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EPA ENVIRONMENTAL RESEARCH BRIEF

Pollution Prevention Assessment for a Manufacturer of Pressure-Sensitive Adhesive Tape

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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 That document has been superseded by the Facility Pollution Prevention Guide (EPA/600/R-92/088, May 1992).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 three varieties of pressure-sensitive tape. Tape production involves the three basic operations of backing fabrication, coating, and slitting. Three separate coating operations are used, as determined by the type of tape being manufactured (natural rubber, acrylic, or hot-melt). The team's report, detailing findings and recommendations, indicated that waste natural rubber adhesive is shipped offsite for disposal in large quantities, and that significant cost savings could be achieved by redesigning the adhesive applicator on the coater for natural rubber adhesive.

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 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 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 adhesive tape that is distributed nationally and internationally. Over 100 million m^2 of tape are produced each year during 24 hr/day production.

Manufacturing Process

Three varieties of pressure-sensitive adhesive tape—natural rubber, acrylic, and hot-melt—are produced by the plant. Several colors of tape, sold in rolls of 1-1/2 to 6 inches in width, are manufactured.

Tape production involves the three basic operations of backing fabrication, coating, and slitting. The backing, or non-stick surface of the tape that gives it strength, is made from polypropylene film in a cast-film process. Polypropylene pellets are melted in electricallyheated extruders, and the resulting molten plastic is applied to the top of a rotating cylinder and cooled into a sheet in a water bath at the bottom of the cylinder.

The material is pulled from the die with a width of about one meter and a thickness of 1.5 to 2 mm. Then the film is stretched by rollers to over five times its original length and by mechanical "fingers" to about seven times its original width as it is heated in an oven. After stretching, the backing is cooled over water-cooled rollers. Next, the edges of the backing are trimmed; these trimmings as well as other backing waste, are shredded, melted, pelletized, and reused.

The final stage in the backing process involves the use of a pull-rod stand, where 12,000 m of backing material with a width of 6 m are rolled onto a balanced steel roller. A bridge crane transports the rolls to a slitting machine, where the rolls are unrolled, cut to smaller widths, and re-rolled into shorter lengths. A small percentage of the resulting rolls is sold as a finished product. The remaining rolls are transported to the coating areas.

Three separate coating operations are used to make the three varieties of tape produced. Production of acrylic tape begins by unwinding the film and feeding it into the coating machine. Acrylic adhesive is applied to one side of the film and the tape is then passed through a steam heater to dry the adhesive while maintaining proper moisture levels. Finished tape is then wound onto temporary rollers.

Fabrication of natural rubber tape follows a similar process. Film is unwound and fed into a coater. A release coat, which prevents the tape from adhering to itself on the roll, is applied to one side of the film. A primer coat, which prepares the surface of the film for the adhesive, is applied to the other side. Then the tape passes by a reservoir where the natural rubber adhesive flows onto the film in a thin coat. The film passes through a chamber where the solvent carriers evaporate. The vapors are collected using a recovery system and reused. Finally, the finished tape is wound onto temporary rollers.

Hot-melt tape fabrication begins by unwinding the film and feeding it into a coater. A release coat is applied to one side of the film and the hot-melt adhesive, which has been melted with electric heaters, is applied to the other side. Evaporated solvent carrier is recovered and reused as in the natural rubber tape production process. The finished tape is then wound onto temporary rollers.

The temporary rollers from the three coating operations are taken to the slitting area, where the tape is unrolled, slit, and rewound onto paper cores of various widths. The finished tape rolls travel down a conveyor to a boxing station. After inspection, the boxes are sealed, sorted, loaded, and stored or shipped to customers.

An abbreviated process flow diagram for the production of pressure-sensitive adhesive tape is shown in Figure 1.

Existing Waste Management Practices

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

- Water usage for clean-up of the acrylic tape coater is limited to a specific quantity per shift.
- A portion of the waste natural rubber adhesive from the coater is reused in subsequent product formulations.
- Evaporated carrier solvents are recovered and reused. The vapor recovery system is being redesigned to improve its efficiency.
- Waste film trimmings are pelletized and reused.
- Waste hot melt adhesive purged from equipment lines is sold when possible.
- Waste release that becomes too thick for use is diluted and reused.

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 opportunity 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 opportunity results from 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.

Additional Recommendations

In addition to the opportunity recommended and analyzed by the WMAC team, several other 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.

- Reformulate the natural adhesive, primer, and release coat using a single solvent as the carrier for each.
- Develop a program to test the release periodically for parameters that can determine its effective life. Discontinue the practice of arbitrarily replacing the release.
- Install a solvent recovery unit for processing waste toluene onsite.
- Monitor the development and application of the Brayton-cycle heat pump for use in recovering solvent vapors.

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.**

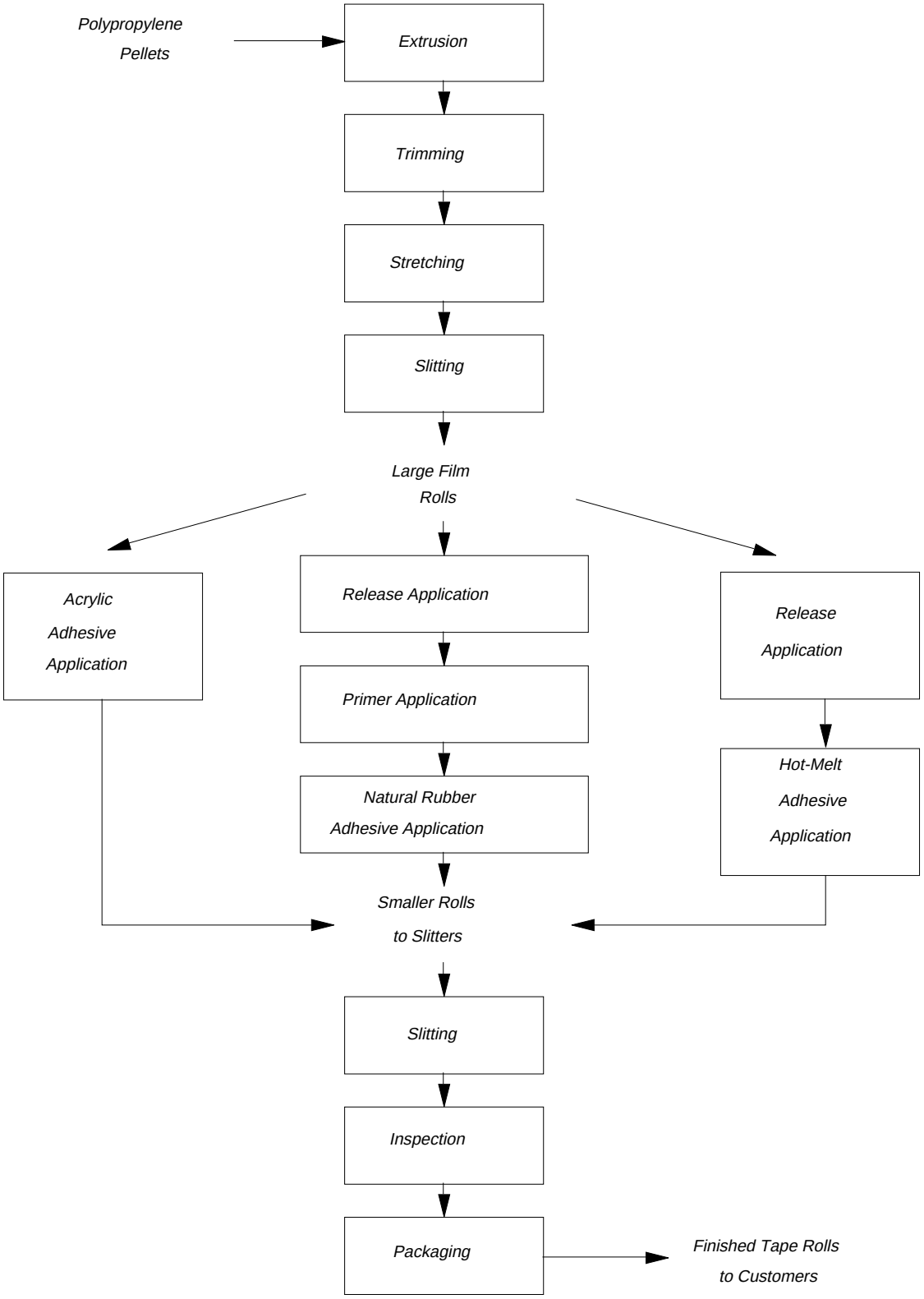

Figure 1. *Abbreviated process flow diagram for pressure-sensitive adhesive tape production.*

Table 1. *Summary of Current Waste Generation*

Waste Generated	Source of Waste	Waste Management Method	Annual Quantity Generated (lb/yr)	Annual Waste Management Cost
Wastewater and pigment	Coater for water-based acrylic tape	Shipped offsite; incorporated into cement and buried	89,130	$8,420
Waste natural rubber adhesive	Coater for natural rubber tape	Collected; reused onsite	128,270	12,900[1]
Waste natural rubber adhesive	Coater for natural rubber tape	Shipped offsite; incinerated	63,980	77,410[1]
Waste film	Coater for natural rubber tape	Shipped offsite; incinerated	27,420	58,330[1]
Waste primer	Coater for natural rubber tape	Shipped offsite; recycled and/or incinerated	9,740	5,460
Waste release	Coater for natural rubber tape	Diluted; reused onsite	1,320	0[2]
Waste hot-melt adhesive	Coater for hot melt adhesive	Sold when possible; if not sold, disposed of as nonhazardous waste	26,670	0[2]
Waste release	Coater for hot melt adhesive	Diluted; reused onsite	6,960	0[2]
Waste natural rubber adhesive	Equipment maintenance	Shipped offsite; incinerated	1,320	1,720[1]
Waste release	Equipment maintenance	Shipped offsite	480	270
Waste release	Equipment maintenance	Diluted; reused onsite	18,550	0[2]
Used hydraulic oil	Equipment maintenance	Shipped offsite to be used as boiler fuel	2,960	40
Waste natural rubber	Mixing of adhesive	Shipped offsite; incinerated	9,770	12,760[1]
Waste paint	Painting of equipment and building	Shipped offsite; incinerated	410	200

[1]Includes lost raw material value
[2]No cost reported by plant.

Table 2. *Summary of Recommended Pollution Prevention Opportunity*

Pollution Prevention Opportunity	Waste Reduced	Annual Waste Reduction		Net Annual Savings	Implementation Cost	Simple Payback (yr)
		Quantity (lb/yr)	Per Cent			
Redesign the adhesive applicator on the coater for natural rubber adhesive.	Waste natural rubber adhesive (not reused)	57,700	90	$122,250	$125,000	1.0
Replace the reservoir applicator with an extrusion applicator. Waste generated during line shutdowns will be reduced significantly.	Waste film	24,700	90			

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