured in ovens. The plant uses powder-based paint coatings on a small portion of parts. The type of paint used is dictated by customer requirements.

Machined Parts

Bar stock is cut, drilled, milled, and ground as needed. Finished parts are assembled (if required) and shipped to customers. Metal scrap is shipped to a scrap metal dealer for recycle. Spent cutting fluid and waste hydraulic oil are combined with similar waste from the manufacture of sheet metal parts and shipped offsite for recycle or incineration.

Existing Waste Management Practices

This plant has taken the following steps to manage and minimize its wastes:

- Scrap metal is segregated onsite and sold to a recycler.
- All reagent tanks in the phosphating and chromating lines are located in a large pit with a central drain to contain spills.
- Drain boards are used between surface treatment tanks to reduce drag-out.
- Reagent solutions in the surface treatment lines are agitated with air to increase the effectiveness of the reagents.
- Dry paint booths are used for painting to avoid generating aqueous paint-laden wastes that are generated in wet paint booths.
- A small powder coating unit is used for painting some products in order to avoid using solvent-based paints.
- Tank dumps are coordinated to achieve neutralization so that the sewered effluent meets POTW requirements.

Waste Minimization Opportunities

The type of waste currently generated by the plant, the waste management method used, 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 present practice, the recommended action, and the waste reduction and associated savings are also given in Table 2. 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.

Additional Recommendations

In addition to the opportunities recommended and analyzed by the WMAC team, several additional measures were considered. These measures were not analyzed completely because of insufficient data, implementation difficulty, or a projected lengthy payback. Since one or more of these approaches to waste reduction may, however, increase in attractiveness with changing conditions in the plant, they were brought to the plant's attention for future consideration.

- Install filtration units for the iron phosphating and caustic cleaner solutions to increase solution lifetime.

- Use deionized water to make-up and maintain the caustic cleaner and iron phosphating solutions, thereby reducing sludge formation.

- Substitute nonchromate conversion coating for the chromate conversion coating currently used on aluminum parts.

- Increase drainage times over the tanks in the iron phosphating and chromate conversion lines in order to reduce drag-out.

- Segregate waste oil from the spent cutting fluid and recycle it.

- Improve segregation of scrap metal before recycling.

- Implement a preventive maintenance program for the machine shop to reduce the quantities of spent cutting fluid and waste oil.

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.

Table 1. Summary of Current Waste Generation

Waste Generated	*Waste Management Method*	*Annual Quantity Generated (gal)*	*Annual Waste Management Cost ($)*
Machining			
Scrap metal	*Shipped to scrap dealer for recycle*	*N/A*	*N/A*
Cutting fluid/hydraulic oil	*Offsite recycle or incineration*	*1,320*	*5,780*
Chromate Conversion Coating			
Spent caustic cleaner	*Sewered as industrial wastewater*	*14,400*	*20*
Caustic cleaner sludge	*Conventional disposal in landfill*	*60*	*0*
Caustic cleaner rinse water	*Sewered as industrial wastewater*	*359,160*	*660*
Spent desmut solution	*Sewered as industrial wastewater*	*14,400*	*20*
Desmut rinse water	*Sewered as industrial wastewater*	*345,260*	*640*
Spent chromating solution	*Sewered as industrial wastewater*	*300*	*0*
Chromating rinse water	*Sewered as industrial wastewater*	*345,260*	*640*
Heated dead rinse	*Sewered as industrial wastewater*	*2,880*	*0*
Iron Phosphate Coating			
Spent caustic cleaner	*Sewered as industrial wastewater*	*33,600*	*60*
Caustic cleaner sludge	*Conventional disposal in landfill*	*60*	*0*
Caustic cleaner rinse water	*Sewered as industrial wastewater*	*378,360*	*700*
Spent iron phosphate solution	*Sewered as industrial wastewater*	*33,600*	*60*
Iron phosphate sludge	*Conventional disposal in landfill*	*60*	*0*
Phosphating rinse water	*Sewered as industrial wastewater*	*378,360*	*1,160*
Spent deoxidizer solution	*Sewered as industrial wastewater*	*33,600*	*60*
Painting			
Waste paint and paint sludge	*Offsite recycle or incineration*	*1,430*	*61,370*
Spent paint thinner	*Offsite recycle or incineration*	*1,320*	*11,330*

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Table 2. Summary of Waste Minimization Opportunities Recommended

Present Practice	*Proposed Action*	*Savings*
Solvent-based paints are used to coat the majority of this plant's products. Waste paint, paint sludge, and spent thinner are disposed of offsite.	*Replace solvent-based painting with powder-based painting for a portion of the plant's products. Cost savings will result from reduced disposal costs and reduced raw material costs. Installation of a batch spray booth for powder coating will be required.*	*Waste reduction = 72 gal/yr (waste paint and paint sludge) + 66 gal/yr (spent thinner)* *Waste management cost savings = $740/yr* *Net raw material cost savings = $14,230/yr* *Total cost savings = $14,970/yr* *Implementation cost = $20,600* *Simple payback = 1.4 yr*
	Replace solvent-based painting with water-based painting for a portion of the plant's products (a separate portion from previous WMO). Cost savings will result from reduced disposal costs and reduced raw material costs. Requires the purchase of new paint application equipment and may require increased curing times.	*Waste reduction = 72 gal/yr (waste paint and paint sludge) + 66 gal/yr (spent thinner)* *Waste management cost savings = $740/yr* *New raw material cost savings = $10,930/yr* *Total cost savings = $11,670/yr* *Implementation cost = $2,500* *Simple payback = 0.2 yr*
A solvent recovery unit in the plant currently is not operational because of oil and water leaks.	*Overhaul the solvent recovery unit to permit reuse of spent paint thinner. Cost savings will result from reduced disposal costs and reduced purchases of thinner.*	*Waste reduction = 660 gal/yr* *Waste management cost savings = $3,890/yr* *Raw material cost savings = $1,780/yr* *Operating cost of recovery unit = $430/yr* *Net cost savings = $5,240/yr* *Implementation cost = $2,500* *Simple payback = 2.1 yr*
Cutting fluid currently is used until it becomes malodorous or until its viscosity and lubricity are unacceptable. Average fluid lifetime is about three months.	*Institute a program to recycle the cutting fluid onsite. Fluid should be filtered periodically to remove metal chips and particulate matter, thereby extending the life of the cutting fluid. In addition, the spent cutting fluid can be treated with acid to reduce the volume of wastes that must be shipped offsite. The addition of acid will cause a phase separation; the aqueous phase can be neutralized and sewered and the organic phase should be disposed of offsite.*	*Waste reduction = 425 gal/yr* *Waste management cost savings = $2,920/yr* *Raw material cost savings = $570/yr* *Operating cost of filtration unit = $370/yr* *Total cost savings = $3,120/yr* *Implementation cost = $7,050* *Simple payback = 2.3 yr*
Rinse water rates set by operators exceed flow rates required by the rinses in the chromate conversion and phosphating lines.	*Install a flow reducer and flow meter in the water supply line upstream of the rinses in the chromate conversion and iron phosphating lines, thus reducing the quantity of water purchased and sewered.*	*Waste reduction = 331,500 gal/yr* *Waste management cost savings = $100/yr* *Raw material cost savings = $510/yr* *Total cost savings = $610/yr* *Implementation cost = $100* *Simple payback = 0.2 yr*

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