United States
Environmental Protection
Agency
Research and Development

Risk Reduction
Engineering Laboratory
Cincinnati OH 45268
EPA/600/S-92/009 June 1992

EPA

ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Manufacturer of Components for Automobile Air Conditioners

Gwen P. Looby and F. William Kirsch*

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. 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 performed an assessment at a plant manufacturing charged air coolers, round tube plate fin (RTPF) condensers, and air conditioner tubes for automotive air conditioning systems—approximately two million lb/yr. Even though this plant has three distinct product manufacturing lines, the processes can be generalized to the following: initially fins are produced and partially assembled with various components. These partial assemblies are vapor degreased and then either packaged and shipped or brazed either manually or in a vacuum brazing oven. Units are assembled into final products, painted black, inspected, packaged, and shipped. The team's report, detailing findings and recommendations, indicated that the majority of waste was generated in the rinse tanks and the hot water flush testing stations but that the greatest savings could be obtained by replacing solvent-based vapor degreasing systems with a detergent-based immersion system to eliminate still bottoms and evaporated solvent losses.

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.

* University City Science Center, Philadelphia, PA 19104

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 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 waste but who lack the in-house 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 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 in-house 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.

Printed on Recycled Paper

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 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

This plant manufactures components for automobile air conditioners: charged air coolers, round tube plate fin condensers, and air conditioner tubes. The plant operates 6,240 hr/yr to produce approximately two million pounds of automobile air conditioner components.

Manufacturing Process

Three distinct product components involve three separate manufacturing processes. Each will be described in turn so that the various operations and their waste-generating capacity can be kept in perspective.

Charged Air Coolers

Sand-cast aluminum tanks are cleaned in an aqueous alkaline bath at 160°F and then water-rinsed in successive stages before being air-dried and inspected.

Coil stock is the source from which air fins and turbulator fins are fabricated for this product. Cutting oil is the lubricant used during fabrication, and afterward it is filtered (to remove metal particles) before reuse. Extruded aluminum tubes also require oil to be sprayed on them when they are cut to length and deburred. Product headers and side sheets, also made from aluminum coil stock, generate metal scrap, require cutting oil during formation, and ultimately involve 1,1,1-trichloroethane and perchloroethylene for degreasing. Spent solvent recovered from a distillation unit is recycled to the process, while still bottoms are ultimately treated offsite after further distillation. Tube assembly, air fins, headers, and side sheets are processed through a vacuum oven for brazing after manual assembly.

Air coolers are hand-assembled from the clean components before being painted with a paint-solvent mixture. The paint booth generates its own waste in the form of solvent and paint from paint-gun cleaning, water from the paint booths' water curtain, waste paint solids, and overspray. Product parts are air-dried.

Round Tube Plate Fin Condensers (RTPF)

Like the air coolers, the RTPF condensers are formed from steel headers, aluminum hairpins and aluminum coil stock (from which the fins are made). After mechanical and manual assembly, the product is degreased with perchloroethylene, dried, assembled manually to the condenser body, hand brazed, flushed with hot water, leak tested, and oven-dried (at 180°F). Finished product is dip painted and air-dried. Paint drainage accumulates on the plastic booth lining.

Air Conditioner Tubes

Aluminum coil tubing is the raw material which is made into air conditioner tubes by being cut to length, formed, and straightened. Of course, some cutting oil is needed. About 39% of the product is degreased in 1,1,1-trichloroethane, which is recovered via recycling through a distillation unit. The other 61% of the product is first welded, pierced, and welded again before being degreased, dried, and leak tested before shipping.

Other Sources of Waste

Still bottoms from perchloroethylene and 1,1,1-trichloroethane distillation units are stored separately and redistilled before reuse. The remaining still bottoms are shipped offsite.

Water from washing operations during production is collected and treated before being pumped to a clarifier and sewered.

Existing Waste Management Practices

- A solvent distillation unit has been installed for each solvent degreaser and a secondary still recovers solvent from the still bottoms derived from the primary units.
- Sludge has virtually been eliminated from the waste water treatment system through improved manufacturing processes and waste stream segregation.
- Scrap aluminum and steel are sold to offsite recyclers for a net return of more than $146,500 per year.

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 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 minimization opportunity, in most cases, results from the need for less raw material and from reduced present and future 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 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.

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 Costs ($)
Liquid Waste			
Machining Oils	Spent oil from machining operations.	40 bbl	976
Still Bottoms	Still bottoms from perchloroethylene solvent recovery system.	25 bbl	7,402
	Still bottoms from 1,1,1-trichloroethane solvent recovery system.	11 bbl	3,649
Process Waste Water	Cleaning solution and rinse tank overflow from air cooler production.	1,057,000 gal	39,673
	Hot water flush from condenser production.	327,000 gal	12,273
Solid Waste			
Aluminum Scrap	Scrap from production of air coolers, air-conditioner tubes, and round tube plate fin condensers.	215,177 lb	-145,721 (credit)
Steel Scrap	Scrap from round tube plate fin condensers.	40,200 lb	-810 (credit)
Dried Epoxy Waste	Small amount from air cooler production (to repair dents).	4 gal	32
Paint Sludge	Spray painting of air coolers and immersion painting of condensers.	20 bbl	5,869

*U.S. Government Printing Office: 1992 — 648-080/60016

Table 2. Summary of Recommended Waste Minimization Opportunities

Present Practice	Proposed Action	Cost Savings
Two vapor degreasing units utilize on an annual basis perchloroethylene (7795 gal) and 1,1,1-trichloroethane (3630 gal). About 92-98% is lost by evaporation from the vapor-treating units. Also, solvent recovery via distillation generates still bottoms consisting of 219 gal/yr of perchloroethylene and 528 gal/yr of 1,1,1-trichloroethane which are sent offsite for disposal.	Substitute soluble biodegradable cleaners/degreasers to replace chlorinated hydrocarbon solvents. These materials are nonhazardous and can be sewered directly.	Estimated still bottom reduction = 747 gal/yr Estimated still bottom disposal cost reduction = $6,007/yr Estimated raw material cost saving = $62,640/yr [1] Estimated implementation cost = $20,700 Simple payback = 0.3 yr
Charged air coolers are cleaned and rinsed in a succession of three tanks, each holding 1200 gallons. Overflow to waste treatment occurs even when plant is idled at a rate of 527,904 gal/yr/rinse tank.	Turn off water to the two rinse tanks when not in use (approximately 15 hr/day) and convert to a counterflowing rinse system.	Estimated waste reduction = 857,844 gal/yr [2] Estimated cost saving = $33,235/yr [3] Estimated implementation cost = $3,480 Simple payback = 0.1 yr
Paint applied to two products (air coolers and round tube plate fin condensers) creates about 1100 gal/yr of waste (water, paint solids, used plastic linings, and spray booth coating).	Convert to electrostatic powder coating to apply heat-fusible polymers to metal substrates. Solvent and other waste will be eliminated, and overspray powder can be collected and reused.	Estimated waste reduction = 1,100 gal/yr Estimated waste disposal cost reduction = $5,869/yr Estimated net raw material cost saving = $22,885/yr Estimated implementation cost = $100,640 Simple payback = 3.5 yr
Evaporative loss of perchloroethylene and 1,1,1-trichloroethane occurs from vapor degreasing units.	Fabricate and apply lightweight plastic tops to cover tanks except when parts are being removed from or added to degreasing units to reduce evaporative loss by 50%.	Estimated solvent evaporation reduction = 5,339 gal/yr Estimated net raw material cost saving = $26,375/yr [1] Estimated implementation cost = $3,600 Simple payback = 0.1 yr

[1] Perchloroethylene: $4.76/gal; 1,1,1-trichloroethane: $5.38/gal.

[2] Gallons saved by turning off the water 15 hr/day, 5 day/wk, 47 wk/yr: 659,800
Gallons saved by instituting a counterflowing rinse system: 197,964
857,844 gal/yr

[3] Water: $0.0012/gal in addition to 62% volume reduction in on-site waste water treatment system.

United States
Environmental Protection
Agency

Center for Environmental
Research Information
Cincinnati, OH 45268

BULK RATE
POSTAGE & FEES PAID
EPA PERMIT NO. G-35

Official Business
Penalty for Private Use $300

EPA/600/S-92/009