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ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Manufacturer of Compressed Air Equipment 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 hazardous waste but 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 inspected a plant manufacturing zinc and aluminum alloy filters, regulators, lubricators, fittings, and valves — components for compressed air equipment. Each step of the manufacturing process creates waste: fabricating zinc and aluminum diecast parts generates scrap metal and spent lubricants and hydraulic fluid; milling, drilling, and tapping generate spent cutting/cooling fluid and solvents and metal shavings; cleaning machined parts and steel parts fashioned off-site generates waste oil and 1,1,1,-trichloroethane; and surface coating of metal parts generates effluents from chemical baths and alkaline rinses, e.g., chromium, sulfate, and phosphate precipitates. Other processes generate additional waste hydraulic fluid, cutting/cooling fluid, and Freon.† Although the plant had already changed several procedures to minimize its wastes, the WMAC team's report, detailing findings and recommendations, identified several practices that might be changed to effect greater waste reduction and savings. The recommendation resulting in the greatest reduction involves replacing chromium-containing reagents with those that generate no hazardous waste; the proposed coating process requires no rinsing and would, therefore, not contaminate rinse waters.

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 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.

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† Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

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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. 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 manufactures zinc and aluminum alloy filters, regulators, lubricators, fittings, and valves. The plant is operated over 7,000 hr/yr by its 400 employees to produce nearly 4 million units annually.

Manufacturing Process

The manufacture of compressed air equipment components begins with the fabrication of zinc and aluminum diecast parts. Zinc and aluminum alloy ingots are melted in separate furnaces and the molten metals are then transported to diecasting machines. The diecasting machines force the liquid metals into a mold-and-plunger assembly by hydraulic compression. A water-based lubricant is sprayed on the molds, and an oil-based lubricant is used for the plunger. Excess lubricants collect in a sump and are mixed with other oil wastes for disposal. Small amounts of solvent used to clean the diecasting machines are also mixed with the oil wastes. An ethylene glycol/water-based hydraulic fluid provides the required hydraulic compression. Extensive leakage in the hydraulic fluid reservoir requires that fresh hydraulic fluid be added to maintain the proper fluid level. Used fluid is mixed with the miscellaneous oil and solvent wastes for disposal. Solid wastes in the diecasting area consist of scrap and excess metal, which is remelted in the proper furnace along with the raw metal ingots.

Diecast metal parts are transported to the machining area to be milled, drilled, and tapped as required. Most of the machining equipment uses a water-based cutting/cooling fluid. A centrifuge removes metal contaminants so that the fluid may be reused. Solids and sludge that remain are mixed with oil and solvent wastes for disposal. Some of the machining equipment uses an oil-based lubricant; no liquid wastes are generated from these machines because the oil is recycled. Occasionally, lubricant is added to compensate for lubricant that remains on the metal parts. Small amounts of solvent used to clean the machines are mixed with the oil wastes. Oil-contaminated metal shavings from the machining area are sold to an outside firm for reuse.

After machining, parts are washed with an alkaline solution containing borax to remove remaining cutting oil and are deburred before application of protective coatings. Oil is collected by a skimmer in the alkaline washer and mixed with the water-based lubricant from the machining area. Effluent from the washer is combined with other aqueous wastes that flow to an on-site wastewater treatment unit.

Steel parts that have been manufactured at an off-site facility are cleaned in a small vapor degreasing unit with 1,1,1-trichloroethane. Waste solvent and still bottoms from the vapor degreaser are drummed and disposed of as hazardous waste.

Surface coatings are applied to all metal parts. Chromate conversion, phosphate, or anodized coatings are applied by immersing the parts in a series of chemical baths and rinses. The chromate conversion coating line is automated, and the phosphate and anodized coating lines are operated manually. The actual treatment process varies for each metal coated. Effluents from the coating lines and alkaline washer are combined and treated in the wastewater treatment facility. Sodium metabisulfite is added to reduce hexavalent chromium to trivalent chromium. Sodium hydroxide is then added to raise the pH from about 2.75 to 8.5 and to form insoluble metal hydroxides. Adding calcium chloride removes sulfate and phosphate ions as insoluble calcium compounds. Precipitates are flocculated with a polymer and allowed to settle to form a metal hydroxide sludge, which is periodically pumped to a filter press for dewatering and shipped to a hazardous waste disposal facility. The supernatant's contaminant level is below the pretreatment specifications of the local Publicly Owned Treatment Works (POTW), so it is discharged to the sewer system.

Powder coating is applied to some of the metal parts, which are then cured in a furnace. No hazardous waste is generated in the powder coating process.

Plastic injection molding machines, which use an oil-based hydraulic fluid, produce the plastic components of the compressed air equipment. The hydraulic fluid is filtered periodically and reused. Contaminated fluid is mixed with other oil and solvent wastes for disposal.

Hazardous wastes are also generated in processes not directly related to manufacturing. The tooling area, where molds and equipment are maintained, contains equipment that employs the same water-based cutting/coolant fluid used for machining. This fluid is also reused after processing with the centrifuge. The clean room generates about 10 gal/mo of waste Freon from cleaning components to be used for medical and other special applications; the waste is sent off-site for disposal. Small amounts of solvent-based paints are used for machinery, and any waste is sent off-site for disposal.

Existing Waste Management Practices

Before the WMAC's assessment, the plant had already taken the following steps to minimize and manage its generation of hazardous wastes:

- Using a centrifuge to remove metal chips and fine particles from the water-based coolant/cutting fluid used in the machining area. The clean fluid is then collected and reused.
- Eliminating on-site treatment of steel parts in the near future; this will reduce or eliminate the need for solvent degreasing and also the need to dispose of contaminated 1, 1, 1- trichloroethane.
- Using an alkaline wash to remove oil from metal parts before surface treatment. This alkaline wash replaced more traditional cleaners, such as halogenated organic compounds.
- Using a filter press to reduce the water content of the hazardous metal hydroxide sludge before shipment off-site for disposal.
- Using powder coatings on metal parts. Replacing solvent-based paints with powder coating eliminated solvent-based paint wastes and reduced the emission of volatile organic compounds.
- Collecting metallic wastes from the diecasting process and remelting them in the appropriate furnace. Oil-contaminated metal chips from the machining area are collected and sold to a metal recycler.
- Minimizing the use of solvent-based paints for general painting. Solvent-based paints are only used on machinery and other items not suited for water-based paints.

Waste Minimization Opportunities

Table 1 summarizes the principal sources of waste, the amounts generated, and the associated management costs.

Table 2 briefly describes current plant practices, the recommended waste minimization opportunities, and savings and cost data.

Additional Recommendations

The WMAC also investigated several other opportunities for waste minimization that require relatively lengthy paybacks or are considered to be beyond the scope of this program. These measures are:

- Implementing a preventative maintenance program for the diecasting machinery to reduce the frequency and cost of unscheduled repairs.
- Establishing a program to segregate oil wastes to allow recycling of waste oils.
- Using a water/glycol fluid instead of a petroleum-based fluid as the hydraulic fluid in the plastic injection molders. The water/glycol fluid would reduce waste generation because of its longer lifetime.
- Installing a solvent recovery unit to remove contaminants from the 1,1,1-trichloroethane used in the vapor degreasing unit.
- Using deionized water in the reagent baths in the chromate conversion coating line.
- Removing waste oil from the alkaline wash water.

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Table 1. Summary of Current Waste Generation

Waste Stream	Source of Waste	Annual Quantity Generated (gal)	Annual Waste Management Cost
Combined wastes including water-based die lubricant, oil-based plunger lubricant, water- soluble cutting coolant, water/glycol hydraulic fluid, and equipment cleaning solvents.	Die casting	9,660	$ 5,300
Combined wastes including petroleum-based cutting coolant, water-soluble cutting coolant, water/glycol hydraulic fluid, and equipment cleaning solvents.	Plastic molding	1,780	980
Combined wastes including petroleum-based and water-based cutting coolants and equipment cleaning solvents.	Machining of die cast parts	18,060	9,920
1,1,1-trichloroethane and still bottoms.	Vapor degreaser unit	350	1,750
Rinse water laden with heavy metals and reagents used in chromate conversion coating, phosphating, and anodizing.	Treatment of rinse water from the coating operation and the alkaline washer	2,930,000	4,900
Chromium hydroxide and other metal hydroxide solids.	Treatment of rinse water from the coating operation and the alkaline washer	5,700	10,400

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Table 1. Continued.

Waste Stream	Source of Waste	Annual Quantity Generated (gal)	Annual Waste Management Cost
Waste Freon.	Cleaning of parts used in special applications	100	130
Waste solvent-based paint and thinner.	Painting of plant equipment	400	2,560

Table 2. Summary of Recommended Waste Minimization Opportunities

Present Practice	Proposed Action	Waste Reduction and Associated Savings
Reagents used to create a conversion coating on aluminum parts contain chromium and therefore generate hazardous waste. These reagents contaminate rinse water and contribute to the amount of hazardous solid waste that is generated.	Replace the chromium-containing reagents with reagents that generate no hazardous waste. The proposed coating process does not require rinsing after coating and therefore will not contaminate rinse waters.	Solid waste reduction = 1280 gal/yr Liquid waste reduction = 659,300 gal/yr Cost savings = $5,480/yr Implementation cost = $0 Payback is immediate.
Oil wastes from the die casting, injection molding, and machining areas are combined and form a multiphase fluid that is sent to a disposal facility.	Use magnesium chloride as a de-emulsifying agent to break the oil-water emulsion. The oil waste can be collected in a tank and sent to an oil recycler. The aqueous phase can be treated at the plant's wastewater treatment facility.	Waste reduction = 16,230 gal/yr Cost savings = $6,820/yr Implementation cost = $2,500 Payback = 0.4 yr
Drainage time over reagent baths in the chromate conversion coating line is 5 sec.	Increase the drainage time to 10 sec to allow more reagent to drain back into the bath. Waste reduction will result from extended lifetimes for the baths.	Waste reduction = 17 gal/yr Cost savings = $210/yr Implementation cost = $ 0 Payback is immediate.

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