United States Environmental Protection Agency
Research and Development

Risk Reduction Engineering Laboratory
Cincinnati, OH 45268

EPA/600/S-94/012 September 1994

EPA

ENVIRONMENTAL RESEARCH BRIEF

Waste Minimization Assessment for a Manufacturer of Mountings for Electronic Circuit Components

Richard J. Jendrucko*, Kelly L. Binkley*, 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. 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 That document has been superseded by the *Facility Pollution Prevention Guide* (EPA/600/R-92/088, May 1992).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 ceramic mountings for electronic circuit components. Several types of mountings, varying in size and number of ceramic layers and connectors, are manufactured by the plant. Ceramic sheets are manufactured onsite and coated with tungsten paste. The sheets are scored or cut, cured, inspected, and nickel-plated, gold-plated, and brazed as required. The team's report, detailing findings and recommendations, indicated that the waste stream generated in the greatest quantity is wastewater from the plating lines and that significant cost savings could be achieved by purifying and reusing the effluent from the onsite wastewater treatment plant.

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

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

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, 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.

Printed on Recycled Paper

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

This plant produces ceramic mountings for electronic circuit components. Approximately 600,000 mountings are produced each year by the plant, which operates 4,160 hr/yr.

Manufacturing Process

Several types of mountings or "packages", varying in size and number of ceramic layers and connectors, are manufactured by the plant. The unit operations used to produce the plant's products are described below.

Ceramic Tape Production

A ceramic slurry is mixed from dry and liquid ingredients such as alumina, talc, clay, silica, and solvent and then deaerated. The slurry is then poured into a thin film on a conveyor to form a tape and cured in an oven. As the tape exits the drying oven, it is slit into strips of various widths, rolled onto cardboard cores and stored until testing. Tape rolls that pass inspection are pressure- and heat-stabilized. The rolls of tape are transported to a punch-and-cut machine in which a series of holes is punched into the tape and the tape is cut into rectangular sheets.

Tungsten Paste Mixing

Tungsten paste is produced from dry and liquid ingredients including tungsten powder and solvent. The ingredients are mixed together and the resulting mixture is dried overnight in an oven. Finished paste is poured into small jars for storage until required for production.

Screening

Ceramic tape that has been cut into sheets and punched as described previously is loaded into a screening machine. A vacuum is used to pull tungsten paste through the holes that have been punched in the tape, thereby coating the holes' inner surfaces. The sheets are then stacked and transferred to another screening machine where a circuit pattern is automatically screened onto the parts. The screened sheets are dried with an ultraviolet light. About 85% of the product repeats these last two steps up to three times to produce double-sided and multi-layer packages.

The screened sheets proceed to a metal press where they receive a dielectric coating as needed to prevent plating in certain areas in subsequent operations. After receiving the coating, some of the sheets undergo lamination. Some of the sheets proceed directly to laminating after screening.

After lamination (to be described in the next section), the products are scored for later separation or cut completely into individual packages. (Products that do not require lamination also undergo scoring or cutting.) The products are then conveyed through a high temperature kiln for several hours of curing. After curing, the packages are inspected and those that pass inspection proceed to the nickel-plating area (to be described in a following section).

Laminating

Those sheets that require laminating are moved through a booth where they are sprayed with adhesive. The individual screens are stacked into groups of two or three, indexed, and heat- and pressure-treated. Multi-layer packages are automatically conveyed to a lamination press where heat and pressure are again applied to bond the layers together. As described previously, the products are then scored or cut.

Nickel Plating

The packages are nickel plated using one of three automated operations—electrolytic, vapor deposition, or electroless. Packages that have been electrolytically nickel-plated are transferred to electrolytic gold plating, brazing, or to a sintering furnace followed by electrolytic gold plating. The packages that undergo vapor deposition are transferred to electroless gold plating or to brazing. After electroless nickel plating, packages are transferred to electroless gold-plating.

Gold Plating

Packages are gold-plated in one of two electroless plating lines or in an electrolytic plating line. After electroless gold plating, packages are taken to brazing or to inspection and shipping. Packages from brazing and packages from electrolytic nickel-plating are gold-plated electrolytically, brazed, and inspected and shipped.

Brazing

Whether or not a package is brazed and at what stage it is brazed depends on the product being produced. Pins and/or seal rings are attached to packages which are then moved through a brazing oven.

An abbreviated process flow diagram that depicts this plant's processes for production of mounting for electronic circuit components is shown in figure 1.

Existing Waste Management Practices

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

- A citric-based cleaning solution is used instead of toluene for clean-up in the screening area.
- Most of the off-specification ceramic tape and cuttings from ceramic tape is recycled onsite.
- Toluene is decanted and reused in the cleaning processes.
- Sodium hydroxide from alkaline cleaning tanks in the plating process and hydrochloric acid solutions from plating are used to adjust wastewater Ph levels in the onsite wastewater treatment system.

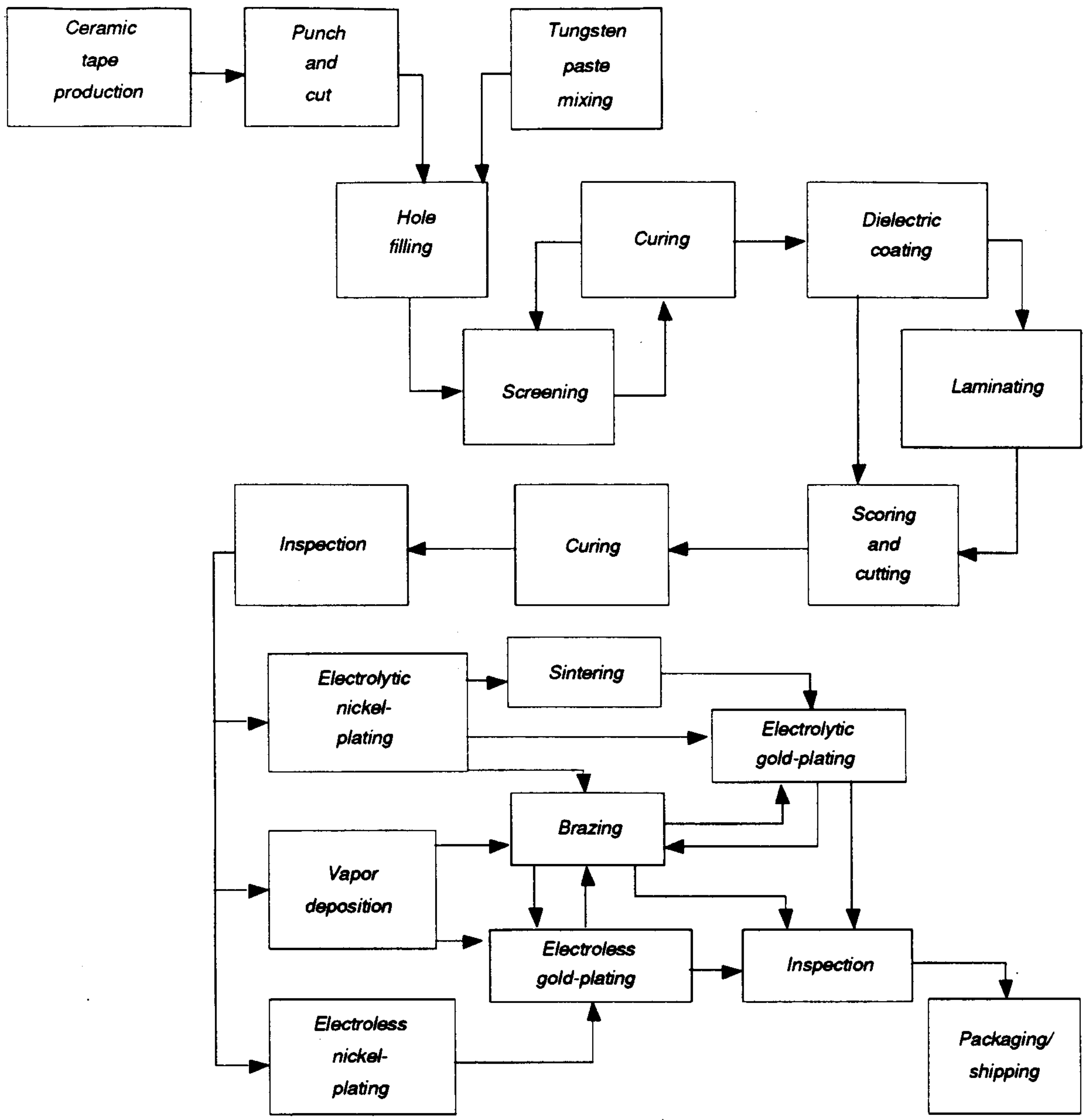

Figure 1. *Abbreviated Process Flow Diagram for production of mountings for electronic circuit components.*

- Rags wetted with citric-based cleaning solution are washed in-house and reused.

Waste Minimization 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 annual waste management cost for each waste stream are given in Table 1.

Table 2 shows the opportunities for waste minimization that the WMAC team 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.

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, several additional measures were considered. These measures were not completely analyzed because of insufficient data, minimal savings, implementation difficulty, or a projected lengthy payback. Since one or more of these approaches to waste reduction may, however, increase in attractiveness with changing conditions in the plant, they were brought to the plant's attention for future consideration.

- Compact the contaminated nickel plating solution filters prior to disposal to reduce the volume of space they occupy and the associated removal cost.
- Install a natural gas-fired dry-out oven to reduce the amount of water contained in the sludge from the onsite wastewater treatment plant.
- Automate the measuring and delivery process of solvents to the mixing chambers in the tape production area to reduce evaporative losses.
- Recover evaporated solvents from tape production, tungsten paste mixing, and clean-up for reuse.
- Substitute a nonhazardous cleaner for the solvent cleaners used in the tape production and tungsten paste mixing lines.
- Substitute a nonhazardous cleaner for 1,1,1-trichloroethane used for clean-up in the screening area.

This research brief summarizes a part of the work done under Cooperative Agreement No. CR-914903 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)	Annual Waste Management Cost [1]
Solvent-soaked clean-up rags	Equipment cleaning	Shipped offsite as hazardous waste for incineration	11,690	$37,010
Evaporated organic solvents	Ceramic tape production	Ducted to incinerator	19,610	37,080
Evaporated organic solvents	Equipment cleaning	Evaporates to plant air	500	190
Contaminated toluene	Equipment cleaning	Shipped offsite as hazardous waste	1,090	2,770
Evaporated organic solvents	Tungsten paste production	Evaporates to plant air	4,260	1,800
Evaporated organic solvents	Laminating	Evaporates to plant air	4,760	16,620
Jars containing dried tungsten paste	Screening	Shipped to landfill	2,140	2,460
Evaporated citric cleaner	Screening	Evaporates to plant air	980	2,140
Contaminated 1,1,1-trichloroethane	Screen cleaning	Shipped offsite as hazardous waste for fuels burning	2,410	8,420
Evaporated 1,1,1-trichloroethane	Screen cleaning	Evaporates to plant air	3,340	1,940
Cleaning rags	Screen cleaning	Washed onsite; reused	3,180	0
Waste adhesive/solvent	Laminating	Shipped offsite as hazardous waste	1,000	2,730
Rinse water	Nickel plating and gold plating	Treated in onsite WWTP; sewered	19,469,030	68,400
Spent acid solution	Nickel plating and gold plating	Treated in onsite WWTP; sewered	777,100	2,730
Spent plating solution	Nickel plating	Treated in onsite WWTP; sewered	5,910	20
Evaporated Freon™	Cleaning in nickel-plating and gold-plating lines	Evaporates to plant air	33,740	97,040
Contaminated Freon™	Cleaning in nickel-plating and gold plating lines	Shipped offsite as hazardous waste	4,930	34,330
Alkaline solution	Nickel plating	Treated in onsite WWTP; sewered	74,950	260
Spent gold solution	Gold-plating	Shipped offsite for gold reclamation	26,700	(152,740) [2]
Spent gold filters	Gold plating	Shipped offsite for gold reclamation	110	140
Rinse water and photochemicals	Screen production	Treated in onsite WWTP; sewered	374,950	1,320
Wastewater treatment sludge	Wastewater treatment plant	Shipped offsite as hazardous waste	35,610	18,010
Miscellaneous solid waste	Various processes	Shipped to landfill	8,790	6,050

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

Table 2. *Summary of Recommended Waste Minimization Opportunities*

Minimization Opportunity	Waste Stream Reduced	Annual Waste Reduction: Quantity (lb)	Annual Waste Reduction: Per cent	Net Annual Savings	Implementation Cost	Simple Payback (yr)
Further purify the effluent from the wastewater treatment plant and reuse it in the plating rinses.	Wastewater	9,372,780	50	$28,750	$136,760	4.8
Install a tight-fitting lid and supplemental refrigeration coils on Freon™ tanks to reduce evaporative losses.	Evaporated Freon™	16,870	50	48,020[1]	10,200	0.2
Contract with an outside firm to clean rags and return them to the plant for reuse. Spent cleaning rags will continue to be generated but the related costs incurred by the plant will decrease.	Solvent-soaked clean-up rags	0	0	18,190[1]	0	Immediate
Install a distillation unit for the onsite recovery and reuse of solvents.	Contaminated 1,1,1-trichloroethane	2,170	90	8,480	15,980	1.9
	Waste adhesive/solvent	900	90			
	Contaminated toluene	980	90			
Clean tungsten paste jars and reuse them.	Jars containing dried tungsten paste	2,140	100	1,680[1]	3,070	1.8

[1] Total savings have been reduced by an annual operating cost required for implementation of this opportunity.

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

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

Official Business
Penalty for Private Use
$300

EPA/600/S-94/012