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EPA ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Manufacturer of Brazed Aluminum Oil Coolers

F. William Kirsch and Gwen P. Looby*

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 the University of Tennessee inspected a plant manufacturing brazed aluminum oil coolers that are used in heavy equipment. After the cooler components are fabricated, they are degreased (with Chlorothene†, which is recycled); assembled; brazed to join internal and external coil fin surfaces (involving a molten salt bath and a quench tank whose sludge is disposed of on-site in a sand filter bed); cleaned (with solutions and rinse waters needing treatment and disposal); and painted. The team's report, detailing findings and recommendations, indicated that a significant minimization opportunity could be effected by replacing molten salt bath brazing with vacuum brazing. The implementation cost would be high and the payback years relatively long, but the percent waste reduction (80%) and annual savings would be pronounced.

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 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 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

* University City Science Center, Philadelphia, PA 19104.

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

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 aluminum brazed oil coolers for use in heavy equipment. The plant produces approximately 60,000 units each year.

Manufacturing Process

The raw materials used in the production of the oil coolers include aluminum in sheet and coil form, aluminum castings and extrusions, tubes, fittings, brackets, caution labels, and plastic plugs.

The following steps are involved in the production:

- Shearing, punching, and forming operations to fabricate the oil cooler tanks, headers, air fins, sides, and oil turbulator fins.

- Degreasing oil cooler tanks, headers, sides, fittings, and brackets. The solvent Chlorothene (95% 1,1,1- trichloroethane) is used in an open-air, steam-heated vapor degreaser. The unit is equipped with a refrigeration unit that condenses Chlorothene vapor and minimizes evaporative losses to surrounding plant air.

- Recycling of spent Chlorothene to the degreasing operation with the use of an on-site still. Chlorothene is continuously circulated between the degreaser and a steam-heated solvent recovery still. Still bottoms containing spent Chlorothene, water, and oil are shipped off-site as hazardous waste.

- Assembling oil coolers.

  Brazing assembled oil coolers to join the internal and external coil fin surfaces for enhanced heat transfer. The oil coolers are first preheated in a gas-fired oven at 1020° F for 15 min. After they are dipped into an electrically heated molten salt bath containing a sodium- chloride-based compound, lithium chloride, and aluminum fluoride for 1.5 min at 1128°F, they are dipped in a water quench tank. Sludge from the salt bath and quench tanks is disposed of in the on-site sand filter bed. Solids remaining in the filter are landfilled on company property; water is fed to the settling pond and eventually discharged to a river.

- Cleaning oil coolers to remove all residual salt, to expose copper cells (which could cause corrosion failure), and to condition metal surface before painting. The following steps are involved in the cleaning:

  - submersion in a 2% nitric acid bath (1 to 2 hr residence time),
  - cold water rinse,
  - dipping in NaOH caustic soda etching solution,
  - hot water (102°F) rinse,
  - cold water rinse,
  - dipping in a 50% nitric acid bath,
  - two cold water rinses,
  - dipping in a chromic acid wash,
  - two deionized water rinses, and
  - drying in a natural gas-fired oven.

- Treating hazardous spent process solutions and contaminated rinse water streams. The liquids are treated in a neutralization tank with lime for pH control and flocculant to enhance removal of suspended solids. The solution leaving the tank is pumped to a clarifier that removes solids and allows filtered water to flow to the settling pond. A solids-rich stream is pumped to a sludge-thickener settling tank for secondary sedimentation. Supernate from the settling tank is transferred to the sand filter beds for final water removal before on-site landfilling of solids.

- Treating of effluent from the chromic acid and deionized rinse water washes. Because these hazardous waste streams contain chromium in hexavalent form, they are treated to obtain a sludge containing less toxic trivalent chromium compounds. Several chemical agents are added to the waste to produce relatively insoluble compounds that are recovered on the sandfilter beds and disposed of in the landfill. The liquid is pumped to the settling pond and is eventually released to the river.

- Painting oil coolers. The coolers are dipped in a paint-filled tank, allowed to drip after immersion, and transferred to a spray booth for additional spray painting. Paint is collected on floor coverings (plastic sheet or cardboard) and in spray booth filters and is disposed of daily in barrels, which are sent to an off-site landfill.

Existing Waste Management Practices

The plant has taken the following steps in managing its hazardous wastes.

- The plant owns and operates a landfill for its private use.

- Chromium is reduced from the hexavalent to the trivalent form in-house.

- A refrigeration unit and a solvent recovery still have been added to the degreasing unit to minimize evaporative loss and liquid waste.

- The plant constantly monitors its waste stream effluents and has installed its own hazardous waste treatment facility.

- Water-based paints are currently used.

- A designated professional staff person, based at corporate headquarters, periodically visits satellite plant locations to provide assistance in both hazardous waste monitoring and manage ment techniques.

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 treatment and disposal 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 upon the production level of the plant. All values should be considered in that context.

It should be noted that the economic savings of the minimization opportunity, in most cases, 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 opportunity independently and do not reflect duplication of savings that would result when waste minimization opportunities are implemented in a package.

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The EPA contact, Emma L. George, can be reached at:

Pollution Prevention Research Branch
Risk Reduction Engineering Laboratory
U.S. Environmental Protection Agency
Cincinnati, OH 45268

Table 1. Summary of Current Waste Generation

Waste Generated	Source of Waste	Annual Quantity Generated	Annual Wast Management Cost
Still bottoms containing spent, contaminated Chlorothene (95%-1,1,1-trichloroethane), water, and oil	On-site solvent recycing still associated with the degreasing operation.	150 gal	$4,650
Evaporation of Chlorothene	Degreasing operation	6,520 gal	0[1]
Sludge containing compounds derived from the salt bath constituents, impurities from the baths, and contaminants on the products' surfaces	Salt bath tank and water quench tank in the brazing process. The sludge is collected on the sand filter beds.	514,920 lb	28,500
Sludge containing various solids from the treatment of the spent cleaning solutions	Treatment process for spent solutions from the cleaning of the brazed product. The sludge is collected on the sand filter beds.	1,171,060 lb	36,380
Sludge containing various compounds from the chromium reduction process	Chromium reduction process. The sludge is collected on the sand filter beds.	88,940 lb	16,500
Paint-contaminated filters and cardboard and plastic sheets	Painting of product.	9,810 lb	13,480

[1] Currently the plant reports no waste management costs associated with the evaporation of Chlorothene.

Table 2. Summary of Recommended Waste Minimization Opportunities

Waste Generated	Minimization Opportunity	Annual Waste Reduction Quantity	Annual Waste Reduction Percent	Net Annual Savings	Implementation Cost	Payback Years
Evaporation of Chlorothene from the degreaser unit	Install a conveniently removable cover on the vapor degreaser tank to reduce evaporative losses. Cover the tank except when parts baskets are being lowered into or taken out of the tank.	3,260 gal	50	$17,180[1]	$220	0.01
Still bottoms from the on-site solvent recycling still	Reduce the amount of lubricants used during metal-working and reduce the openness of machine work areas to decrease the amount of oil picked up by parts during processing, thereby minimizing the amount of degreasing required.	30 gal	20	1,010[1]	290	0.3
Evaporation of Chlorothene and Chlorothene contained in the still bottoms	Replace the vapor degreaser system with an ultrasonic cleaning system that uses biodegradable detergents.	6,600 gal	99	20,450[2]	50,000	2.4
Sludge from the water quench tank in the brazing process	Modify the procedure for dipping the coolers in the salt bath to minimize carry-over to the water quench tank. Achieve maximum salt removal by gently vibrating or shaking the parts baskets and subjecting the parts to a hot air blast.	23,170 lb	4	20,520[3]	43,880	2.1
Sludge from the salt bath and water quench tanks in the brazing process	Replace molten salt bath brazing with vacuum brazing. Vacuum brazing is suitable for 80% of this plant's products.	411,930 lb	80	203,440[3]	720,640	3.5
Paint-contaminated cardboard and plastic sheets	Reduce paint loss by installing a low-pressure air-jet system over the paint dipping area to blow excess paint downward into tank. Install an IR paint-drying lamp to prevent dripping when coolers are moved to the spray booth area.	2,180 lb	22	4,350[4]	2,490	0.6
Paint-contaminated filters and cardboard and plastic sheets	Install an electrostatic spray paint system for applying the oil cooler second coat of paint to reduce overspray loss.	3,510 lb	36	11,200[4]	13,200	1.2
	Discontinue the practice of painting oil coolers that will be repainted by the customer. Vacuum seal the oil coolers to provide corrosion protection.	4,910 lb	50	59,720[4]	28,440	0.5

[1] Includes cost savings because less Chlorothene purchased.
[2] Total savings have been reduced by the cost of detergents required.
[3] Includes cost savings because less salt bath constituents purchased.
[4] Includes cost savings because less paint supplies purchased.

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