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ENVIRONMENTAL RESEARCH BRIEF

Waste Reduction Activities and Options for a Scrap Metal Recovery Facility

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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 30 small- to medium-sized businesses in the state of New Jersey. One of the sites selected was a facility that processes scrap metal to recover refined metals for reuse. The facility concentrates on recovery of tungsten, molybdenum, and tantalum. The processes used by the facility involve washing, degreasing, mechanical cleaning, and acid treatment. A site visit was made in 1990 during which several opportunities for waste minimization were identified. Options identified include improved process pH control, changes in solid precipitation technology, and acid reuse. Implementation of the identified waste minimization opportunities was not part of the program. Percent waste reduction, net annual savings, implementation costs and payback periods were estimated.

This Research Brief was developed by the Principal Investigators and EPA's Risk Reduction Engineering Laboratory in Cincinnati, OH, to announce key findings of this completed assessment.

Introduction

The environmental issues facing industry today have expanded considerably beyond traditional concerns. Wastewater, 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 30 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 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 the processing of scrap metal to recover refined metals (1 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 inhouse 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

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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.

No sampling or laboratory analysis was undertaken as part of these assessments.

Facility Background

The facility purchases scrap metal from manufacturers in the United States and throughout the world and uses recovery technology to produce marketable quantities and quality of tungsten, molybdenum, and tantalum. The facility uses techniques of cleaning and acid treatment to recover and prepare the metals for resale.

The facility is located in a suburban area and employs about 25 people. This particular facility is one of the few businesses of its type in operation in the world. This assessment presents an interesting opportunity to consider what happens to materials from pollution prevention activities at other types of facilities which are sent offsite for recovery.

Manufacturing Processes

The metal recovery processes used at the facility are different for the three major types of metals which form the core of the activity. Tungsten scrap is simply washed with nitric acid to remove impurities. Molybdenum scrap is washed with commercial detergents in water to remove grease and cutting oils. The degreased surfaces are cleaned further using mechanical means such as sand-blasting. The tantalum is recovered most frequently by extraction from capacitors which have plastic resin components as well. The capacitors are crushed and the plastic is separated by a water wash taking advantage of the differential in the density of the two materials. The recovered tantalum is treated with nitric acid and with hydrochloric acid to remove contaminants.

Existing Waste Management Activities

The company represents an important part of the pollution prevention infrastructure. The processes and procedures carried out at this facility demonstrate that recovery from waste streams of materials for reuse is an industrial process and also has potential for pollution prevention activities. This facility has already considered opportunities for pollution prevention. For example, degreasing of the molybdenum scrap is carried out with aqueous detergents rather than with solvents and the removed grease and cutting oils are separated from the water and sent for recovery. Further cleaning of the molybdenum scrap is done mechanically, rather than chemically. The goal of this assessment was to identify additional opportunities for pollution prevention at the facility.

Because the processes for the recovery of the three major metals of interest are different, they produce somewhat different types of waste streams. For the tungsten process, the scrap is treated with 70% nitric acid and then rinsed. The acid washes and the rinses are sent to a common sump for further processing.

The molybdenum scrap is washed with aqueous detergents to remove grease and oil. The oil layers are separated mechanically and sent offsite for heat value recovery. The aqueous layer is sent to the POTW. Further cleaning of the metal is done by sand-blasting which results in production of nonhazardous solid waste.

Recovery of tantalum requires separation of the metal from the plastic components of capacitors. This separation is accomplished by mechanical crushing and then washing away the plastic components with water. The recovered metal is cleaned by treatment with hot concentrated nitric acid, followed by a second wash with hydrochloric acid. The metal is then rinsed with water. All of the acid washes and the rinses are sent to the same common sump used for the tungsten recovery process.

The liquid in the sump is processed periodically by pH adjustment with caustic followed by addition of ferric chloride to act as a coagulant. The mixture is then passed through a filter press to recover solids. The effluent is passed through a bag filter for polishing and then is sent to a holding tank for a final pH check and adjustment, if necessary. After an additional pass through a bag filter for polishing the effluent is discharged to the POTW. The solids from the bag filters are returned to the filter press.

The facility produces about 8-9,000 lb/month of nonhazardous solids from the filter press which are sent offsite for disposal. About 900 gal of effluent is discharged to the POTW daily. Some concerns about the effluent include occasionally exceeding the allowable tungsten limit, occasional elevated levels of phenols, and total dissolved solids which exceed the standards of the POTW.

Waste Minimization Opportunities

The type of waste currently generated by the facility, the source of the waste, the quantity of the waste and the annual treatment and disposal costs are given in Table 1.

Table 2 shows the opportunities for waste minimization recommended for the facility. 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 waste currently generated at the facility and possible waste reduction depend on the level of activity of the facility.

It should be noted that the economic savings of the minimization opportunity, in most cases, results from the need for less raw material and from reduced present and future costs associated with waste treatment and disposal. 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. Also, no equipment depreciation is factored into the calculations.

Some of the major issues to be addressed include reduction of the level of dissolved solids in the aqueous effluent, lowering of the tungsten level in the effluent, and addressing the issue of phenols in the effluent.

Total dissolved solids can come from many sources. This facility uses substantial quantities of concentrated acid which is neutralized with caustic. The neutralization results in salt formation. Additionally, coagulation of suspended solids is accomplished with ferric chloride, which can also result in production of additional dissolved solids after neutralization. It is also true that the acids are used largely for the purpose of dissolving material from the scrap metal. The dissolved materials that are not precipitated when the solution is neutralized are carried along in the effluent.

A potential solution to this problem may be to extend the life of the acid baths. The current practice is to visually examine the baths after treatment of each batch of metal. If the acid in the bath is discolored or appears to be contaminated, it is discarded into the neutralization tank. Otherwise, it is returned to the process. The management estimates that about 20% of the nitric acid is recycled. It would appear that a more analytical approach to evaluate the continued effectiveness of the acid would allow more of it to be recycled. Because the process depends upon acid mediated reaction of the surface of the metal fragments, the process could continue even if the acid is discolored as long as the pH is sufficient for reaction with the metal. It may be more effective to determine the optimum range of pH for the surface cleaning to occur and to continue using the acid bath as long as the pH remains in that range. The life time of the bath conceivably could be extended further by mixing of addition of fresh acid. Ultimately, it may be desirable to consider uses for this acid stream other than straight neutralization and discharge to the POTW. It could be collected and sent for treatment as hazardous waste. Alternatively, and better from a pollution prevention perspective, it could be listed on a waste exchange and offered for use in the processes of other organizations.

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

The issue of phenols in the aqueous effluent appears to be related to the plastic materials which are separated from the tantalum metal contained in capacitors. Current practice is that once the capacitors are crushed, the plastic material is washed away with water and the washings are transferred directly to the common sump. Assuming that the plastic is a phenolic based resin, it would be common for a depolymerization to take place under acid conditions, resulting in elevated levels of free phenols. It is recommended therefore that this stream be segregated and that it be handled through the filter press separately. In any event, it is desirable to avoid exposure of this material to acid conditions.

Regulatory Implications

A significant incentive for consideration of additional pollution prevention opportunities at this facility was the level of certain materials in the wastewater discharged to the POTW for treatment. This concern was the result of clean water regulations. If decisions are made to segregate acid streams and to send them offsite for treatment, then the facility will become a hazardous waste generator and a new type of regulatory scrutiny will come into place.

This Research Brief summarizes a part of the work done under cooperative Agreement No. CR-815165 by the New Jersey Institute of Technology under the sponsorship of the New Jersey Department of Environmental Protection and Energy and the U.S. Environmental Protection Agency. The EPA Project Officer was Mary Ann Curran. 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 Costs*
Nonhazardous Solid Waste	*Solids recovered from aqueous stream through filter press*	*102,000 lb*	*$3600*
Aqueous Discharge to POTW	*Neutralized acid stream, rinses, and plastic residue washings after passing through the filter press*	*225,000 gal*	*400*
		(In addition to these direct charges, processing charges for chemicals and equipment add an estimated $10,000 annually to these costs.)	

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Table 2. *Summary of Recommended Waste Minimization Opportunities*

Waste Stream Reduced	Minimization Opportunity	Annual Waste Reduction Quantity	Annual Waste Reduction Percent	Net Annual Savings	Implementation Cost	Payback Years *
Phenolics in Effluent	*Segregate capacitor plastic residues from exposure to acid conditions to minimize polymer degradation and phenol formation*	*(There would be essentially no change in waste quantity, rather the quality of the waste stream would be improved by lowering the level of phenolics in the effluent improving the ability of the POTW to manage the effluent.)*				
Dissolved Solids in Effluent and Filter Press Cake	*Investigate use of organic polymer as coagulant in place of ferric chloride. This should reduce the levels of dissolved solids in the discharge and reduce the quantity of the filter cake.*	*20,400 lb*	*20*	*$720*	*$1200*	*1.7*
Tungsten Level in Aqueous Effluent	*Segregate tungsten processing stream, neutralize with calibrated pH measuring equipment to assure reproducible endpoint. Segregation will eliminate the possibility of formation of a soluble complex of tungsten and components of other processing stream.*	*(There would be essentially no change in waste quantity, rather the quality of the waste stream would be improved by lowering the level of tungsten in the effluent, improving the ability of the POTW to manage the effluent.)*				
Acid Streams	*Extend lifetime of acid baths by developing quantitative methods to determine when they are no longer effective. The methods could include pH measurements, dissolved solids content,water content, or other variables. A realistic initial goal would be for 50% reuse rather than the present 20%.*	*38,250 lb*	*37.5*	*5,350*	*3,000*	*0.6*

* Savings result from reduced raw material and treatment and disposal costs when implementing each minimization opportunity independently.

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