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ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for Rotogravure Printing Cylinder Manufacturing

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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. 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 That document has been superseded by the *Facility Pollution Prevention Guide* (EPA/600/R-92/088, May 1992).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 Louisville performed an assessment at a plant that manufactures rotogravure printing cylinders from new stock and customer returns. Used cylinders and new cylinders undergo surface preparation, plating, and image transfer operations. The team's report, detailing findings and recommendations, indicated that process wastewater and wastewater treatment sludge are generated in large quantities and that significant cost savings could be realized by recovering plating chemicals from wastewater.

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 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 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 assessments require several site visits to each client served. In general, the WMACs follow the procedures outlined in the EPA *Waste Minimization Opportu-*

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nity 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

The plant manufactures rotogravure printing cylinders from new stock and customer returns. It operates approximately 7,500 hr/yr to produce over 5,000 engraved cylinders annually.

Manufacturing Process

Chrome-plated engraved copper-plated steel cylinders for rotogravure printing are produced by the plant. The principal raw materials used are new and used steel cylinders and various chemicals for stripping and plating. The processes involved are cylinder preparation by nickel and copper plating, image processing, engraving or etching, and chrome plating.

Used Cylinders

Used cylinders requiring only re-chroming (approximately 10% of the returned cylinders) are stripped of their existing chrome layer using an acid stripping-solution. Then they are top-etched with ferric chloride and/or re-chromed.

Used cylinders that are returned for a new design or are otherwise uncorrectable are lathed to remove both the chrome and the copper layers and are designated as "cutoffs". The cutoffs are then processed in the same manner as new cylinders.

New Cylinders

New steel bases and cutoffs are first degreased in a caustic bath and rinsed. Following cleaning, the cylinders are nickel plated and then copper plated. (Initial nickel plating enhances the bond between copper and steel during subsequent copper plating). After copper plating, the cylinders are polished using a water-cooled grinding wheel.

While the cylinders are being plated, customer provided artwork is prepared for image processing in another area. Black and white artwork is photographed and then scanned electronically. Negatives are produced for each color to be printed. Further processing is determined by the manner in which the image will be transferred to the cylinder.

If mechanical engraving is the transfer method to be used, the negatives are developed onto bromide films which are attached to an optical scanning drum in tandem to the cylinder to be engraved. The other method used is direct transfer etching which requires photoresist application followed by acid etching.

After engraving or etching, the cylinders are inspected for defects. Then a complete ink proof is made from the finished cylinder. The cylinders that are deemed acceptable after proofing are chrome plated and then shipped. If the cylinders are deemed unacceptable, they may be top-etched to add necessary depth for proper image transfer, proofed again, and, if acceptable, chrome plated. Otherwise, the rejected cylinders are lathed and the entire process is repeated.

An abbreviated process flow diagram for new cylinders is shown in Figure 1.

Existing Waste Management Practices

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

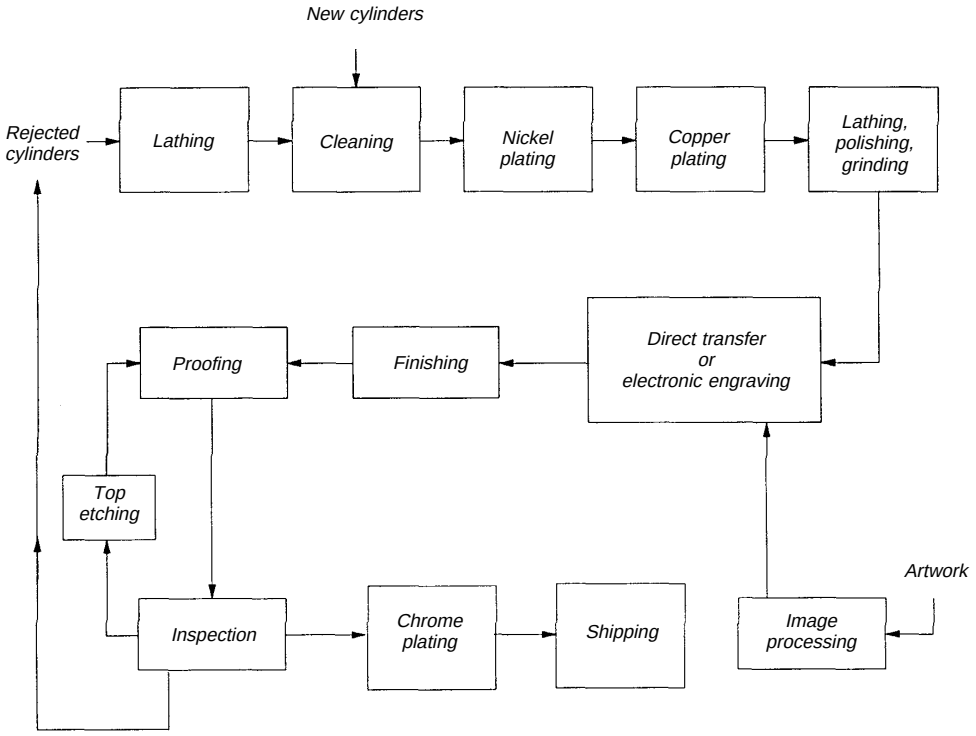

Figure 1. *Abbreviated process flow diagram for new cylinders.*

- An effort is made to collect copper scrap and send it offsite for recycling.
- High-speed copper electroplating tanks are used to prevent process and plating chemicals from clinging to the cylinders, thereby extending bath life.
- Deionized water is used in all of the plating line rinses. Its use eliminates the presence of calcium and magnesium ions and thus reduces sludge formation.
- Diversion tanks are used to segregate the plating baths from the rinse waters to prevent dilution and maintain bath composition.
- Silver is reclaimed from solution overflow in the developers through a vendor-sponsored ion-exchange program. Silver is also reclaimed from waste film by an offsite recycler.
- Dry-film photoresist is used in the direct transfer process thus eliminating the chlorinated solvents frequently used in photoresist applications.
- Direct transfer is being completely replaced by electronic engraving for image transferring. The direct transfer process generates hazardous wastes such as xylene and ferric chloride but electronic engraving generates only copper dust, waste sandpaper, and towels.
- Fumes and mist from the chrome-plating tank are scrubbed and recirculated to the plating bath.
- Raw materials are purchased in returnable containers and finished products are shipped in customer-provided returnable boxes.

Pollution Prevention 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 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 financial savings of the 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 pollution prevention 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, minimal savings, implementation difficulty, or a projected lengthy payback. Since one or more of these approaches to pollution prevention may, however, increase in attractiveness with changing conditions in the plant, they were brought to the plant's attention for future consideration.

- Install a sewer meter to measure the actual volume of wastewater discharged from the plant.
- Extend the life of the acid-stripping solution by using an acid purification unit.
- Regenerate spent ferric chloride etchant onsite or offsite by electrolysis of the copper.
- Reblend waste inks offsite into a black ink that can be reused.
- Recycle containers in which copper anodes are received.
- Filter and reuse caustic cleaning solution.
- Reduce volume of trash discarded using a compactor.
- Recover spent butyl acetate used for cleaning in the proofing process.
- Reduce drag-out losses to the onsite wastewater treatment plant by using multistage countercurrent rinsing following plating.
- Use an alternate reagent to complex the soluble metals in the wastewater to obtain a reduced volume of sludge.
- Install a filmless electronic camera system that can transfer images directly, eliminating the need for film developing and finishing.
- Reduce drag-out losses by removing protective cones on the cylinder ends directly over the plating tanks.
- Remove copper anodes from plating bath when not plating.
- Remove chromium (VI) from process waste streams using granular activated carbon units.

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*	*Waste Management Method*	*Annual Quantity Generated (lb/yr)*	*Annual Waste Management Cost*[1]
Scrap copper	*Cutting and lathing of cylinders*	*Bundled; sold to scrap recycler*	*16,000*	*-14,950 (revenue received)*
Scrap copper	*Cutting and lathing of cylinders*	*Mixed with trash; shipped to nonhazardous landfill*	*16,000*	*170*
Recovered silver from ion exchange unit and waste film	*Image processing*	*Sold to recycler*	*140*	*-1,780 (revenue received)*
Waste ink, xylene, and dye	*Proofing of cylinders and photo-resist development*	*Shipped offsite for fuels blending*	*7,150*	*7,700*
Ferric chloride sludge	*Etching tank*	*Shipped offsite for disposal as hazardous waste*	*1,420*	*1,100*
Wastewater treatment sludge	*Onsite wastewater treatment plant*	*Shipped offsite for disposal as hazardous waste*	*33,150*	*8,500*
Evaporated solvents	*Cylinder cleaning*	*Evaporated to plant air*	*18,490*	*0*
Used filters	*Plating baths*	*Shipped to nonhazardous landfill*	*4,220 filters/yr*	*included in waste manage-ment cost for miscellaneous solid waste*
Grinding sludge	*Grinding of cylinders*	*Shipped to nonhazardous landfill*	*470*	*same as above*
Miscellaneous solid waste	*Various plant operations*	*Shipped to nonhazardous landfill*	*2,592,000*	*27,030*
Process wastewater	*Cylinder preparation and plating*	*Treated in onsite wastewater treatment plant; sewered*	*1,003,000*	*29,930*[2]
Process wastewater	*Grinding, etching, image process-ing, direct transfer, and polishing*	*Sewered*	*8,689,000*	*29,930*[2]
Domestic wastewater	*Domestic uses*	*Sewered*	*9,765,000*	*29,930*[2]

[1] *WMAC estimates total administration and record-keeping costs associated with waste management of $2,400/yr, excluding wages.*
[2] *Includes operation of onsite waste water treatment plant, sewer costs, and water purchase cost.*

Table 2. *Summary of Recommended Waste Minimization Opportunities*

Pollution Prevention Opportunity	Waste Reduced	Annual Waste Reduction: Quantity (lb/yr)	Annual Waste Reduction: Per cent	Net Annual Saving ($/yr)	Implementation Cost	Simple Payback (yr)
Improve collection of copper scrap for offsite recycling. Currently, half of the copper scrap generated is disposed of trash.	Scrap copper mixed with trash	0[1]	—-	$12,370	0	0
Install an electric furnace for melting and ingoting of copper scrap for reuse as anodes on-site. (Degreasing of copper scrap may be required.)	Scrap copper recycled Scrap copper mixed with trash	16,000 16,000	100 100	47,150	49,300	1.1
Reuse the acid stripping solution used for chrome removal before treating it in the onsite wastewater treatment system.	Process wastewater (cylinder preparation)	5,860	50	2,960	0	0
Use a hot deionized water rinse followed by drying with an air knife in place of alcohol for drying.	Process wastewater (etching and direct transfer)	negligible	—-	800	1,100	1.4
Replace cotton filters used in conjunction with copper plating with reusable ceramic cartridge filters.	Used filters	1,900 filters	45	36,530	400	.1
Collect, filter, and reuse cooling water used for grinding.	Process wastewater (grinding)	3,829,000	44	810	1,260	1.6
Concentrate copper-plating rinse water and reuse as plating bath make-up. Recover and reuse evaporated water.	Process wastewater (cylinder plating) Wastewater treatment sludge	144,470 4,590	14 14	6,840	24,210	3.5
Concentrate nickel-plating rinse water and reuse as plating bath make-up. Recover and reuse evaporated water.	Process wastewater (cylinder plating) Wastewater treatment sludge	165,110 1,100	16 3	4,900	24,210	4.9
Recover nickel from plating rinse water using reverse osmosis and reuse as plating bath make-up. Reuse water.	Process wastewater (cylinder plating) Wastewater treatment sludge	165,110 990	16 3	5,480	10,200	1.9

[1] *The same quantity of waste will be generated onsite.*

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