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ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Manufacturer of Speed Reduction Equipment

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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 performed an assessment at a plant manufacturing speed reduction equipment -- approximately 110,000 speed reduction units/yr. Plant operations include machining and assembling parts for worm gear shafts and other shafts, worm gear bodies, hubs and housings, bearings and seals. Keyed and threaded shafts are case-hardened, ground with a thread grinder, and deburred. Component parts are washed with an aqueous cleaner before assembly, and finished assemblies are spray painted with solvent-based paints and lacquer thinner. Spent cutting fluid and sludge, including turnings, and spent wash water are shipped offsite for disposal. Spent hydraulic oil and nonaqueous cutting fluid are shipped to a recycler. Waste paint and spent lacquer thinner are shipped offsite for incineration. The team's report, detailing findings and recommendations, indicated that most waste consists of spent aqueous cutting fluid, and that the greatest savings could be obtained by ultrafiltration and recycle of spent wash water.

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.

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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.

The waste minimization assessments are done for small- and medium-size manufacturers at no out-of-pocket cost to the

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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 produces speed-reduction equipment. The plant operates 7,480 hr/yr to produce approximately 110,000 speed reduction units.

Manufacturing Process

The plant machines and assembles parts for worm gear shafts and other shafts, worm gear bodies, hubs and housings, bearings and seals. (The term "worm gear" refers to a component part of speed reduction units.) Except for bearings, motors and cast housings, all speed reduction unit parts are made in the plant. Raw materials include steel and bronze bar stock, aluminum and iron castings, cutting fluids, paint and lacquer thinner.

The following operations are involved in making the speed reduction units:

- Worm gear shafts are machined from bar stock. Key slots are cut, and a thread mill cuts worm gear threads in the shafts. After case-hardening in a gas-fired carburizing furnace, the shafts are ground with a thread grinder and deburred in a tumbler with ceramic chips and an aqueous slurry of aluminum oxide.
- Worm gear bodies, made of a bronze alloy, are machined on a numerically controlled machine and pressed on the hubs.
- Spent cutting fluid and sludge containing metal turnings are shipped for offsite disposal. Spent hydraulic oil and nonaqueous cutting fluid are shipped to a waste oil recycler.
- Most component parts are washed with a water soluble cleaner before assembly. Spent wash water and mop water from cleanup around machinery are shipped offsite for disposal.
- Many of the finished assemblies are spray painted using solvent-based paints and lacquer thinner. Waste paint and spent lacquer thinner are shipped offsite for incineration in a cement plant. Spent paint-booth air-filter elements are discarded with conventional trash.

Existing Waste Management Practices

- Metal scraps and chips are segregated and sold to a scrap metal dealer for recycling.
- For drilling and tapping operations the plant uses a lubricant with reduced emission of volatile organic compounds (VOCs). Nonhazardous waste oil is processed offsite by a recycler and blended into industrial boiler fuel. Solvent-based cleaners have been replaced by a nonhazardous aqueous cleaning solution.
- Spent cutting fluid is occasionally filtered and re-used.
- Dry booths are used for painting, eliminating the aqueous paint-laden wastes associated with wet paint booths.

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.

Additional Recommendations

In addition to the opportunities recommended and analyzed by the WMAC team, four additional measures were considered. These measures were not completely analyzed because of insufficient data or minimal savings as indicated below. They were brought to the plant's attention for future reference, however, since these approaches to waste reduction may increase in attractiveness with changing plant conditions.

- Treat spent wash water and mop water containing sulfuric acid to separate organic and aqueous phases. The organics would be shipped for offsite disposal, but the water phase could be sewered to a local industrial wastewater treatment facility. Because the plant does not have an industrial sewer connection at this time, this measure was not recommended. Ultrafiltration was recommended instead, because it provides an aqueous phase suitable for discharge to the POTW sewer or re-use as mop water.
- Install a tramp-oil separator and two outside atmospheric evaporators to reduce the quantity of wastewater shipped

offsite for disposal. Because expected savings are small, with a long payback period, this measure was not recommended.

- Replace two water-soluble cutting fluids now in use with a single standardized cutting fluid. Because the resulting waste reduction and savings resist quantification, this measure was not recommended. However, if the recommendation to recycle the cutting fluid is implemented, use of a single cutting fluid will reduce substantially the cost of equipment and operating costs.

- Install tramp-oil separators on the washers to allow recycle of the alkaline wash water. The extended life of the wash water would result in waste reduction, but the expected cost savings would be small in comparison to operating costs.

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	Source of Waste	Annual Quantity Generated	Annual Waste Management Cost
Spent cutting fluid	Decanted from metal chips produced in machining operations. Shipped for offsite disposal.	61,380 gal	$19,640
Cutting fluid sludge	Metal chips sludge produced in machining operations. Shipped for offsite disposal.	650 gal	330
Cutting fluid and rainwater	Runoff to pit drainage from metal chips collection bins.	12,480 gal	-
Spend hydraulic oil and nonaqueous cutting oil	Drained from machinery when no longer effective. Shipped to a waste oil recycler.	3,000 gal	300
Waste paint (sludge) and thinner	Sludge formed as the paint becomes too thick and the thinner no longer useful for thinning or cleaning. Shipped for incineration in a cement plant.	2,150 gal	16,250
Spent air filter elements	Paint booth ventilation air filtration. Conventional trash disposal.	-	-
Spent wash water	Spent aqueous cleaning solution from cleaning finished metal parts before assembly. Shipped for offsite disposal.	1,200 gal	380
Spent mop water	Soapy mop water from cleanup around plant machinery. Shipped for offsite disposal.	9,420 gal	3,000

Table 2. Summary of Recommended Waste Minimization Opportunities

Waste Generated	Minimization Opportunity	Annual Waste Reduction		Net Annual Savings	Implementation Cost	Payback Years
		Quantity	Percent			
Paint waste from cleaning spray guns	Use waste-based paints instead of solvent-based paints to eliminate solvent and thinner and produce only conventional, nonhazardous waste.	2,150 gal	100	$27,370[1]	$13,750	0.5
Spent aqueous cutting fluids	Filter and recycle the aqueous cutting fluids.	31,340 gal	51	17,430[1]	22,400	1.3
Spent mop water from cleanup around machinery	Install an ultrafiltration system to process spent wash water for use as mop water. Excess treated water can be discharged to the POTW. Only the separated oil layer need be shipped for disposal.	9,420 gal	13	33,410[1]	35,100	1.1
Spent cutting fluid from chip collection bins	Use a portable sump cleaner to remove accumulated cutting fluid from chip collection bins for filtration and recycle (as proposed above for recycle of spent cutting fluid).	12,480 gal	100	3,120[1]	0	0

[1]Includes savings on raw materials.

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