United States Environmental Protection Agency
Research and Development
National Risk Management Research Laboratory
Cincinnati, OH 45268
EPA/600/S-95/029 September 1995

EPA

ENVIRONMENTAL RESEARCH BRIEF

Pollution Prevention Assessment for a Manufacturer of Electrical Load Centers

Richard J. Jendrucko*, Todd M. Thomas*, 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 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 That document has been superseded by the *Facility Pollution Prevention Guide* (EPA/600/R-92/088, May 1992).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 electrical load centers. Raw materials, including coiled sheet steel and coiled copper strips, polystyrene pellets, and miscellaneous fasteners, are used in metalworking, injection molding, painting, and assembly operations. The team's report, detailing findings and recommendations, indicated that a large quantity of waste overflow rinse water is generated and that significant cost savings could be achieved by installing valves that will allow operators to turn off the flow during periods of nonuse.

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 (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

* University of Tennessee, Department of Engineering Science and Mechanics
** University City Science Center, Philadelphia, PA

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 electrical load center housings for use in residential and commercial buildings. It operates 6,000 hr/yr to produce over one-million units annually.

Manufacturing Process

Electrical load center housings are manufactured by this plant from raw materials including coiled sheet steel stock and coiled copper strips, polystyrene pellets, and miscellaneous fasteners. The major operations performed by the plant are metal working, injection molding, painting, and assembly.

Metal Working

Metal housing boxes are fabricated from either cold-rolled steel or galvanized steel received at the plant in coils. After inspection, coils are transferred to impact cutting operations in which the steel is sheared into flat patterns and then sent to box-forming operations.

Next, the cut patterns are loaded into the die of a large press that punches hole patterns which provide inlets or outlets for electrical wiring into the metal sheets. Then the metal pieces are formed into a box shape using another press. Box corners are spot-welded for reinforcement. Finished boxes undergo inspection, and those that pass are transported to the electrocoating painting operation. Defective boxes are shipped offsite for recycling.

Copper electrical contacts used in the internal components of the finished product are also manufactured onsite. Copper strip rolls are inspected and transferred to cutting operations. Appropriately cut copper pieces are dropped onto a chain conveyor and transported through a gas-fired heat-treatment oven. After heat treatment, about 20% of the parts are sent offsite to be nickel plated. Parts that have been plated are fastened to plastic parts manufactured onsite to form subassemblies. Unplated copper parts are stored until needed in final assembly.

Injection Molding

Various plastic structural pieces that are used to hold electrical contacts and switches in place are manufactured onsite using injection molding machines. Polystyrene pellets are vacuum-conveyed to a feed hopper above the injection molding machine. The pellets are metered into the machine's heated barrel in the appropriate quantity.

Inside the molding machine, plastic is melted and injected under high pressure into a separable cavity-mold. Once the cavity is filled with molten plastic, the mold is allowed to cool, thus hardening the plastic into the desired shape. After plastic solidification, the mold opens allowing the formed parts to drop onto a conveyor belt. After storing 95% of the parts until needed in final assembly, the remaining parts are shipped offsite for the production of subassemblies used in the final products.

Electrocoating

Metal boxes are painted using a cathodic electrocoating system in which resinous materials containing pigments in a water suspension are deposited on the part's surface using an electric potential difference. Because this paint system is a form of electrocoating, boxes must be thoroughly washed and rinsed to remove contaminants prior to coating.

The metal boxes are conveyed through the following tanks in sequential order:

- heated dilute potassium hydroxide solution spray-wash for removal of surface particulates and oils
- clean water rinse
- heated dilute phosphorous solution spray-wash for etching of the metal
- clean water rinse
- deionized water wash
- paint solution
- deionized water rinse to remove residual paint solution
- surfactant solution rinse to facilitate water drainage

Painted boxes are conveyed through a gas-fired oven for curing. After the boxes exit the oven, they are cooled and inspected. Those boxes that pass inspection are transferred into storage to await final assembly.

Final Assembly

Final assembly of the electrical load centers consists of installation of component parts, such as breakers and switches, into painted steel housings on an automated-robotic assembly line and manual installation of internal and external components that require part manipulation not suitable for robots.

An abbreviated process flow diagram for the production of electrical load centers is shown in Figure 1.

Existing Waste Management Practices

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

- Waste computer paper is collected and recycled.
- The use of chlorinated cleaning solvents has been eliminated.
- Wooden pallets are repaired and reused.
- Copper and steel scrap are recycled.
- Self-adhering labels are used on the load centers in order to eliminate the use of glue.

Pollution Prevention Opportunities

The type of waste currently generated by the plant, the source of the waste, the waste management method, the quantity of

DISCLAIMER

DISCLAIMER

Portions of this document may be illegible electronic image products. Images are produced from the best available original document.

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 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 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 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**.

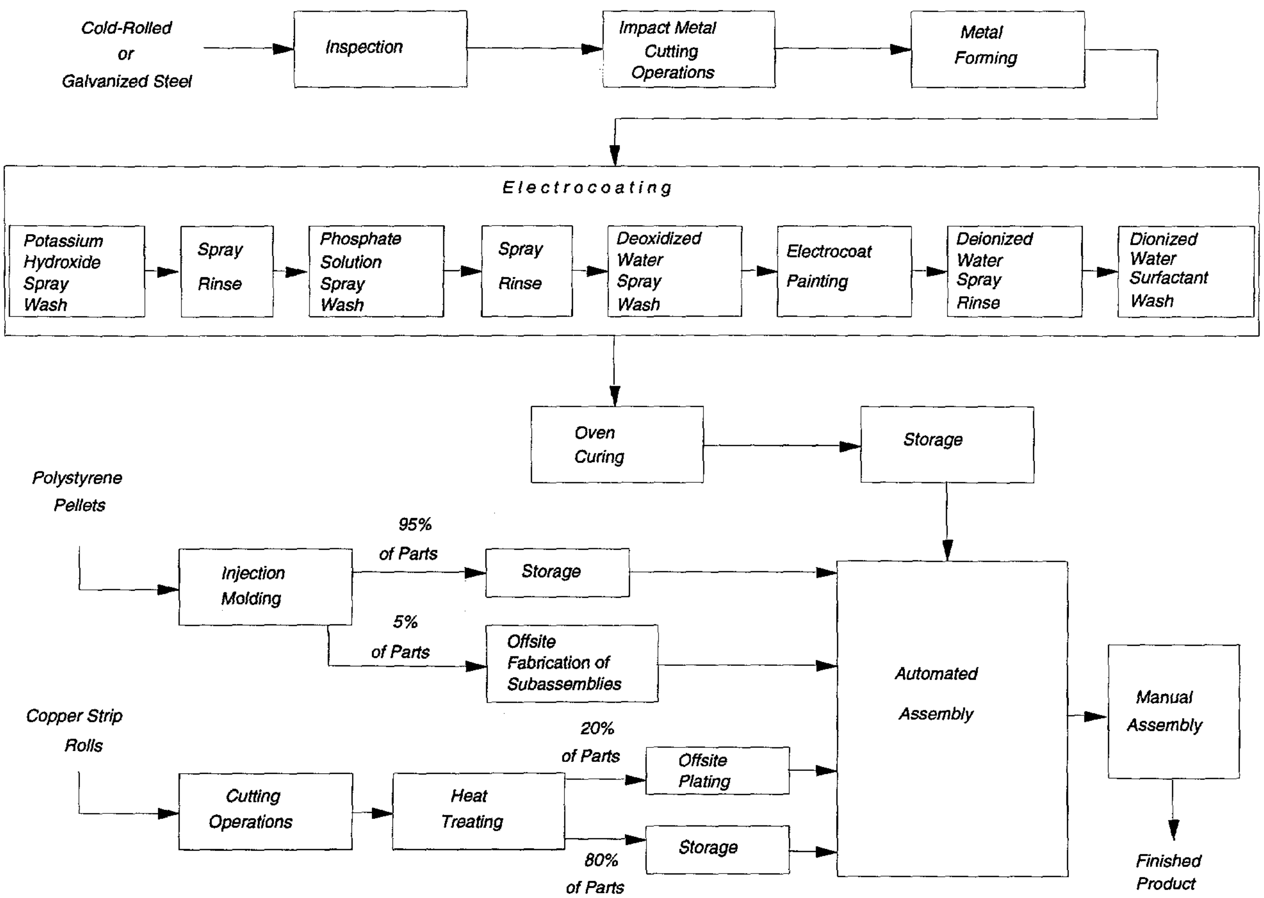

Figure 1. *Abbreviated process flow diagram for electrical load center manufacture.*

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
Miscellaneous solid waste	Metalworking, injection molding, final assembly	Shipped offsite to municipal landfill	1,080,000	$28,950
Scrap steel	Metal cutting	Sold to recycler	301,220	-6,550[1]
Spent hydraulic oil	Metalworking and injection molding machines	Shipped offsite to be blended into fuel	16,660	12,065
Absorbent and oil	Leaks from metalworking and injection molding machines	Shipped offsite to controlled landfilled	4,325	7,530
Scrap copper	Metal cutting	Sold to recycler	9,990	-2,790[1]
Plastic scrap	Injection molding	Shipped offsite to municipal landfill	2,400[2]	6,300[3]
Potassium hydroxide cleaning solution	Cleaning of boxes prior to painting	Treated in onsite wastewater treatment system	1,525,125	1,340
Evaporated water	Potassium hydroxide and sodium phosphate tanks	Evaporates to plant air	3,423,750	0
Rinse water	Rinse following potassium hydroxide cleaning	Treated in onsite wastewater treatment system	1,029,200	900
Sodium phosphate solution	Etching of metal prior to painting	Treated in onsite wastewater treatment system	127,960	110
Rinse water	Rinse following sodium phosphate treatment	Treated in onsite wastewater treatment system	971,100	850
Overflow rinse water	Rinse following potassium hydroxide cleaning and sodium phosphate treatment	Treated in onsite wastewater treatment system	83,000,000	72,890
Deionized wash water	Wash prior to painting	Treated in onsite wastewater treatment system	439,900	390
Paint tank sludge	Cleaning of paint tank	Shipped offsite to controlled landfill	2,600	5,710
Waste permeate	Ultrafiltration of paint solution	Treated in onsite wastewater treatment system	2,116,500	1,860
Waste filter paper	Filtration of paint solution	Shipped offsite to municipal landfill	1,250[2]	0[4]
Deionized water rinse	Post-painting rinsing	Treated in onsite wastewater treatment system	1,037,500	910
Wastewater from deionized water and surfactant rinse	Post-painting rinsing	Treated in onsite wastewater treatment system	332,000	290
Spent HCl	Ion exchange regeneration	Treated in onsite wastewater treatment system	19,780	20
Spent caustic	Ion exchange regeneration	Treated in onsite wastewater treatment system	24,720	20

[1] Net revenue received
[2] Also included in total amount of miscellaneous solid waste generated (1,080,000 lb/yr)
[3] Cost represents raw material cost only. Other waste management costs are included in $28,950 cost associated with miscellaneous solid waste
[4] Included in $28,950 cost associated with miscellaneous solid waste

Table 2. *Summary of Recommended Pollution Prevention Opportunities*

Pollution Prevention Opportunity	Waste Stream Reduced	Annual Waste Reduction		Net Annual Savings	Implementation Cost	Simple Payback (yr)
		Quantity (lb/yr)	Per Cent			
Install electrically-activated flow valves that will allow operators to turn off the continuous rinse water overflow during periods when painting does not occur.	Overflow rinse water	14,940,000	18	$ 15,800	$ 1,000	0.1
Filter and reuse hydraulic oil used in the metal-working and injection molding machines in order to extend its useful life. The filtered oil should be tested periodically to ensure that it is suitable for reuse.	Spent hydraulic oil	8,330	50	10,200	5,000	0.5
Utilize reusable cloth rags provided by a rental service to replace paper towels used for clean-up.	Miscellaneous solid waste	4,500	negligible	13,800	625	0.1
Collect and store waste hydrochloric acid and sodium hydroxide produced from the regeneration of the deionized water ion exchange unit and use to neutralize the effluent waste-water stream.	Spent HCl Spent caustic	19,780 24,720	100 100	8,000	18,200	2.3
Implement an improved maintenance program for the injection molding and metal working machines to ensure that all hydraulic oil leaks are repaired in a timely fashion.	Absorbent and oil	3,240	75	7,170	14,880	2.1
Collect scrap plastic from the older injection molding machines used in the plant and reuse it as feedstock in the newer injection molding machines.	Plastic scrap	1,800	75	4,730	0	immediate