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ENVIRONMENTAL RESEARCH BRIEF

Pollution Prevention Assessment for a Manufacturer of Automotive Battery Separators

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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 That document has been superseded by the *Facility Pollution Prevention Guide* (EPA/600/R-92/088, May 1992).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 Louisville performed an assessment at a plant that manufactures automotive battery separators. Two types of separators—polyethylene/silica sheet and vinyl rib—are produced. Processes used in polyethylene/silica sheet production include blending, extruding, extraction, drying, and slitting. Mixing, dipping, extrusion, and cutting are required in vinyl rib separator production. The team's report, detailing findings and recommendations, indicated that waste spill absorbents are generated in large quantities and at a significant waste management cost, and that waste reduction could result from using wringable, reusable absorbents.

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.

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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 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 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 two types of automotive battery separators. It operates approximately 8,400 hr/yr to produce almost 3.5 bil ft^2 of polyethylene/silica separators and over 2 bil vinyl rib separators annually.

Manufacturing Process

Automotive battery separators, which are thin sheets placed between battery electrodes to prevent the electrodes from shorting out, are manufactured by this plant. The production processes for the two types of separators manufactured—polyethylene/silica sheet and vinyl rib—will be described here.

Polyethylene/silica Sheet

Polyethylene/silica sheet is manufactured from a mixture of high density polyethylene, ultrahigh molecular weight polyethylene, silica, oil, and other ingredients. The raw materials are blended together and the resulting mixture is extruded through a die bar into a sheet and calendered. The oil, which prevents the silica from damaging the extruder and provides porosity to the product when extracted, is then removed by countercurrent extraction with trichloroethylene (TCE). After oil removal, the sheet passes through a drying oven for TCE removal and enters a water bath where a wetting agent is added to change the electrical properties of the sheet. The sheet is then dried again for water and further TCE removal and is inspected, wound onto a roll, and slit.

Countercurrent extraction of oil generates a mixture of oil and TCE that is known as miscella. The miscella is distilled to separate the oil and TCE so that both can be reused.

An abbreviated process flow diagram for polyethylene/silica sheet production is shown in Figure 1.

Vinyl Rib Separators

A latex batch containing latex, silane, water, and other ingredients is mixed in two steps and placed in a dip tank. Plastisol, which is composed of diethylhexyl phthalate (DEHP), polyvinyl chloride, mineral spirits, and other ingredients, is mixed separately for use in extrusion through the rib die bar.

In order to produce the vinyl rib separators, fiberglass sheet paper is dipped into the dip tank, squeezed between rollers to remove excess latex, and then passed under the rib die bar where plastisol is extruded onto the sheet to form the ribs. The resulting product sheet is dried in an oven, cut into squares, inspected, and packaged.

An abbreviated process flow diagram for the manufacture of vinyl rib separators is shown in Figure 2.

Existing Waste Management Practices

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

- Waste fiberglass paper from vinyl rib production is used to adsorb spills from polyethylene/silica sheet production thus reducing the quantity of adsorbents purchased.
- Trichloroethylene fugitive emissions are reduced as a result of the extraction pans, turnaround, drier, wetting agent bath, and water drier being welded together.
- Disposable cotton wound cartridge filters are being replaced by reusable metal mesh strainers on the miscella recovery still feed lines.
- Recovered materials such as oil and TCE are reused extensively onsite.
- Equipment to regrind blacksheet trim for reuse in the polyethylene/silica sheet production line has been purchased.
- Roll cores from the fiberglass sheet used in the vinyl rib production line are returned to the supplier for reuse.

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, result from the reduction in raw material and 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 that pollution prevention opportunity only 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 including the following 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 attractive-

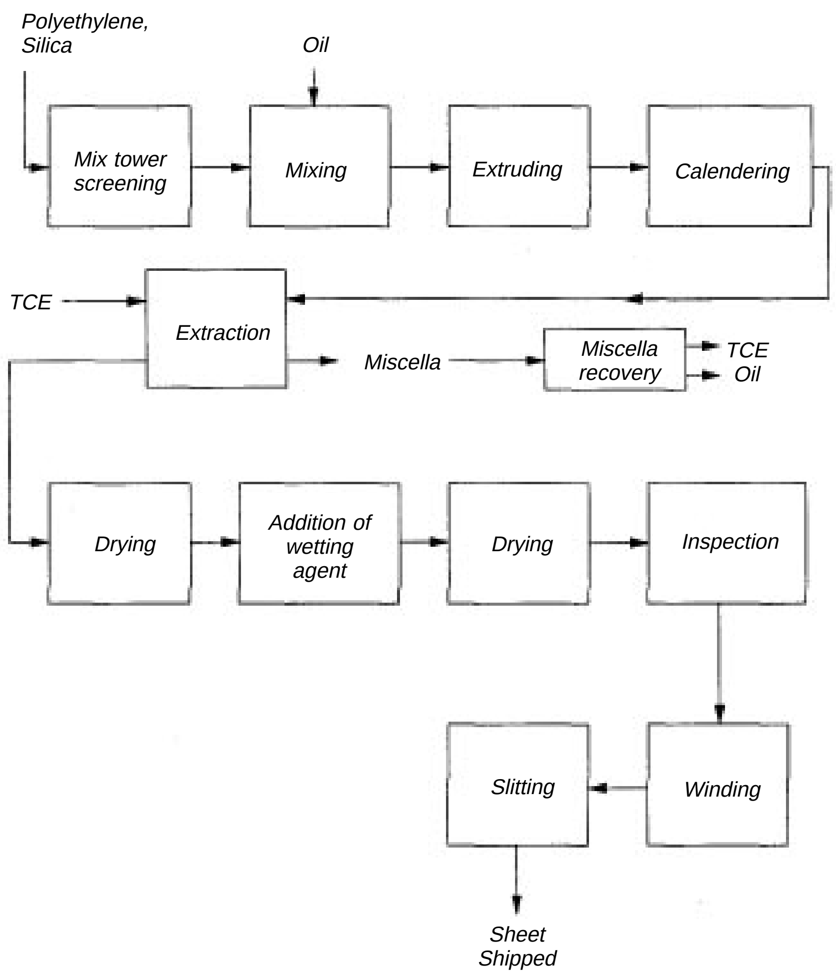

Figure 1. *Abbreviated process flow diagram for polyethylene/silica sheet production.*

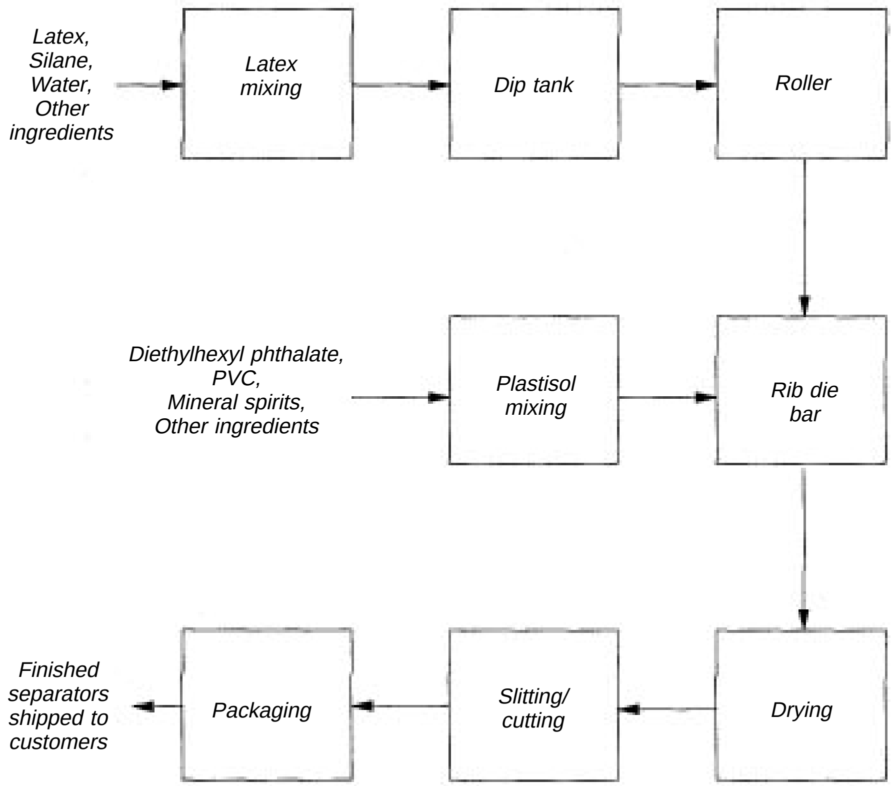

Figure 2. *Abbreviated process flow diagram for vinyl rib separator production.*

ness with changing conditions in the plant, they were brought to the plant's attention for future consideration.

- Identify a suitable alternative for trichloroethylene currently used for oil removal.
- Identify an alternative oil for use in the process, thereby making it possible to use a different solvent for extraction.
- Grind waste black sheet for reuse onsite. (The plant is in the process of implementing this measure.)
- Replace the steam stripper used for oil recovery on one of the process lines with a newer, more efficient unit.
- Install a back-up centrifuge to take the place of the primary centrifuge when it is not working.
- Regenerate the carbon beds with nitrogen instead of steam in order to eliminate the generation of wastewater containing TCE.
- Recover dioctyl phthalate from stack gases prior to incineration by carbon bed adsorption and condensation.
- Reuse empty Gaylords internally and/or substitute shipments currently received in paper bags with shipments in returnable bulk bags.

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 Stream Generated	Source of Waste	Waste Management Method	Annual Quantity Generated (lb/yr)	Annual Waste Management Cost
Oversize silica	Screening of raw material	Landfilled as special waste	73,600	$44,940[1]
Bad batches and leaks	Mixing of recycled oil with polyethylene and silica	Shipped offsite for disposal as hazardous waste	33,840	76,000[1]
Vacuum pump liquid	Extruder knockout drum (disposed of when centrifuge is not operating)	Shipped offsite for disposal as hazardous waste	18,280	18,900[1]
Centrifuge sludge	Extruder knockout drum	Shipped offsite for disposal as hazardous waste	2,990	5,000
Waste black and gray sheet	Start-up of polyethylene/silica sheet production and trimming of sheet	Landfilled as special waste	4,684,000	2,856,800[1]
Solid wastes (e.g., filter cartridges)	Extraction, extrusion, and oil/TCE recovery	Shipped offsite for disposal as hazardous waste	1,250	1,750[1]
Spill absorbents	Clean-up of spills from extractor and oil/TCE recovery	Shipped offsite for disposal as hazardous waste	7,620	22,290[1]
Fiberglass paper used as absorbent	Clean-up of spills from extractor and oil/TCE recovery	Shipped offsite for disposal as hazardous waste	8,930	96,930[1]
Paper filters	Carbon adsorption system for vented process gases	Shipped offsite for disposal as hazardous waste	80	350[1]
TCE emissions	Fugitive emissions	Evaporated to plant air	211,000	52,900[1]
TCE emissions	Stack emissions	Vented from plant	266,500	66,600[1]
Skimmed waste oils	Sump in conjunction with floor drains	Shipped offsite for disposal as hazardous waste	9,060	8,900
Sump sludge	Sump in conjunction with floor drains	Shipped offsite for disposal as hazardous waste	4,910	8,300
WWTP sludge	Onsite WWTP	Accumulating onsite	208,100	—[2]
Foamed plastisol (unneeded or unacceptable)	Vinyl rib production line	Shipped offsite for disposal as hazardous waste	660	1,670[1]
Nonfoamed plastisol	Vinyl rib production line	Shipped offsite for disposal as hazardous waste	31,110	78,140[1]
Iron scrap (revenue received)	Worn out belts from drying ovens	Sold to scrap recycler	17,900	-1,360
Stainless steel scrap (revenue received)	Worn out belts from drying ovens	Sold to scrap recycler	16,900	-1,630
Diethylhexyl phthalate emissions	Stack emissions	Vented from plant	106,800	53,400[1]
Phenol and formaldehyde emissions	Stack emissions	Vented from plant	6,900	—
Unusable fiberglass paper	Vinyl rib production line	Compacted; landfilled	196,000	3,960
Latex sludge	Onsite WWTP	Landfilled	280,000	100,000
Process wastewater	Various	Treated onsite; sewered	124,000,000	31,410
Process wastewater	s-line	Treated onsite; sewered	87,736,000	
Sanitary wastewater		Sewered	8,263,000	
Blowdown	Cooling towers	Sewered	103,283,000	
Pallets	Raw material delivery	Landfilled	20,000	200
Cardboard	Raw material delivery	Given to recycler	122,000	0
Empty drums	Raw material delivery	Shipped to reconditioner	9,000	300
Paper bags	Raw material delivery	Landfilled	20,000	200
Plastic-lined bags	Raw material delivery	Landfilled	350	10
Spent solvent	Parts washer	Removed by supplier for offsite recycling	1,890	960
Gear oil		Recycled offsite	6,680	200

[1]Includes applicable lost raw material value.
[2]Not yet disposed.

Table 2. *Summary of Recommended Pollution Prevention Opportunities*

Pollution Prevention Opportunity	Waste Stream Reduced	Annual Waste Reduction: Quantity (lb/yr)	Annual Waste Reduction: Percent	Net Annual Savings	Implementation Cost	Simple Payback (yr)
Replace TCE solvent extraction operation with supercritical carbon dioxide extraction. Implementation of this measure would eliminate all TCE-related wastes and waste management operations. Oil recovery using supercritical CO_2 extraction should be easier than the current method. Further investigation and testing is necessary in order to determine if this option is technically feasible.	*TCE fugitive emissions* *TCE stack emissions* *TCE containing wastes*	*211,000* *266,500* *87,000*	*100* *100* *100*	*$365,000*	*$1,500,000*	*4.1*
Replace the currently used single-use absorbents with wringable, reusable absorbents for clean-up of spills and leaks. The oil/TCE recovered by the wringer could be processed onsite in the recovery system. A small quantity of wringable pads will be disposed of periodically, as the pads lose their effectiveness.	*Spill absorbents*	*7,620*	*100*	*21,400*	*990*	*0.1*
Reduce fugitive emissions and leaks and spills of TCE from pumps by upgrading the driveshaft seals on the current pumps using magnetic fluid seals. The proposed seals would act as backup for the existing mechanical seals; the space between the seals can be vented to the on-site carbon adsorption system for TCE recovery.	*TCE fugitive emissions* *Spill absorbents* *Fiberglass paper absorbent*	*95,000* *640* *1790*	*45* *8* *20*	*43,850*	*248,000*	*5.7*
Give wooden pallets received with incoming shipments to a local recycler or rebuilder instead of shipping them to the landfill.	*Pallets*	—-	—-	*200*	*0*	*immediate*
Give empty non-plastic-lined bags from raw material shipments to a local recycler instead of shipping them to the landfill.	*Paper bags*	—-	—-	*200*	*0*	*immediate*
Ship oversize silica currently disposed of in a landfill to a cement manufacturer for use as an additive.	*Oversize silica*	—-	—-	*10,300*	*0*	*immediate*
Transfer clean wasted fiberglass paper to a supplier or recycler instead of shipping it to a landfill.	*Fiberglass paper*	—-	—-	*1,760*	*0*	*immediate*

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