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ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Manufacturer of Iron Castings and Fabricated Sheet Metal Parts

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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. 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 That document has been superseded by the *Facility Pollution Prevention Guide* (EPA/600/R-92/088, May 1992).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 Louisville performed an assessment at a plant that manufactures iron castings and fabricated sheet metal parts. Foundry operations include mixing and mold formation, core making, metal pouring, shakeout, finishing, and painting. Cutting, shaping, and welding are the principal metal fabrication operations. The team's report, detailing findings and recommendations indicated that paint-related wastes are generated in large quantities, and that significant waste reduction and cost savings could be realized by installing a dry powder coating system or by replacing conventional air spray paint guns with high-volume low-pressure spray guns.

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

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 Louisville'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.

Methodology of Assessments

The pollution prevention opportunity assessments require several site visits to each client served. In general, the WMACs

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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

The plant performs casting of gray iron and ductile iron, fabricates heavy metal plate parts, and fabricates sheet metal parts. It operates 4,000 hr/yr to cast approximately 25,000 tons of metal and fabricate over 4 mil ft^2 of metal annually.

Manufacturing Process

Foundry Operations

Three basic departments—large moldings, medium moldings, and small moldings—make up the foundry. Mixing and mold formation, core making, metal pouring, shakeout, finishing, and painting operations take place in each of the three departments.

Patterns produced onsite are made from wood boards and are used to form the sand molds for casting. Saws, planes, drills, sanders, band-saws, and a press are used to shape the wood.

Sand that is used to form the molds and cores is mixed with a binding agent so that the sand will set into a mold. The sand is then pumped into the pattern, compacted, and allowed to harden. Small, molded spacers called cores are made onsite in a similar manner.

Metals used include virgin pig iron, old rails, and purchased slitter scrap (from metal cutting). In addition, all of the internally generated scrap metal is remelted and reused. No metal pretreatment is performed prior to melting. Weighed amounts of metal are placed in one of three electric induction furnaces. Once the metal is placed in the furnace, some alloying agents are added. As the metal melts, slag (impurities and dirt) separates from the metal and is skimmed off. After the metal leaves the furnace, silicon and other alloying agents are added to produce either gray cast iron or ductile iron.

The melted metal is collected in ladles and transported via crane to the assembled mold and poured. The mold is then allowed to cool.

After the metal has cooled, the mold is moved to the shakeout (a large vibrating metal grating). The vibration causes the casting to separate from the sand mold. If necessary, employees dig the sand core out of the casting. Remaining sand is removed from the casting surface with steel shot. Some of the castings are painted before they are shipped.

An abbreviated process flow diagram for the foundry operations is shown in Figure 1.

Metal Fabrication Operations

Heavy metals fabrication operations include cutting, shaping, and welding plates of low carbon steel from 3/8 to 8 in. thick. Parts requiring painting are sent offsite and returned.

The light metals fabrication department produces metal cabinets and similar products from 4 by 8 ft sheets of 1/4 in. or smaller thickness. After metal shaping operations, oil present on the sheets is removed using a mixture of phosphoric acid and steam.

All parts fabricated in this area receive a primer coat and 90% of products receive a topcoat onsite.

An abbreviated process flow diagram for the metal fabrication operations is shown in Figure 2.

Existing Waste Management Practices

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

- All scrap metal generated in the foundry operations is remelted and reused.
- The plant recently replaced the binder used to make large molds with one that does not contain methanol.
- Sand from the molds is collected and reused.
- High-volume low-pressure paint spray guns are used for large painting jobs.
- Onsite painting is limited in order to control volatile organic compound (VOC) emissions.
- Pallets received with raw material shipments are reused for shipping products.
- Sand used for making molds contains a lesser amount of chromium than the sand used previously.

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 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 economic savings of the opportunities, in most cases, results from the need for less raw material and from reduced present and future costs associated with

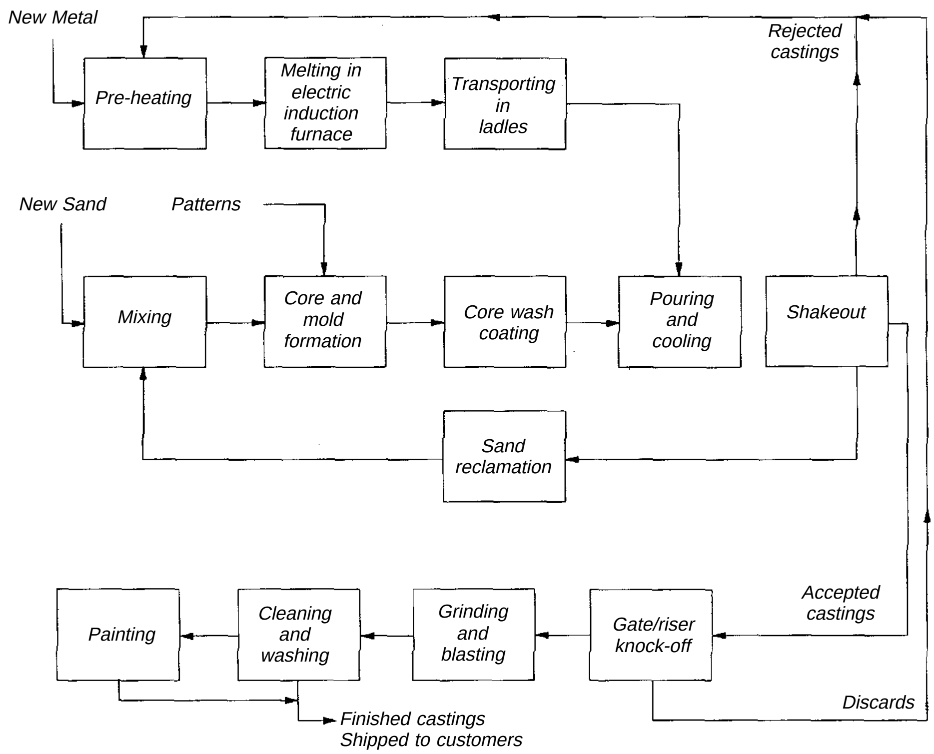

Figure 1. *Abbreviated process flow diagram for foundry operations.*

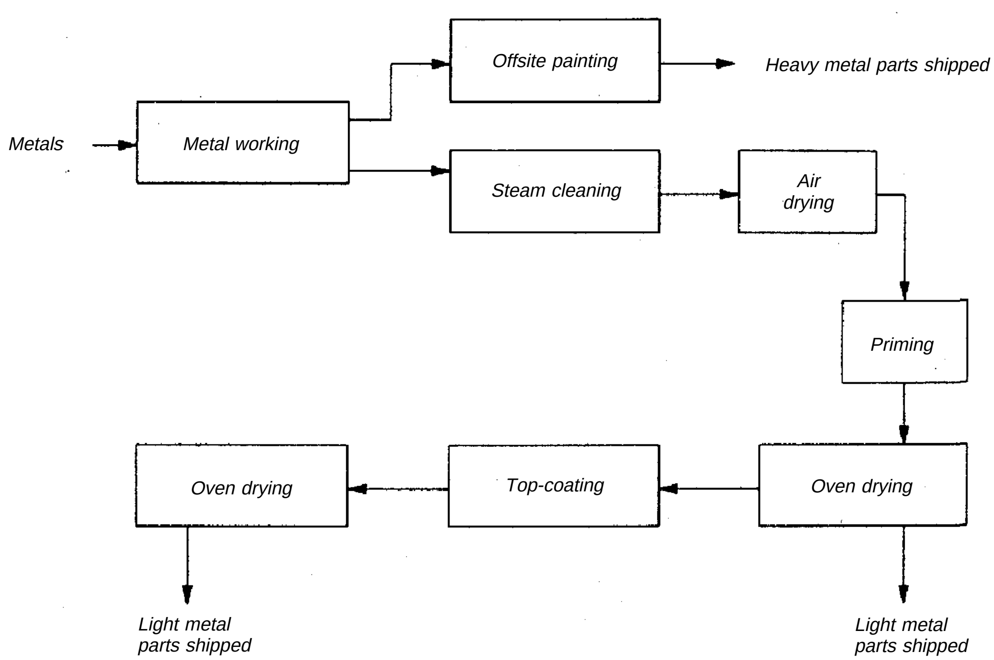

Figure 2. *Abbreviated process flow diagram for fabrication operations.*

Table 1. Summary of Current Waste Generation

Waste Stream Generated	*Source of Waste*	*Waste Management Method*	*Annual Quantity Generated (lb/yr)*	*Annual Waste Management Cost*
Empty drums and totes	*Raw material receiving*	*Reconditioned or recycled offsite*	*52,200*	*$2,720*
Pallets and scrap wood	*Raw material receiving*	*Recycled offsite*	*200,000*	*3,950*
General trash	*Various operations*	*Shipped to landfill*	*75,240*	*9,740*
Paint and solvent wastes	*Painting operations*	*Shipped to fuels program*	*89,350*	*25,250*
Dirt slag and waste sand	*Metal preparation and foundry operations*	*Shipped to landfill*	*8,720,000*	*49,270*
Metal scrap	*Metal fabrication*	*Sold to recycler*	*4,132,000*	*-92,160*
Dirt and broken refractory	*Metal charging and metal pouring*	*Shipped to landfill*	*868,000*	*13,080*
Waste acid and binder	*Cleaning of storage tanks*	*Disposed of as hazardous waste*	*1,080*	*800*
Waste corewash	*Cleaning of dip tank*	*Shipped to landfill*	*13,,200*	*500*
Chromium emissions	*Emitted from sand*	*Vented from plant*	*600*	*0*
Spent shot and sand	*Removal of molds and cores*	*Shipped to landfill*	*400,000*	*3,540*
Metal and sand dust	*Shakeout and finishing*	*Shipped to landfill*	*130,620*	*2,740*
Fugitive emissions	*Painting*	*Evaporated to plant air*	*7,200*	*0*
VOC emissions	*Painting*	*Evaporated to plant air*	*43,000*	*0*
Paint solids	*Painting (filtered from water)*	*Shipped to fuels program*	*825*	*300*
Exhaust filters and paint overspray	*Paint booth*	*Shipped to landfill*	*43,650*	*1,000*
Air intake filters	*Paint booth*	*Shipped to landfill*	*1,250*	*12,000*
Wastewater	*Various operations*	*Treated onsite; sewered*	*13,694,280*	*1,730*
Wastewater treatment sludge	*Onsite wastewater treatment*	*Shipped to landfill*	*134,000*	*10,400*
Waste oils	*Maintenance of machinery*	*Recycled offsite*	*4,680*	*0*
Office waste	*Office operations*	*Shipped to landfill*	*40,000*	*3,150*
Sanitary wastewater	*Plant and office*	*Sewered*	*5,404,320*	*630*
Spent solvent	*Parts washer*	*Removed by supplier*	*2,060*	*2,420*

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 pollution prevention opportunity independently and do not reflect duplication of savings that may 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 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.

- Install a sewer meter to measure the volume of wastewater discharged to the sewer. Current sewer charges are based on the amount of water that enters the plant.
- Explore the possibility of shipping sawdust to an area nursery or to a local cement or brick kiln.
- Give scrap wooden crates and pallets to employees for use as kindling.
- Use the scrap metal from machining and trimming operations in the sheet metal shop in the foundry operations. Use of the scrap metal would require removal of the rust-preventing oil from its surface.
- Recycle waste cardboard and paper sacks.

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 2. *Summary of Recommended Pollution Prevention Opportunities*

Pollution Prevention Opportunity	Waste Stream Reduced	Annual Waste Reduction Quantity (lb/yr)	Annual Waste Reduction Per Cent	Net Annual Savings	Implementation Cost	Simple Payback (yr)
Use an aqueous-based parts washer to replace the solvent-based rental unit. The recommended unit uses a biodegradable detergent, automatic parts washing action, and a dirty - water evaporator. The small quantity of sludge generated by the proposed washer (720 lb/yr) can be disposed of as non-hazardous waste.	Spent solvent from parts washer	2,060	100	$ 8,500	$ 8,460	1.0
Use an alternate parts washer service, similar to the current solvent-based service, for which the waste solvent is not regulated as a hazardous waste. Waste solvent will continue to be generated, but the generated waste will be nonhazardous and the associated costs to the plant will be reduced.	Spent solvent from parts washer	470[1]	23	1,350	0	Immediate
Install baffles made from waste cardboard in the paint booths between the painting area and the exit air filters. Much of the paint overspray will be deposited on the baffles, thereby lessening the load on the filters.	Paint booth exhaust filters	590	1	2,560	775	0.3
Used expanded kraft paper exit air filters in place of the fiberglass filters used currently as exit air filters. The recommended filter type has a larger holding capacity than the fiberglass filters.	Paint booth exhaust filters	790	2	2,650	0	Immediate
Replace all conventional air spray paint guns with either high-volume low-pressure or airless-air assisted spray guns. Implementation of this recommendation would reduce paint purchases, VOC emissions, disposal of paint filters, and disposal of paint solids. The plant is currently investigating the purchase of an afterburner to reduce VOC emissions. This recommendation could eliminate the need for an afterburner or decrease the size of the afterburner required. It is possible that the spent filters and paint overspray will be reclassified as hazardous waste in the future. In that case, cost savings will be higher than estimated here. The evaluation presented assumes filters will continue to be disposed of as nonhazardous waste and that high-volume low-pressure guns will be installed. This analysis does not include the avoided purchase of an afterburner. A more detailed technological and financial feasibility analysis of this recommendation should be done prior to implementation.	Paint solids VOC emissions Paint booth exhaust filters	675 22,735 35,820	82 53 82	431,600	1,530	Immediate
Install automatic gun cleaners for cleaning paint spray guns. Implementation of this recommendation will lead to reduced solvent purchase and disposal costs.	Solvent waste (disposed of with paint waste)	3,000	3	42,500	1,620	0.1
Install a solvent recovery still to recover solvent from the paint wastes shipped offsite. Reuse the recovered solvent for paint gun cleaning.	Paint waste	62,545	70	12,200	20,660	1.7

Table 2. *(continued)*

Pollution Prevention Opportunity	Waste Stream Reduced	Annual Waste Reduction: Quantity (lb/yr)	Annual Waste Reduction: Per Cent	Net Annual Savings	Implementation Cost	Simple Payback (yr)
Pack the wood-waste dumpster more efficiently. Carefully screen the wastes placed in the dumpster to evaluate whether some of the pallets could be returned to the supplier for reuse. Wood waste should be stacked in the dumpster neatly in order to decrease the volume occupied in the dumpster.	*Pallets and wood crates*	—-	—-	*1,450*	*0*	*Immediate*
Negotiate with a cement company to accept the plant's waste sand for use in cement manufacture.	*Waste sand*	—-	—-	*27,250*	*4,720*	*0.2*
Sell non-reconditionable drums to a solid waste recycler.	*Empty drums*	—-	—-	*855*	*0*	*Immediate*
Replace the currently used paint application system with a dry powder coating system. Implementation of this recommendation will lead to reduced paint/solvent wastes and reduced VOC emissions. This recommendation could eliminate the need for an afterburner. The paint booth can be equipped to capture and recirculate powder that does not adhere to parts during spraying. This analysis assumes that the waste filters will continue to be classified as non-hazardous waste and that the powder will be recycled. The avoided cost of an afterburner is not included in this analysis. A more detailed technological and financial feasibility analysis of this recommendation should be done prior to implementation.	*Paint and solvent wastes* *Exhaust filters and paint overspray* *Paint solids* *VOC emissions*	*89,350* *43,650* *825* *43,000*	*100* *100* *100* *100*	*681,000*	*163,780*	*0.2*
Replace the currently used paint application system with supercritical CO_2 spraying. In supercritical CO_2 spraying, the supercritical fluid replaces as much as 80% of the organic solvents required for ordinary paint spraying. In addition, the proposed system offers improved transfer efficiency. This recommendation could eliminate the need for an afterburner or reduce the size of the afterburner required. The avoided cost of an afterburner is not included in this analysis.	*Exhaust filters and paint overspray* *Paint solids* *VOC emissions*	*19,600* *450* *34,390*	*45* *55* *80*	*87,230*	*262,220*	*3.0*

[1] *Net waste reduction*

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