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ENVIRONMENTAL RESEARCH BRIEF

Pollution Prevention Assessment for a Manufacturer of Components 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 That document has been superseded by the *Facility Pollution Prevention Guide* (EPA/600/R-92/088, May 1992).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 power heads and midsections for use in marine outboard motors. Aluminum castings undergo metal working, chromate conversion, spray painting, and assembly operations. The team's report, detailing findings and recommendations, indicated that a large amount of wastewater from the chromate conversion of raw aluminum castings is generated and that significant cost savings and waste reduction could be achieved by recycling the wastewater using a reverse osmosis system.

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.

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 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*

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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

The plant manufactures power heads and midsections for use in marine outboard motors from aluminum castings. It operates 6,000 hr/yr to produce approximately 200,000 units annually.

Manufacturing Process

Power heads and midsections are produced by this plant and shipped to another plant owned by the same company to be assembled into the final consumer product, outboard motors. Raw materials used by the plant include aluminum castings such as motor blocks and heads, steel flywheels, and connecting rods. The operations of this plant include metal working, chromate conversion of raw aluminum castings, spray painting, and final assembly.

Raw aluminum castings and chrome-converted aluminum castings are received and stored temporarily prior to being used in production operations. The castings are transferred to a chrome conversion or spray painting operation, or to a series of machining operations. Each part will undergo chrome conversion, painting, and metal working, but the sequence of the operations is determined by the production line.

Residues from machining are cleaned from parts (such as heads, blocks, and manifolds) in aqueous washers dedicated to each production line. After cleaning, the parts are bolted together in a series of assembly operations. The finished power heads and midsections are tested, and accepted products are shipped to the assembly plant.

The chrome conversion and spray painting operations are described below.

Chrome Conversion

The chrome conversion process provides a protective surface finish to raw aluminum castings. Initially, parts are washed and rinsed and their surfaces are chemically etched in an acid bath. Then the parts are rinsed twice and submersed in a chromic acid bath in which the surface metal is oxidized to form a corrosion-resistant protective finish. Chromic acid residue remaining on the surfaces of the parts is removed in three final rinses.

Spray Painting

Parts receive a protective coating of black paint in the spray painting operation. The parts to be painted are placed on hangers attached to an overhead conveyor. Masking is applied manually to surfaces that do not require painting. Paint is applied to the parts using a hand-held electrostatic spray gun as they travel through the spray painting booth. Following paint application, the coating is cured in an oven and then the masking is removed.

A simplified process flow diagram for this plant is shown in Figure 1.

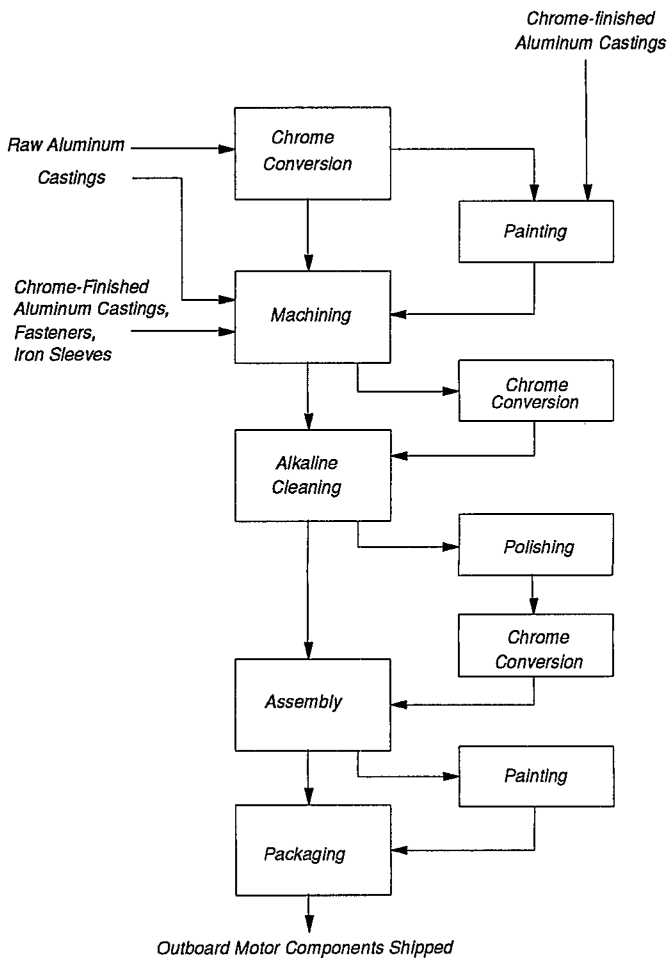

Figure 1. *Simplified process flow diagram for manufacture of outboard motor components.*

Existing Waste Management Practices

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

- Wet/dry vacuums have replaced the use of absorbent socks for oil clean-up, thereby eliminating a significant solid waste stream.
- A state agency recently performed a waste assessment for this plant.
- Corporate environmental audits are performed for this plant periodically.

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 annual 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 financial savings of the opportunities result from the need for less raw material and from reduced present and future costs associated with waste management. 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 the savings achievable when implementing each pollution prevention opportunity independently and do not reflect duplication of savings that would result when the opportunities are implemented in a package.

This research brief summarizes a part of the work done under Cooperative Agreement No. CR819557 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	Waste Management Method	Annual Quantity Generated (lb/yr)	Annual Waste Management Cost*
Miscellaneous solid waste	Various plant operations	Shipped offsite to municipal landfill	2,300,000	$7,950
Spent hydraulic oil	Machining operations	Shipped offsite to be blended into fuel	6,860	1,070
Spent honing oil and other honing-related waste	Machining operations	Shipped offsite to be blended into fuel	24,400	24,080
Wastewater	Washers (machining operations)	Treated in onsite wastewater treatment facility; sewered	879,220	1,820
Aluminum chips	Machining operations	Sold to recycler	540,370	-327,080 (net revenue received)
Scrap aluminum parts	Rejected following leak testing	Sold to recycler	103,580	-62,690 (net revenue received)
Mixed aluminum and iron chips	Machining operations	Shipped offsite for recycling (no revenue received)	352,780	2,550
Scrap iron	Machining operations	Shipped offsite for recycling (no revenue received)	32,350	1,350
Wastewater	Chrome conversion	Treated in onsite wastewater treatment facility; sewered	14,188,230	97,680
Wastewater	Washers (spray painting)	Treated in onsite wastewater treatment facility; sewered	13,337,020	28,340
Spent paint filters and floor coverings	Spray paint booth	Compacted; shipped offsite for use in fuel program	69,900	83,080
Spent solvent	Cleaning of paint lines	Shipped offsite to be blended into fuel	3,320	4,710
Evaporated solvent	Storage of cleaning solvent	Evaporates to plant air	4,440	450
Evaporated paint carrier solvent	Spray painting	Evaporates to plant air	61,020	1,500
Spent coolant	Machining operations	Shipped offsite to be blended into fuel	2,797,460	63,460
Wastewater	Cleaning during final assembly	Treated in onsite wastewater treatment facility; sewered	501,980	270
Filter cake	Onsite wastewater treatment facility	Shipped offsite as hazardous waste	114,000	19,540
Dirty rags	Various plant operations	Shipped offsite to be cleaned; returned for reuse	83,410 units	n/a
Domestic water	Plant operations	Sewered	7,852,920	4,300
Pallets and other waste wood	Plant operations	Shipped offsite	28,000	1,350
Cardboard	Plant operations	Sold to recycler	320,000	-2,250 (net revenue received)

Includes waste treatment, disposal, and handling costs, and applicable raw material costs.

Table 2. Summary of Recommended Pollution Prevention Opportunities

Pollution Prevention Opportunity	Waste Reduced	Annual Waste Reduction: Quantity (lb/yr)	Annual Waste Reduction: Per Cent	Net Annual Savings	Implementation Cost	Simple Payback (yr)
Magnetically separate cast iron chips from the mixed chip waste. Sell the relatively pure aluminum chips remaining to a metal recycler.	Mixed chip waste	0	0	$148,680[1]	$105,640	0.7
Install a closed-loop system for recycling of chrome-conversion rinse water and process chemicals utilizing reverse osmosis. Process chemicals lost in the rinse water will be removed for reuse in the process tanks. The purified rinse water can be reused.	Wastewater from chrome conversion Filter cake	11,205,000 91,200	79 80	$101,590[1]	84,440	0.9
Drill drain holes in the bottom of the metal chip collection bins in order to allow coolant to drain into collection pans. Recondition the coolant for reuse onsite.	Spent coolant	805,440	29	52,750[1]	2,260	0.1
Install an atmospheric evaporator to remove excess water from spent coolant waste.	Spent coolant	2,774,150	99	50,280[1]	29,800	0.6
Reinstall missing or damaged shrouding on all metal-working machines to prevent losses of coolant during metal operations	Spent coolant	402,750	14	33,880	9380	0.3
Segregate aqueous washer wastewater from other plant wastewater, treat in an ultrafiltration unit and reuse it onsite. A small quantity of oily waste will be generated as the system's membranes are backflushed and cleared. In addition, a small quantity of wastewater will be generated should the system water need to be purged.	Wastewater from machining Wastewater from spray-painting	879,220 13,337,020	100 100	19,110[1]	67,260	3.5
Install a distillation unit to recover spent cleaning solvent for reuse onsite. In addition, reduce evaporative losses of cleaning solvent through worker training and equipment modification. A small quantity of still bottoms will be generated if this measure is implemented.	Spent solvent Evaporated solvent	3,320 2,220	100 50	6,260[1]	12,150	1.9

[1] *Total annual savings have been reduced by the annual operating cost required for implementation of this measure.*

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