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ENVIRONMENTAL RESEARCH BRIEF

Pollution Prevention Assessment for a Manufacturer of Aircraft Landing Gear

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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 That document has been superseded by the *Facility Pollution Prevention Guide* (EPA/600/R-92/088, May 1992).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 aircraft landing gear. Metal forgings undergo machining operations to form the various components needed to manufacture the landing gear. The resulting components are heat treated offsite, chrome plated offsite, painted, and assembled into the final product. The team's report, detailing findings and recommendations, indicated that painting-related wastes are generated in large quantities and that significant cost savings could be realized by reactivating the currently unused electrostatic paint spray system.

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 Tennessee's (Knoxville) 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

This plant manufactures aircraft landing gear. It operates 24 hr/day, year-round to produce over 300 landing gear units annually.

Manufacturing Process

The plant manufactures many different aircraft landing gear components which are assembled into complete landing gear units for various commercial and military aircraft models. Raw materials used by the plant include steel, aluminum, and titanium forgings, fasteners, and bushings. The basic processes used by the plant are described below in more detail.

Machining

Steel, aluminum, and titanium forgings are inspected upon receipt for acceptable quality. Forgings that fail inspection are returned to the vendor. The acceptable forgings undergo machining operations—sawing, milling, grinding, drilling, boring, reaming, turning, stamping, forging, and shaping—to achieve the desired shape and dimension. After machining, the forgings are sprayed with a protective oil coating that controls corrosion until the forgings undergo grinding; an alkaline wash solution is used to remove the oil coating before grinding.

After grinding, the forgings are honed and buffed to smooth their surfaces; spray-washed with an alkaline cleaner; and blown dry using compressed air. Another protective coating of oil is applied to parts which are then stacked on pallets and shipped offsite to a heat-treating facility.

Heat-treated parts are machined, honed, and deburred after they are returned to the plant. The parts are cleaned, sprayed with corrosion-preventing oil, and shipped offsite for hard-chrome plating. The plated parts are placed in a temporary storeroom or sent directly to painting and assembly after they are returned to the plant.

Painting and Plating

Aluminum, nickel, and bronze bushings are pressed into the forgings. Occasionally, touch-up plating is necessary on some small parts. The touch-up plating is done on an in-house plating line that consists of six separate tanks for cleaning, rinsing, and plating. Following touch-up plating, the parts are cleaned in a cold solvent-cleaning tank.

Next the parts are vapor-degreased and blown dry with compressed air. In preparation for painting, plated surfaces on the parts are masked with paper and tape to prevent plating in those areas. A coat of primer pre-mix is then sprayed onto the parts. The primed parts are transported through an electric infrared drying oven. After the primer has cured, a finish coat of paint is applied. The parts are then transferred into the drying unit for final paint curing and placed in a circulating air cool-down chamber. Lastly, a final layer of clearcoat is applied to all parts.

After the painting process, a corrosion preventative is applied to all unpainted surfaces and the parts are palletized and transported to the assembly area.

Assembly

The landing gear components parts are de-masked and mechanically fastened together to produce complete assemblies. All hydraulic parts are pressure-tested for oil leaks. Finished units are sent to the packaging and shipping area.

An abbreviated process flow diagram for the production of aircraft landing gear is shown in Figure 1.

Existing Waste Management Practices

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

- Certain operations that generated 1,1,1-trichloroethane and perchloroethylene waste streams have been eliminated at this plant.
- A separate employee committee is responsible for tracking each waste stream in the plant. The goal of each committee is a 10% reduction in quantity of waste generated.
- Cardboard and paper waste is recycled.
- Fluid evaporators are used to concentrate waste coolant, thereby reducing the volume of waste shipped offsite.
- Many chemicals and solvents are purchased in bulk to eliminate disposal of small non-reusable containers.
- Solid paint waste is compacted to reduce its volume before it is shipped offsite.
- 1,1,1-trichloroethane is no longer used as a hand-washing agent.
- The temperature of the vapor degreaser has been lowered in order to reduce evaporative losses of 1,1,1-trichloroethane.
- A recycling unit has been installed in the paint spraying areas to reclaim waste paint solvent.

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 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.

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**.

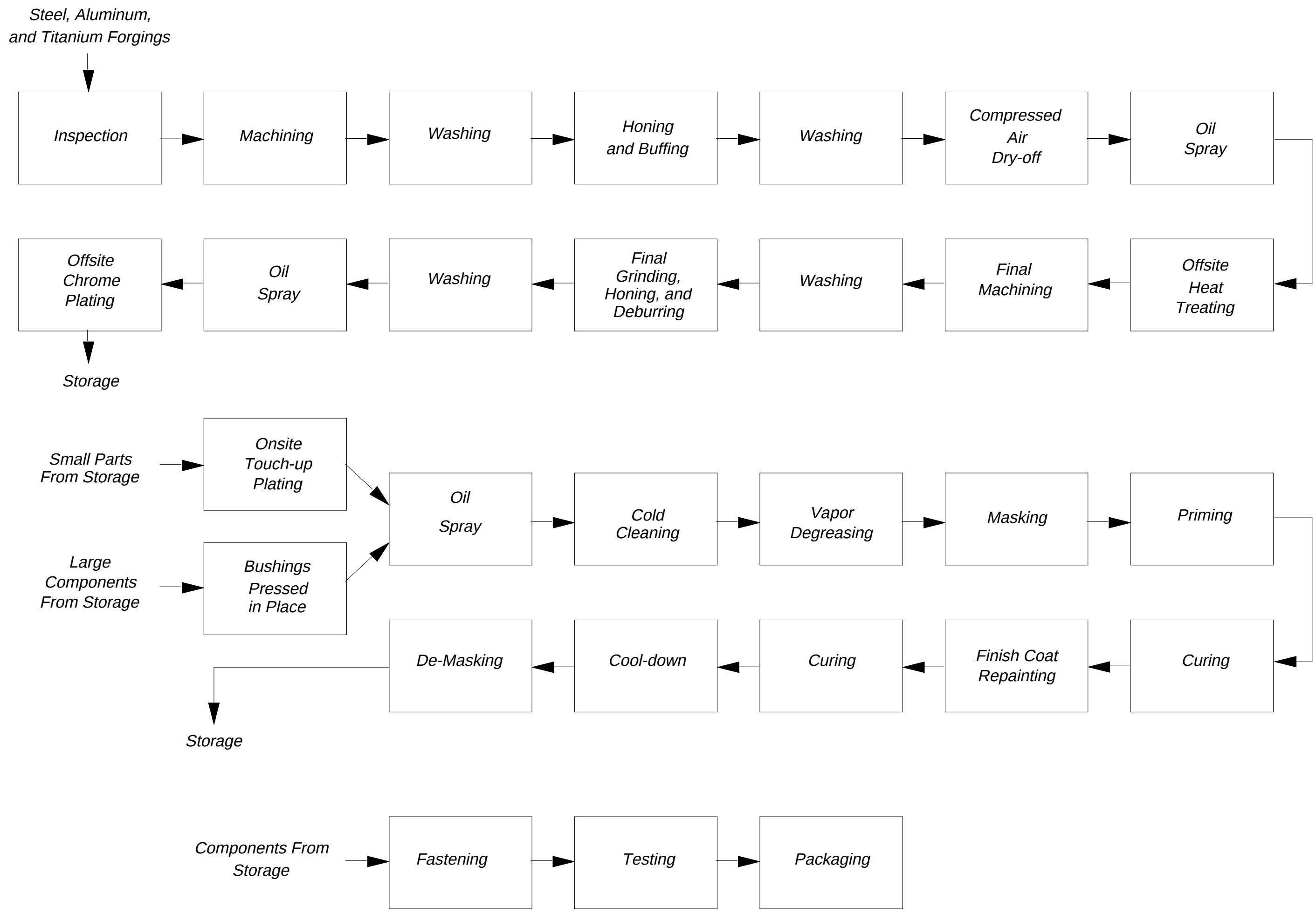

Figure1. *Abbreviated process flow diagram for manufacture of aircraft landing gear.*

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 ($/yr)*
Scrap metal	*Machining*	*Sold to recycler*	*2,600,000*	*$-10,460 (credit received)*
Waste coolant	*Machining*	*Concentrated in evaporator; shipped offsite to fuels blending program*	*20,000*	*40,380*
Adsorbent/hydraulic and machining oil	*Leaks from machines*	*Shipped offsite to controlled landfill*	*50,000*	*22,280*
Hydraulic and machining oil	*Periodic machine oil changes*	*Shipped offsite to fuels blending program*	*20,000*	*19,060*
Abrasive waste	*Grinding*	*Shipped offsite to landfill*	*88,000*	*2,270*
Paint liquid waste	*Painting*	*Shipped offsite to fuels blending program*	*4,000*	*15,780*
Solid paint waste	*Painting*	*Incinerated offsite*	*1,500*	*13,720*

Table 1. (continued)

Waste Stream Generated	Source of Waste	Waste Management Method	Annual Quantity Generated (lb/yr)	Annual Waste Management Cost ($/yr)
Spent 1,1,1-trichloroethane	Vapor degreasing	Shipped offsite for recycling	3,000	12,850
Spent paint booth filters	Paint booths	Incinerated offsite	1,100	14,000
Waste solvent blend	Cleaning	Incinerated offsite	1,500	8,300
Empty paint containers	Painting	Shipped offsite for reconditioning	1,800	11,700
Plating liquid waste	Touch-up plating	Shipped offsite for treatment and disposal	6,000	11,680
Plating solid waste	Touch-up plating	Incinerated offsite	400	4,110
Evaporated 1,1,1-trichloroethane	Vapor degreasing	Evaporates to plant air	55,080	0
Evaporated solvent blend	Cleaning	Evaporates to plant air	34,800	0
Evaporated paint solvent and thinner	Painting	Evaporates to plant air	900	0
Miscellaneous solid waste	Various processes	Shipped offsite to landfill	362,000	36,630

Table 2. Summary of Recommended Pollution Prevention Opportunities

Pollution Prevention Opportunity	Waste Stream Reduced	Annual Waste Reduction		Net Annual Savings ($/yr)	Implementation Cost	Simple Payback (yr)
		Quantity (lb/yr)	Per Cent			
Reactivate the currently unused electrostatic paint spray system in order to improve the paint transfer efficiency.	Spent paint booth filters	360	33	$36,680	$ 5,500	0.2
Install plastic covers with roller tracks on all four sides of the vapor degreaser tank with openings just large enough for the cables used to suspend the components to reduce evaporative losses of 1,1,1-trichloroethane.	Evaporated 1,1,1-trichloroethane	49,570	90	22,530	6,960	0.3
Construct a containment area around the bases of the metal working machines to collect waste oil. Use the available wet-vacuum to collect the waste oil for disposal	Adsorbent/hydraulic and machining oil	45,000[1]	9	12,740	16,750	1.3
Utilize reusable thin plastic shielding instead of paper to mask parts prior to the spray-painting process.	Solid paint waste	1,010	67	4,200	2,500	0.6

[1] Approximately 8,000 lb/yr of waste oil will be collected and disposed of (at a much lower unit cost)

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