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ENVIRONMENTAL RESEARCH BRIEF

Pollution Prevention Assessment for a Manufacturer of Gear Cases for Outboard Motors

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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. In an effort to assist these manufacturers 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). That document has been superseded by the *Facility Pollution Prevention Guide* (EPA/600/R-92/088, May 1992). The WMAC team at the University of Tennessee performed an assessment at a plant that manufactures gear cases for outboard motors. Aluminum castings are machined and polished, and undergo chemical immersion, chromate conversion, and, in some cases, painting. Steel castings are machined, heat treated, shot-peened offsite, deburred, and ground. The finished component parts are assembled together. The team's report, detailing findings and recommendations, indicated that absorbent socks and leaked oil and coolant are generated in large quantities, and that significant cost savings could be achieved by eliminating the use of the absorbent socks by constructing containment areas around the machines.

This Research Brief was developed by the principal investigators and EPA's National Risk Management Research 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.

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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 generation 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 generation of waste but who lack the in-house expertise to do so. Under agreement with EPA's National Risk Management Research Laboratory, the Science Center has established three WMACs. This assessment was done by engineering faculty and students at the University of Tennessee's (Knoxville) 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 pollution prevention opportunity 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 in-house expertise in pollution prevention.

The potential benefits of the pilot project include minimization of the amount of waste generated by manufacturers, and reduction of waste treatment and disposal costs for participating plants. In addition, the project provides 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 pollution prevention opportunity 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 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

This plant manufactures steel and aluminum lower gear cases for outboard motors and assorted small steel parts. The plant operates approximately 6,600 hr/yr to produce almost 200,000 units annually.

Manufacturing Process

Aluminum Part Production

Aluminum castings for gear cases are received and machined in a series of operations in which they are milled, bored, and cut. Machined castings which have a light residual surface coating of coolant following machining operations are allowed to dry on racks before they are polished.

Approximately half of the machined aluminum castings are transported to a traditional polishing operation in which the parts are held against a rotating polishing wheel. The remaining machined aluminum castings undergo a drag-through polishing process in which the parts are fastened to a circular turntable and pulled through a tank containing a soap and water solution and abrasives.

All of the polished castings then undergo a series of chemical immersions to wash the cases and to seal micro-cracks and pores. A chrome conversion process is utilized to provide surface corrosion protection and to improve paint adhesion and surface texture. After the chromate conversion process, the castings are dried and approximately 99% of them are transported to the lower-unit assembly area. The remaining 1% of the castings are first painted using hand-held spray guns.

Steel Part Production

Steel gear casting families are received by the plant and machined in a work cell process configuration. The machined gears are then transported to the heat treatment area where they are heated in a large high-temperature oven for hardening. After heat treatment, the gears are quenched in an oil tank.

The cooled heat-treated gears are shipped offsite to a "shot-peening" process in which the gears are pelted with tiny steel balls ion order to harden the metal surface, clean rough edges, and shine dark areas that result from heat treatment.

Gears that have been shot-peened undergo a deburring process in which vibratory slurry stones remove any residual rough edges. The final inner and outer diameter tolerances of the gear shaft and shaft hole are achieved in a final grinding step.

The finished gears are then matched to a fitting pinion and are dipped in a tank where they receive a coating of oil in order to prevent rust formation before their use. Approximately 80% of the gears are transported to the assembly area, and the remaining gears are packaged and shipped to dealers to be sold as replacement parts.

Assembly

The finished component parts are mounted on racks and transported to one of several different assembly lines dedicated to different product families. During assembly, seams are sealed and parts are bolted together. Crankcases are tested and the accepted units are packaged and shipped to customers.

An abbreviated process flow diagram for the production of gear cases for outboard motors is shown in Figure 1.

Existing Waste Management Practices

This plant already has implemented the following techniques to manage and minimize its wastes.

- Alkaline soap is used instead of 1, 1, 1-trichloroethane in the drag-through polishing process.
- The use of Freon™ for parts cleaning has been eliminated throughout the plant.

Pollution Prevention Opportunities

The type of waste currently generated by the plant, the source of the waste, the waste management method, the quantity of the waste, and the waste management cost for each waste stream identified are given in Table 1.

Table 2 shows the opportunities for pollution prevention that the WMAC team recommended for the plant. The opportunity, the type of waste, the possible waste reduction and associated savings, and the implementation cost along with the simple payback time are given in the table. The quantities of 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 the economic savings of the opportunities, in most cases, results from the reduction in raw material and costs associated with 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 also should be noted that the savings given for each opportunity reflect that pollution prevention opportunity alone and do not reflect duplication of savings that may result when the opportunities are implemented in a package.

This research brief summarizes a part of the work done under Cooperative Agreement No. CR-819557 by the University City Science Center under the sponsorship of the U. S. Environmental Protection Agency. The EPA Project Officer was **Emma Lou George**.

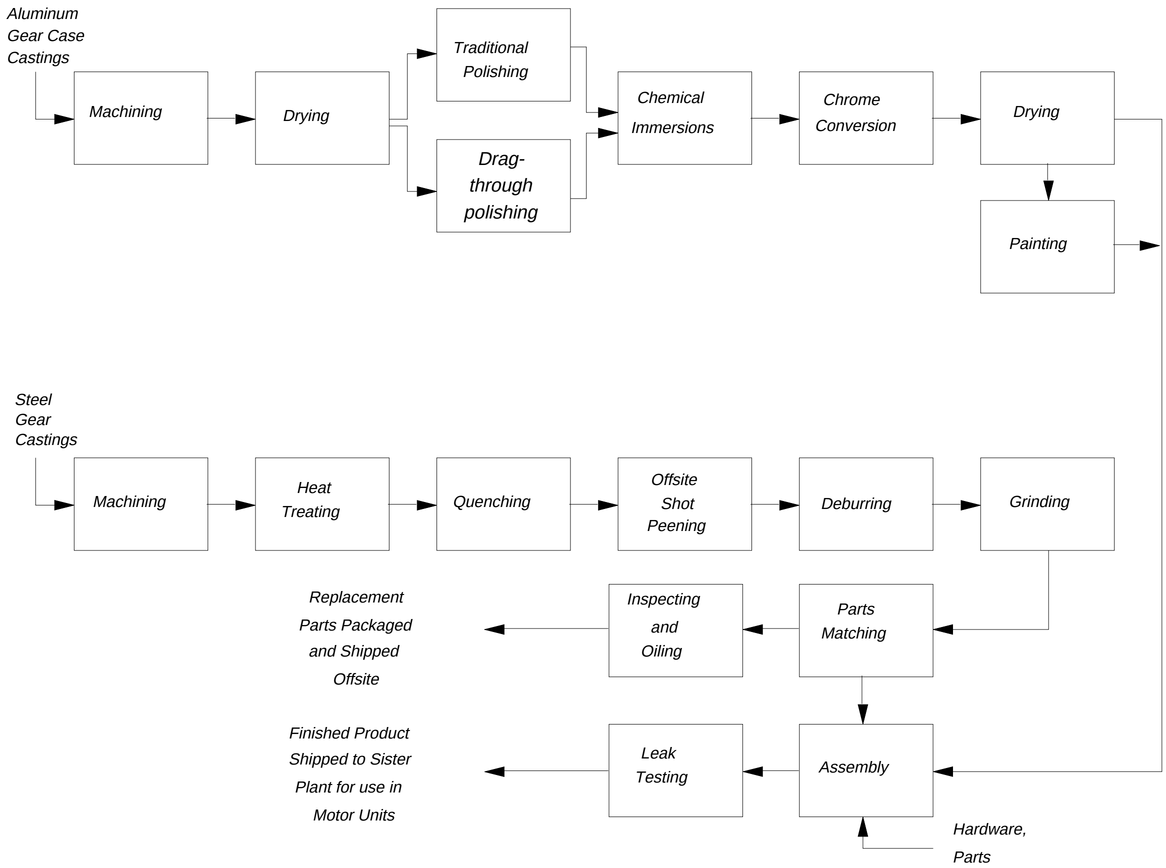

Figure 1. *Abbreviated process flow diagram for gear case manufacture.*

Table 1. *Summary of Current Waste Generation*

Waste Stream Generated	Source of Waste	Waste Management Method	Annual Quantity Generated (lb/yr)	Annual Waste Management Cost ($/yr)
Cardboard	Parts receiving	Shipped offsite to municipal landfill	95,180	$360
Soiled gloves	Various plant operations	Shipped offsite to municipal landfill	4,160	20
Hydraulic oil and coolant	Leaks from machines	Shipped offsite to reclaimer	188,000	12,230
Absorbent socks/oil	Absorbing of leaked oil and coolant from machines	Shipped offsite as hazardous waste	17,640	14,370
Aluminum dust sludge	Polishing	Shipped offsite to municipal landfill	913,680	3,410
Spent abrasive	Drag-through polishing	Shipped offsite to municipal landfill	28,000	100
Filter cake	Drag-through polishing	Shipped offsite to municipal landfill	1,152,000	4,300
Sludge filter cake	Wastewater treatment	Shipped offsite as hazardous waste	13,200	7,480
Methyl ethyl ketone/paint	Paint line cleaning	Shipped offsite to fuels blending program	740	2,410
Steel scrap	Machining	Shipped offsite	63,900	7,410
Vaporized liquid nitrogen	Heat treating	Vented	4,982,200	0
Methanol	Heat treating	Vented	126,590	0
Slurry stones	Deburring	Shipped offsite to municipal landfill	8,900	30
Filtered particulate metal	Grinding	Shipped offsite to municipal landfill	76,800	290
Wastewater	Various plant operations	Treated onsite; sewered	34,997,000	28,580

Table 2. Summary of Recommended Pollution Prevention Opportunities

Pollution Prevention Opportunity	Waste Stream Reduced	Annual Waste Reduction Quantity (lb/yr)	Annual Waste Reduction Per Cent	Net Annual Savings	Implementation Cost	Simple Payback (yr)
Construct a containment area around the bases of the metal working machines to collect waste oil and coolant instead of using absorbent socks to do so. Use the available wet-vacuum to collect the waste oil and coolant and dispose of it with other oil waste.	Absorbent socks (See note below)	15,880	90	$ 13,150	$ 8,450	0.6
Install a sludge drying oven to reduce the mass and volume of wastewater treatment sludge to be shipped offsite. Although this opportunity will not lead to waste reduction, it will lead to lower disposal costs.	Sludge filter cake	0	—-	5,820	12,000	2.1
Bale the waste cardboard currently shipped to the municipal landfill and sell it to a recycling company. Although this opportunity will not lead to waste reduction, it will lead to lower disposal costs and revenue for the plant.	Cardboard	0	—-	4,850	10,580	2.2

Note: Approximately 12,000 lb/yr of waste oil/coolant will be collected and disposed of (at a much lower unit cost).

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