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ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Manufacturer of Metal Bands, Clamps, Retainers, and Tooling

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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 at a plant that manufactures metal bands, clamps, retainers, and tooling—approximately 2 million lb/yr of product. Metal undergoes cutting, machining, cleaning, and electroplating as required. The specific processes are determined by the particular product being produced. The team's report, detailing findings and recommendations, indicated the most waste was generated by metal cleaning and that the greatest cost savings would result from using deionized water instead of tap water to make up and maintain the reagent baths in the metal cleaning and electroplating lines.

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 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 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 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 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 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. Fi-

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nally, 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 metal clamps, bands, retainers, and tools used to install clamps and fittings. The plant's 125 employees operate the plant 4,680 hours per year to produce approximately 2 million lb of product annually.

Manufacturing Process

The raw material for the manufacture of bands is received in 24-in. wide stainless steel coils. The coils are cut into several narrower coils with carbide cutters in a continuous process and are wound onto spools. Sharp edges are removed and the coils are beveled. Scrap stainless steel from these operations is sold to a scrap-metal dealer.

Two types of clamps, a closed clamp, with the band threaded through the buckle to form a round slip-on clamp, and an open-ended clamp, with the buckle attached to the end of a band, are manufactured.

Clamp fabrication begins by punching out buckles of stainless and carbon steel on a hydraulic punch press. The buckles are combined with strips of stainless steel to form the clamps. For a closed clamp, a buckle is crimped onto one end of the band, and the other end is inserted into the buckle to form a cylindrical clamp. Open-ended clamps are fabricated by crimping buckles onto the end of the flat band material. Following inspection, the bands are packaged and stored in the warehouse prior to final shipment.

For customers who prefer to purchase the band material and the buckles separately, specialized tools to apply and install clamps and fittings are also fabricated by this plant. Iron blanks are forged off-site by a third party and machined on-site by drilling holes, tapping threads, cutting slots, and creating various surface finishes. Waste cutting fluid and hydraulic oil are sent to an incinerator. To remove in-situ stresses created from machining, the tools are heated to about 1700°F, quenched in oil, washed with a caustic cleaner, and annealed in one of two draw furnaces.

The tools are then placed in electroplating barrels in preparation for further processing. The barrels are immersed in the following tanks which make up the metal cleaning line: caustic cleaner, electrosoap, tap-water rinse, acidic cleaner, cascade rinse (consists of two tanks), and acid stripper.

The caustic cleaning solution is prepared from a concentrate that contains sodium hydroxide and sodium metasilicate and is maintained at 180°F. The 560-gal tank is dumped about every 6 months; the spent solution, along with other waste liquids from the metal-cleaning line, drains into a small sump, is tested and balanced for proper pH in a surge tank, and is discharged to the sewer system as industrial waste water. Usually, very little pH adjustment is required because the spent cleaning solution is mixed with spent acidic solutions.

The alkaline electrosoap solution is prepared from a reagent that contains sodium hydroxide and sodium silicate. A voltage is applied to provide anodic electrocleaning. This solution is maintained at 180°F, and the 281-gal tank is dumped about every 6 months. Spent solution is treated with other waste water from the cleaning line.

Sludge, which contains precipitated hard-water ions, surface contaminants removed from the parts, and heavy metals from cleaning buckles and reworked material, accumulates in the bottoms of the caustic cleaner and electrosoap tanks. Periodically, the sludge is removed from the tanks, drummed, and shipped off-site for hazardous waste disposal.

The tap-water rinse and the cascade rinse are continuous-flow rinses. Most of the liquid waste from the cleaning line consists of water from the tap-water rinse following the electrosoap bath and the cascade rinse following the acidic cleaner. The two effluents mix in the sump and tend to neutralize and thus, little pH adjustment is required.

The acidic cleaner solution is prepared by diluting a cleaning reagent that consists of sodium fluoride. The 281-gal tank is drained about every 6 months. Spent cleaner is treated with other waste from the cleaning line.

The last tank of the metal cleaning line is the acid stripping tank. The acid stripping solution which consists of sulfuric, hydrochloric, phosphoric acids, and soaps, is used to remove zinc plating from rejected parts. There is no continuous discharge from this tank; the solution lifetime is at least 2 years. Spent stripper is shipped to an off-site hazardous waste facility for disposal.

After the metal cleaning line, the electroplating barrels are then sent through the zinc electroplating line which consists of the following 6 tanks: acid zinc plating, 2-tank cascade rinse, brightener, tap-water rinse, and hot rinse. The acid zinc plating solution contains sulfuric acid and ammonium chloride. Hydrogen peroxide is added weekly to the plating solution for maintenance, and the solution is filtered to remove any solid contaminants. To provide optimum plating conditions, the solution is cooled to below 80°F. Spent plating solution is shipped off-site for hazardous waste disposal.

Rinse water from the zinc plating line is treated to remove zinc and reused. Lime is added for pH adjustment prior to treatment in an electrocoagulation unit which consists of two parallel tubes containing aluminum anodes. Current applied to the sacrificial anodes precipitates metal hydroxides. Treated water flows through a filter press to remove hydroxides and is reused as rinse water. Sludge is shipped off-site for hazardous waste disposal. The barrels containing the plated parts are then sent through the cascade rinse.

The brightener tank, which follows, contains a solution prepared from an acidic reagent that consists of nitric acid, chromic nitrate, and ammonium bifluoride. The 281-gal tank is not dumped during normal operations, although the solution is periodically drained and replenished. Spent brightener is drummed and shipped off-site for hazardous waste disposal.

Following an air-agitated, recycled-water rinse, is a heated rinse. Effluent from the heated rinse is treated with other rinse waters and sewered.

The plated tools are combined with assorted fittings and parts in the assembly area. After inspection, the tools are packaged and stored to await shipment.

Minor liquid waste streams include kerosene and quenching oil. Kerosene is used as a cleaning solvent in the air-tool assembly area. The minor amounts that are used typically evaporate; no waste kerosene is manifested and shipped off-site for disposal, so this waste stream was not included in Table 1. About 700 gallons of petroleum-based quenching oil are used in the heat treating operations. The oil typically lasts about 7 years before disposal is required, so this waste was not evaluated for this assessment.

Existing Waste Management Practices

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

- Excess metal is segregated on-site and sold to a scrap-metal dealer for recycling.
- Rinse water from the plating line is treated to remove metal contaminants and reused.
- Air-agitation is used for rinses in the zinc plating line.
- The zinc plating solution is filtered to remove solid contaminants.
- The use of leaded steel for banding tools has been discontinued.
- Cascade rinses are used in the metal cleaning and zinc plating lines.

Waste Minimization Opportunities

Table 1 shows the sources of the plant's waste streams, the amounts of waste generated, the management method used, and the associated costs.

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 as indicated below. 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.

- Institute a formal cutting-fluid management program to reduce the volume of spent cutting-fluid wastes that require disposal.
- Replace the kerosene, which is used as a cleaning solvent in the assembly area, with a nonhazardous aqueous cleaner.
- Install an automated pH-adjuster to regulate the pH of the effluent from the metal cleaning line in order to prevent potential compliance problems.

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 Stream	*Disposal Method*	*Waste Disposal Annual Quantity (gal)*	*Annual Cost*
Liquid waste			
Metal Cleaning			
Caustic cleaner	*pH adjusted and sewered*	*1,120*	*$ 0*
Electrosoap	*pH adjusted and sewered*	*560*	*0*
Rinse	*pH adjusted and sewered*	*650,000*	*750*
Acidic cleaner	*pH adjusted and sewered*	*560*	*0*
Cascade rinse	*pH adjusted and sewered*	*650,000*	*750*
Acid stripper	*Off-site disposal*	*170*	*900*
Zinc Plating			
Electroplating	*Off-site disposal*	*280*	*1,200*
Brightener	*Off-site disposal*	*170*	*700*
Machining			
Waste oil/cutting fluid	*Off-site incineration*	*660*	*70*
Solid waste			
Metal cleaning			
Caustic cleaner/electrosoap sludge	*Off-site disposal*	*170*	*1,200*
Zinc plating			
Water recycler sludge	*Off-site disposal*	*230*	*1,000*

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Table 2. Summary of Recommended Waste Minimization Opportunites

Present Practice	*Proposed Action*	*Waste Reduction and Associated Savings*
The tap-water rinse in the metal cleaning process line uses tap-water as make-up	*Redirect the rinse water overflow from the cascade rinse in the metal cleaning process line to replace the tap-water make-up. Waste reduction and cost savings will result from the reduced amount of water that must be purchased and sewered.*	*Waste reduction = 650,000 gal/yr* *Cost savings = $1,110/yr* *Operating cost of required pump = $20/yr* *Net cost savings = $1,090/yr* *Implementation cost = $470* *Simple payback - 0.4 yr*
Higher-grade scrap metals are combined with lower grade scrap before being sent to the metal recycler. The recycling credit is reduced because of this practice.	*Improve the segregation of stainless steel scrap, iron turnings, and ohter scrap metals. No waste reduction will result from this measure, but the amount of cash received from the recycler will increase.*	*Cost savings = $950/yr* *Implementation cost = $0* *Simple payback is immediate.*
Tap-water is uesed to make and maintain the reagent baths in the metal cleaning and zinc electroplating process lines.	*Use deionized water to make and maintain the caustic cleaner, electrosoap, acid cleaner, zinc electroplating, and brightener solutions. Less sludge will thereby be generated in the caustic cleaner tank.*	*Waste reduction = 150 gal/yr* *Cost savings = $1,820/yr* *Operating cost of the required ion exchange unit = $450/yr* *Net cost savings = $1,370/yr* *Implementation cost = $0* *(The ion exhange unit will be rented and that cost is included in the above operating cost.)* *Simple payback is immediate.*
The drainage time of parts over the caustic cleaner and electrosoap tanks is about 5 seconds.	*Increase the drainage time over the caustic cleaner and electrosoap tanks to ten seconds. The volume of solution which drains back into the tanks will increase and therefore the bath lifetimes will increase..*	*Waste reduction = 250 gal/yr* *Cost savings = $340/yr* *Implementation cost = $0* *Simple payback is immediate.*
Rinse water rates set by opertors in the tap-water and cascade rinses of the metal cleaning line are often higher than required by the process.	*Reduce water usage by installing flow reducers and flow meters on the rinse tanks in the metal cleaning line.*	*Waste reduction = 124,800 gal/yr* *Cost savings = $220/yr* *Implementation cost = $130* *Simple payback = 0.6 yr*

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