United States Environmental Protection Agency
Risk Reduction Engineering Laboratory Cincinnati, OH 45268
Research and Development
EPA/600/S-95/003 April 1995

EPA ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Manufacturer of Paper Rolls, Ink Rolls, Ink Ribbons, and Magnetic and Thermal Transfer Ribbon

Richard J. Jendrucko*, Brian T. Hurst*, and
Gwen P. Looby**

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 That document has been superseded by the *Facility Pollution Prevention Guide* (EPA/600/R-92/088, May 1992).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 Tennessee performed an assessment at a plant that manufactures paper rolls, ink rolls, ink ribbons, and magnetic and thermal transfer ribbon. The raw materials required and the process operations used are specific to the product being produced. Production of ink ribbons requires application of ink to fabric ribbon and winding the ribbon into a plastic cassette or onto a reel-to-reel assembly. To produce rubber ink rolls, rubber sheets are kneaded until porous by a series of operations and extruded into rubber cylinders which are then filled with ink. Paper rolls are converted from bolt paper through a series of cutting operations. The remaining products, magnetic and thermal transfer ribbons, are produced by applying proprietary coating mixtures to mylar film. The assessment team's report, detailing findings and recommendations, indicated that the plant generates a great deal of hazardous waste in the coating operations of the magnetic and thermal transfer ribbon production and in the clean-up of production equipment. The greatest cost saving opportunity recommended to the plant involved the reuse of tracer ribbon in the ink ribbon production line in order to reduce raw material purchase costs.

* University of Tennessee, Department of Engineering Science and Mechanics
** University City Science Center, Philadelphia, PA

This Research Brief was developed by the principal investigators and EPA's Risk Reduction Engineering 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 Risk Reduction Engineering 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 waste minimization 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 waste minimization.

The potential benefits of the pilot project include minimization of the amount of waste generated by manufacturers, reduced waste treatment and disposal costs for participating plants, 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 waste minimization 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

The plant manufactures small paper rolls for calculators and cash registers, ink ribbon assemblies, rubber ink rolls, and magnetic and thermal transfer ribbons. Total production for all products is approximately 14 billion units/yr for this plant, which operates 6,240 hr/yr.

Manufacturing Process

The manufacturing processes used to produce each type of product are described below.

Ink Ribbon Assemblies

Raw materials for the process include oil-based ink, fabric ribbons, plastic cassette components, plastic and metal spool cores, and white fabric tracer ribbon.

Pre-mixed oil-based ink is applied to the fabric ribbon which is wound onto a spool and stored until needed for product assembly. The majority of the inked ribbon is used in the production of cassette containment units, and a small portion of the ribbon is used in reel-to-reel ribbon assembly.

The first step in cassette containment unit manufacturing is the manual assembly of cassette components into one-half of a housing. A white fabric tracer ribbon is then wound through the internal system of rollers to designate the path that the inked ribbon is to follow. The second half of the housing is then bonded to the assembled cassette. Then, the inked ribbon is inserted into the cassette; as the tracer ribbon is removed, it is replaced with the inked ribbon.

In reel-to-reel ribbon assembly, the inked ribbon is cut to length, inserted into a pair of metal or plastic spool cores, and wound onto the cores.

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

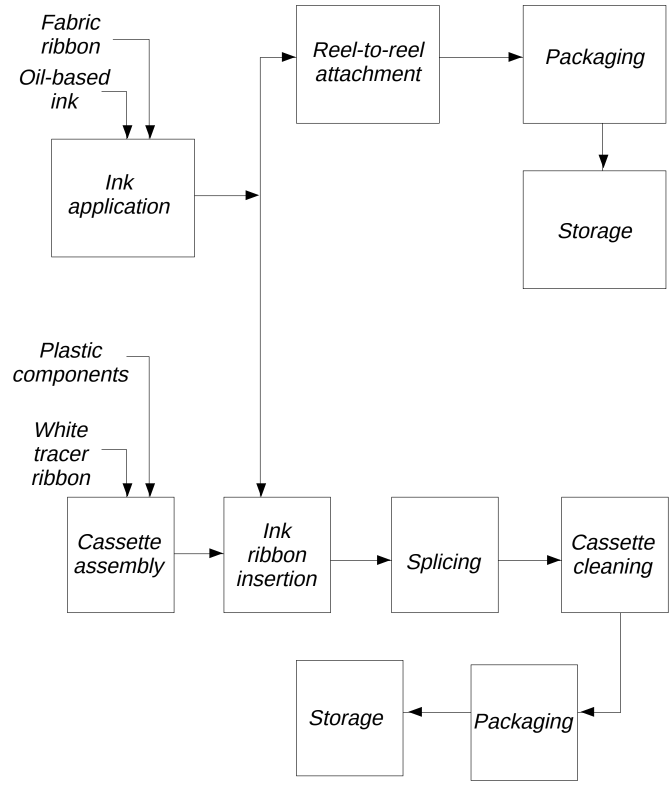

Figure 1. *Abbreviated process flow diagram for ink ribbon assemblies.*

Rubber Ink Rolls

Raw materials used in the manufacture of rubber ink rolls include synthetic rubber sheets, oil-based ink, toluene, plastic and metal cores, and sodium nitrate. The rubber, toluene, and sodium nitrate are placed into a rubber mill where the sodium nitrate is kneaded into the rubber. (Toluene renders the rubber more receptive to the sodium nitrate which makes the rubber more porous, thereby facilitating ink absorption.) The resulting rubber ball is formed into a rubber sheet.

The rubber sheets are allowed to air dry for several weeks. Dried sheets are then cut to size and fed through an extrusion molder which forms hard rubber cylinders. Next, the cylinders are placed into a warm water wash to remove sodium nitrate from the rubber. Following electric drying for one day, the rubber rolls are soft and porous and able to absorb ink.

In order to introduce the ink into the rolls, they are placed in a vat containing pre-mixed ink. A vacuum is placed on the vat to remove air from voids, and when the vacuum is removed, the ink is driven into the pores.

The flow diagram for this process is shown in Figure 2.

Paper Roll Conversion

Bolt paper, red powdered ink dye, rubber cement, and plastic cones are among the raw materials used in paper roll conversion. The bolt paper is placed on a machine which slits the roll for the production of smaller rolls.

The paper is marked with red ink along the first few feet of each roll to serve as an end-of-roll warning to the eventual user. The desired length of paper is wound onto a plastic core, the end of the paper is cut free from the slitting machine, and a light strip of rubber cement is applied to the paper end to

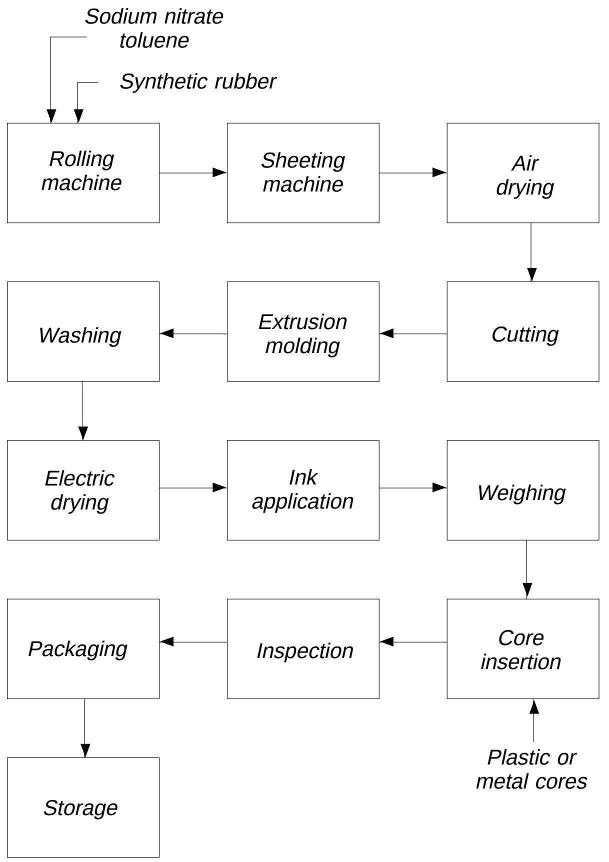

Figure 2. *Abbreviated process flow diagram for rubber ink roll production.*

prevent the roll from unwinding. Groups of smaller rolls are conveyed to a hydraulic press which separates the individual rolls along score lines.

An abbreviated process flow diagram for paper roll conversion is shown in Figure 3.

Magnetic and Thermal Transfer Ribbon

Raw materials used in the production of magnetic and thermal transfer ribbon include mylar film and a variety of proprietary materials.

Initially, the mylar to be coated is passed through a gauge to determine material thickness. Then coating solution is applied in a coater. The specific make-up of the coating solution is determined by the type of transfer ribbon produced. The solution is applied to the moving mylar film in a thickness which is measured with a gauge to ensure uniform product quality.

From the gauge the coated film goes through a drying tunnel. After drying, the ribbon is wound onto a core and aged as needed. Then the rolls are placed on a slitter and cut into smaller rolls as determined by specifications.

Magnetic and thermal transfer ribbon production is shown in Figure 4.

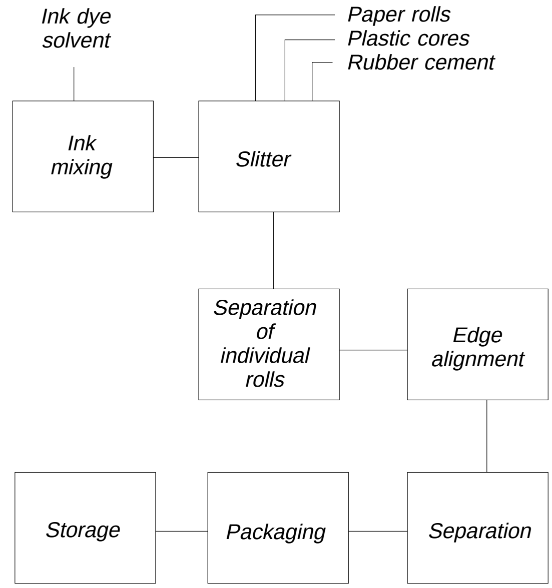

Figure 3. *Abbreviated process flow diagram for paper roll conversion.*

Existing Waste Management Practices

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

- A paper compactor bales the trim waste from paper roll conversion for recycle by an outside firm.
- Water used to cool the braking system on the paper conversion slitters is reused in the warm water wash tanks for the rubber ink roll production line.
- Shrink-wrap trim waste from the paper roll conversion line is baled for recycle by an outside firm.
- Aqueous-based cleaner is used instead of alcohol hand cleaner in order to reduce the amount of hazardous waste shipped offsite.
- Separate ball attrition mills are used for magnetic and thermal transfer ribbon production to reduce the amount of clean-up waste generated.
- Plant personnel, with the assistance of outside agencies, are evaluating the composition of solid waste generated in order to develop measures to reduce landfilled quantities.

Waste Minimization Opportunities

The type of waste generated by the plant, the source of the waste, the waste management method, the quantity of waste, and the annual waste management cost for each waste stream identified are given in Table 1.

Table 2 shows the opportunities for waste minimization that the WMAC recommended for the plant. The minimization 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.

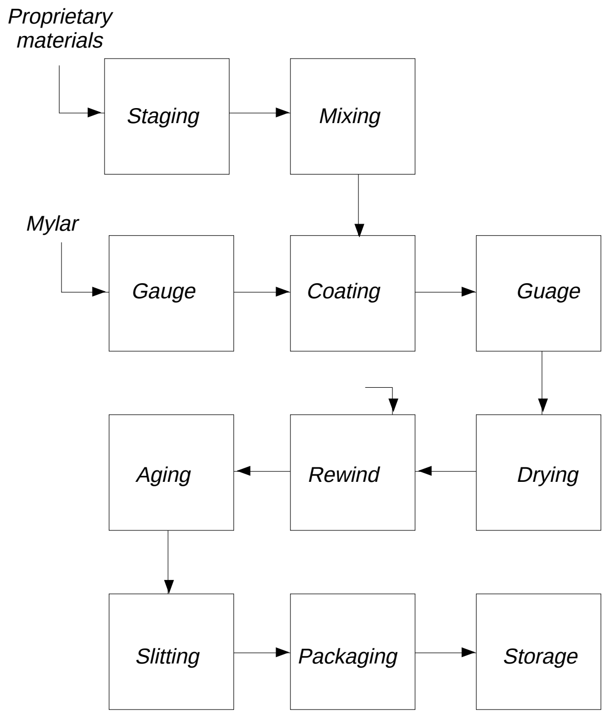

Figure 4. *Abbreviated process flow diagam for magnetic and thermal transfer ribbon production.*

It should be noted that the financial savings of the minimization 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 opportunity reflect the savings achievable when implementing each waste minimization 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, one additional measure was considered. This measure was not analyzed completely because of its technological complexity and anticipated lengthy payback period. Since this approach to waste reduction may, however, increase in attractiveness with changing conditions in the plant, it was brought to the plant's attention for future consideration.

- Install an onsite wastewater treatment system to permit removal of nitrate from washwater so that the water and the nitrate can be reused.

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 Generated	Source of Waste	Waste Management Method	Annual Quantity Generated (LB)	Annual Waste Management Cost [1]
Corrugated containers	Component and raw material delivery	Sold to recycler	294,070	$180
Off-specification ink	Quality assessment of ink in ink ribbon production line	Shipped back to vendor	310	1,870
Ink-contaminated solvent	Cleaning of machines	Shipped offsite as hazardous waste	5,540	21,610
Tracer ribbon	Ink ribbon production	Shipped to landfill	44,110	37,330
Evaporated toluene	Rubber ink roll production	Evaporates to plant air	11,920	7,950
Flashing and rejected rolls	Extrusion molding of rubber	Shipped to landfill	44,110	630
Overflow wash water	Wash tanks in rubber ink roll production	Sewered	55,136,010	18,980
Evaporated water	Drying of rubber ink rolls	Evaporates to plant air	3,625,440	1,720
Paper edge waste	Slitter in the paper roll conversion line	Compacted baled sold to recycler	391,240	(8,700) [2]
Unusable stock paper	Paper roll conversion line	Sold to recycler	163,660	2,240
Waste shrink wrap	Trimming from packaging of paper rolls	Baled sold to recycler	8,500	1,590
Miscellaneous paper waste	Various processes	Shipped to landfill	441,100	6,270
Contaminated cleaning solution	Magnetic transfer and thermal transfer ribbon production	Shipped offsite as hazardous waste	41,240	21,030
Transfer ribbon edge trim	Slitter in magnetic transfer and thermal transfer ribbon production line	Shipped to landfill	8,270	120
Evaporated solvents	Drying tunnels in transfer ribbon production line	Ducted outdoors	213,090	55,980
Contaminated solvents	Coater in transfer ribbon production line	Shipped offsite as hazardous waste	75,430	32,740
Chipboard and corrugated waste	Various operations	Shipped to landfill	294,070	4,180
Waste shrink wrap	Various operations	Shipped to landfill	132,330	1,880
Packaging plastic	Various operations	Shipped to landfill	73,520	1,040
Metal buckets	Various operations	Sold to recycler	1,020	1,610
Air compressor cooling water	Air compressors	Sewered	33,017,400	11,890
Miscellaneous wastes	Various operations	Shipped to landfill	147,040	2,090

[1] Includes waste treatment, disposal, and handling costs, and applicable raw material costs.
[2] Net revenue received.

Table 2. *Summary of Recommended Waste Minimization Opportunities*

Minimization Opportunity	Waste Reduced	Annual Waste Reduction: Quantity (LB)	Annual Waste Reduction: Per cent	Net Annual Savings	Implementation Cost	Simple (yr)
Reuse white tracer ribbon in the ink ribbon production line instead of shipping it to the landfill.	Tracer ribbon	33,080	75	$27,330	$0	Immediate
Agitate the trays holding the rubber rolls in the wash-out tank to reduce the quantity of water needed for sodium nitrate removal.	Overflow wash water	27,568,000	50	11,290	7,400	0.7
Reuse air compressor cooling water as wash-out tank make-up.	Air compressor cooling water	33,017,400	100	10,890	11,100	1.0
Segregate recyclable white trim waste from colored trim waste to increase the recycling credit received by the plant. (No waste reduction will be achieved, but a significant increase in recycling credit will result.)	Paper edge waste	—-	—-	9,390	1,600	0.2
Install a distillation unit in order to recover solvent from ink solids for reuse in cleaning operations.	Ink contaminated solvent	4,440	80	3,100	5,980	1.9

United States
Environmental Protection Agency
Center for Environmental Research Information
Cincinnati, OH 45268

BULK RATE
POSTAGE & FEES PAID
EPA
PERMIT No. G-35

EPA/600/S-95/003