United States Environmental Protection Agency
Research and Development

Risk Reduction Engineering Laboratory
Cincinnati, OH 45268

EPA/600/S-92/064 October 1992

EPA

ENVIRONMENTAL RESEARCH BRIEF

Waste Reduction Activities and Options for a Manufacturer of Orthopedic Implants

Alan Ulbrecht and Daniel J. Watts*

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 manufactures orthopedic implants for use by the health care industry. The parts are produced in a molding operation using stainless steel or cobalt chromium alloy. Computer-controlled cutting is used to produce the bearings for the implants according to precise specifications. A site visit was made in 1990 during which several opportunities for waste minimization were identified. Options identified include onsite distillation and reuse of solvent, alternative degreasing techniques, and reuse of metal cutting fluids. 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.

* New Jersey Institute of Technology, Newark, NJ 07102

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 manufacturing of orthopedic implants for use by the health care industry (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

Printed on Recycled Paper

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.

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

Facility Background

The facility is a manufacturer of orthopedic implants for the health care industry. Specific products include hip, shoulder, and knee replacements made from stainless steel or cobalt chromium alloys. The products are made through a molding operation with machining of precision bearings.

The facility, located in a suburban area, employs about 50 people and has been in its present location approximately 20 years.

Manufacturing Processes

The production of the orthopedic implants is in essence a 3-step process. Initially, a wax prototype with the desired size and shape of the finished implant is prepared and all imperfections are repaired with an alcohol treatment. The wax is then coated and gradually a shell is built up with a slurry of colloidal silica. The finished shell is dried in an oven to produce a ceramic mold.

The ceramic is then seal-coated with more silica and then placed in an oven to melt and drain the inner wax and to complete hardening of the outer shell. A hole is cut in the ceramic shell to allow draining of the wax and covered with a plastic plug to prevent dirt and other contamination from entering.

An ingot of either cobalt chromium or stainless steel is melted in an electric inductive furnace. The plastic cap is removed from the ceramic mold and the molten metal is poured into the ceramic cavity. When the metal hardens, the ceramic shell is chipped away and the solid metal implant remains.

The bearings for the implants are cut to precise and specific tolerances using a computer numerical control production machine. Excess water soluble lubricants used in this process are removed in a 1,1,1-trichloroethane vapor degreasing tank, the implant is stencilled for identification, and packaged in plastic in a clean room for shipment to the customer.

Existing Waste Management Activities

The company has already begun consideration of pollution prevention options to be used in its processes. One example of this consideration is an examination of the possibility of using terpene-based degreasers in place of the chlorinated solvent currently used.

Denatured alcohol is currently used for working the wax molds. Annually about 165 gal of this solvent are sent offsite for recycling or for recovery of fuel value.

From the numerically controlled metal machining process 1,155 gal of water soluble oils and 770 gal of petroleum-based oils are generated annually. They are sent offsite for recycling or fuel value recovery.

From the vapor degreaser, 770 gal of 1,1,1-trichloroethane is sent offsite for disposal each year. Approximately 400 gal is lost annually as fugitive emissions.

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. This particular facility is kept scrupulously clean and illustrates that production of critical medical products can generate hazardous waste and benefit from pollution prevention initiatives.

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.

Regulatory Implications

There are no significant regulatory issues which would impede the introduction of further pollution prevention concepts at this facility. Increased regulatory concern about releases of chlorinated hydrocarbons may accelerate the investigation of possible use of terpenic or alkaline aqueous degreasing systems. Use of terpenic material for this purpose may eventually raise questions about the advisability of discharging such materials to a POTW, even though they are usually naturally occurring materials.

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:

Pollution Prevention Research Branch
Risk Reduction Engineering Laboratory
U.S. Environmental Protection Agency
Cincinnati, OH 45268

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

Table 1. *Summary of Current Waste Generation*

Waste Generated	*Source of Waste*	*Annual Quantity Generated*	*Annual Waste Management Costs*
Chlorinated Solvent	*Effluent from vapor degreaser*	*770 gal*	*$2,450*
Chlorinated Solvent	*Evaporative losses from solvent degreaser*	*400 gal*	*2,600 (raw material loss)*
Denatured Alcohol	*Wax mold working*	*165 gal*	*525*
Water Soluble Oils	*Metal machining*	*1155 gal*	*3,675*
Petroleum Oils	*Lubrication*	*770 gal*	*2,450*

*U.S. Government Printing Office: 1992 — 648-080/60125

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 ***
Chlorinated Solvent	*Acquisition of onsite distillation equipment to recycle and reuse degreasing solvents.*	*616 gal*	*80*	*$5,960*	*$4,000*	**0.6**
	Continue investigation of change to alkaline aqueous based or terpene based degreasers. Ultrasonic bath in combination with the alkaline aqueous based degreaser may be most effective.	*1170 gal*	*100*	*9,957*	*3,500*	**0.3**
Denatured Alcohol	*Recycle and reuse this solvent by onsite distillation.*	*132 gal*	*80*	*820*	*4,000*	**5.0**
Water Soluble Oils	*Segregate and use onsite recovery and recycling service.*	*925 gal*	*80*	*2,940*	*0*	**immed**

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

United States
Environmental Protection Agency
Center for Environmental Research Information
Cincinnati, OH 45268

Official Business
Penalty for Private Use
$300

EPA/600/S-92/064