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ENVIRONMENTAL RESEARCH BRIEF

Waste Reduction Activities and Options at a Printer of Forms and Supplies for the Legal Profession

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Abstract

The U.S. Environmental Protection Agency (EPA) funded a project with the New Jersey Department of Environmental Protection and Energy (NJDEPE) to assist in conducting waste minimization assessments at thirty small- to medium-sized businesses in the state of New Jersey. One of the sites selected was a printer of forms, business cards, and office supplies for the legal profession. A site visit was made in 1990 during which several opportunities for waste minimization were identified. Prior to the site visit, the company had already incorporated several waste minimization activities into its operations. These activities included waste and scrap paper sorting for recycling and reuse, laundering cleaning rags for reuse, and identifying less hazardous process-related materials. The assessment team identified waste minimization opportunities in addition to those the company had already implemented. One opportunity was the off-site recovery of silver from the photographic process waste stream. The team also identified 3 options in the engraving process. The first two involved regeneration of the spent bath solution either by off-site electrolytic process or the use of an electrolytic recirculating cell. The third option was the use of cupric chloride solution as an etchant rather than the more hazardous ferric chloride solution in use. The site team also recommended that the company shift from chemical plate cleaning to a mechanical technique, similar to those adopted in the metal finishing industry. Typically, such techniques include polishing (including abrasion), brushing, and sand blasting. The waste reduction option for ink sludge generated from water-based cleaning of equipment included consideration of whether the residual solids could be used for reincorporation into the ink.

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Introduction

The environmental issues facing industry today have expanded considerably beyond traditional concerns. Waste water, air emissions, potential soil and groundwater contamination, solid waste disposal, and employee health and safety have become increasingly important concerns. The management and disposal of hazardous substances, including both process-related wastes and residues from waste treatment, receive significant attention because of regulation and economics.

As environmental issues have become more complex, the strategies for waste management and control have become more systematic and integrated. The positive role of waste minimization and pollution prevention within industrial operations at each stage of product life is recognized throughout the world. An ideal goal is to manufacture products while generating the least amount of waste possible.

The Hazardous Waste Advisement Program (HWAP) of the Division of Hazardous Waste Management, NJDEPE, is pursuing the goals of waste minimization awareness and program implementation in the state. HWAP, with the help of an EPA grant from the Risk Reduction Engineering Laboratory, conducted an Assessment of Reduction and Recycling Opportunities for Hazardous Waste (ARROW) project. ARROW was designed to assess waste minimization potential across a broad range of New Jersey industries. The project targeted thirty sites to perform waste minimization assessments following the approach outlined in EPA's *Waste Minimization Opportunity Assessment Manual* (EPA/625/7-88/003). Under contract to

Printed on Recycled Paper

NJDEPE, the Hazardous Substance Management Research Center at the New Jersey Institute of Technology (NJIT) assisted in conducting the assessments. This research brief presents an assessment of a printing company (one of the 30 assessments performed) and provides recommendations for waste minimization options resulting from the assessment.

Methodology of Assessments

The assessment process was coordinated by a team of technical staff from NJIT with experience in process operations, basic chemistry, and environmental concerns and needs. Because the EPA waste minimization manual is designed to be primarily applied by the in-house staff of the facility, the degree of involvement of the NJIT team varied according to the ease with which the facility staff could apply the manual. In some cases, NJIT's role was to provide advice. In others, NJIT conducted essentially the entire evaluation.

The goal of the project was to encourage participation in the assessment process by management and staff at the facility. To do this, the participants were encouraged to proceed through the organizational steps outlined in the manual. These steps can be summarized as follows:

- Obtaining corporate commitment to a waste minimization initiative
- Organizing a task force or similar group to carry out the assessment
- Developing a policy statement regarding waste minimization for issuance by corporate management
- Establishing tentative waste reduction goals to be achieved by the program
- Identifying waste-generating sites and processes
- Conducting a detailed site inspection
- Developing a list of options which may lead to the waste reduction goal
- Formally analyzing the feasibility of the various options
- Measuring the effectiveness of the options and continuing the assessment

Not every facility was able to follow these steps as presented. In each case, however, the identification of waste-generating sites and processes, detailed site inspections, and development of options was carried out. Frequently, it was necessary for a high degree of involvement by NJIT to accomplish these steps. Two common reasons for needing outside participation were a shortage of technical staff within the company and a need to develop an agenda for technical action before corporate commitment and policy statements could be obtained.

It was not a goal of the ARROW project to participate in the feasibility analysis or implementation steps. However, NJIT offered to provide advice for feasibility analysis if requested.

In each case, the NJIT team made several site visits to the facility. Initially, visits were made to explain the EPA manual and to encourage the facility through the organizational stages. If delays and complications developed, the team offered assistance in the technical review, inspections, and option development.

The Legal Supply Printing Company

The legal supply printing company produces, on a quick-turnaround basis, legal forms, business cards, and office supplies for the legal profession. The company is noted for the high quality of its product and takes care to ensure that the manufacturing process is carried out in such a way as to yield acceptable products.

The manufacturing operations of the facility involve two major procedures. Impressions are made using either an engraving process or a printing process. These activities and related procedures, including photo processes and etching, present potential opportunities for waste reduction.

Typical steps in the manufacturing process include the following activities:

- After creative design, artistic, and layout work is completed by the design group, a photographic negative is produced using a normal photographic process with typical development techniques.
- A subsequent phototransfer step reproduces the image on a metal plate using photoresist polymers which form in areas exposed to light passing through the photographic negative. Thus, light-exposed areas of the plate become coated with the protective polymer and unexposed areas remain uncoated (unprotected). Copper plates are used in the engraving process and aluminum plates in the printing process.
- For the engraving process, the next step is the etching operation, involving further processing of the copper plate upon which the desired image was transferred by the photographic process. The etching step accomplishes the chemical removal of unprotected copper, creating depth differences on the plate which can be used to transfer the image to paper.
- The final step in the engraving plate preparation is plate cleaning to remove the polymeric photoresist coating. Currently, the final cleaning step is done by immersing the plate in a bath of N-methylpyrrolidone, which dissolves the polymer leaving a clean, bare-metal plate.
- The final operation in the engraving process is printing the impression which requires use of ink to transfer the desired image from the plate onto paper.
- For the preparation of the printing plates, photoresist monomer coated on aluminum sheets is polymerized by light passing through a photographic negative. After washing away unreacted monomer, the unprotected aluminum is partially dissolved away using acid. The protective polymer is cleaned away.
- The final operation in the printing process is printing the impression which requires use of ink to transfer the desired image from the plate onto paper.

The company is conducting a waste reduction program involving:

(1) sorting, recycling, and reusing waste and scrap paper;

(2) laundering and reusing cleaning rags that are widely used during printing operations;

(3) using inks, cleaners, and related materials that reduce hazardous levels compared with products previously used. This step also promotes employee health and safety.

For example, the facility shifted to the use of water-based inks and equipment cleaners where possible.

The main objective of the company for beginning a waste minimization opportunities assessment was to identify (1) other areas of possible waste reduction and (2) options for reducing waste in these areas. While the technical and management staffs of the company are committed to the goal of waste reduction, the time available for them to focus on the question is limited. One objective of this study, therefore, is to make more efficient the investment of technical time by developing a concise listing of opportunity areas and technological options.

The Processes, Waste Streams, and Options

Within manufacturing operations there are two major processes, engraving and printing, which are used for different purposes and products. While these two processes involve different steps, the first step (a photographic operation) is common to both.

After the creative design, artistic, and layout work is completed by the design group, a photographic negative is produced using a normal photographic process with typical development techniques. A subsequent phototransfer step is used to reproduce the image on a metal plate. Copper plates are used in the engraving process and aluminum plates in the printing process.

Historically, the wastestreams from photo developing processes, as in many photographic operations, entered the sewage treatment system with the knowledge of the local sewage authority. Currently, the developer and related solutions are managed as hazardous waste. Because of the silver content of the photographic process, it is possible that the liquid waste streams, particularly the spent developer solution, contain enough silver to support a silver recovery operation. The volume may be too low to justify the recovery step onsite, but it is recommended that contact be made with silver reclamation facilities to explore this possibility.

The Engraving Process

The primary step within the engraving process where waste reduction opportunities occur is in the etching operation. The etching step further processes the copper plate upon which the desired image was transferred by the photographic process. Etching involves the chemical removal of unprotected copper, creating depth differences on the plate which can be used to transfer the image to paper.

The chemical system used is a solution with a starting composition of 55% ferric chloride and 45% hydrochloric acid. The copper plates move through this bath, allowing the unprotected metal surfaces to dissolve. As the copper content in the bath rises, the system loses it effectiveness. At a copper concentration of about 17 mg/L, the bath is replaced. The spent acidic iron and copper chloride solution is currently disposed of as hazardous waste at an annual cost exceeding $10,000. The metal mixture complicates reuse and recycling possibilities for the spent bath. Three options can be used to reduce waste generated from the process:

(1) Use an off-site vendor to regenerate the spent bath solution (probably by an electrolytic process) and return the renewed solution to the company for reuse. The renewal process may also require pH adjustment before reuse.

(2) Establish the bath regeneration step at the site. An example of applicable equipment is a metal recovery system, "Napzap,"* which is available from Napco Systems.

Napzap is an electrolytic recirculating cell. This circular plating cell can be used to remove the dissolved copper from the spent etching solution. The recovered metal is removed mechanically from the electrode and sold as scrap copper. The copper-free etching solution can be reused, perhaps needing some readjustment of pH and ferric chloride content. The recovery system is easy to operate and does not require staff expansion dedicated only to its operation.

(3) Use a cupric chloride solution as the etchant rather than a ferric chloride solution. The basic chemistry involved is described by the following reaction:

$$Cu + CuCl_2 \longrightarrow 2\ CuCl$$

Regenerate the etching solution by oxidation using hydrogen peroxide, for example, as an oxidizing agent.

$$2\ CuCl + H_2O_2 + 2\ HCl \longrightarrow 2\ CuCl_2 + 2\ H_2O$$

This process builds up the copper content in the etching solution necessitating periodic bleed-off. The bleed stream should be relatively pure copper chloride which could be used for other beneficial purposes or serve as a source for metallic copper. It should not require disposal.

The final step in engraving plate preparation is plate cleaning, which removes the polymeric photoresist coating that protected the portions of the copper plate during the etching process. Currently, the final cleaning step is done by immersing the plate in a bath of N-methylpyrrolidone. The polymer dissolves, leaving a clean, bare-metal plate.

Eventually, the solute level increases and the bath solvent becomes ineffective. Currently this spent solvent is drummed and shipped as hazardous waste for disposal.

Waste reduction options are: 1) Recover and reuse the organic solvent. This option would require distillation to purify the solvent. Still bottoms would continue to require disposal, but the total volume and intrinsic value of the materials sent for disposal should be substantially reduced compared to the existing practice. 2) Shift from a chemical cleaning to a mechanical plate cleaning technique. Analogous approaches have been adopted in the metal finishing industry. These techniques typically avoid the use of chemicals and include:

- polishing (including abrasion)
- brushing
- sand blasting

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

Special care would have to be taken in selecting such a mechanical cleaning process in order to protect the integrity of the fine detail on the plate surface. Proper selection of the gritty material used in the sand blasting option could provide the needed balance between coating removal and surface protection. Usually, even the mechanical surface cleaning technologies will produce wastes. The waste stream will be a mixture of the abrasive material and the residue cleaned from the surface. In individual situations, a determination must be made regarding the regulatory status of the waste.

The final operation in the engraving process is printing the impression itself. The waste generated from this step is ink sludge which results from water-based cleaning of equipment. The waste ink is transferred to a sink where the soluble components are washed away. The insoluble components are collected in a trap from which the sludge is removed weekly. Approximately 110 gal of this material is generated annually. The waste reduction option for this operation included consideration of whether these residual solids could be used for reincorporation into the ink. This option would require coordination with the ink manufacturer.

The Printing Process

Two fundamental differences between the engraving process and the printing process are the type of plate used and the composition of the ink. The printing plate is aluminum and the ink used is solvent-based rather than water-based. Two pollution prevention opportunities in the printing process are the impression step and the equipment-cleaning step.

Impression

The inks used in making the impressions contain the following major components:

- middle distillates
- mineral spirits
- solvent naphtha
- carbon black

The formulation is carefully devised to provide fluidity, which changes with the evaporation of the low boiling solvents. The higher boiling solvents evaporate later, yielding the final "cured" impression. In this process, the solvent is transferred into the air. Switching to a water-based ink system which has the necessary performance properties to maintain production rates and product quality is a pollution prevention option. Water-based inks are commercially available for this application. One type of water-based inks which has been successfully applied in Canada uses materials derived from soy beans.

Equipment Cleaning

Because solvent-based inks are currently used, the equipment is cleaned with a solvent-based product. The current cleaner is a formulation containing:

- aromatic hydrocarbons
- aliphatic hydrocarbons
- glycol ether
- esters

Two pollution prevention options in the equipment-cleaning step are (1) laundering and reusing cleaning rags (already done at this facility) and (2) using a non-solvent-based cleaner. Cleaners based on the use of surfactants in water solutions are available commercially. Changing to a water-based ink eliminates the need for a solvent-based cleaner.

Training and Incentives

An ultimate goal of a corporate waste reduction/pollution prevention program is to make the idea of waste reduction a part of the everyday thinking and actions of each employee. A key aspect of this is a training program for every employee. The training could include discussions and illustrations of the corporate commitment to waste reduction, the types of waste currently generated at the facility, and the areas within the facility where they are generated. Training could also include discussion of the methods of storage, treatment, and disposal required for these wastes; the costs of treatment and disposal; and some examples of waste reduction success stories at the facility or at other corporate sites. Such training could be incorporated into general employee training programs.

Some discussion of the importance of each employee to the continuing waste reduction effort is also valuable. Companies such as DuPont, Monsanto, Dow Chemical, and 3M have found that the development of an incentive and recognition program for waste reduction ideas developed and submitted by employees has been very successful. Obviously, the employees who carry out the activities are the ones most directly responsible for the generation of waste. They have the best ideas for reducing the amount of waste created. These companies, among others, reward such ideas monetarily or provide other recognition in newsletters or posters. A similar program at this facility might have value.

Because a waste reduction program is not a one-time activity, continuous employee training and awareness is important. Regular monitoring and reporting of waste reduction results can facilitate the ongoing effectiveness of the program with employees.

Conclusion

The waste minimization opportunities assessment at the facility has identified several options which potentially reduce the quantity of waste generated during the company's operations. The etching process, in particular, presents opportunities with regard to the etchant bath and the etched plate cleaning procedure for significant waste reduction with attendant cost savings.

Other options, such as the move toward non-solvent-based inks and cleaners, may have to wait until suppliers can provide the appropriate materials to allow maintenance or improvement of production rates and product quality. It is suggested, however, that the facility make the suppliers aware that such products are desired.

Summary of Waste Minimization Opportunities

Table 1 presents the type of waste currently generated by the plant, the sources of waste, the quantity of waste, and the annual treatment and disposal costs (where known and available).

Table 2 presents the opportunities for waste minimization identified during the assessment. The types of waste, the minimization opportunities, and possible waste reductions are presented in the table. When available or estimable, the associated savings, implementation costs, and payback times are usually determined. However, because the feasibility analysis was to be carried out by the staff of the facility, that information was not readily available for this assessment.

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Table 1 Summary of Generated Wastes

Waste Generated	*Source of Waste*	*Annual Quantity Generated (gal)*	*Annual Costs ($)*
Photographic Darkroom Wastes	*Photographic Development*	*130,000*	*40*
Solvent Containing Photoresist Polymer	*Cleaning of Printing and Engraving Plates*	*165*	*750*
Spent Etching Solution	*Removal of Unprotected Metal from Water Soluble Inks*	*2,200*	*10,000*
Ink Sludge	*Insoluble Residues from Water Soluble Inks*	*55*	*350*
Solvents	*Used for Press Cleanup from Solvent Based Inks*	*110*	*450*

Table 2 Summary of Waste Minimization Options Identified

Waste Generated	*Minimization Opportunity*	*Annual Waste Reduction*		*Net Annual Savings ($)*	*Implementation Cost ($)*	*Pay-back Years*
		Quantity	*Percent*			
Darkroom Wastes	*Consider Silver Recovery by ion exchange or electro-deposition.*	*The volume of water would be essentially unchanged, but the silver content would be lowered.*		*125*	*2,500*	*20*
Solvent containing Photoresist Polymer	*Distill and reuse the solvent*	*130 gal*	*60%*	*7,630*	*6,000*	*0.8*
					(This is a high boiling solvent which will need vacuum distillation equipment to prevent decomposition. A waste stream of still bottoms will also be generated.)	

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