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ENVIRONMENTAL RESEARCH BRIEF

Pollution Prevention Assessment for a Manufacturer of Stainless Steel Pipes and Fittings

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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 That document has been superseded by the *Facility Pollution Prevention Guide* (EPA/600/R-92/088, May 1992).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 Tennessee performed an assessment at a plant that manufactures stainless steel pipes and fittings. In order to fabricate the pipes, stainless steel coil stock is processed in tube mills to form continuous, cylindrical pipe. Seams are welded and the pipe is cut to specified lengths. The pipes are hardened in annealing furnaces and quenched. Then the pipe ends are deburred and straightening is done as required. The final step is acid pickling for cleaning and etching of the pipes. The team's report, detailing findings and recommendations, indicated that the onsite treatment of pickling rinse water generates a large quantity of hazardous sludge and that significant cost savings could be realized by installing a sludge drying oven to reduce the volume and weight of sludge shipped offsite.

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 separate report of the same title available from University City Science Center.

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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 Tennessee'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.

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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 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 produces stainless steel pipes of various diameters and lengths and custom-made pipe fittings. It operates over 6,240 hr/yr to produce nearly 30 million pounds of pipe annually.

Manufacturing Process

Raw materials used by the plant include coil and sheet metal stock, solvent-based marking ink, and protective plastic end caps. The two major operations in this plant, pipe and fitting formation and acid pickling, are described in this section.

Pipe and Fitting Formation

Stainless steel coil and sheet stock is unloaded and stored outdoors under protective cover. As it is needed, the coil stock is moved indoors by forklift to one of six automatic tube mills where the sides of unrolled metal strips are curled up to form a continuous, cylindrical pipe. The seam of the resulting pipe is fused in an electric in-line welding operation. An abrasive saw is used to cut the continuously-formed pipe to specified lengths; sections of poorly welded pipe are cut away.

Stainless steel sheet stock is used to form custom products such as T's, elbows, and reducers. The sheets are cut with a band saw or plasma torch into smaller pieces and custom-formed into final product shapes using various forming and bending equipment.

All pipes and fittings are hardened in electric induction or gas annealing furnaces. After annealing, the pipes are water spray-quenched or quenched in a water-filled tank outdoors, depending on their size.

The roughened ends of the pipe are manually deburred with an air grinder. Then the pipes are straightened as necessary and transported to the acid pickling process.

Acid Pickling

All pipes and fittings are transported to the pickling process in which an overhead crane is used to lower them into an acidic pickle liquor solution which chemically cleans and etches the black oxide surface layer resulting in a clean, rust resistant pipe.

Each pipe is rinsed with water in one of two rinse tanks and is then mounted on a wash rack and manually sprayed with water in a second rinsing operation. After the pipes dry, they are labeled with a solvent-based ink spray jet and protective plastic caps are hammered onto the ends. The finished products are stored outdoors until they are shipped to customers.

An abbreviated process flow diagram for pipe production is shown in Figure 1.

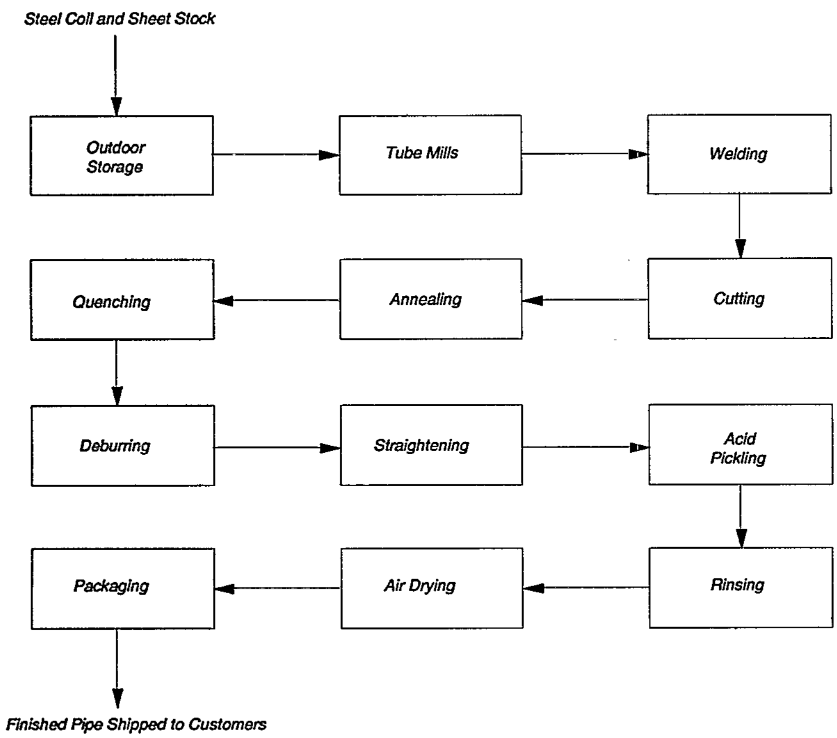

Figure 1. Abbreviated process flow diagram for straight pipe manufacture.

Existing Waste Management Practices

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

- The polymer previously used by this plant as a flocculent in the onsite wastewater treatment system has been replaced by magnesium hydroxide in order to reduce the volume of sludge generated and shipped offsite.
- An acid regeneration system has been installed to regenerate spent pickle liquor for reuse onsite.

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 pollution prevention opportunity reflect the savings achievable when implementing each 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, 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.

- Recycle waste packaging material that is currently shipped to the municipal landfill.
- Periodically renew the filter press cloths that have lost the maximum potential to pass clean water from the wastewater treatment sludge.
- Modify material handling procedures in order to remove metal shavings that have fallen inside the pipes during the mill process prior to the acid pickling process. Implementation of this measure will lead to reduced generation of hazardous sludge.
- Remove pipe surface oxide flakes in a high-pressure spray wash or with mild mechanical abrasion to reduce the quantity of flakes carried over into the pickling tanks.

This research brief summarizes a part of the work done under Cooperative Agreement No. CR-819557 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*
Packaging and protective barrier waste	*Receipt and storage of raw materials*	*Shipped to municipal landfill*	*7,500*	*$0*[1]
Leaked and spent lubricating oil	*Machining*	*Shipped to fuels blending program*	*8,540*	*5,980*
Spent abrasive saw blades	*Cutting of pipe*	*Shipped to municipal landfill*	*5,200*	*0*[1]
Stainless steel scrap	*Machining and cutting of pipe*	*Sold to scrap recycler*	*700,000*	*-164,300 (net revenue received)*
Oxidized metal flakes and metal dust	*Annealing, deburring, and cutting*	*Shipped to special landfill*	*30,000*	*15,810*
Quench water	*Quenching of pipes following annealing*	*Sewered to POTW*	*49,800*	*40*
Damaged plastic end caps	*Packaging of finished product*	*Shipped to municipal landfill*	*130*	*0*[1]
Pickling rinse water	*Acid pickling of product*	*Treated in onsite WWTP; sewered to POTW*	*84,598,000*	*89,100*
Wastewater treatment sludge	*Onsite treatment of wastewater*	*Shipped to hazardous waste landfill*	*1,560,000*	*265,370*
Miscellaneous solid waste	*Various plant operations*	*Shipped to municipal landfill*	*135,000 cu ft*[2]	*26,990*

[1] *Included in annual waste management cost for miscellaneous solid waste.*
[2] *Includes specific quantities given for packaging and protective barrier waste, spend abrasive saw blades, and damaged plastic end caps. The majority of this waste stream is cardboard waste.*

Table 2. Summary of Recommended Pollution Prevention Opportunities

Pollution Prevention Opportunity	Waste Reduced	Annual Waste Reduction Quantity (lb/yr)	Annual Waste Reduction Percent	Net Annual Savings	Implementation Cost	Simple Payback (yr)
Install a propane-fired sludge drying oven to reduce the volume and weight of the sludge that is generated in the onsite wastewater treatment system and shipped offsite.	Wastewater treatment sludge	928,200	60	$141,150	$66,200	0.5
Utilize a trash compactor to reduce the volume of municipal trash shipped offsite, thereby reducing disposal costs.	Miscellaneous solid waste	0[1]	0	12,810	15,000	1.2
Remove the poor quality length of each coil of raw material prior to forming in the mills. Current practice is for the entire length of raw material to undergo the normal forming and welding operations, regardless of the quality. The current procedure leads to unnecessary expenditures of welding gases, worker labor, and energy.	n/a	—	—	9,300	0	0
Automate the addition of caustic to the wastewater treated in the onsite wastewater treatment plant in order to reduce caustic purchases and reduce labor costs.	n/a	—	—	12,620	12,600	1.0

[1] A significant volume reduction would occur.

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