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EPA ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Manufacturer of Heating, Ventilating, and Air Conditioning 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 the University of Tennessee inspected a plant manufacturing heating, ventilating, and air conditioning equipment. Of the distinct process lines in the plant, three generated hazardous waste: the manufacture of fan coil units and air terminal units and the painting process. The manufacture of fan coil units generated the most and the greatest variety of these wastes. The team's report, detailing findings and recommendations, suggested that to reduce adhesive overspray, defectively glued insulation board, and adhesive carrier vapor, the plant should consider using nonferric screws instead of adhesives to attach insulation to sheet metal parts, or replace solvent-based adhesives (wholly or in part) with water-based adhesives. The amount of waste would be the same, but it would be nonhazardous and could be disposed of in municipal waste.

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 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 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(EPAJ625l7- 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 evaluated for this waste minimization assessment manufactures various types of heating, ventilating, and air conditioning equipment for both residential andcommercial use. It operates 6000 hr/yr to produce approximately 700,000 units.

Manufacturing Process

The plant's five distinct process lines produce:

- fan coil units by metal working, welding, cleaning, rinsing, painting, brazing, Boehmiting, and assembly;
- electric heat component units by metal working, coiling of wire, and assembly;
- air treatment units such as air cleaners and humidifiers by metal working, painting, and assembly;
- accessory components such as air volume control units by metal working, cleaning, Boehmiting, and assembly; and
- air terminal units such as air volume control units by metal working, painting, and assembly.

Raw materials used in the production include sheet metal, aluminum extrusions, copper tubing, purchased components, formed plastics, and paint.

In this plant, the fan coil and airterminal production lines and the painting process generate hazardous waste streams. Those processes are described in more detail below.

The steps involved in manufacturing the fan coil units include:

- Metal working. Sheets of metal are punched, formed, and sheared into desired shapes to form fan coil housings. Spot welding is done as needed.
- Painting. Approximately 30% of pans are painted in the electrostatic paint line.
- Producing the heat exchanger. Aluminum sheet is drawn through a press to form fins for the heat exchanger component to fan coil units. Copper tubing is bent to produce desired shapes. The fins and coils are joined on an expanding machine.
- Brazing. Coil and fin assemblies are brazed at 3000° F to 4000° Fin a natural gas- and gaseous-brazing, flux-fired, spot brazing machine. Hand brazing is performed as needed.
- Washing. The coil and fin assemblies are dipped in a 165° F phosphate wash tank and then rinsed.
- Boehmiting. Boehmiting is an etching process that enhances the wettability of the aluminum fin surface. The Boehmiting tank is heated to 200° F. Lime is added to it as needed. The assemblies are rinsed with water on removal.
- Assembling. The heatexchangers, metal housings, insulation boards, and other components are assembled into completed fan coil units.

The production of air terminal units requires:

- Metal working. Sheets of metal are processed by punching, shearing, and forming.
- Painting. Approximately 10% of the parts are transferred to the electrostatic paint line.
- Assembling. The various components are assembled into the air terminal units.

Painting pans from the production lines involves:

- Washing. Parts are cleaned with a phosphate wash and then rinsed with water.
- Drying. Parts are conveyed through a natural gas-fired 200°F dry-off oven.
- Painting. Painting is done in two electrostatic paint booths.

Existing Waste Management Practices

- The plant is considering switching to water-based, nonhazardous adhesives. The plant was dissatisfied with water-based adhesives in the past because of the long drying time; however, the

Table 2. Summary of Recommended Waste Minimization Opportunities

Waste Generated	Minimization Opportunity	Annual Waste Reduction Quantity	Percent	Net Annual Savings	implementation cost	Payback Years
Adhesive overspray. defectively glued insulation board, and adhesive carrier vapor	Discontinue use of all adhesives. Use nonferric screws to attach insulation to sheet metal parts. Implementation will require the selection of an acceptable fastening method and the purchase of appropriate tools.	214 bbl 345 gal (vapor)	100 100	$58,350[1,2]	$6,400	0.1
	Replace all solvent-based adhesives with water-based (nonhazardous) adhesives. To eliminate production delays resulting from the long drying time required by water-based glues, install an overhead conveyour system so that freshly glued parts will travel on the conveyor and will be delivered to the operator dry. The same quantity of solid waste will be generated. but all waste will be nonhazardous. Dispose of water-based adhesive waste in municipal waste.	345 gal (vapor)	100	25.690[3]	31,740	1.2
	Modify the use of adhesives to maximize the use of water-based (nonhazardous) glue. Spot glue 10% of the surface area with the quick-drying solvent-based adhesive and cover the remaining 90% with the slow-drying water-based adhesive. The same quantity of solid waste will be generated, but all waste will be nonhazardous. Dispose of water-based adhesive waste in municipal waste.	311 gal (vapor)	90	23,120[3]	5,100	0.2
Paint sludge	Reduce exhaust-air flow rate to minimize paint mist loss in the paint booth.	1,719 gal	25	44,910[1]	2,100	0.1
	Retrain paint personnel to improve spray technique and thus reduce overspray loss.	330 gal	5	8,610[1]	3,500	0.4
Lubricating oil vapor	Install a recirculating air-oil condensing system adjacent to the fin press to reclaim evaporating oil.	18,750 gal	50	56,250[1]	7,400	0.1

[1] Includes savings on raw materials cost.
[2] Savings are reduced by a yearly materials cost.
[3] Savings are reduced by a net increase in the cost of adhesives.

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quantity of adhesive waste is large enough that the plant may change back.

- The paint line will be removed from the plant by 1991.

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 paybacktime 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. Othersavings 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.

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Table 1. Summary of Current Waste Generation

Waste Generated	Source of Waste	Annual Quantity Generated	Annual Waste Management Cost
Lubricating oil vapor	Evaporation of lubricating oil from the fin press in the fan coil unit production line.	37,500 gal	$0[1]
Boron-based brazing gas flux vapor	Exhaust containing brazing flux fumes from the natural gas-fired, spot brazing machine and the hand-brazing process.	440 gal	0[1]
Phosphate wash sludge	Sediment from the heated phosphate wash tank in the fan coil production line.	660 gal	3,900
Lime sludge	Sediment from the gas-fired Boehmite etch tank in the fan coil production line.	1,980 gal	13,206
Solvent-based (thermoplastic) overspray on paper and defectively glued insulation board	Assembly of components into fan coil units.	107 bbl	23,250
Adhesive carrier vapor	Assembly of components into fan coil units.	345 gal	0[1]
Water-based, adhesive overspray on paper and detectively glued insulation board. (The water-based adhesive waste is considered non-hazardous and is disposed of in municipal waste.)	Assembly of components into fan coil units	43 bbl	2,365
Hydraulic motor oil	Waste from the expander in the fan coil production line.	1,320 gal	7,245
Ethylene-vinyl acetate adhesive overspray on paper and defectively glued insulation board	Assembly of components into air terminal units.	64 bbl	13,905
Phosphate wash sludge	Sediment from the heated phosphate wash tank in the paint line.	1,980 gal	11,700
Paint sludge	Overspray collected in water in the paint booths. The paint sludge and water are separated, and the water is then recycled.	6,875 gal	72,375

[1] Plant reports no waste management costs associated with the evaporation.