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ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Manufacturer of Surgical Implants

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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 That document has been superseded by the *Facility Pollution Prevention Guide* (EPA/600/R-92/088, May 1992).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 Colorado State University performed an assessment at a plant that manufactures surgical implants from stainless steel and titanium stock. The metal stock is machined, vibratory polished, electropolished, passivated, inspected, and shipped. The team's report, detailing findings and recommendations, indicated that wastewater and waste cutting fluid are the wastes generated in the greatest quantities and that significant cost savings would result from implementing a formal cutting fluid management plan.

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 a separate report of the same title available from University City Science Center, Philadelphia, PA.

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 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 Colorado State University's (Fort Collins) 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-

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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 surgical implants. Nearly four million parts are produced each year during 4,160 hr of operation.

Manufacturing Process

Fasteners and plates are manufactured from stainless steel and titanium sheets, rectangles, and round stock.

The first step in the plate manufacturing process is the sanding and cutting to size of stainless steel stock. Computer numerically-controlled (CNC) mills are used to mill the sides of the plate, and another mill finishes the top and bottom of the plate. Lathes, drills, broaches, and additional mills are used for further machining operations. Then the parts are placed in one of several vibratory polishers that utilize aluminum oxide chips and water for additional finishing. Sand blasting may be used in place of vibratory polishing for some parts. The final finishing step is electropolishing, which uses an alkaline cleaner, a hot water rinse, a cold water rinse, a phosphoric acid solution, a hot water rinse and hold, an electropolishing solution, and a deionized water rinse. After the part dries, a logo and serial number are etched chemically onto its surface. Finally, the parts are passivated (made less reactive) in a nitric acid solution, inspected, boxed, and shipped.

Fasteners are manufactured in a separate area of the plant. Cylindrical metal blanks are cut and machined to form a screw head on one end. Centerless grinders are used to shape the head and reduce the outside diameter. Threads are cut into the blanks using mills. The fasteners are polished in the vibratory polishers, electropolished, and passivated. The finished products are inspected, packaged, and shipped.

An abbreviated process flow diagram for surgical implant manufacture is shown in Figure 1.

Existing Waste Management Practices

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

- An aqueous, citric-based cleaner has replaced solvents used for cleaning machined plates prior to polishing.
- Water meters have been installed on all aqueous waste streams that are discharged to the treatment unit, to monitor and control water usage.
- Scrap metal is shipped offsite for recycling.
- Centrifuges have been installed on many of the machines used in fastener fabrication to separate metal chips from the oil-based cutting fluid, extending the fluid's life and reducing waste generation.

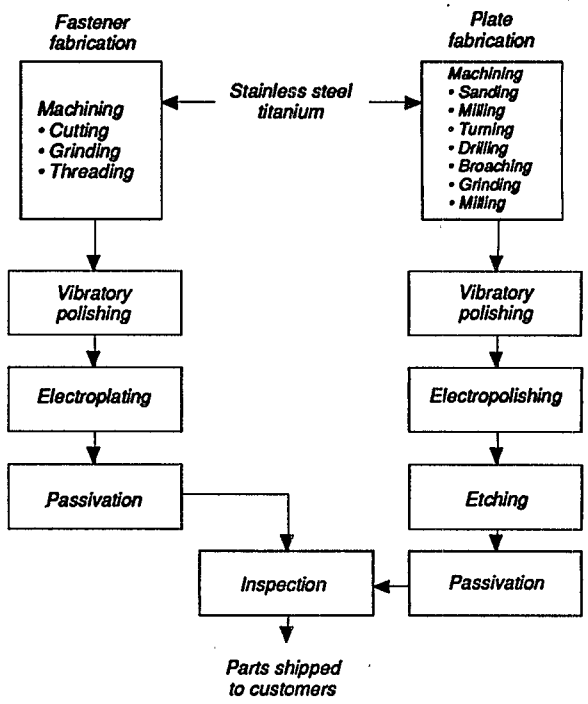

Figure 1. *Abbreviated process flow diagram for surgical implant manufacture.*

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 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. 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 may result when the opportunities are implemented in a package.

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)	Annual Waste Management Cost*
Oil-based cutting fluid	Machining of fasteners	Shipped offsite for disposal (recycled or incinerated)	85,900	$88,100
Scrap metal	Machining of fasteners	Sold to recycler	80,600	(16,100)[1]
Water-based cutting fluid	Machining of plates	Shipped offsite for disposal (recycled or incinerated)	76,000	58,530
Scrap metal	Machining of plates	Sold to recycler	27,400	(5,500)[1]
Rinse water	Electropolishing of fasteners and plates	Treated onsite; sewered	995,000	1,920
Spent electropolishing solution	Electropolishing of fasteners and plates	Treated onsite; sewered	18,300	8,060
Spent passivating solution	Electropolishing of fasteners and plates	Treated onsite; sewered	3,720	140
Wastewater	Vibratory polishing of fasteners and plates	Treated onsite; sewered	6,350,000	12,250
Wastewater	Sparge ring around clarifier in onsite wastewater treatment plant	Treated onsite; sewered	2,870,000	5,530
Wastewater treatment sludge	Onsite wastewater treatment plant	Shipped to municipal landfill	16,900	0[2]

* Includes waste treatment, disposal, and handling costs, and applicable raw material costs.
[1] Credit received.
[2] Plant pays a flat monthly rate for trash hauling.

Table 2. *Summary of Recommended Waste Minimization Opportunities*

Minimization Opportunity	Waste Stream Reduced	Annual Waste Reduction		Net Annual Savings	Implementation Cost	Simple Payback (yr)
		Quantity (lb)	Per cent			
Institute a formal cutting fluid management program for machines using water-based cutting fluids. To help maintain the quality of the fluid and extend its life, install coalescing oil skimmers on certain machines	Water-based cutting fluid	24,330	32	$19,900[1]	$6,400	0.3
Reuse treated wastewater in the vibratory polishers instead of using tap water.	Wastewater	6,350,000	100	3,250	900	0.3

[1] Total annual savings have been reduced by the annual operating cost required for implementation.

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