United States
Environmental Protection
Agency

Risk Reduction
Engineering Laboratory
Cincinnati, OH 45268

Research and Development

EPA/600/S-95/004 April 1995

EPA ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Manufacturer of Labels and Flexible Packaging

Richard J. Jendrucko*, Brian T. Hurst*, 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 That document has been superseded by the *Facility Pollution Prevention Guide* (EPA/600/R-92/088, May 1992).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 printed labels and flexible packaging. Operations performed by this plant include printing cylinder plating, printing cylinder etching, printing plate production, printing, and extrusion-coating-laminating. The team's report, detailing findings and recommendations, indicated that waste solvents are generated in large quantities and that the greatest cost savings could be realized by installing a second distillation unit to recover solvents from ink solids.

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 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 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 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 in-house expertise in waste minimization.

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 waste minimization assessments require several site visits to each client served. In general, the WMACs follow the proce-

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

dures 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 printed spiral wound labels for commercial use and flexible packaging for foods. It operates 6,240 hr/yr to produce over 14 billion units of product annually.

Manufacturing Process

The operations used by this plant include printing cylinder plating, cylinder etching, printing plate production, printing, and extrusion-coating-laminating. Each process is described briefly below.

Cylinder Plating and Etching

Chrome is removed from used cylinders in an electrolytic dechrome unit and then the cylinders are lathed to remove the previous copper-plated pattern. New cylinders and used cylinders accidently lathed beyond the nickel layer are then nickel plated.

The cylinders are cleaned and copper plated. Next, the cylinders are lathed, polished, and cleaned prior to etching. A thin coating of photoresist chemical is sprayed onto the copper-plated cylinders. A plastic positive pattern is manually wrapped around the cylinder which is then exposed to high intensity ultraviolet light.

To develop the design onto the cylinder surface, dye is poured over the cylinder. Cylinders are rinsed and dried. The cylinders are then inspected for irregularities and hand-coated with staging lacquer.

Patterns are etched into the cylinders by immersing them in a chemical solution. Lastly the photoresist and dye solutions are removed with solvent-laden rags. Photoresist stripper is applied as a final step to remove all remaining solvents and etching solution.

Once the design has been etched into the cylinder, the cylinder is inspected and chrome plated. A set of printed samples is produced for approval before printing runs in the rotogravure printing line.

An abbreviated process flow diagram for cylinder plating and etching is shown in Figure 1.

Printing Plate Production

For flexographic printing, another type of cylinder is prepared. Used cylinders are reprocessed by first removing the previous pattern and adhesive backing from them.

Multiple positive patterns of the desired pattern supplied by the customer are aligned on a grid to insure proper position on a photopolymer sheet. The pattern/grid combination is cut and trimmed to fit the photopolymer sheet. Then, the sheet is exposed to ultraviolet light on both sides sequentially.

Each sheet is washed in solvent to remove the areas of the sheet not exposed to the ultraviolet light. Then, each plate is positioned onto a steel-based cylinder and attached using an adhesive backing. Printing samples from each cylinder are produced, and accepted cylinders are transferred to the flexographic printing area.

An abbreviated process flow diagram for flexographic printing plate production is shown in Figure 2.

Printing

Rotogravure printing and flexographic printing are similar except for the type of ink and the printing cylinder used. Ink concentrate is mixed in-house with various solvents (alcohol for flexographic printing) by the supplier. The mixed ink is then poured into a reservoir located on the press.

A printing cylinder is partially immersed in an ink-filled trough and excess ink is removed. A continuous sheet of paper rolls across the cylinder. After each ink application, the paper passes through a heated tunnel to dry the ink prior to subsequent printings. Varnish is applied to products that require it in a similar manner.

The finished product is wound onto a core and removed from the press. The roll of product is then rewound so that the printed label will be on the outside. The roll is then placed onto a slitter to cut large rolls that are several labels wide into smaller rolls. The smaller rolls are reverse-wound again, packaged, and stored.

An abbreviated process flow diagram for printing is shown in Figure 3.

Extrusion-Coating-Laminating

In the extrusion-coating-laminating line a flexible packaging composed of up to five layers of material is produced. Various combinations of paper and foil are combined to form the multilayer product. Plastic pellets for laminating are melted in extruders which are positioned over the paper in a laminating machine. This process yields an outer lamination coating on the other various layers. The paper is then cooled as it rolls across a water-cooled cylinder. Once the product is removed from the press, the roll is packaged and stored.

An abbreviated process flow diagram for this line is shown in Figure 4.

Existing Waste Management Practices

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

- Mixtures of ink solids and solvents are separated by distillation; recovered solvents are sold to an outside company.
- Plant personnel are evaluating a clean-up program utilizing a water-based cleaner instead of alcohol for alcohol-based ink printing runs.
- An onsite incinerator is used to oxidize volatilized ink solvents so that evaporative emissions to the atmosphere meet federal guidelines.
- A computerized monitoring system for press set-up is used to reduce paper waste.

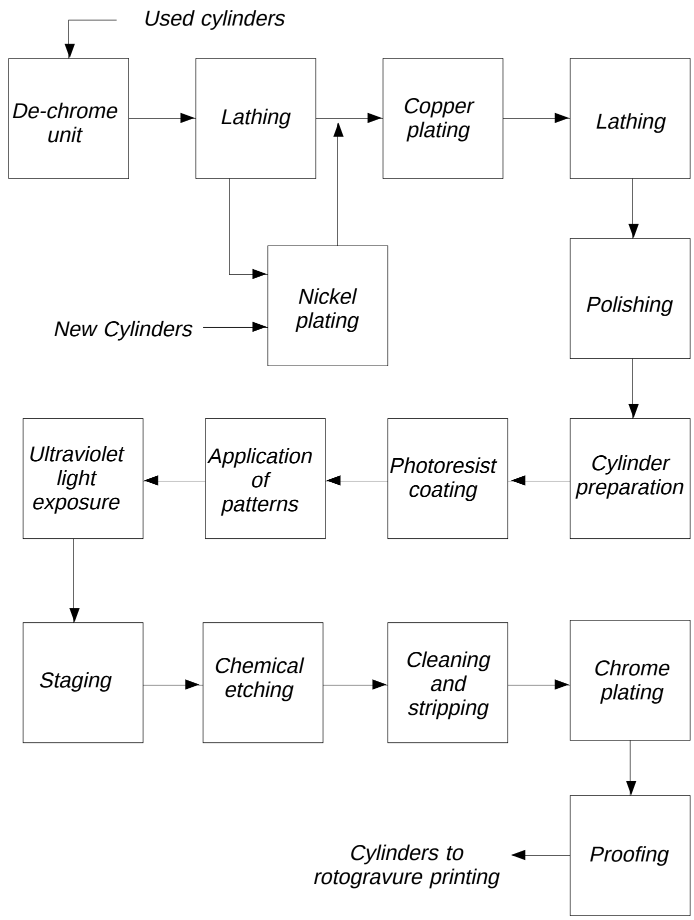

Figure 1. *Abbreviated process flow diagram for cylinder plating and etching.*

Waste Minimization Opportunities

The type of waste currently generated by the plant, the source of the waste, the waste management method, the quantity of the waste, and the annual waste management cost for each waste stream identified are given in Table 1.

Table 2 shows the opportunities for waste minimization that the WMAC team recommended for the plant. The minimization 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 financial savings of the minimization opportunities result from the need for less raw material and from reduced present and future costs associated with waste management. 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 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 additional measures were considered. These measures were not analyzed completely because of insufficient data, implementation difficulty, or a projected lengthy payback. Since one or more of these approaches to waste reduction may, however, increase in attractiveness with changing conditions in the plant, they were brought to the plant's attention for future consideration.

- Clean solvent-laden rags onsite instead of shipping them offsite for cleaning.
- Reuse treated wastewater in the preliminary stations of the cylinder plating line prior to sewering.
- Minimize dragout from the plating bath by installing an array of rinse spray nozzles above a "dead rinse" tank following the plating bath. Install drag-out boards around the plating tank to return dripping solution as cylinders are lifted out of and moved away from the plating tank.

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**.

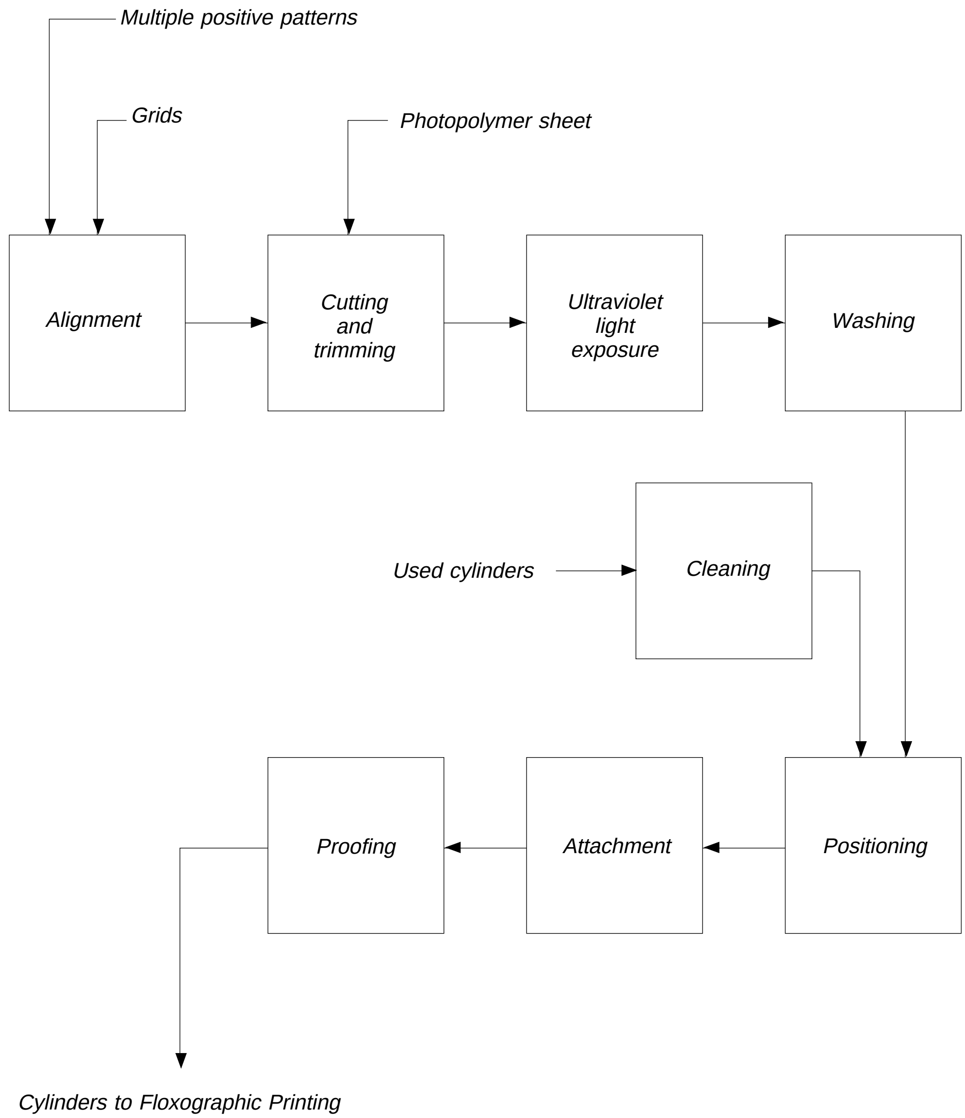

Figure 2. *Abbreviated process flow diagram for flexographic printing plate production.*

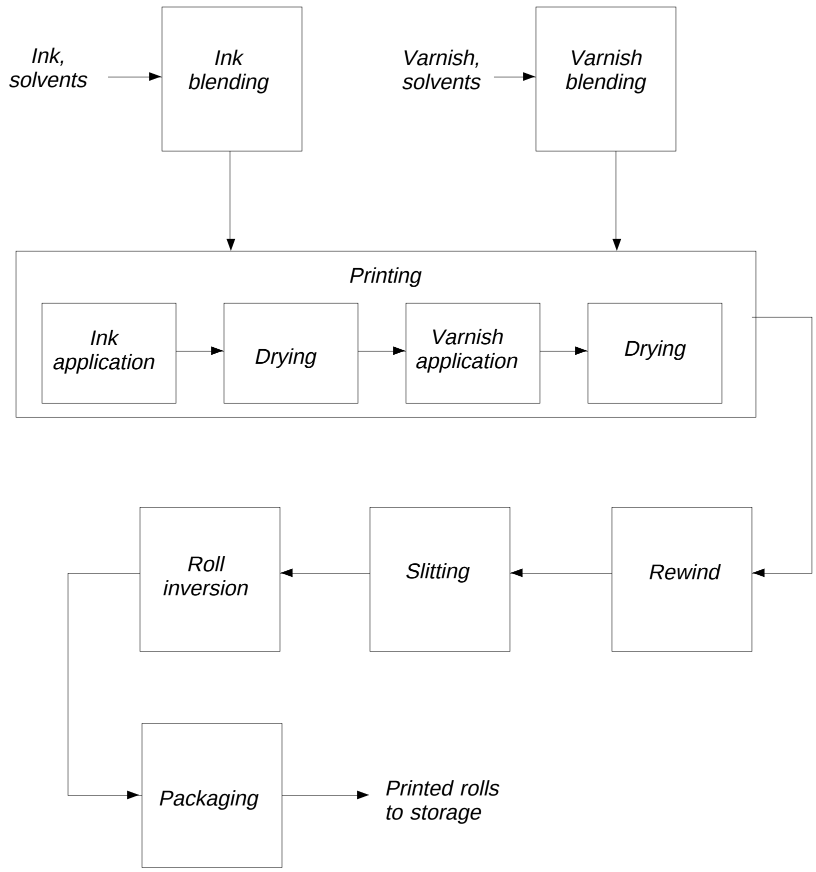

Figure 3. *Abbreviated process flow diagram for printing.*

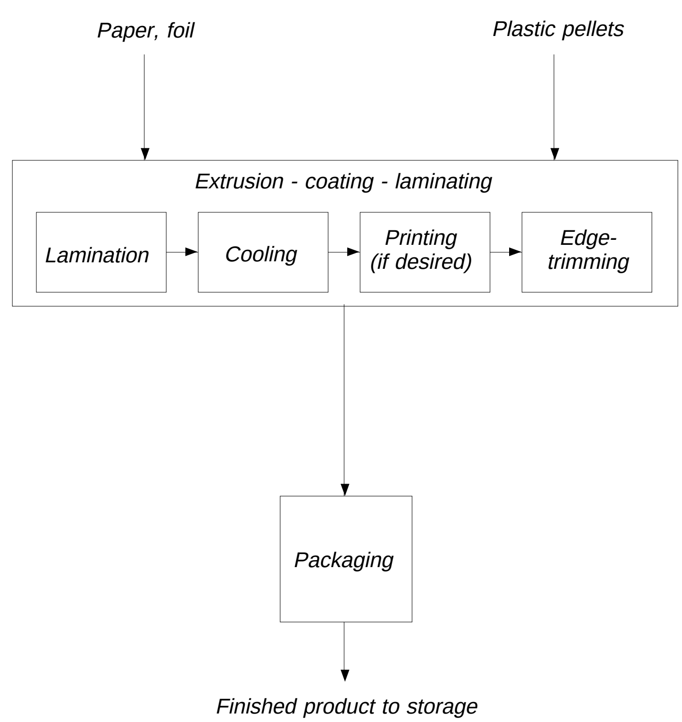

Figure 4. *Abbreviated process flow diagram for extrusion - coating - laminating.*

Table 1. Summary of Current Waste Generation

Waste Generated	*Source of Waste*	*Waste Management Method*	*Annual Quantity Generated (LB)*	*Annual Waste Management Cost**
Copper and nickel turnings	*Lathing of cylinders*	*Sold to recycler*	*3,900*	*$7,170*
Evaporated solvent	*Cylinder plating and mixing of inks and varnish*	*Evaporates to plant air*	*35,780*	*23,140*
Solvent-laden paper towels	*Cylinder plating and etching*	*Shipped offsite to landfill*	*560*	*30*
Evaporated dye	*Etching of cylinders*	*Evaporates to plant air*	*70*	*4,410*
Obsolete patterns	*Etching of cylinders and flexographic printing plate production*	*Shipped offsite to landfill*	*5,670*	*300*
Solvent-laden cloth rags	*Various processes*	*Shipped offsite and laundered for reuse*	*119,400*	*11,000*
Adhesive backing	*Flexographic cylinder recycle*	*Shipped offsite to landfill*	*1,200*	*60*
Photopolymer trim	*Flexographic printing plate production*	*Shipped offsite to landfill*	*1,200*	*60*
Evaporated solvent	*Ink and varnish application in various lines*	*Incinerated onsite*	*712,500*	*370,540*
Ink-laden filters	*Printing in various lines*	*Shipped offsite to landfill*	*11,440*	*620*
Waste paper	*Various processes*	*Compacted; shipped offsite to landfill*	*3,166,960*	*69,740*
Evaporated alcohol	*Ink mixing in flexographic printing line*	*Evaporates to plant air*	*1,790*	*1,790*
Waste plastic logs	*Extrusion-coating-laminating*	*Shipped offsite to landfill*	*178,420*	*9,260*
Ink-laden solvent	*Various printing lines and parts washing*	*Shipped offsite as hazardous waste*	*346,080*	*302,400*
Ink-laden solvent	*Various printing lines and parts washing*	*Distilled onsite; recovered solvent is sold to another plant for use as fuel*	*260,000*	*86,490*
Decantation sludge	*Onsite solvent recovery system*	*Shipped offsite as hazardous waste*	*37,490*	*$24,150*
Still bottoms	*Onsite solvent recovery system*	*Shipped offsite as hazardous waste*	*16,070*	*10,350*
Extracted polymer	*Onsite distillation of spent plate wash solution*	*Shipped offsite to landfill*	*1,060*	*4,690*
Wastewater	*Various processes*	*Treated in onsite wastewater treatment plant; sewered*	*917,600*	*7,390*
Wastewater treatment plant sludge	*Onsite wastewater treatment plant*	*Shipped offsite as hazardous waste*	*32,900*	*64,500*
Spent lubricant	*Printing presses*	*Shipped offsite*	*1,640*	*3,160*
Miscellaneous solid waste	*Various processes*	*Shipped offsite to landfill*	*96,310*	*5,000*

**Includes waste treatment, disposal, and handling costs, and applicable raw material costs.*

Table 2. Summary of Recommended Waste Minimization Opportunities

Minimization Opportunity	Waste Reduced	Annual Waste Reduction: Quantity (LB)	Annual Waste Reduction: Per cent	Net Annual Savings	Implementation Cost	Simple (yr)
Install a second distillation unit to recover all solvent from ink solids for sale and to reduce cost of offsite shipments of hazardous waste.	*Ink-laden solvent*	*—-* [1]	*-*	*$129,110*	*$21,480*	*0.2*
Install pumps, piping, valving, and computer hardware and software to automate ink and solvent mixing to reduce unnecessary waste and evaporative losses.	*Ink-laden solvent* *Evaporated solvent (not incinerated)* *Evaporated alcohol (not incinerated)*	*54,030* *20,310* *1,340*	*16* *57* *75*	*88,940* [2]	*288,800*	*3.2*
Install a natural gas-fired sludge drying oven in the onsite wastewater treatment system to further dry sludge for volume reduction prior to shipment offsite.	*Wastewater treatment plant sludge*	*17,770*	*54*	*28,510* [2]	*40,700*	*1.4*
Use recovered solvent for most cleaning and discontinue use of virgin solvent except for final wiping.	*Ink-laden solvent*	*204,120*	*79*	*11,560* [2]	*0*	*Immediate*
Use copper lathing waste instead of purchasing nuggets for copper plating tank.	*Copper and nickel turnings*	*2,920*	*75*	*1,510* [2]	*0*	*Immediate*
Utilize existing cleaning tank lids to minimize solvent evaporation.	*Evaporated solvent (not incinerated)* *Evaporated alcohol (not incinerated)*	*600* *1,200*	*2* *67*	*900*	*0*	*Immediate*

[1] *The same total quantity of waste will be generated.*
[2] [b] *Total annual savings have been reduced by an annual operating cost required for implementation.*

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