United States
Environmental Protection
Agency

Risk Reduction
Engineering Laboratory
Cincinnati, OH 45268

Research and Development

EPA/600/S-93/008 September 1993

EPA

ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Manufacturer of Product Carriers and Printed Labels

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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. 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 Louisville performed an assessment at a plant manufacturing high density polyethylene product carriers and printed polystyrene packaging labels. The team's report, detailing findings and recommendations, indicated the most waste was generated by the cleaning of printing presses and printing plates. Several opportunities for minimizing solvent waste were recommended to the plant.

This Research Brief was developed by the principal investigators and EPA's Risk Reduction Engineering Laboratory (RREL), 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 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 waste but who lack the inhouse expertise to do so. Under agreement with EPA's RREL, the Science Center has established three WMACs. This assessment was done by engineering faculty and students at the University of Louisville'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 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 $75 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* (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 support-

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ing 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 printed polystyrene packaging labels and high density polyethylene (HDPE) product carriers. Over 400 employees operate the plant 8,400 hr/yr to produce eight billion labels and over 500 million product carriers each year.

Manufacturing Processes

The manufacturing processes used in this plant and the wastes generated are described below.

Polystyrene Extrusion

The production of polystyrene labels begins with the extrusion of bulk polystyrene into rolls of film. Both new polystyrene pelletized stock and re-pelletized reground polystyrene material are used, along with additives. The polystyrene is co-extruded into foam rolls consisting of two layers using Freon-22™* blowing agent to form cells in the inner layer. The extruded film is then slit and rolled. Running trim is removed from the film as it is rolled and is pneumatically conveyed to the regrind area of the plant for recycle. The rolls are then sent to the warehouse for curing prior to printing. Volatile emissions from the extrusion process include the blowing agent and residual impurities in the polystyrene (including styrene monomer and ethyl benzene), which leave the plant through its ventilation system.

Photopolymer Plate Production

Artwork for the label-printing plates is generated onsite or received from the customer. The artwork is photographed and the resulting negative is then used to sensitize an ultraviolet-sensitive sheet of plate stock. The plate is then washed with n-butanol/perchloroethylene solvent mixture, leaving a raised printing surface on the plate. Damaged or obsolete plates are disposed of with the general trash. Any silver-containing photoprocessing wastes are collected and sent to the film manufacturer for reclamation. Spent solvent mixture is sent to the solvent recovery area. A portion of the solvent mixture evaporates to the plant air.

Polystyrene Label Printing

As production is scheduled, the required roll stock is delivered to the printing area from the warehouse. The required blends of solvent-based inks are prepared using concentrated dispersions. Propylene glycol methyl ether (PM glycol ether) is added to the mixtures for volume and viscosity adjustment

The ink is transported to the correct press station, a circulating pump is attached to each ink bucket, and the ink is pumped to the appropriate feed tray on the press.

The presses are washed down with a mixture of fresh ethyl acetate and reclaimed solvent following printing runs. Spent solvent is sent to the solvent recovery system. Fresh PM glycol ether solvent is used to wash the printing plates.

A large quantity of propylene glycol methyl ether solvent evaporates from the printing operation and is vented from the plant. Ethyl acetate, which is also used during clean-up, also evaporates to plant air. Soiled shop rags are cleaned by an outside service and reused by the plant. Misprinted polystyrene is reground and sold to a reclaimer at a discount.

Post-Printing Operations

The post-printing operations are product specific. Defective labels are removed, labels are die-cut and slit, and rolls of labels are shrink-wrapped. The labels are then transferred to the warehouse to await shipping.

HDPE Extrusion

The processing of HDPE for use in product carriers proceeds in a manner similar to that for the processing of polystyrene film. Running trim from this line is also sent to the regrind area for recycle.

HDPE Thermoforming

The HDPE roll material is delivered to the thermoforming line where the carriers are formed, cut, and packaged. The finished carriers are then transported to the warehouse to await shipping.

Regrind

Waste material (polystyrene and HDPE) from various areas of the plant is sent to the regrind area. The material is separated by type and reground into flakes. The flakes are then repelletized in preparation for reuse onsite or sale to brokers.

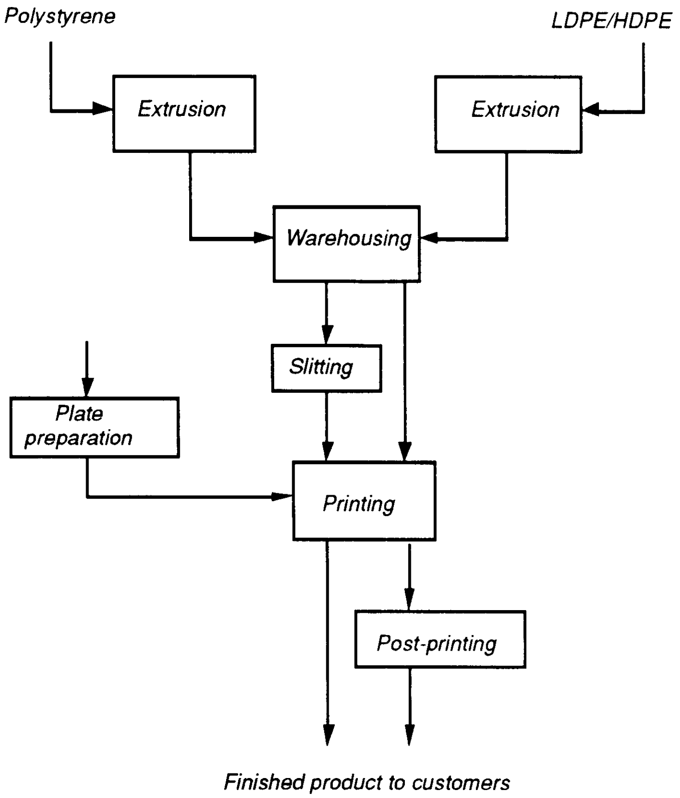

***Figure 1.** Abbreviated process flow diagram for label manufacturing.*

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

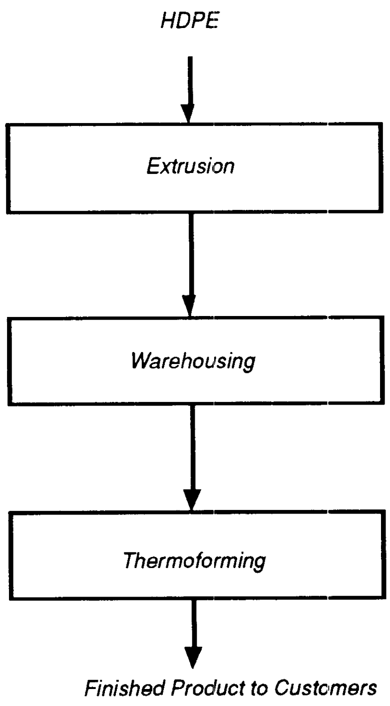

Figure 2. *Abbreviated process flow diagram for product-carrier manufacturing.*

Solvent Recovery

Two large distillation units are operated by the plant to recover spent solvent (ethyl acetate and PM glycol ether) from the printing operation. The recovered solvent is reused in cleaning the presses. A smaller distillation unit is used to recover solvent from the photopolymer shop for reuse in plate preparation.

Abbreviated process flow diagrams for the two products manufactured are shown in Figures 1 and 2.

Existing Waste Management Practices

This plant has already taken the following steps to manage and minimize its wastes:

- All extrusion wastes that have not been inked are reground and reworked onsite.
- A minimum amount of waste is generated by the ink formulation process. Off- specification inks and surplus inks are reworked.
- Ink runs are scheduled to allow light-to-dark transitions in the printing trays. The trays on the presses are dedicated to specific colors as much as possible.
- Wash-up solvent is recovered onsite for reuse.
- The number of different solvents used by the plant for ink formulation has been reduced.

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 payback time 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. 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.

Additional Recommendations

In addition to the opportunities recommended and analyzed by the WMAC team, several other possibilities for waste minimization were evaluated by the assessment team. These measures were not analyzed completely because of insufficient data or minimal savings. They were brought to the manufacturer's attention for future reference, however, since these approaches to waste reduction may increase in attractiveness with changing plant conditions.

- Recover the Freon™ blowing agent used in conjunction with polystyrene extrusion. A large capital cost would be required for implementation of this opportunity. Alternative blowing technologies are being investigated by the plant.
- Develop a better use for the waste inked-polystyrene.
- Convert to water-based inks to reduce or eliminate solvent emissions and waste management costs.
- Recover stack gases from the curing ovens.

This research 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. She can be reached at:

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Table 1. *Summary of Current Waste Generation*

Waste Generated	*Source of Waste*	*Annual Quantity Generated*	*Annual Waste Management Cost*
Freon™-22 (blowing agent)	*Polystyrene extrusion. The Freon blowing agent is used during the formation of the polystyrene film. The unretained blowing agent is vented from the plant.*	*579,000 lb*	*$ 550,050*[1]
Residual volatiles	*Polystyrene extrusion. The residual volatile impurities present in the polystyrene are vented from the plant during the extrusion process.*	*21,610 lb*	*0*
Perchloroethylene	*Photopolymer plate preparation. A portion of the perchloroethylene used in the cleaning of printing plates evaporates to plant air.*	*6,000 lb*	*1,860*[1]
n-butanol	*Photopolymer plate preparation. A portion of the n-butanol used in the cleaning of printing plates evaporates to plant air.*	*1,500 lb*	*570*[1]
Propylene glycol methyl ether	*Label printing. A portion of the propylene glycol methyl ether that is used for thinning ink and cleaning the presses and plates evaporates to plant air.*	*728,540 lb*	*393,400*[1]
Ethyl acetate	*Label printing. A portion of the ethyl acetate that is used for cleaning the presses evaporates to plant air.*	*146,000 lb*	*62,050*[1]
Soiled shop rags	*Label printing. The rags used in the cleaning operations are laundered offsite and returned to the plant.*	*35,000 pieces*	*N/A*
Misprinted polystyrene	*Label printing. Misprinted labels are reground and sold to a broker at a discount.*	*4,000,000 lb*	*-1,208,950*[2]
Wash solvent still bottoms (ethyl acetate/propylene glycol methyl ether)	*Solvent recovery. Still bottoms from the recovery process for the wash solvent are shipped offsite as hazardous waste.*	*18,770 gal*	*154,130*
Plate washing solvent still bottoms (perchloroethylene/ n-butanol)	*Solvent recovery. Still bottoms from the recovery process for plate washing solvent are shipped offsite as hazardous waste.*	*385 gal*	*3,160*
Purge waste from wash solvent recovery.	*Solvent recovery. The entire contents of the wash solvent recovery system are purged periodically as a result of maintenance problems. The waste is shipped offsite as hazardous waste.*	*9,500 gal*	*39,020*[1]
General trash	*Various processes.*	*6,000 yd^3*	*18,750*

[1]Includes cost of raw material.
[2]Revenue received.

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
Purge waste from wash solvent recovery	Install a membrane pervaporation system to remove water from the spent wash solvent prior to solvent recovery in the distillation units. The removal of water will alleviate the corrosion problems which have led to the need to purge the system periodically.	9,500 gal	100	$ 44,060[1]	$ 123,700	2.8
Wash solvent still bottoms (ethyl acetate/propylene glycol methyl ether)	Install a secondary solvent recovery system to recover reusable solvent from the still bottoms. The proposed system consists of a solvent recovery still equipped with a vacuum recovery attachment. Dispose of the secondary still bottoms cake as a delisted nonhazardous waste in order to reduce disposal costs.	15,020 gal	80	69,460[1,2]	88,710	1.3
Wash solvent (ethyl acetate/propylene glycol methyl ether)	Install a fractional distillation unit to recover PM glycol ether and ethyl acetate as essentially pure components. Reuse the ethyl acetate for washing the presses and reuse the PM glycol ether in formulating the inks. No waste reduction will result from this measure, but significant cost savings will be realized.	0	0	71,300[1,2]	350,000	4.9
Propylene glycol methyl ether	Install a cooling system to chill the ink/solvent mixture in the press station trays to reduce the evaporative losses of PM glycol ether.	31,440 lb	4	16,980[1]	11,200	0.7
Wash solvent (ethyl acetate/propylene glycol methyl ether)	Install hand-held rinse spray guns on each of the rinse stations on the printing presses to reduce the amount of solvent needed for rinsing.	0	0	67,130[1]	770	0.01

[1]Includes savings on raw materials.
[2]Total savings reduced by annual operating cost of system.

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