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IMPROVED EQUIPMENT CLEANING IN COATED AND LAMINATED SUBSTRATE MANUFACTURING FACILITIES (PHASE I)

Prepared for

Office of Pollution Prevention and Toxics

Prepared by

Air and Energy Engineering Research Laboratory
Research Triangle Park NC 27711

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IMPROVED EQUIPMENT CLEANING IN COATED AND LAMINATED SUBSTRATE MANUFACTURING FACILITIES (PHASE I)

By:

Beth W. McMinn and Jill B. Vitas
TRC Environmental Corporation
100 Europa Drive, Suite 150
Chapel Hill, North Carolina 27514

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EPA Project Officer: Michael Kosusko
Air and Energy Engineering Research Laboratory
Research Triangle Park, North Carolina 27711

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ABSTRACT

The report gives results of a Phase I study to characterize current equipment cleaning practices in the coated and laminated substrate manufacturing industry, to identify alternative cleaning technologies, and to identify demonstrable technologies and estimate their emissions impacts. It presents information from sources including literature searches, industry questionnaires, plant visits, pollution prevention experts, and industry and trade association personnel. (NOTE: Phase II activities will be the actual demonstration of selected alternative technologies, and Phase III will be to transfer related technology by means of conference papers, journal articles, and newsletters, prepared and presented at industrial workshops, pollution prevention conferences, and other events where industrial application of pollution prevention technologies is discussed.) Facilities within this industry tend to operate in one of two segments: (1) large facilities operating coating lines dedicated to one type of product, such as masking tape or label stock; or (2) batch processors or plants that manufacture comparatively small quantities of a wide variety of high value-added products. Both segments of the industry use essentially the same cleaning methods, even though the segments differ substantially in the range of substrates, coatings, and application equipment used at the plants.

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EXECUTIVE SUMMARY

As a result of the Pollution Prevention Act of 1990, the Environmental Protection Agency (EPA) established the 33/50 Program which calls for voluntary industry emissions reductions of 17 high-priority toxic chemicals. The goal of this program is to reduce the total amount of these chemicals released into the environment and transferred off-site by 33 percent by the end of 1992 and by 50 percent by the end of 1995.

In support of the 33/50 Program, EPA's Air and Energy Engineering Research Laboratory (AEERL) is investigating ways to reduce air emissions of these 17 chemicals through pollution prevention in selected industry segments. Two criteria were used to select industrial categories for study: annual toxics emissions and the potential for pollution prevention opportunities. First, the Toxic Release Inventory System (TRIS) was reviewed to identify categories with the greatest mass emissions of the 33/50 chemicals. Categories with the greatest emissions were then ranked according to the potential for successful pollution prevention projects.

One of the key industries identified through this process was the coated and laminated substrate manufacturing industry. This industry is the number one source of methyl ethyl ketone (MEK) and the number three source of the toluene releases in TRIS. Both toluene and MEK are 33/50 chemicals. With the assistance of the Pressure Sensitive Tape Council (PSTC), the Tag and Label Manufacturers Institute (TLMI), industry personnel, and TRC Environmental Corporation (TRC), AEERL is conducting a three-phased effort to investigate in detail the pollution prevention options for process equipment cleaning associated with the coated and laminated substrate industry.

Through the use of an industrial questionnaire and the results of an extensive literature search, this industry was characterized, and alternative cleaning technologies were identified. In addition, seven site visits were conducted to better understand the manufacturing process, current cleaning technologies, and to identify possible demonstrable technologies that will be the basis for the demonstration phase (Phase II) of this project. The results of these Phase I activities are discussed in this document.

Facilities within the coated and laminated substrate manufacturing industry tend to operate in one of two segments. One segment consists of large facilities operating coating lines dedicated to one type of product such as masking tape or label stock. The other segment consists of batch processors or plants that manufacture comparatively small batches of a wide variety of high value-added products.

Both segments of the coated and laminated substrate manufacturing industry use essentially the same cleaning methods, even though the segments differ substantially in the range of substrates, coatings, and application equipment used at the plants. The solvents required to clean equipment in a coated and laminated substrate manufacturing facility are, in large part, determined by the resin in the coating formulation.

AEERL plans to conduct demonstrations in facilities that represent the two industry segments. The first demonstration facility will be a facility operating lines dedicated to one product type. The focuses at this facility would be the implementation and evaluation of a cleaning solvent substitute, improved operating practices, and process modifications such as Teflon coated rollers. AEERL has discovered through their contacts with industry personnel that some "dedicated line" facilities are pursuing these options while others are not. The focus at the second type of facility, the batch processor, would be geared toward improving the efficiency of cleaning operations. AEERL has found that the nature of the batch processing business requires a high degree of cleaning between jobs and that this cleaning often takes place much more frequently than does cleaning at dedicated line facilities. The objective at the batch processing would be to calculate the optimum amount of cleaning solution necessary to achieve the required degree of cleanliness. A second objective at this facility would be to identify the optimum method of administering the cleaning solution. The details and the results of both of the facility studies would be documented in a final report. It is intended that the case studies described in the final report will assist not only the dedicated line facilities and the batch processors, but also those facilities that have characteristics of each. In a subsequent report, AEERL will describe demonstration activities and results.

METRIC EQUIVALENTS

Certain non-metric units are used in this document for the reader's convenience. Readers more familiar with metric units may use the following equivalents to convert to that system.

Non-metric	Multiplied by	Yields Metric
atm	101	kPa
gal.	0.00379	m^3
lb	0.454	kg
ton	907	kg
yd^2	0.836	m^2

CHAPTER 1

INTRODUCTION AND BACKGROUND

1.1 PROJECT BACKGROUND

As a result of the Pollution Prevention Act of 1990, the Environmental Protection Agency (EPA) established the 33/50 Program which calls for voluntary industry reductions in releases of the following 17 high-priority toxic chemicals which are listed by mass of emissions.

Toluene	Trichloroethylene
Xylenes	Methyl Isobutyl Ketone
1,1,1-Trichloroethane	Tetrachloroethylene
Dichloromethane	Benzene
Methyl Ethyl Ketone	Chloroform
Chromium and Compounds	Nickel and Compounds
Lead and Compounds	Cyanide and Compounds
Cadmium and Compounds	Mercury and Compounds
Carbon Tetrachloride	

The goal of the 33/50 program is to reduce the total amount of these chemicals released into the environment and transferred off-site by 33 percent by the end of 1992 and by 50 percent by the end of 1995. These reductions will be based upon the Toxic Release Inventory System (TRIS), with 1988 as the base year.[1]

In support of the 33/50 Program and the Agency's pollution prevention goals, EPA's Air and Energy Engineering Research Laboratory (AEERL) is investigating ways to reduce air emissions of these 17 chemicals through pollution prevention. The Pollution Prevention Act of 1990 defines pollution prevention as "any practice which reduces the amount of any hazardous substance, pollutant, or contaminant entering the waste stream or otherwise released to the environment (including fugitive emissions) prior to recycling, treatment, or disposal; and reduces the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants."[2] Pollution prevention efforts offer economic and reduced health and ecological risk benefits to many sectors of society that are not available through traditional pollution control methods.

In 1991, AEERL representatives met with industry, academia, and State environmental agency representatives to identify several source categories deserving of pollution prevention research. Two criteria were used to select the industrial categories for study: annual toxics emissions and the potential for pollution prevention opportunities. First, the TRIS was reviewed to identify categories with the greatest mass emissions of the 33/50 chemicals. Categories with the greatest emissions were then ranked according to the potential for successful pollution prevention projects resulting in significant reductions of 33/50 chemical releases. One of the industries identified during the 1991 meeting was the adhesives-coated and laminated paper manufacturing industry [Standard Industrial Classification (SIC) 2672]. This industry was chosen because of significant air emissions of 33/50 Program chemicals methyl ethyl ketone (MEK) and toluene as reported through the TRIS.

In October of 1991, a Focus Group Meeting was held between AEERL, pollution prevention experts, and representatives of the adhesives-coated and laminated paper manufacturing industry to discuss specific pollution prevention projects that would support the 33/50 Program. Meeting participants indicated that emissions of toluene and MEK from equipment cleaning operations are second only to emissions from the coatings and coating application steps, and, therefore, would present a good opportunity for the implementation of pollution prevention techniques. As a result of this meeting and preliminary industry inquiries, the scope of the industry investigation was later expanded to include other coating and substrate varieties (such as those included in SIC 2671-Coated and Laminated Packaging Paper and Plastics Film) because the manufacturing methods and cleaning processes are similar; therefore, technology transfer is possible over a wider range of industries. Figure 1-1 illustrates how the equipment cleaning research project fulfills part of EPA's goal to stimulate the development and use of products and processes that result in reduced pollution.[3]

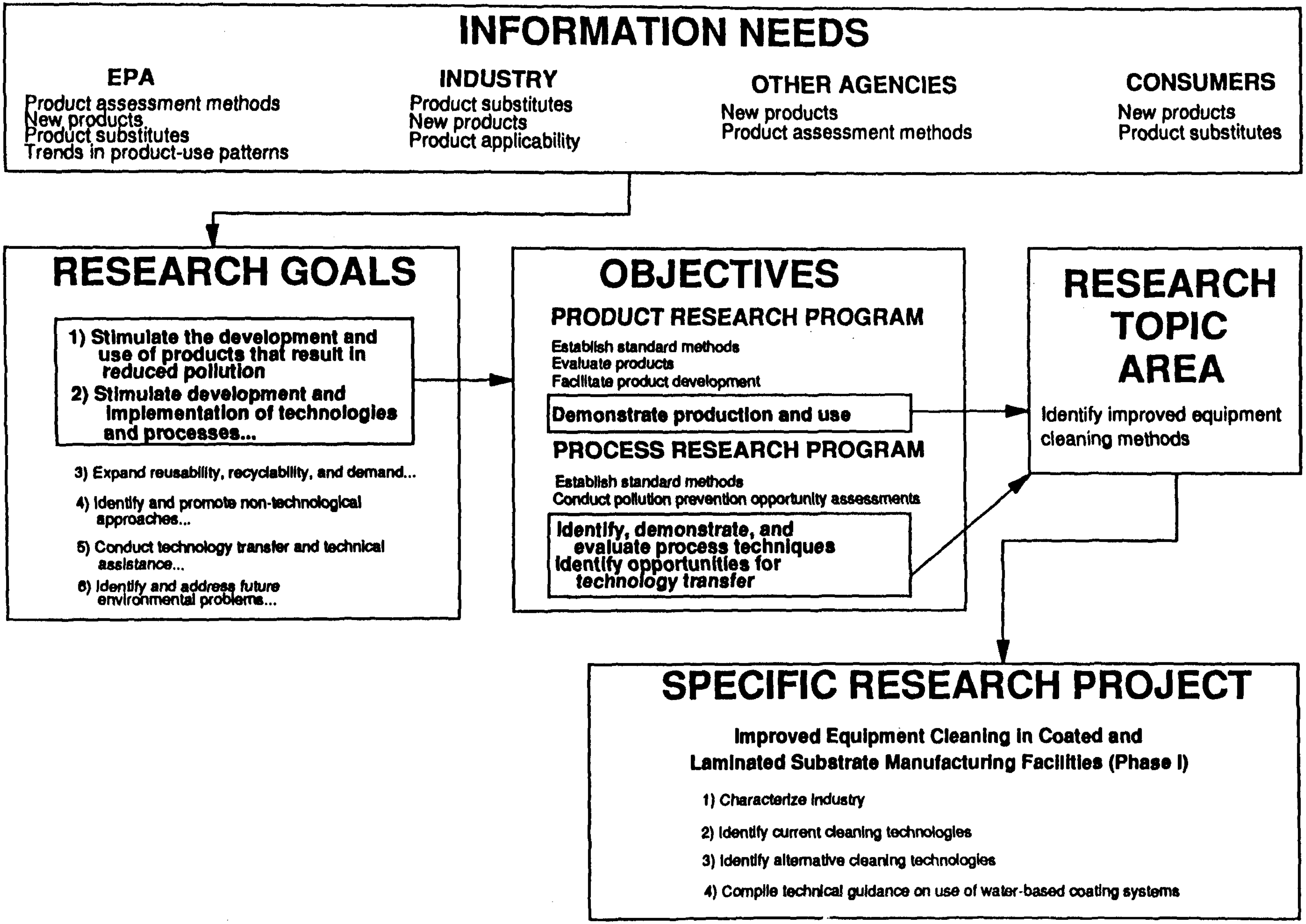

Figure 1-1. EPA's Pollution Prevention Research Plan.

1.2 PROJECT OBJECTIVES

This report presents the results of a Phase I study to characterize current equipment cleaning practices in the coated and laminated substrate manufacturing industry, to identify alternative cleaning technologies, and to identify demonstrable technologies and estimate their emissions impacts. In order to successfully accomplish these objectives, information was collected from several sources including literature searches, industry questionnaires, plant visits, pollution prevention experts, and industry and trade association personnel.

Literature searches of the EPA on-line databases, local university library databases, and Dialog® were conducted. The Pollution Prevention Information Clearinghouse (PPIC) and the Pollution Prevention Information Exchange System (PIES) were accessed on a biweekly basis. The E-Mail capabilities of PIES were also used to communicate with other PIES users with knowledge of the coated and laminated substrate manufacturing industry.

The second source of project background information was data retrieved through industry questionnaires. Two separate questionnaires were distributed, under a previous EPA contract, to 14 adhesive-coated and laminated paper manufacturers, primarily pressure sensitive tape manufacturers and tag and label manufacturers. A separate questionnaire was prepared for manufacturers operating under either SIC 2672 or SIC 2641 (Paper Coating and Glazing) depending on their SIC. Neither questionnaire was sent to more than 8 manufacturers. The results of the questionnaires were clarified through follow-up contacts with the recipients and through revised questionnaires. Over 30 additional facilities (*i.e.*, not recipients of the original questionnaires) were contacted for further information on equipment cleaning practices. The second group of facilities contacted were representative of the expanded scope of the research project, and consisted of facilities involved in the coating and laminating of flexible substrates (SIC 2671) as well as those included in SIC 2672.

In addition to conducting literature searches and distributing two industry questionnaires, contacts were made with industry and pollution prevention experts with the Massachusetts Office of Technology Assistance (OTA), the North Carolina Office of Waste Reduction (OWR), the Pressure Sensitive Tape Council (PSTC), the Tag and Label Manufacturers Institute (TLMI), and equipment manufacturing firms.

The final source of project and industry information was compiled during a total of seven site visits. Two of these site visits were conducted under a previous EPA effort. The trip reports and associated data for these facilities were combined with the information resulting from the additional five trips. Together, these information gathering efforts provided the background needed to accurately describe the coated and laminated substrate manufacturing industry, to evaluate the range of equipment cleaning methods used in the industry, to identify demonstrable technologies, and to form the foundation for future Phase II and III efforts of this project.

Phase II activities will begin upon the completion of Phase I. Phase II of the project will be the actual demonstration of selected alternative technologies. This phase will quantify air emissions and other media wastes, record production parameters, and make other observations and measurements necessary to assess the impacts of the alternative technology. The demonstration project will include a training component focused on the production personnel at the demonstration site to teach any skills or modified techniques that are required to properly implement the alternative technology. Phase II will also involve summarizing the results of the demonstration.

The final phase of the project (Phase III) is to conduct technology transfer. Focused documents such as conference papers, journal articles, and newsletters will be prepared and presented at industrial workshops, pollution prevention conferences, and other events where industrial application of pollution prevention technologies is discussed. Trade associations and contacts made during Phases I and II will be targeted audiences and vehicles used for technology transfer. PPIC, the National Roundtable of State Pollution Prevention Programs, and other groups focused on pollution prevention will also be used.

1.3 REPORT ORGANIZATION

This report is divided into five chapters and three appendices. Chapter 2 identifies and describes current manufacturing and cleaning practices. It includes an overview of the industry's use of raw materials, coating application equipment, current cleaning techniques, current cleaning solvents, and resulting waste streams.

Chapter 3 describes the evolution of the industry questionnaires and the methodology by which the recipients were selected. Chapter 3 also presents a summary of efforts to compile and tabulate the questionnaires' results. This chapter identifies current industry trends in coating formulations, current trends in equipment cleaning methodologies and technologies, and opportunities for pollution prevention research as indicated by the questionnaire respondents.

Chapter 4 discusses some of the pollution prevention alternatives to currently used equipment cleaning techniques and materials. This chapter also briefly identifies some of the opportunities for retrofitting current processing equipment to allow for the use of waterbased coatings.

The last chapter (Chapter 5) presents a summary and evaluation of pollution prevention demonstration opportunities. Appendix A lists coated and laminated substrate facilities with annual sales greater than one million dollars. Appendix B lists SIC 2671 and 2672 facilities and their associated emissions as they appear in the TRIS. Appendix C contains copies of the seven trip reports conducted under this and the previous EPA-led effort to investigate and identify the improved equipment cleaning methods for the coated and laminated substrate manufacturing industry.

1.4 REFERENCES

1. U.S. Environmental Protection Agency. *Pollution Prevention Fact Sheet: EPA's 33/50 Program*. Office of Pollution Prevention, Washington, DC. August 1991.

2. Pollution Prevention Act of 1990, 42 U.S.C. §13101, et seq.

3. U.S. Environmental Protection Agency. *Pollution Prevention Research Plan: Report to Congress*, EPA-600/9-90-015. Office of Research and Development, Washington, DC. March 1990.

CHAPTER 2
CURRENT MANUFACTURING AND CLEANING PRACTICES

2.1 GENERAL

This chapter provides an overview of the coated and laminated substrate manufacturing industries. The chapter is divided into eight sections: (1) Industry Structure, (2) Raw Materials and Products, (3) Manufacturing Process Description, (4) Specific Production Processes, (5) Cleaning Requirements, (6) Current Cleaning Techniques, (7) Properties of Current Cleaning Solvents, and (8) Pollution Characterization. The industry structure section addresses the current market, materials used in the manufacturing process, products manufactured, and product end-uses. The manufacturing process section describes the various elements of the manufacturing process with emphasis on equipment and procedure. Current cleaning techniques and cleaning materials are discussed in relation to the manufacturing processes. The last section characterizes the air emissions and liquid and solid waste streams that result from current industry manufacturing practices.

2.2 INDUSTRY STRUCTURE

2.2.1 Introduction

This section gives an overview of the coated and laminated substrate manufacturing industry, including geographic distributions, production trends, industry issues, and the major subdivisions within the industry. Much data are based on SICs 2671 and 2672.

2.2.2 Industry Market

The coated and laminated substrate industry, as defined by SIC 2671 and 2672, consists of firms that manufacture coated or flexible materials made of combinations of paper, plastic films, metal foils, and similar materials for packaging (SIC 2671) and other purposes, including pressure sensitive tapes (SIC 2672). Some facilities continue to report SIC 2641, Paper Coating and Glazing, as their primary SIC even though SIC 2641 was discontinued in 1972. (During the information gathering phases of this project, several of these facilities were identified and contacted through a questionnaire.) In 1972, SIC 2641 was split into 2671 and 2672.[1,2] (Facilities operating under these SICs were contacted through separate questionnaires.) Because the current SICs are 2671 and 2672, this discussion will focus on these two classifications. However, Table 2-1 summarizes the effect of the SIC revisions on the industry and the corresponding employment data.

According to the 1987 Census of Manufactures, SIC 2671 employed 15,000 people in 21 states, and SIC 2672 employed nearly 31,000 people in 23 states. The leading states in employment of 2671 personnel, accounting for 42 percent of the industry's employment, were Wisconsin, Indiana, Pennsylvania, and Illinois. Similarly, Massachusetts, Ohio, Illinois, and Pennsylvania accounted for 38 percent of SIC 2672's employment. Over 93 percent of SIC 2671 and 55 percent of SIC 2672 plants are small facilities employing less than 20 people.[2] These smaller facilities often provide a highly customized product line marketed within a small geographic region. Some of the larger companies, however, own multiple manufacturing facilities and distribute products nationwide.

TABLE 2-1. 1987 DISTRIBUTION OF SIC 2641 FACILITIES AMONG SIC 2671 AND SIC 2672 FACILITIES

Industry	No. of Facilities	No. of Companies	No. of Employees (thousands)	Cost of Materials (million $)	Value of Shipments (million $)	New Expenditures (million $)
Old Industry SIC 2641, Paper Coating and Glazing	532	439	45.9	4,476.5	8,307.7	329.6
New Industry SIC 2671, Paper Coated and Laminated, Packaging	120	89	15.0	1,442.0	2,416.0	128.3
New Industry SIC 2672, Paper Coated and Laminated, N.E.C.	412	362	30.9	3,034.5	5,891.7	201.3

Source: Reference 2
NEC - Not Elsewhere Classified

2.3 RAW MATERIALS AND PRODUCTS

2.3.1 Introduction

The products manufactured by the coated and laminated substrate industry are used in a variety of applications. Generally, these produces can be categorized as being either tapes, labels, or miscellaneous products. Each of these product types is composed of some combination of backings and coatings which can be described in terms of its construction or function. The product backings often designate construction. In the case of pressure-sensitive adhesive (PSA) products, which constitute a large portion of the industry, the adhesive may be the defining component. The other method of subdivision is functional use. End-use product categories include hospital and first aid products, office and graphic arts products, packaging and surface protection products, building industry materials, electrical products, and automotive industry products. This section includes information relating to raw materials, finished products, and product end-uses.

2.3.2 Raw Materials

The raw materials used in the coated and laminated substrate manufacturing process consist of substrates, adhesives and other coatings, and cleaning materials. Commonly used raw materials in both SIC 2671 and SIC 2672 facilities are listed in Table 2-2.

2.3.2.1 Substrates

A substrate (backing) is the material to which an adhesive is applied to make the desired product. Substrates are supplied to the manufacturer in large, continuous rolls called webs. Substrates provide strength, protection, and/or a colored surface for the adhesive. Substrate categories include paper, film, fabric, foil, and foam. Paper and film are the two most frequently used backing materials.[2,3]

Paper is the most common and one of the least expensive web materials available, however, at least one facility considers raw paper its most expensive production raw material, ranging in cost from $0.50 to $0.75 per pound, depending on the paper grade and specification.[3,4] Paper

TABLE 2-2. RAW MATERIALS CONSUMED IN 1987

Material	Quantity
INDUSTRY 2671, PAPER COATED AND LAMINATED, PACKAGING	
Primary Materials, parts, containers, and supplies	
Paper	926 million lb
Glues and adhesives	NA
Plastics resins consumed in the form of granules, pellets, powders, liquids, etc.	520.9 million lb
Plastics, products consumed in the form of sheets, rods, tubes, and other shapes	NA
Printing ink (complete formulations)	NA
Petroleum wax	30.1 million lb
Paperboard containers, boxes, and corrugated paperboard	NA
Aluminum foil:	
Plain	25.9 million lb
Converted	NA
INDUSTRY 2672, PAPER COATED AND LAMINATED, N.E.C.	
Primary Materials, parts, containers, and supplies	
Paper	NA
Glues and adhesives	NA
Plastics resins consumed in the form of granules, pellets, powders, liquids, etc.	NA
Plastics, products consumed in the form of sheets, rods, tubes, and other shapes	NA
Printing ink (complete formulations)	NA
Petroleum wax	NA
Paperboard containers, boxes, and corrugated paperboard	NA
Aluminum foil:	
Plain	NA
Converted	NA

Source: Reference 2
NA = Not Available
N.E.C. = Not Elsewhere Classified

substrates may be either coated with a saturant (*i.e.*, saturated) or uncoated (*i.e.*, unsaturated). Saturated paper backings include flatback paper (which is smooth) and creped paper (which has small "folds" giving it high stretching properties). Unsaturated kraft papers have also been developed within the last twenty years. This substrate variety is common in the United States, and is used extensively in Japan. Additional paper substrates are classified as specialty papers and include rope fiber paper which has a high tensile strength and nylon paper tape which has increased temperature resistance in electrical applications.[3]

One common use of paper substrates is the manufacture of masking tapes. Masking tapes were first used in the automotive industry for painting applications in which the tape, or maskant, had to be resistant to elevated temperatures for long periods of time. New applications for masking tapes quickly developed, to include general-purpose masking tapes which serve a variety of household needs.[3]

Polymeric film substrates include cellophane, acetates, polyester, vinyl, polypropylene, and polyethylene. These polymeric films have many properties (*e.g.*, impermeability, thinness, smooth surface, good dielectric properties, and chemical inertness) which make them desirable in a variety of applications including packaging, and electrical and pipe wrapping. The cost of film substrates is currently declining, consequently films are competing more in traditional paper markets.[3]

Cellophane tape, the oldest transparent film tape, is used widely in office and general-purpose household applications. Because cellophane is hygroscopic and becomes brittle when dry and soft when humid, it is being replaced by other films (such as acetates) in certain applications despite the higher cost of the replacement films.[3]

End-uses of some of the common film tapes are presented in Table 2-3. Polyester films are used in electrical applications requiring high tensile strength and high tear resistance. Polyethylene films are often used in high volume applications, because of the film's low cost. Tetrafluoroethylene (TFE) film, one of the most expensive of the film substrates, imparts high dimensional stability, resistance to elevated temperatures (482°F/250°C), chemical inertness, and a low coefficient of friction.[3]

A third substrate category used in coating and laminating applications is foil. Foils are typically aluminum, lead, or copper, with aluminum used most frequently. Aluminum backings create a moisture seal and are often used in electrical applications, in heating and air conditioning

TABLE 2-3. END-USES OF ADHESIVE COATED AND LAMINATED FILMS

Tape Type	End-Use
Plasticized vinyl film	Electrical insulation applications Protection of electroplating racks Maskant of metal surfaces to be plated Can sealer Protection of metal window frames Corrosion resistance for underground pipes Printable label tapes
Rigid vinyl film	Packaging General purpose
Polyester film	Packaging Electrical applications
Polypropylene film	Packaging
Colored vinyl film	Identification Floor markings
Polyethylene film	Medical tapes Electrical insulating Duct insulating Carpeting Corrosion protection for underground gas and oil lines
Tetrafluoroethylene (TFE) film	Coil winding Transformers Cables Relays Condensers Resisters Dry film lubricants
Polyimide film	Electrical applications Flat cable construction Masking in soldering operations

Source: Reference 3, 5

insulation ducts as a reflective heat shield, in high temperature masking operations (*e.g.*, printed circuit board manufacture), in repairing sheet metal, and in blocking radiation on X-ray plates. Aluminum laminated to cloth or foam provides vibrational and acoustical damping. Lead foils are used for their resistance to the chemicals in plating operations, in acoustical damping applications, and in radiation shielding.

Foam substrates include polyethylene, vinyl, urethane, and polychloroprene. The structure of a foam backing imparts many unique characteristics including the ability to conform to uneven surfaces and to distribute force loads to prevent stress concentration and ultimate product failure. Low density foam substrates are used for sealing and gasketing, while foam/foil and foam/film laminates are used for thermal and acoustical insulations. Two-sided adhesive-coated foam products are used to mount a wide variety of objects including vehicle reflectors and balancing weights, bathroom fixtures to walls, medallions to wine and liquor bottles, and electrocardiogram terminals to patients.[3] Fabric tapes offer a backing with both high tensile strength and high flexibility. Low tear strength may also be incorporated with no loss of tensile strength. Medical tapes and duct tapes are made with fabric backings.

2.3.2.2 Coatings

The various coatings applied, along with the type of substrate, define the end-use of a coated and laminated product. Coatings typically consist of solvents, resins, and additives, with the composition varying depending on the desired characteristics. The fluid portion of the coating is referred to as the vehicle. Vehicles maintain a coating in liquid form for easy application. Once a coating is deposited on a substrate, the vehicle solvents should evaporate completely. Vehicles transfer the solid portion of the coating to the substrate surface in a uniform layer and typically play no role in film formation. Some commonly used coatings include saturants, release coats, tie coats, and adhesives. Not all coated and laminated products incorporate all of these coatings. For example, saturants are used primarily with paper substrates, while tie coats are used mainly with film products. A brief discussion of each type of coating follows.

Saturants are mixtures applied to raw paper to improve the paper's internal strength and resistance to various environments. The backing of paper tape, for example, may contain as much as 50 percent saturant by weight.[6] The two types of saturants used are solvent-based and waterbased. Saturants are used to reduce the amount of loose fibers extending from the surface of a paper web. They also impart strength to the web once dried. Solvent-based saturants orient all the fibers uniformly and provide better water resistance than the waterbased coating; however, they do not strengthen the web as much as waterbased saturants. Natural rubber and styrene-butadiene rubber (SBR) are the preferred polymers for solvent-based saturants. Other saturant raw materials include polyurethanes, toluene, polyether blends, and hydrocarbon resins. Although pollution problems and high costs of solvents make waterbased saturants more attractive, solvents are necessary for the manufacture of electrical paper tapes because of the high performance characteristics currently offered only by solvent-based saturants.[3]

Waterbased saturants or latexes are used more often than solvent-based saturants for tape backing. Waterbased latexes are easier to use than solvent-based saturants, which must be broken down and compounded to dissolve the rubber. Several synthetic latexes used in the waterbased saturants are SBR, acrylics, and carboxylated SBR. Acrylics provide excellent saturation, have a light color, and are heat and light stable. Other waterbased coatings are available but not used as frequently as the ones previously mentioned.

Release coatings are applied to the substrate backing on the side opposite of the adhesive. The release coat allows rolled adhesive products to be unwound, prevents tearing, and provides resistance to fluids.[6] A release coat or "backsizing" contains release material, liquid resins, and solvents such as silicone solution, isopropyl alcohol, and toluene.[3,7] The release coat should provide an adequate and consistent release, the release agent should not transfer to the adhesive surface, and aging should not effect the ability to unwind the tape. Polymer coatings, waxes, silicones, and chained polymers are used in release coatings. Polymers are used to prevent the adhesive from penetrating into the backing. Waxes are added to polymer coatings to improve the slip, blocking resistance, and release of the coating.

Tie coats or primers are coatings applied between natural rubber adhesives and film substrates to improve the bond between the adhesive and the film. Primers may be a mixture of creep rubber, diphenylmethane diisocyanate, and toluene or blends of SBR, with and without resins.[3,5]

Adhesive is applied to the saturated/backsized substrate. The adhesive product may contain petroleum resins, solvents, natural and synthetic rubber, antioxidant, and filler.[6] Adhesives are required to have three main properties: peel adhesion, cohesive holding power, and surface tack.

Natural rubber has a low tack and adhesion to surfaces. Therefore, tackifying resins must be added to natural rubber-based adhesives. Wood rosin and its derivatives, terpene resins, and petroleum-based resins are the main resins used with natural rubber. Other adhesive products include block copolymers; thermoplastic rubbers including polyethylene or polybutylene; butyl rubber, a copolymer of isobutylene with a minor amount of isoprene; polyisobutylene, a homopolymer; acrylic polymers; vinyl ether polymers; and, silicon adhesive which is both a gum and a resin. Facilities have a wide variety of choices for raw material inputs for adhesive mixing.

2.3.3 Finished Products and End-Uses

A summary of coated and laminated substrate product end-uses is included in Tables 2-4a and 2-4b. In 1987, the value of all product shipments for SIC 2671 was $2.4 billion and the value of all product shipments for SIC 2672 was $5.9 billion.[2] *Ward's Business Directory* lists 43 SIC 2671 facilities and 81 SIC 2672 facilities with 1992 sales greater than one million dollars. These lists are provided in Appendix A, Table A-1 (SIC 2671) and Table A-2 (SIC 2672).[8]

There are several types of products manufactured by coated and laminated substrate manufacturers. Two of the largest product categories are tapes and labels. Classes of tape, identified by construction, include woven and nonwoven fabric tape, paper tape, film tape, foil tape, and foam tapes. Some of the web materials mentioned previously are used in combination with glass, rayon, nylon, polyester, or acetate fibers to produce reinforced substrates. Films such as polyethylene, polyester, or polypropylene are often combined with these fibers to produce tapes used in heavy-duty packing and bundling applications. The type and number of reinforcing strands per area, the thickness of the coating applied, and the type of film used differentiate the grades and types of film tape.[3,5] Two-faced tapes are substrates with an adhesive coating applied on both sides of the substrate (usually foam or film). Two-faced tapes have both heavy-duty uses (*e.g.*, carpet tapes and securing plates to a printing cylinder) and light-duty uses (*e.g.*, business forms and nametags).

TABLE 2-4a. SIC 2671 PRODUCT END-USES

1987 Product Code	Product	No. of Companies with Shipments of $100,000 or More	1987 Product Shipments: Quantity	1987 Product Shipments: Value (million $)
2671- -	**PAPER COATING AND LAMINATING, PACKAGING**			
	Total	(NA)	(X)	2,460.1
26711 -	**Single-web paper (coated rolls and sheets, including waxed) for packaging uses**	(NA)	(X)	474.4
26711 11	Plastics-coated .... 1,000's tons	26	91.2	168.5
26711 15	Other .... do	34	156.1	285.1
26711 00	Single-web paper, coated rolls and sheets, including waxed, for packaging uses, n.s.k.	(NA)	(X)	20.7
26712 -	**Single-web film (coated rolls and sheets, including coextruded) for packaging uses**	(NA)	(X)	879.1
26712 11	Single-web film, coated .... 1,000's tons	54	197.4	483.4
26712 12	Coextruded film .... do	20	110.7	343.1
26712 00	Single-web film, coated rolls and sheets, including coextruded, for packaging uses, n.s.k.	(NA)	(X)	52.5
26713 -	**Paper/paper multiweb laminations for packaging uses**	(NA)	(X)	249.1
	Polyethylene laminations:			
26713 13	Coated .... 1,000's tons	12	(S)	105.8
26713 14	Uncoated .... do	6	44.8	46.4
	Other laminations:			
26713 18	Coated .... 1,000's tons	9	7.5	10.8
26713 21	Uncoated .... do	10	62.4	51.6
26713 00	Paper/paper multiweb laminations, for packaging uses, n.s.k.	(NA)	(X)	34.6
26714 -	**Multiweb laminated rolls and sheets, except paper/paper and foil, for packaging uses**	(NA)	(X)	857.6
26714 11	Film/paper multiweb laminations ...... 1,000's tons	15	31.0	95.3

(Continued)

TABLE 2-4a. SIC 2671 PRODUCT END-USES (continued)

1987 Product Code	Product	No. of Companies with Shipments of $100,000 or More	1987 Product Shipments: Quantity	1987 Product Shipments: Value (million $)
	Film/film multiweb laminations:			
26714 12	Polypropylene/polypropylene .... 1,000's tons	20	42.4	205.9
26714 13	Cellophane/polypropylene .... do	7	(S)	9.6
26714 14	Cellophane/polyethylene .... do	9	5.5	14.9
26714 15	Metalized film/film laminations .... do	19	14.6	72.3
26714 16	Other film/film laminations .... do	27	99.9	364.1
26714 00	Multiweb laminated rolls and sheets except paper/paper and foil, for packaging uses, n.s.k.	(NA)	(X)	95.4
26710 -	**Paper coating and laminating, packaging, n.s.k.**	(NA)	(X)	(NA)
26710 00	Paper coating and laminating, packaging, n.s.k. typically for establishments with 15 employees or more (see note)	(NA)	(X)	(NA)
26710 02	Paper coating and laminating, packaging, n.s.k., typically for establishments with less than 15 employees (see note)	(NA)	(X)	(NA)

Source: Reference 2
do - Ditto
n.s.k. - not specified by kind
NA - Not Available
X - Not Applicable
S - Withheld because estimate did not meet publication standards

TABLE 2-4b. SIC 2672 PRODUCT END-USES

1987 Product Code	Product	No. of Companies with Shipments of $100,000 or More	1987 Product Shipments Quantity	1987 Product Shipments Value (million $)
2672- -	**PAPER COATING AND LAMINATING, N.E.C.**			
	Total	(NA)	(X)	5,497.7
26721 -	**Printing paper coated at establishments other than where paper was produced**	(NA)	(X)	464.5
26721 13	Coated, one side (for labels and similar uses) .... 1,000's tons	38	(S)	301.7
26721 53	Coated, two sides (for printing of magazines, directories, catalogs, and similar uses) .... do	19	(S)	156.8
26721 00	Printing paper coated at establishments other than where paper was produced, n.s.k.	(NA)	(X)	5.9
26722 -	**Gummed products:**			
26722 00	Gummed products	25	(X)	218.4
26723 -	Pressure-sensitive products:			
26723 00	Pressure-sensitive products	123	(X)	3,100.0
26724 -	**Other coated and processed papers, except for packaging uses**	(NA)	(X)	1,200.0
26724 45	Processed paper (embossed, leatherette, etc.) ..... 1,000's tons	7	53.2	64.2
26724 51	Oiled and similarly treated paper .... do	5	10.0	10.4
26724 53	Waxed and wax-laminated paper for nonpackaging uses, including household .. do	11	(S)	104.0
26724 55	Carbonless paper .... do	4		
26724 56	Plastics-coated paper .... do	7	(S)	953.5
26724 59	Other coated and processed paper, including soap-impregnated paper but excluding sensitized paper .... do	34		
26724 00	Other coated and processed papers, except for packaging uses, n.s.k.	(NA)	(X)	68.0
26720 -	**Paper coating and laminating, n.e.c., n.s.k.**	(NA)	(X)	514.7
26720 00	Paper coating and laminating, n.e.c., n.s.k., typically for establishments with 15 employees or more	(NA)	(X)	339.5

(Continued)

TABLE 2-4b. SIC 2672 PRODUCT END-USES (continued)

1987 Product Code	Product	No. of Companies with Shipments of $100,000 or More	1987 Product Shipments: Quantity	1987 Product Shipments: Value (million $)
26720 02	Paper coating and laminating, n.e.c., n.s.k., typically for establishments with less than 15 employees	(NA)	(X)	175.2

Source: Reference 2
do - Ditto
n.s.k. - not specified by kind
n.e.c. - not elsewhere classified
NA - Not Available
X - Not Applicable
S - Withheld because estimate did not meet publication standards

Tape end-use categories include the following:[3-5,7,9-11]

- *Medical and first aid tapes* were the first application of pressure-sensitive products. These products are used by doctor's offices, and at home for first aid purposes, foot care, and athletic protection wraps.

- *Office and graphic art tapes* were first produced as clear cellophane film tapes, but now include many other substrate varieties.

- *Packing and surface protection* film tapes are the most frequently used tapes for packaging. Saturated paper tape is still dominant in surface protection tape applications and sheet products.

- *Building industry products* include tapes used for paint masking, temporary attachment of wood products, weather sealing a building, bridging narrow cracks to overpaint, electrical wrapping, coverings for doors and walls, floor tile installation, and glass treatments.

- *Electrical tapes* include two classes: tapes intended for original equipment manufacturers (OEM) and tape for electrical insulation during installation. Current OEM tape may have cloth, film, paper, aluminum foil, nonwoven fabrics, or laminated substrates depending upon the desired qualities in the backing. Electrical installation tapes often have either a plasticized vinyl or polyethylene film backing.

- *Automotive industry products* are used in the electrical system of automobiles. These products are similar to the OEM tapes discussed above. Other automotive tape products include tape strips used to mount interior moldings and trim.

- *Shoe industry tapes* are used to cover the backseam to reduce pressure spots. Fabric, paper, and film tapes may be used in this application. Tapes are also used in binding and reinforcing areas in the construction of shoes.

- *Appliance industry products* include decorative strips, nameplates, foam gasketing, and foam pads for sound insulation for attachment to appliances.

- *Splicing tapes* are used to splice various webs during manufacturing operations. Paper tapes, two-faced tapes, and film tapes are used for this purpose.

- *Corrosion protective tapes* help to prevent the breakdown of materials covered by the tape. Consumption of polyethylene film tapes for corrosion protection is very large.

Label manufacturing is similar to pressure sensitive tape manufacturing, with priority properties being backing, printability, flatness, ease of die cutting, and release paper components. A label manufacturer may sell his product either in rolls or sheets as a final product, or as a raw product for a printing and die cutting operation.[3,4]

Other adhesive coated and laminated product lines include adhesive-coated floor tiles, wall coverings, automotive and furniture woodgrain films, and decorative sheets.

2.4 MANUFACTURING PROCESS DESCRIPTION

2.4.1 Introduction

Coated and laminated substrate facilities use numerous methods to process the wide variety of products that they manufacture. Manufacturing variables include the design and capabilities of the coating equipment, the type of substrate, the type and viscosity of the coatings being applied, and the drying or curing method. The manufacturing process generally consists of the following four steps:

- raw material mixing
- coating application
- drying/curing
- rolling, printing, cutting, and product shipment

2.4.2 Raw Material Mixing[4,5,7,9,10]

Many coating and laminating facilities formulate their coatings on-site in a central mix room. The complexity of the mixing process depends on the size of the facility and the number of products manufactured. Generally speaking, large facilities operating dedicated lines formulate all of their own coatings from raw materials. Smaller coating and laminating facilities may purchase premixed coatings which they either use as-shipped or modify to satisfy customer needs. Modification typically consists of adding small amounts of performance enhancing chemicals.

Saturants, release coatings, tie coatings, and some adhesives are typically manufactured in mix tanks using high- or variable-speed dispersers. Facilities that purchase pre-mixed coatings and add performance enhancing chemicals often blend these chemicals directly into the coating drum. Facilities equipped with stainless steel mixing tanks and dispersers are capable of preparing coatings of any chemical composition [*i.e.*, 100 percent solids, waterbased, solvent-based, ultra-violet (UV) curable].

Adhesive preparation often follows a slightly different process. The thicker adhesive stock is prepared by blending natural and synthetic rubbers, hydrocarbon resins, oils, and fillers in a banbury, a specialized disperser similar to a bread mixer. The banbury output is then directed to mills where a sheet of adhesive stock is extruded, cut, and palletized for further processing. The palletized sheets are sent to a mixing area, where they are loaded into large (*e.g.*, 10,000 gallons) mix tanks. Solvent (often toluene) which dissolves the stock, additional resins, rubber (self polymerizing), and oils are pumped into the mix tank to complete the adhesive formulation. Figure 2-1 illustrates the adhesive mixing process.

Once the coatings are formulated, they are either pumped to storage tanks or transferred via tote vessels or dedicated piping to specific process lines for immediate use.

2.4.3 Coating Application

The application of a coating to a flexible web involves four major functions: (1) transport of the web, (2) delivery of the coating supply, (3) metering of the coating, and (4) transfer of the coating from the supply vessel to the substrate. For purposes of this report it is not important to understand web transport, other than to note that the mechanisms used to tension and advance the web can become contaminated with coatings and require cleaning. These mechanisms include items such as rollers, gear boxes, belts, and equipment housings. The mechanisms used to supply, meter, and apply coating are also subject to contamination, and thus require cleaning; but more importantly, their design influences the degree to which coatings are spilled during application. The following sections describe the other three coating application functions, along with some common coating equipment configurations.

2.4.3.1 Delivery of the Coating Supply

After mixing, coatings are stored in permanently installed tanks, movable tote vessels, or drums, depending on the size and production methods of the coating operation. In order to coat a substrate web, the coating must be transferred from such storage locations to a reservoir, from which it can be made available to the coating apparatus. Depending on the size of the operation and production methods, this is accomplished through permanently installed piping and manifold systems, or portable lines that are attached to mobile storage vessels. Various types of pumps

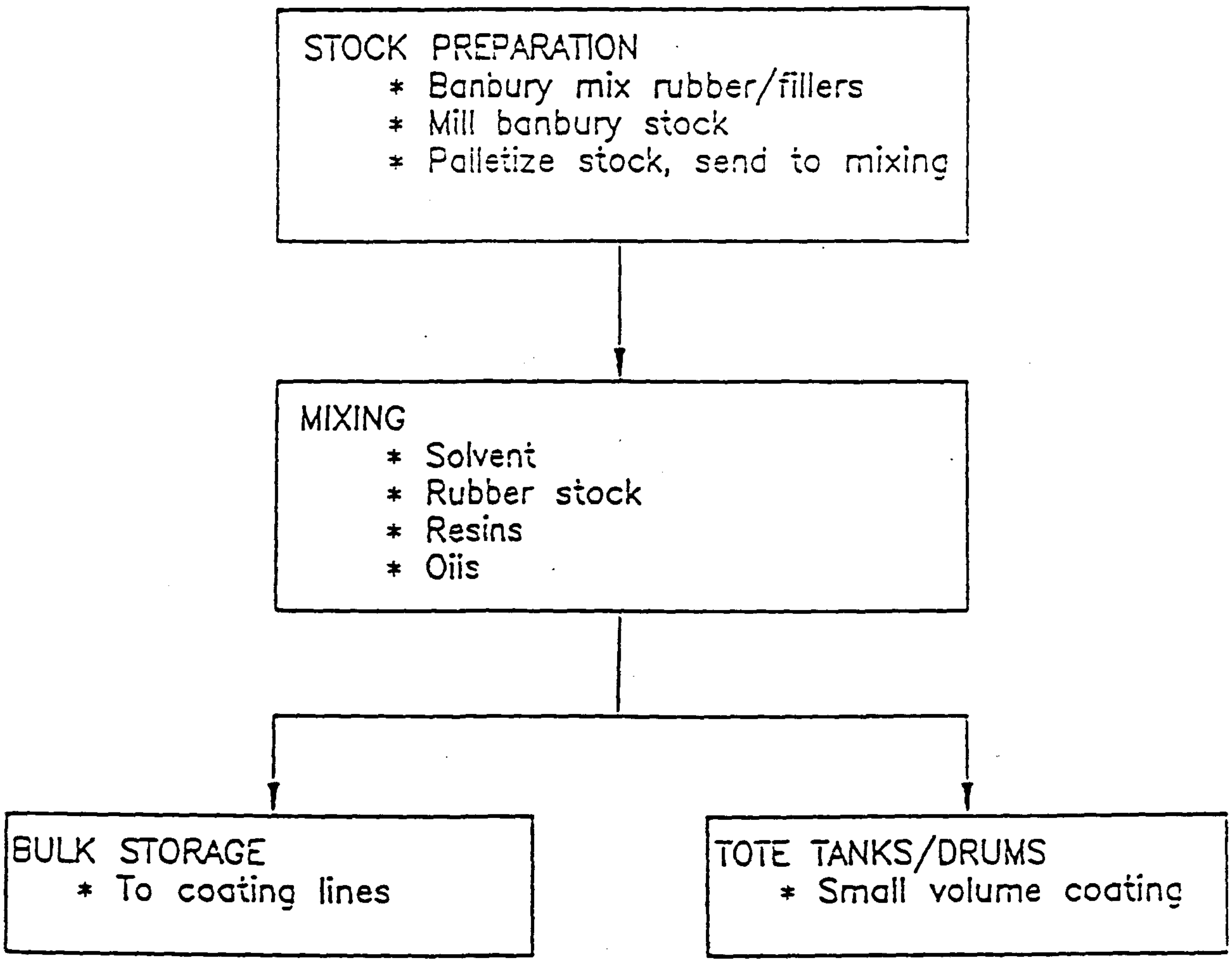

Figure 2-1. Adhesive Mixing Process.

are used to maintain a flow of coating materials through these distribution networks. Most coating operations periodically flush these pumps and transport lines with solvent to prevent a buildup of coating material on the interior surfaces. Some facilities pack their lines with solvent during production shut-down periods to avoid the curing of coatings in the line.

The delivery system brings coating material into close proximity with the web and coating head, depositing the liquid at a steady rate into a reservoir. In some cases, this flow is subjected to continuous monitoring and adjustment, particularly on short runs. But in longer production runs, once the flow is adjusted to the proper rate, the coating supply is left alone, and process control is exercised with the metering mechanism.

The reservoir, the dams around it, and the spill pans beneath it are all regularly subjected to contamination, and require cleaning on a regular basis. The reservoir itself must be cleaned prior to the start of any new job, and the other surfaces are cleaned frequently to avoid contamination of the incoming coating.

2.4.3.2 Metering of the Coating Supply

The coating that is applied to the web must be sufficient to completely wet its surface, but not exceed the design thickness for the application. To some degree, applied coating thickness is controlled through adjustment of the supply system and the coating's viscosity. Fine adjustments are accomplished by a metering device. Metering can occur before or after the coating is applied to the web. The most common metering mechanisms are (1) a metering roller, (2) a doctor blade, (3) a metering rod, and (4) nip rollers.

A metering roller controls the amount of coating that reaches the web in roll coating applications. Metering rollers are very smooth and spin counter to the direction of the application roller. They are set at a predetermined distance from the application roller, so that as the coating laden roller rotates towards the surface of the web, the metering roller restricts the amount of coating that can pass through the preset gap. Coating typically collects at the outer edges of this gap, so many coating heads incorporate a solvent drip that solubilizes this buildup, allowing it to wash away. A coating apparatus employing a metering roll to control coating thickness is depicted in Figure 2-2.

Doctor blades or floating knives are used to remove excess coating either from the surface of the transfer mechanism, or after the coating has been transferred to the web. Doctor blades

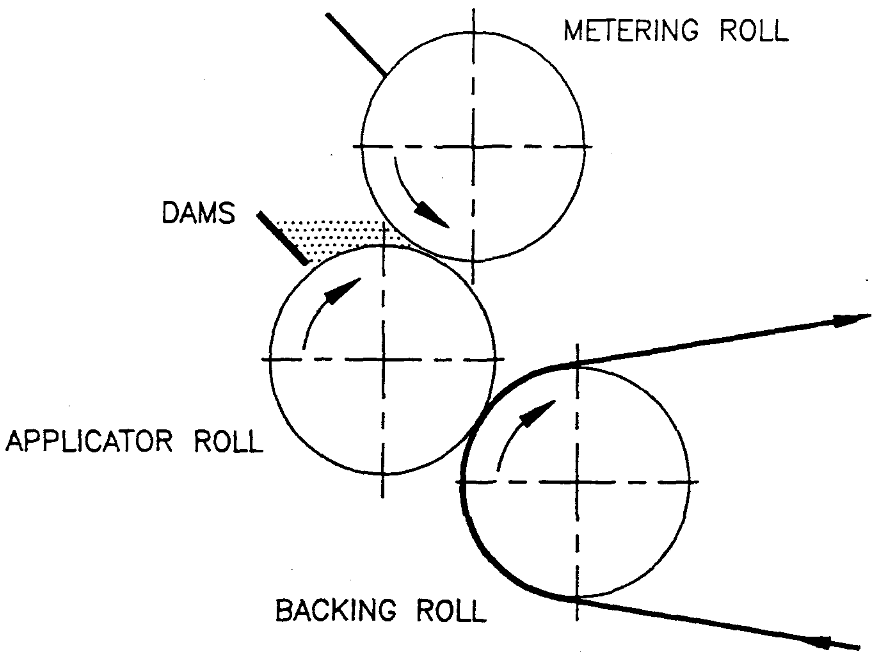

Figure 2-2. Metering Roll Control of Coating Thickness.

have very clean, straight edges, and are finely adjustable to provide a level scraping effect over the surface of the coating. Doctor blades are most effective in providing metering of an already well controlled coating layer. If a doctor blade is set to remove too much coating, either from an application roller or from the surface of a web, it will begin to foul and actually pull too much coating away, resulting in adhesive voids on the web. Figure 2-3 shows a doctor blade-over-roll coater. Figure 2-4 shows various types of knives used to achieve different coating effects.

Metering rods, like doctor blades, can control coating thickness before or after transfer to the web. A metering rod is a thin rod wrapped in wire. It is brought into tangential contact with the coating laden surface and coating passes through the grooves in the wire wraps. The diameter of the wire wrapping determines the amount of coating that is allowed to pass. The viscosity of the coating must be controlled to allow the coating to level after it has passed the metering rod. Figure 2-5 shows a typical metering rod set up to control the thickness of a coating applied by a direct roll coater. Figure 2-6 depicts the flow of coating through the grooves in a metering rod's wire wrapping.

Nip rollers are used to squeeze a saturated web to remove excess coating. Nip rollers are adjacent rollers that rotate counter to one another, allowing the web to travel between them. They are usually covered with a flexible surface material, primarily rubber, so that they may be set in contact with one another, but flex enough to accommodate passage of the web. Figure 2-7 shows a dip and squeeze coater using chilled iron rollers as nip rollers.

Additional metering mechanisms include air knives, which are high speed curtains of air that literally blow excess coating back as an application roller rotates towards the web, and mechanisms uniquely associated with a single coating application, such as the engravings in a gravure cylinder. Gravure coaters are similar to roll coaters in that they transfer coating to the surface of a web through the rotational motion of a cylinder. The major difference is that gravure cylinders are engraved while the surface of standard coating rollers is mirror smooth. Gravure coating is a common way of selectively coating the surface of a web. Figure 2-8 shows a typical air knife coater. The arrows indicate that the applicator roll can be either a reverse or direct roll. Figure 2-9 depicts a simple gravure coating system. Regardless of the mechanism used, the metering device must be kept as clean as possible to allow it to effectively perform its task.

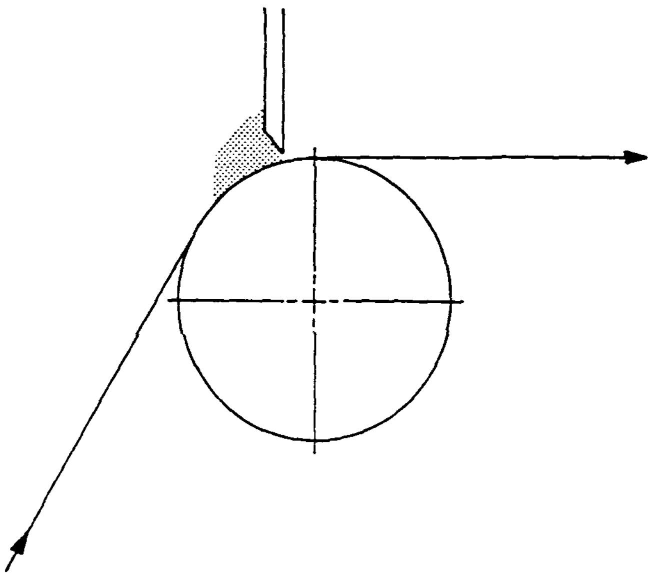

Figure 2-3. Blade-over-roll Coater.

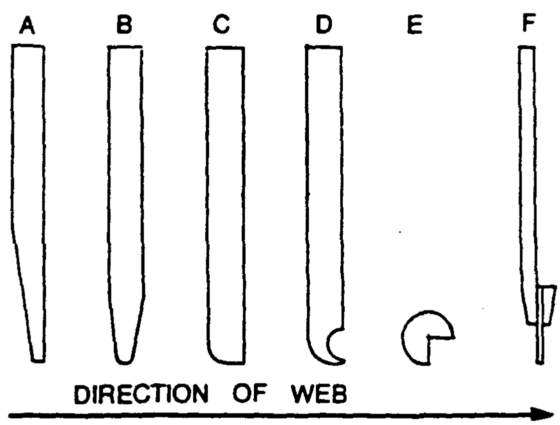

Figure 2-4. Coating Knives (A = beveled; B,C = rounded edge; D = hook; E = bull nose; F = spanishing knife)

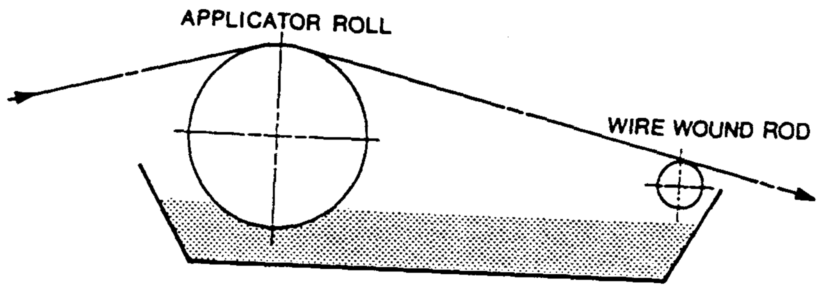

Figure 2-5. Metering Rod Coater.

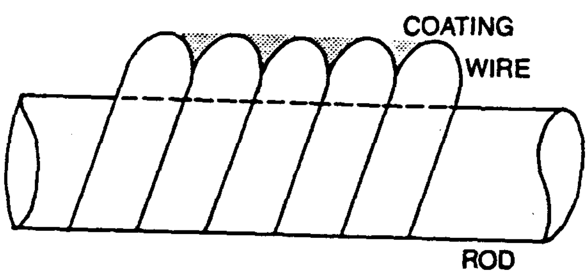

Figure 2-6. Metering Rod.

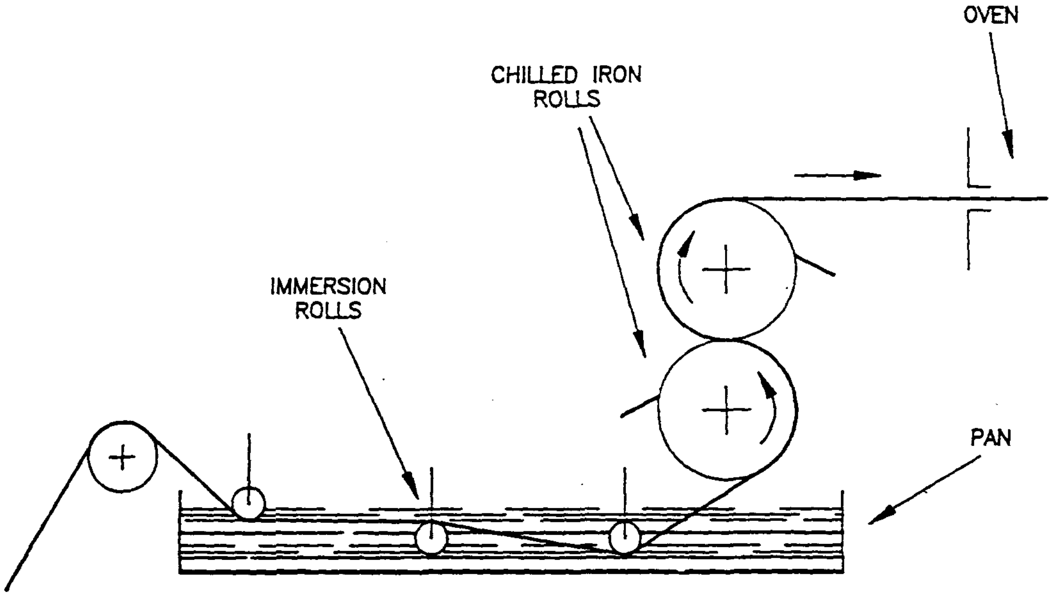

Figure 2-7. Dip and Squeeze Coater.[11]

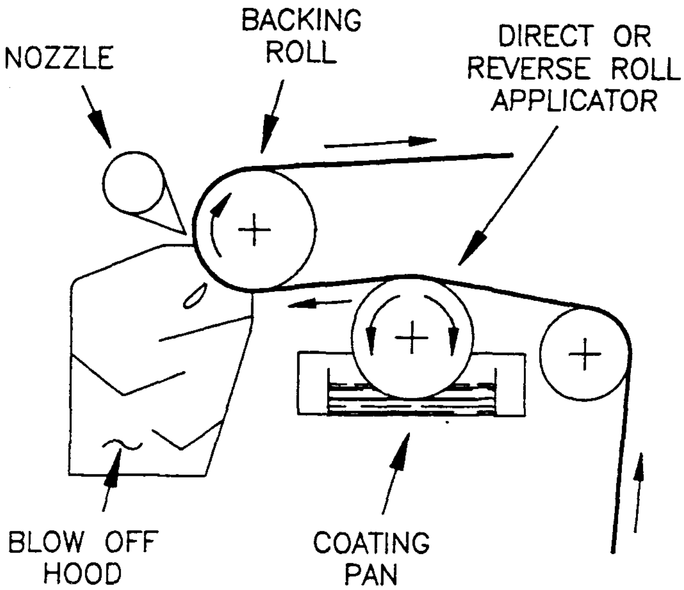

Figure 2-8. Air Knife Coater.[11]

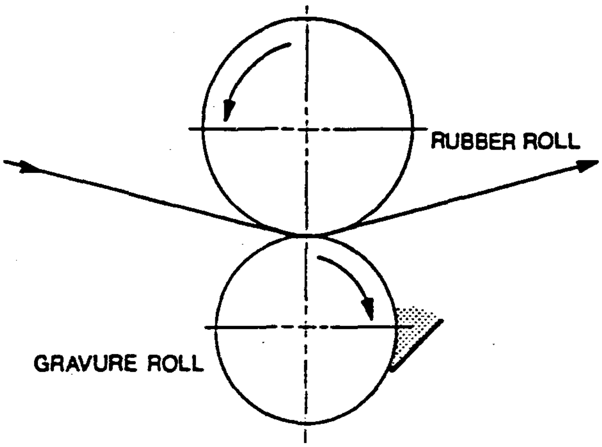

Figure 2-9. Direct Gravure Coater, Coating Reservoir Between the Roll and the Blade.

2.4.3.3 Transfer of the Coating to the Substrate

Transfer of a coating from a reservoir to a web is most commonly accomplished with a roll coating mechanism. Roll coaters are a series of one or more cylinders that remove coating from the reservoir and then contact the web transferring a portion of the coating to the web surface. If the same cylinder that contacts the coating in the reservoir also contacts the web, such as the coater shown in Figure 2-10, the roll coater is known as a direct roll coater. If the supply roller transfers the coating to a counter-rotating cylinder before it reaches the web, the device is called an offset roll coater. Offset roll coaters are capable of greater control of the coating deposit, but require more exacting process control and have more surfaces that require cleaning. Figure 2-11 shows an offset roll coater.

In addition to describing the transfer of coating from the reservoir to the web (*i.e.*, with a single roller), the term direct roll coater is also used to indicate that the web and the coating cylinder surface are moving in the same direction at their tangential point of contact. Figure 2-12 shows the relative direction of motion of the web and application roller in a direct roll coater. If these two surfaces are moving counter to one another at this point, then the system is described as a reverse roll coater, shown in Figure 2-13. Reverse roll coaters are capable of effecting a smoother and more uniform coated surface.

In some coating applications, there is less need for precision and coatings can be poured directly onto the web and metered using a metering roller, doctor blade, or metering rod. These applications generally incorporate a less viscous coating, and are intended for low performance environments, such as disposable labeling or general purpose masking tape. In such cases, the transfer mechanism is the pouring device, such as an aperture in the reservoir, or a weir (dam) that the coating pours over as the reservoir is fed. In such applications it is essential to control the flow of coating to the reservoir to ensure that the pouring mechanism does not deliver too much coating to the surface of the web. Figure 2-14 shows a floating knife coater, which meters the coating from a reservoir directly on the web.

2.4.4 Drying/Curing

Ovens serve two primary functions: to dry the coating by evaporating the solvent or to cure a polymer coating. Important characteristics of an oven are the source of heat, the operating

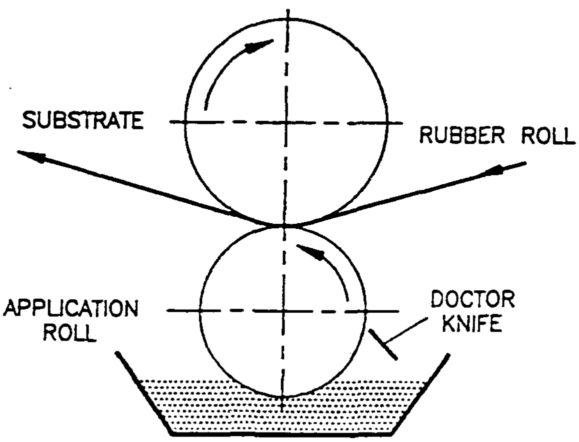

Figure 2-10. A Schematic Diagram of a Direct Roll Coater.

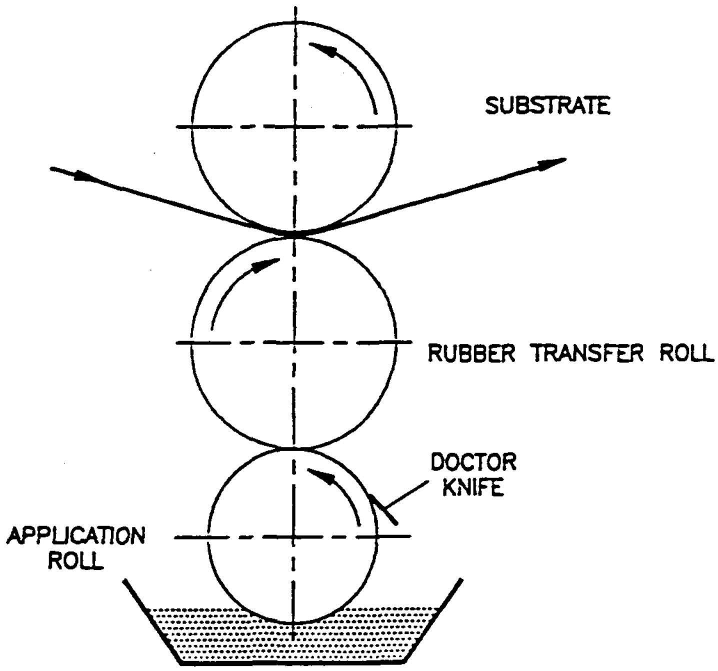

Figure 2-11. Offset Application Roll.

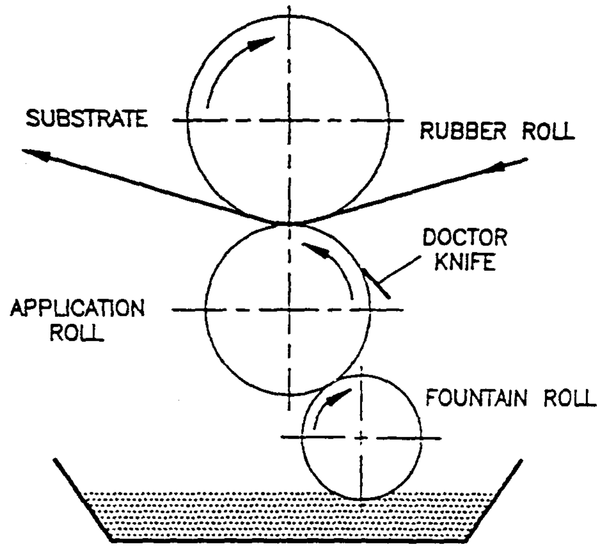

Figure 2-12. Direct Application Roll.

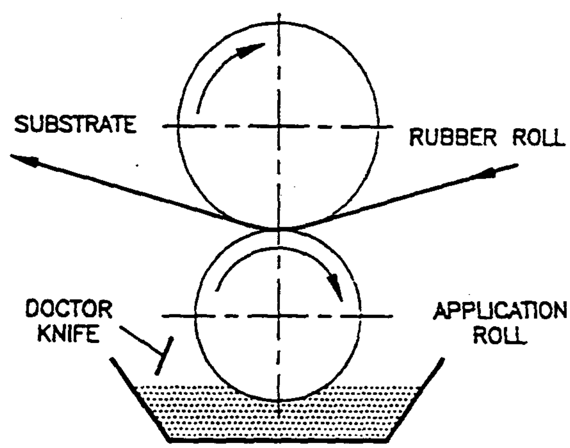

Figure 2-13. A Schematic Diagram of a Reverse Roll Coater.

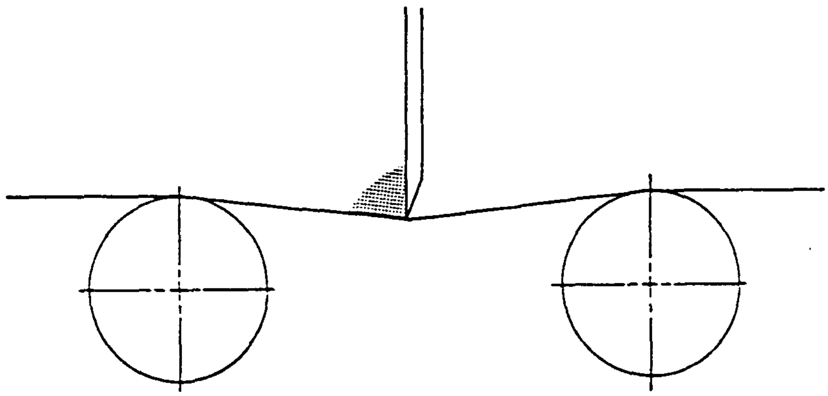

Figure 2-14. Floating Knife Coater.

temperature, the residence time (a function of web speed), the allowable hydrocarbon concentration, and the oven circulation (a function of air velocity).

Ovens are of two types: direct and indirect. An indirect-fired oven involves heat exchange. An incoming air stream exchanges heat with steam or combustion products, but does not mix with them. This heat transfer is often accomplished using shell-and-tube or plate type heat exchangers.[3,11] Direct heating routes the hot products of combustion (blended with ambient air to achieve the desired temperature) directly into the drying zone. The fuels for a direct-fired oven are usually either natural gas or liquefied petroleum gas (*e.g.*, propane). Direct-fired ovens are used most frequently because of their higher thermal efficiency. Indirect-heated ovens lose efficiency in the production of steam and in the heat transfer process.[3,11]

Oven drying involves raising a coating's temperature above the boiling point of the vehicle solvent and keeping the temperature elevated long enough for entrapped solvents to migrate to the surface and evaporate. The time required to drive off vehicle solvents at the boiling temperature is known as the drying residence time. During the drying process, heat is transferred to the coating and backing. Approximately 80 to 95 percent of the vehicle solvent evaporates and is removed with the oven exhaust in most coating processes.[11] The remaining trapped solvents generally migrate to the edge of the adhesive once it is used in its functional application. (This process is known as out-gassing, and is frequently a cause of adhesive failures.) Another important factor to consider with temperature is the temperature profile. If the initial drying proceeds too quickly, voids may develop in the coating. Conversely, if drying occurs slowly at low temperatures, longer ovens may be necessary to achieve sufficient residence time.

Multi-zone ovens almost always overcome these difficulties. A typical two-zoned oven is illustrated in Figure 2-15. Zoned ovens are physically divided into several sections, each with its own exhaust and supply of hot air. The temperature in the first zone is typically low, but gradually increases in later zones. This structure allows for uniform drying. Large drying/curing ovens may have as many as six zones ranging in temperature from 110°F (43°C) to 400°F (204°C). Facilities may also employ recirculating ovens to provide better drying efficiency. Recirculation of the exhaust gas is an energy saving practice, but care must be taken to ensure that sufficient makeup air is circulated to prevent solvent saturation inside the oven. Figure 2-16 illustrates oven exhaust recirculation.[4,5,7,9-11]

2.4.5 Rolling, Printing, Cutting, and Product Shipment

Many coating operations also offer value-added converting services to their customers. Such services include custom slitting and roll winding, printing, die-cutting, and sheeting. A roll of coated product may weigh up to 5,000 lbs and be 30 inches wide when it comes off the production line. Such products are generally slit to a customer specified width, and automatically rolled onto standard cores for customer use in automatic dispensers. Many facilities have the ability to slit and wind product on-site, however, some facilities send finished rolls to contract converters to be sized.

In addition to slitting and winding of stock products, coaters often customize label and packaging products by printing a logo and die-cutting to size. Printing is typically done using flexographic or screen printing. The industry trend is towards the use of waterborne and radiation curable inks for these processes. Die cutting is typically done with hydraulic-ram presses and steel-rule dies. The product is generally cut to the liner with the waste removed and the web rolled and packaged for shipping.

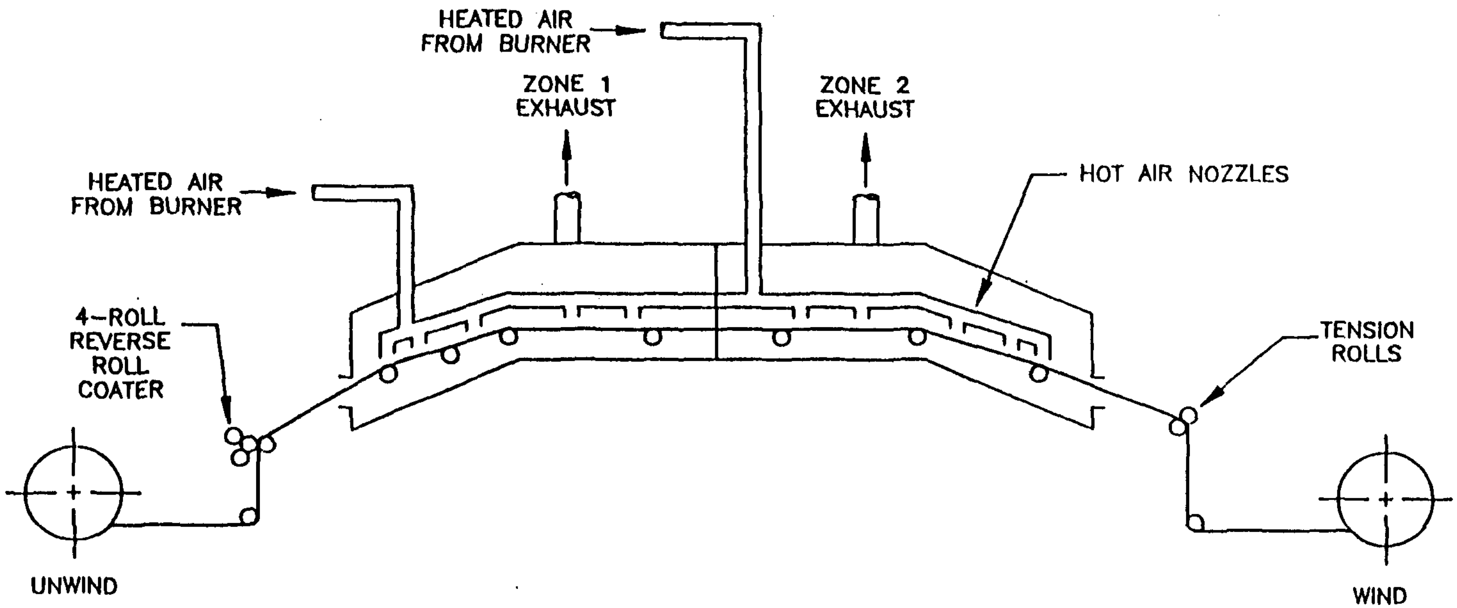

Figure 2-15. Two-Zoned Drying Oven.[11]

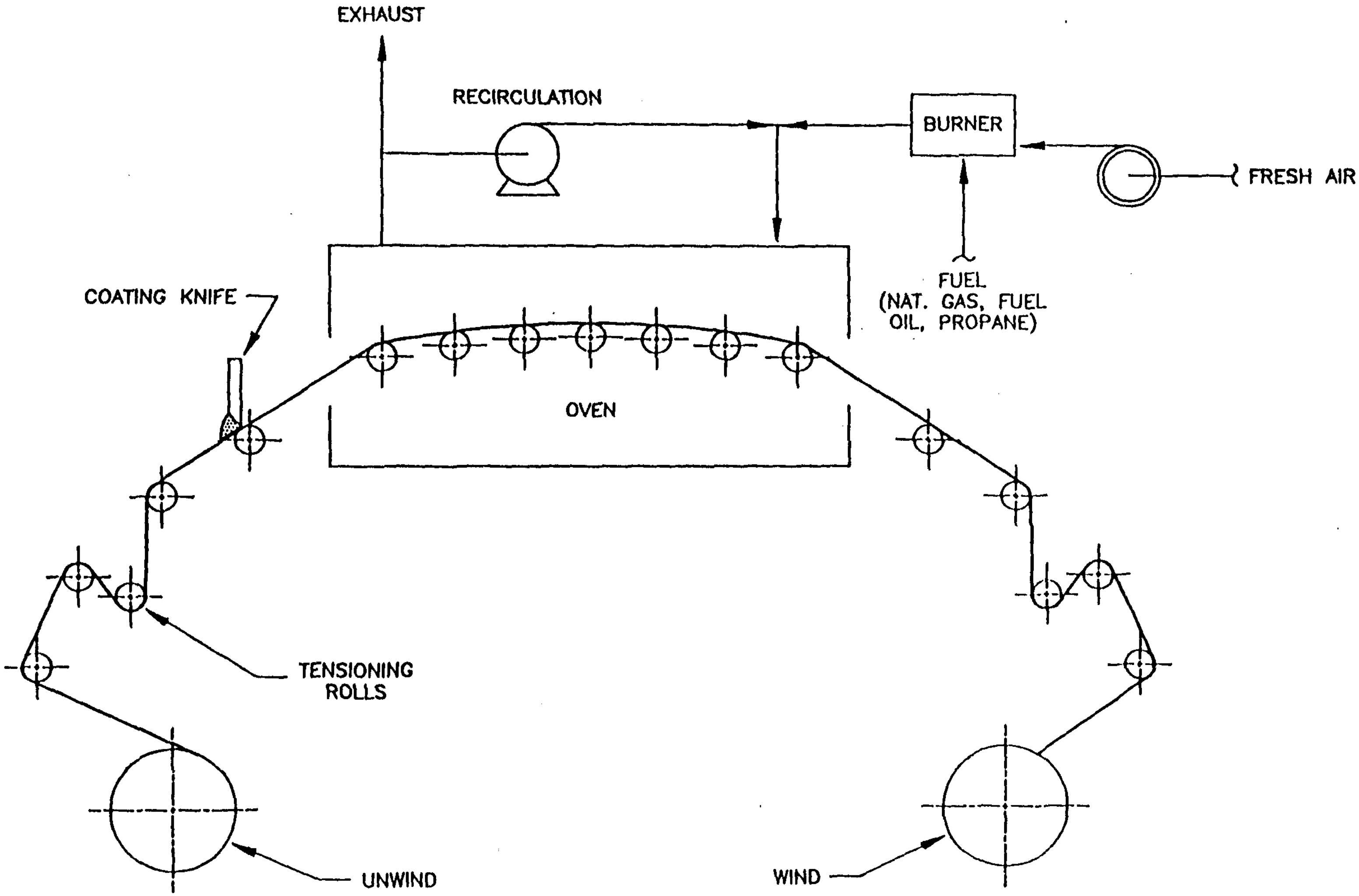

Figure 2-16. Coating Line with Exhaust Recirculation.[11]

When coating and all custom conversion is finished, the product rolls are ready for shipment. Finished products are wound on cardboard cores with plastic caps inserted into the ends of the roll to prevent damage to the edges of the product. The rolls are then placed in containers (*e.g.*, cardboard boxes) for shipment. Large rolls which have not been cut and sized are shipped in open rolls with wood-end caps, and metal straps around the rolls for support.

2.5 SPECIFIC PRODUCTION PROCESSES

2.5.1 Introduction

The following section provides process descriptions specific to certain manufactured products. The actual process descriptions include some of the fundamental processes described in Section 2.4. The production processes described in this section will deal specifically with paper tape, film tape, duct tape, reinforced tape, and labels.

2.5.2 Paper Tape Manufacturing

The manufacture of paper tape involves three basic coating steps: saturation, release coating, and adhesive coating. Coloring and priming may be used in specific applications. In some cases, facilities may purchase saturated paper webs, thus eliminating the saturation step. Facilities choosing to saturate their own webs most frequently use the dip and squeeze method. The paper web is placed on an unwinder and is threaded through the coating line. The web passes through the saturant trough, is squeezed to remove any excess saturant, and is then sent to a drying oven.

Once the paper is saturated, and colored and/or primed, the release coat is applied to the non-bonding surface of the substrate (*i.e.*, the side that will not receive the adhesive coating). Application rollers (direct or gravure) are normally used to apply the release coat to the top side of the substrate. Additional rollers maintain the tension of the paper to ensure an even coating. A doctor blade or knife may be used to remove any excess coating which is fed back to the coating bath for reuse. The release coating bath is often fed from a small line tank which, in turn, is fed from a larger tank in a mixing area. Once release-coated, the tape will pass through a drying oven. The saturated and release-coated paper is then either wound and physically moved to the next coating step (*i.e.*, adhesive coating) or it continues processing on the same coating line.

The adhesive coating is applied to the bottom or non-release coated side of the paper. A doctor blade may also be used to remove excess adhesive and return it to the adhesive bath. The adhesive is fed by a line tank or directly from a large mixing tank. The adhesive coated paper passes through another set of dryers. The product is then wound, followed by slitting, packaging, and shipping. Figure 2-17 is a paper tape manufacturing process flow diagram.

2.5.3 Film Tape Manufacturing

The coating of film substrates is nearly identical to paper coating, with a primer, or tie-coat, replacing the saturant coating step prior to the adhesive coating. The film web, which may be polypropylene, vinyl, polyvinyl chloride (PVC), polyester, acetate, or cellophane, is coated with the primer, which is a thin layer of a high tack polymer material, to improve the bond between the adhesive and the film.

2.5.4 Duct Tape Manufacturing

Duct tape is manufactured in a two stage process. First, a laminated web of cloth and film is prepared. Duct tape adhesive, in solid form, is calendared to the cloth side of this laminated web. In the calendaring process, the web and adhesive are laminated together by a nip roller which contacts the adhesive leaving a very smooth surface. The difference between calendaring and roll coating is that the calendared adhesive is removed cleanly from the roll, while liquid adhesive applied by roll coating actually splits, with some adhesive remaining on the roller. The three layer product is then given a release coating on the film side, slit to width, and wound in rolls of varying length.

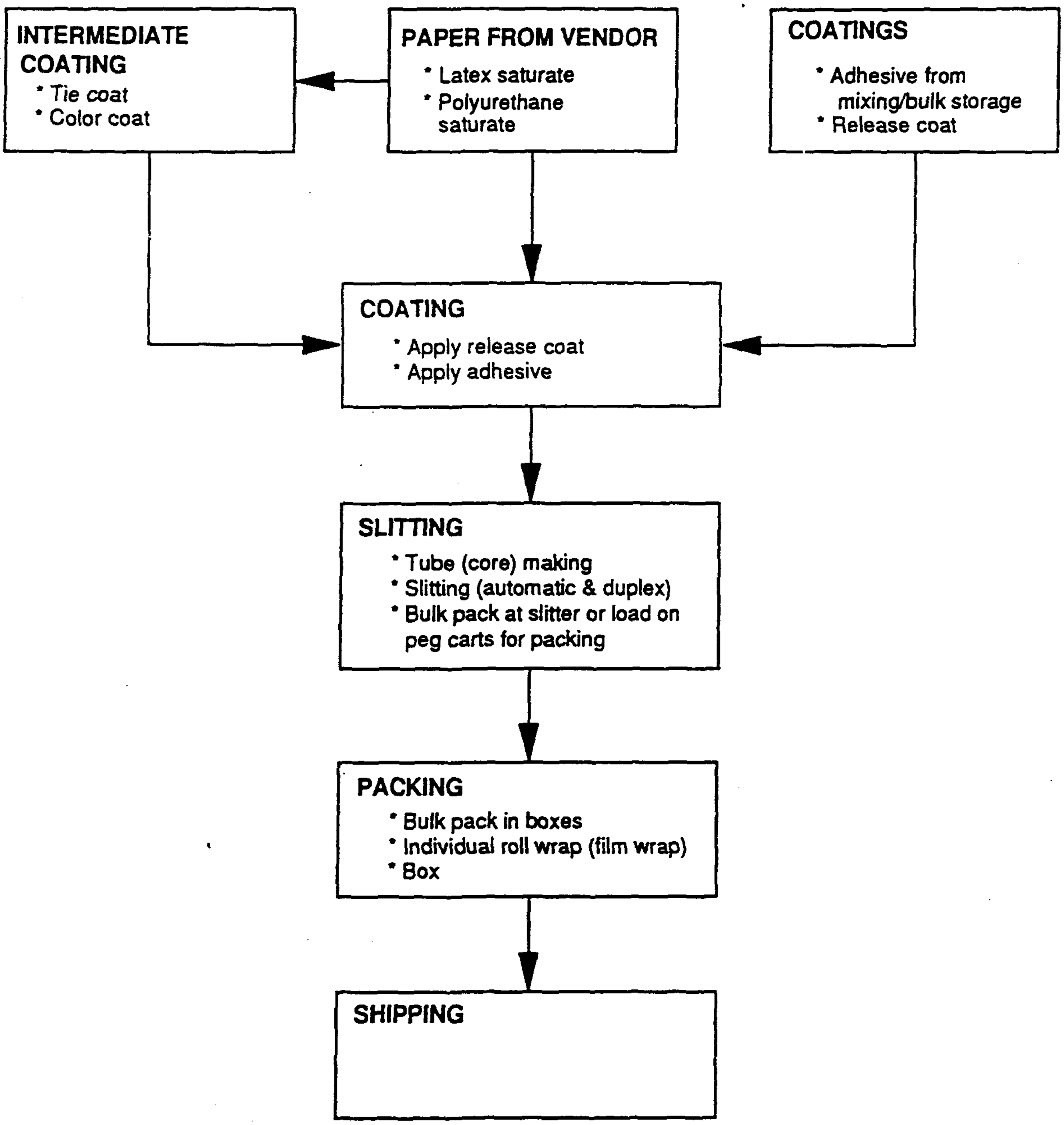

Figure 2-17. Paper Tape Manufacturing Process Flow Diagram.

2.5.5 Reinforced Tape Manufacturing

Reinforced tapes are manufactured in the same manner as film tapes except with an additional step of joining reinforcing fibers to the film backing. The reinforced tape manufacturing process consists of tie, release, and adhesive coatings, and possibly a laminating step. Reinforced tapes consist of a film backing substrate (*e.g.*, polyester, acetate) that has been joined with reinforcing fibers, such as fiberglass. The fiber reinforcers provide superior strength compared to paper or film tape.

The film and reinforcing fibers are threaded through the coating line. The fibers are tie-coated/laminated to the film. The film substrate has the release coat applied on the opposite side of the tie-coat. Several rollers are used to maintain the tension of the substrate during this process. A doctor blade may be used to return any excess release coating to the coating bath. The substrate is then passed through a set of dryers and rewound. The release-coated substrate is then threaded through the adhesive coating system. The adhesive coat is applied over the reinforcing threads. Any excess adhesive may be returned to the coating bath by a doctor blade. The product is then passed through another set of dryers. The finished product is then wound, followed by slitting, packaging, and shipping.

2.5.6 Label Stock Manufacturing

Label stock manufacturing is also similar to paper tape manufacturing. The two rolls of paper that are typically used in the label making process include a release liner (the label backing) and the face stock (the label itself). A release liner is formed by applying a release coating to the saturated paper. This release coating is often a mixture of silicone and solvents. The substrate coated with the release coating is then dried in an oven and rewound. The release-lined substrate is placed on a coater-laminator machine. The silicone-coated surface is coated with an adhesive then dried in a oven. As the coated paper comes from the oven, it is laminated by pressure rollers with the label face stock creating a three-layer lamination (face stock, adhesive, and release liner). Once laminated, the coated paper is slit. Slitting machines cut the paper into particular sizes as a finished product or for further processing. If the slit laminate is to be printed, it is sent to a printing press where it may be die-cut, perforated, and/or printed. The labels are then rolled or fan-folded into sheets and boxed for storage and shipping.

2.6 CLEANING REQUIREMENTS

2.6.1 Introduction

The equipment used in the manufacture of adhesive paper products is cleaned to prevent coating contamination, ensure product performance, maintain equipment operations, and reduce waste buildup. Cleaning materials attack and break the bond between the adhesive and the metal (or other surface) being cleaned. The total quantity of cleaning material used depends on several variables including cleaning frequency; desired level of cleanliness; size, shape, and composition of part to be cleaned; and soil to be removed.

2.6.2 Cleaning Frequency and Desired Level of Cleanliness

Facilities typically clean on an "as-needed" basis, rather than on a set schedule. As-needed often means upon product changeover or during equipment shutdowns. However, as-needed cleaning is also performed when substrate webs break, spilling wet coating material on equipment surfaces, when coatings splash from troughs, and when excess coating seeps from behind dams and splash guards.

The frequency of cleaning during product changeovers varies depending on the type of facility. As discussed previously, the industry may be divided into two groups: "dedicated line" facilities and "batch processing" operations. Dedicated line facilities operate lines dedicated to one type of product (*e.g.*, grades of masking tape or label stock), while batch processors manufacture a wide range of products using a number of different substrates and coatings. Batch processors include facilities that manufacture and market a line of products, and those which provide contract coating services. The latter are known as toll coaters. Dedicated line facilities may run their lines up to 24 hours per day, 7 days per week, and 52 weeks per year. Production runs are typically scheduled with compatible batches in sequence. When a product change is about to occur, the production operator will add only enough coating to the application troughs to coat the length of substrate remaining on the substrate web. This allows the substrate web and the coating to be exhausted at approximately the same time. As the first web finishes, the second web is threaded and the new coating formulation is added to the application trough. A similar technique is used just prior to a shutdown, with the equipment allowed to "run dry."

If such "on-the-fly" changeovers are not possible, excess coating is drained from the application pans and coating lines back into storage drums and is retained for future use, and the equipment is cleaned prior to start-up of the next job. Although some product contamination occurs with either process changeover scenario, the substrate coated with the mixed coatings is the last portion of the first roll or the first part of the succeeding web. In either case, this portion of the web, the "makeready" substrate, can be discarded if it is not suitable for use. Makeready is generated regardless of substrate and coating. Product changeovers in a dedicated line facility generally occur no more often than one time per day. In many cases, major product changeovers occur once per week (following a designated shutdown period during which coating line equipment undergoes thorough cleaning and preventive maintenance.)

In contrast, batch processors generally do not clean equipment on any specific schedule. Due to the relatively short production runs and the custom nature of the specialty products that these facilities manufacture the desired level of cleanliness between jobs is critical. Therefore, at the end of each job, all application equipment is thoroughly cleaned in the manner described for dedicated lines. Batch processors are likely to use the solvents toluene and MEK because a high level of cleaning is required. Alternative cleaners, such as mineral spirits (which may be used by dedicated line facilities for some cleaning applications), are often described by batch processors as achieving "inadequate" cleaning results. Product changeovers in batch facilities may occur as frequently as every one to two hours. Seldom do batch processors run a job longer than one eight-hour shift.

2.6.3 Construction of Part to be Cleaned

The effort required to achieve the desired level of cleanliness is often dependent on the construction of the part to be cleaned. While many small parts (*e.g.*, portions of pipe, or valves) can be removed from the equipment line for thorough cleaning, other pieces of equipment (*e.g.*, ovens and coating application rollers, coating application pans) must be cleaned in place. When components of these larger pieces of equipment are removed from the coating line, they are typically cleaned in centralized cleaning areas in parts washers specifically designed to handle them. Another cleaning apparatus used in some centralized cleaning rooms is an ultrasonic cleaner.

Another illustration of the effect that equipment design can have on cleaning is the material used to construct the application cylinder. Some application rollers are made of rubber rather than carbon steel. Cleaning rubber rollers with a solvent such as toluene or MEK accelerates deterioration of the roller. Therefore, equipment of this nature is often cleaned with a caustic-based cleaning solution.

2.6.4 Soil to be Removed

The soil to be removed from the equipment or part also influences the cleaning method. The solvents required to clean equipment in coating and laminating facilities are, in large part, determined by the resin in the coating formulations. For example, adhesives often stick to application rollers, equipment housings, or transfer pipes. Typically, facilities using solvent-based coatings use the primary vehicle solvent in the coating formulation for cleaning purposes. For instance, if an adhesive is formulated with butyl acetate, butyl acetate would be used to clean the adhesive coating line. If the formulation solvent is not used for cleaning, then another solvent with strong cutting power is used. Toluene and MEK are solvents frequently used because of their strong cutting power.

Waterbased coatings are often easier to clean, as the incorporated resin will dissolve in water. Cleanup of waterbased materials often involves an equipment wipe with a wet rag. Sometimes the cleanup solution will consist of water mixed with an alcohol, like isopropyl alcohol (IPA). The addition of an alcohol results in added "cutting" power for waterbased coatings.

2.7 CURRENT CLEANING TECHNIQUES

This section discusses some of the common cleaning needs and methods of specific pieces of equipment such as ovens, reservoirs, troughs, hoses and dams.

2.7.1 Specific Equipment Cleaning Requirements

2.7.1.1 Ovens

Because ovens are enclosed systems, full cleaning is done during equipment shutdowns, although exterior surfaces may be cleaned during or between production runs. Oven cleaning is necessary because the ovens are used to volatilize the coating solvent and dry the substrate to a specific weight. Consequently, some of the solvent and coating mix and become trapped either as gel or cured adhesive in the oven screens and hoods. If the ovens are not routinely cleaned, the oven screens will become clogged, thereby decreasing the efficiency of drying or curing.

2.7.1.2 Reservoirs

Reservoirs are bins located under the application rollers, that are used to supply the coatings for application purposes. Slashes and breaks in the substrate web result in contamination of the reservoirs and the area around the reservoir. Because these bins act as a catch basin for excess coating, they often become encrusted and require cleaning.

2.7.1.3 Troughs

Troughs are bins which catch any overflow from the reservoirs. Some facilities use the troughs as a holding basin for cleaning solvents. These facilities like the easy access to solvents which encourages workers to clean the immediate area more thoroughly when splashes occur. Moreover, when a coating overflow from the reservoir occurs, the solvent in the trough aided in cleanup.

2.7.1.4 Pumps, Lines, and Hoses

Pumps, lines, and hoses transfer coatings from mixing tanks, holding tanks, and other temporary storage areas to process lines. Coatings that stick to the exterior surfaces of these pieces of equipment are removed with mechanical scraping and solvent-soaked rags. One facility using waterbased adhesives uses plastic vinyl chloride (PVC) pipes to transfer the coating from the mixing tanks to the production lines. When these pipes become clogged, they are replaced rather than cleaned. The facility has not replaced their pipes in approximately three years.

2.7.1.5 Dams

Both overflow containers around reservoirs and flat metal sheets on the end of rollers are considered dams, which prevent coatings from splashing over the side of the machinery. The dams are cleaned during shutdown with rags soaked with the cleaning solvent.

2.7.1.6 Miscellaneous

Miscellaneous cleaning includes the cleaning of product and raw material storage tanks, process lines, and floors. Generally, storage tanks and process lines in dedicated line facilities are limited to one type of material and, therefore, do not require cleaning. When the lines are not in use, some facilities fill (pack) them with solvent to prevent coating in the lines and tanks from solidifying. Floors are often mopped using equipment cleaning solvent. Other facilities use scrap cardboard or off-specification substrate sheets to protect the floor and reduce the amount of mopping. As the floor coverings are torn and become unprotective, they are disposed of as either solid or hazardous waste and are replaced.

2.7.2 Cleaning Techniques

2.7.2.1 Run Dry

Running a line dry is an operating technique, occurring at the end of a production run, that involves adding only enough coating to the application troughs to coat the length of substrate remaining on the web.[7] This process technique reduces coating waste and thus, coating cleanup. Running dry reduces the requirement to remove gross amounts of coating from reservoirs prior to cleaning, results in less adhesive remaining on the coating apparatus, and reduces the amount of cleaning solvent required.

2.7.2.2 Mechanical Scraping

Mechanical scraping involves the use of a putty knife or other straight-edged instruments to physically remove the coating by scraping it from the part surface. Mechanical scraping is of greatest benefit when performed before the coating has time to settle and harden. Many facilities follow mechanical scraping with a solvent wipe. Care must be taken when scraping equipment to avoid damaging surfaces that meter or apply coatings.

2.7.2.3 Solvent Wiping

Solvent wiping is the most commonly used cleaning technique within the coated and laminated substrate industry. It is primarily used in conjunction with mechanical scraping to remove coating residue. A rag is moistened with a cleaning solvent and used to wipe the coating from the part. Facilities often maintain safety cans of solvent with both rags and a scraper next to the machinery for immediate access by the operators to wipe away the coating when a splash occurs. Solvent wiping is a major source of fugitive emissions.

2.7.2.4 Immersion

Immersion involves the "bathing" of products in a solution to remove coating residue. Immersion techniques are most commonly used in centralized parts cleaning areas. A number of different cleaning materials are used in immersion parts washers including toluene, MEK, mineral spirits, aqueous cleaners, and custom blends. Some facilities scrape parts prior to immersion in the baths. This technique removes as much coating as possible before bathing in the solvent bath, helping to increase the useful life of the solvent in the bath by reducing the amount of coating contamination. Some facilities use the spent solvent from the immersion bath as makeup solvent for their coating process. This practice is especially prevalent when the primary vehicle solvent is used as the immersion bath.

2.7.2.5 Other

Other cleaning techniques identified were the use of high pressure water sprayers and coating machinery surfaces with disposable wraps or impregnated metal powders. One facility uses high pressure water washes for yearly cleaning of the floors, storage tanks, and equipment parts. A solution of high pressure water (12,000 psi), heptane, isopropyl alcohol, and salts is used to clean dry adhesives from these areas. This process results in a hazardous waste stream with a low Btu value, and consequently a high disposal cost. Due to the high cost of this service ($800 a day) and the costly disposal of the water as hazardous waste, this process is due to be discontinued. One facility coated the machinery with non-useable paper or aluminum foil which reduced the need for chemicals for cleanup and cleanup time, but increased the cost of solid hazardous waste disposal.[7] Other facilities use porous, flame-coated metal powders, which are then impregnated with release chemicals, to prevent adhesive from adhering to machine surfaces. This technique is discussed in Chapter 4.

2.8 PROPERTIES OF CURRENT CLEANING SOLVENTS

2.8.1 Introduction

Some cleaning materials are used more frequently than others. This section describes the properties of some of the currently used cleaning solvents. The materials discussed include toluene, mineral spirits, methyl chloroform, MEK, and xylene.

2.8.2 Toluene

Toluene is a man-made aromatic hydrocarbon produced from petroleum. Toluene is used as a raw material in several types of coatings including paints, inks, pharmaceuticals, and adhesives. The chemical formula for toluene is $C_6H_5CH_3$. Toluene is not corrosive and will not react with either bases or dilute acids. It has been estimated that 86 percent of all toluene used is released to the biosphere where its life span ranges from 4 days, at high-altitudes during the summer, to several months, in low-altitudes during winter months.[12] Table 2-5 lists the physical and chemical properties of toluene. Toluene is a chemical included in EPA's 33/50 Program.

TABLE 2-5. PHYSICAL AND CHEMICAL PROPERTIES OF TOLUENE

Property	Value
Chemical name	Toluene
Synonyms	Methylbenzene; toluol; phenylmethane; methacide; methylbenzol
Molecular formula	$C_6H_5CH_3$
CAS Registry	108-88-3
Molecular weight	92.14
Melting point	-95 to -94.5°C (-139 to -138.1°F)
Boiling point (760 mm Hg)	110.63°C (231.13°F)
Density, g/cm^3	
at 25°C (77°F)	0.8623
at 20°C (68°F)	0.8667
Physical state (ambient conditions)	Liquid
Color	Clear
Odor	Benzene-like
Solubility:	
Water at 20°C (68°F)	Very slightly soluble (0.05 g/100 mL)
Vapor pressure at 20°C (68°F)	21.9 mm Hg (2.92 kPa)

Source: Reference 12

2.8.3 Mineral Spirits

Most coated and laminated substrate manufacturers that use mineral spirits for cleaning use Varsol. Varsol is a branded petroleum solvent blend manufactured by Exxon Company, USA. It is a clear liquid with a mild mineral spirits odor. Varsol 18, one of the varieties of Varsol, contains approximately 92 percent saturated hydrocarbons (*e.g.*, hexane and heptane), and toluene, xylene, ethylbenzene, and an aromatic mixture for a combined concentration of 7.1 percent. Table 2-6 summarizes the physical properties of Varsol.[13]

TABLE 2-6. PHYSICAL PROPERTIES OF VARSOL

Property	Value
Chemical name	Petroleum solvent blend
Molecular Weight	145
pH	Essentially neutral
Melting Point	<-18°C (0°F)
Boiling Range (760 mm Hg)	153-202°C (308-396°F)
Specific Gravity (15.6°C/15.6°C)	0.78
Physical State Color Odor	Liquid Clear Mineral Spirits
Solubility: Water at 25°C (77°F)	 Negligible: less than 0.1%
Vapor Pressure at 25°C (77°F)	<10 mm Hg (< 1.3 kPa)
Percent Volatile by Volume at 1 atm and 25°C (77°F)	100
Evaporation Rate @ 1 atm. and 25°C (77°F) (n-butyl Acetate = 1)	0.1

Source: Reference 13

2.8.4 Methyl Chloroform

Methyl chloroform or 1,1,1-trichloroethane (TCA) is a man-made chlorinated solvent which is predominantly used in cold cleaning operations and vapor degreasing. Methyl chloroform's use in adhesives accounts for 10 percent of its total use.[14] Methyl chloroform in the atmosphere has a half-life of approximately 6 months to 25 years.[14] Though not all methyl chloroform travels to the stratosphere, that which does contributes to the depletion of the stratospheric ozone layer. It is responsible for approximately 16 percent of the ozone-destroying chlorine in the stratosphere from anthropogenic sources. Table 2-7 provides physical and chemical properties of methyl chloroform.[14] Methyl chloroform is a 33/50 Program chemical.

Consumption and production of methyl chloroform will decline as a result of the implementation of the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer and Title VI of the 1990 Clean Air Act Amendments (CAAA).[15] Under both of these provisions,

TABLE 2-7. PHYSICAL AND CHEMICAL PROPERTIES OF METHYL CHLOROFORM

Property	Value
Chemical name	Methyl Chloroform
Synonyms	1,1,1-trichloroethane; ethylidine chloride; *methyltrichloromethane*; *trielene*; algylen; trichloromethylmethane; chloroethane; inhibisol; trichloran; gemalgene; TCA; TCEA; aerothene; α- Trichloroethane; 1,1,1-TCE; 1,1,1-Tri; trichloroethane
Molecular formula	$C_2H_3Cl_3$
CAS Registry	71-55-6
Molecular weight	133.42
Melting point	-30.4°C (-22.7°F)
Boiling point (760 mm Hg)	74.1°C (165.4°F)
Density, g/cm^3	
at 25°C (77°F)	1.136
at 20°C (68°F)	1.324
Physical state (ambient conditions)	Liquid
Color	Clear
Solubility::	
Water at 20°C (68°F)	Insoluble (0.095 g in 100 g water) 0.034 g (water in 100 g methyl chloroform
Vapor pressure at 20°C (68°F)	99.8 mm Hg (13.3 kPa)

Source: Reference 14

methyl chloroform is classified as a controlled substance scheduled for phase-out within the next ten years (*i.e.*, 2005 under the 1990 Revision of the Montreal Protocol and 2002 under the 1990 CAAA).[16,17] However, the U.S. has pledged to stop methyl chloroform production by December 31, 1995. In addition, in November 1992, 87 nations agreed to accelerate the Montreal Protocol schedule and phase out methyl chloroform by the beginning of 1996.[18]

2.8.5 Methyl Ethyl Ketone (MEK)

MEK or 2-butanone is a colorless organic liquid with an acetone-like odor and a low boiling point. MEK, which is highly reactive, has exceptional solvency and a short atmospheric lifetime (approximately eleven hours.)[19] Table 2-8 provides physical and chemical properties of MEK. MEK is another 33/50 Program chemical.

TABLE 2-8. PHYSICAL AND CHEMICAL PROPERTIES OF METHYL ETHYL KETONE

Property	Value
Chemical name	Methyl Ethyl Ketone
Synonyms	2-butanone, ethyl methyl ketone, MEK, methyl acetone
Molecular formula	C_4H_8O
CAS registry number	78-93-3
Molecular weight	72.1
Melting point	-86.3°C (123.3°F)
Boiling point	79.6°C (175.3°F)
Density at 20°C, g/cm^3	0.8045
Physical State (ambient conditions) Color Odor	Liquid Clear Sweet
Solubility: Water at 90°C (194°F)	190 g/L
Vapor pressure at 20°C (68°F)	77.5 mm Hg (10.3 kPa)

Source: Reference 19

2.8.6 Xylene

Xylene is an aromatic hydrocarbon that occurs naturally in petroleum and coal tar. Xylene is a colorless liquid with a sweet odor and is volatile, flammable, and explosive in air. Xylene is not soluble in water, but is soluble in alcohol and many organic liquids. There are three xylene isomers ortho-xylene (o-xylene), meta-xylene (m-xylene), and para-xylene (p-xylene). Mixed isomers are a mixture of two or more xylene isomers and a small amount of ethylbenzene. Xylenes can be transformed by photo-oxidation in the troposphere, and can participate in the formation of ground-level ozone.[20] Table 2-9 lists some physical and chemical properties for mixed xylene. Xylene is also a 33/50 Program chemical.

TABLE 2-9. PHYSICAL AND CHEMICAL PROPERTIES OF MIXED XYLENES

Property	Value
Chemical name	Xylene isomers
Synonyms	dimethylbenzene xylol methyl toluene
Molecular formula	$C_6H_4(CH_3)_2$
CAS Registry	1330-20-7
Molecular weight	106.16
Melting point	No data
Boiling point (760 mm Hg)	137° to 144°C
Density, g/cm^3 at 20°C (68°F)	0.860
Physical state Color Odor	Liquid Clear Benzene-like
Solubility: Water at 25°C (77°F)	0.013 g/100 l
	Miscible with absolute alcohol, ether, and other organic liquids
Vapor pressure at 20°C (68°F)	6.15 mm Hg (0.82 kPa)

Source: Reference 20

2.8.7 Other

Three other products currently used in equipment cleaning operations at coated and laminated substrate facilities are perchloroethylene, heptane, and isopropyl alcohol. In some facilities perchloroethylene and heptane are used in adhesive cleaning and isopropyl alcohol (IPA) is used to clean the press plates. Approximately seven percent of total perchloroethylene output is dedicated to metal cleaning and degreasing.[21,22] Table 2-10 lists several physical and chemical properties of perchloroethylene.

TABLE 2-10. PHYSICAL PROPERTIES OF PERCHLOROETHYLENE

Property	Value
Chemical name	Perchloroethylene
Molecular formula	C_2Cl_4
Molecular weight	165.83
Melting point	-22.4°C (8.32°F)
Boiling point	121.2°C (250.2°F)
Physical state (ambient conditions) Color	Liquid Clear
Vapor pressure at 20°C (68°F)	14 mm Hg (1.87 kPa)
Specific gravity at 20°C (68°F)	1.623

Source: Reference 21

Heptane is a hydrocarbon solvent made from petroleum products. Table 2-11 provides several physical and chemical properties of research grade heptane.

TABLE 2-11. PHYSICAL PROPERTIES OF HEPTANE

Property	Value
Freezing point	-131.10°F
Boiling point	209.17°F
Specific gravity	0.6882 @ 60°F
Vapor Pressure	1.62 psia @ 100°F

Source: Reference 22

Isopropyl alcohol may be used to clean small amounts of adhesive from application, metering, and tensioning rollers. Isopropyl alcohol is a colorless, flammable, mobile liquid. Table 2-12 list several physical and chemical properties of isopropyl alcohol.

TABLE 2-12. PHYSICAL PROPERTIES OF ISOPROPYL ALCOHOL

Property	Value
Chemical name	Isopropyl alcohol
Molecular weight	60.09
Melting point	-89.5°C (129.1°F)
Boiling point (760 mm Hg)	82.5°C (180.5°F)
Specific gravity at 20°C (68°F)	0.7855
Physical state	Liquid
Color	Clear

Source: Reference 21, 23

2.9 CHARACTERIZATION OF POLLUTION RESULTING FROM CURRENT PRACTICES

2.9.1 Air Emissions

In 1990, the total of all MEK releases to the air by facilities operating under SIC 2671 was 1.1 million pounds.[24] Toluene air releases totalled 8 million pounds.[24] SIC 2672 facilities emitted nearly 15 million pounds of MEK and 18 million pounds of toluene.[24] Facilities contributing to these releases are listed in Appendix B, Table B-1 and Table B-2. Most coated and laminated substrate manufacturing facilities calculate these emissions based on raw material consumption. Therefore, total emissions reflect solvent losses occurring during raw material mixing, coating processing (including fugitive releases), equipment cleaning, and material storage.

Some industry representatives estimate that ten percent of total solvent releases are due to equipment cleaning. This percentage represents the greatest source of fugitive emissions from coated and laminated substrate manufacturing. These emissions are difficult to control with add-on devices, so some facilities are attempting to find alternative cleaning products and methods. Depending upon the cleaning chemicals used (*e.g.*, toluene, methyl chloroform, mineral spirits), VOCs or toxic pollutants may be emitted.

The primary impacts of VOC reductions are dependent on the facility location. In heavily industrialized areas, the reduction of VOC emissions may produce a corresponding reduction in ambient hydrocarbon levels, and thus a reduction in ozone formation. In rural areas, lower VOC emissions will result in lower overall ambient hydrocarbon levels, helping to reduce the transport of ozone precursors to urban areas. Many air toxics are also VOCs. Therefore, the reduction of the toxics will result in benefits similar to those achieved with VOC reduction. In addition, the reduction of air toxics will lead to reduced environmental impacts on other media. For example, improperly handled chlorinated materials (*e.g.*, methyl chloroform) often result in contaminated soil and groundwater. Reducing the quantities of these materials used for cleaning will reduce contaminated aquifers, drinking water wells, and soils.

Emissions from the application of solvent-based coatings are often directed to a control device (*e.g.* carbon absorption, catalytic or thermal incinerators). While such control devices reduce VOC emissions, the use of incineration will actually increase ambient levels of carbon monoxides (CO) and nitrogen oxides (NO_x) in the area.

2.9.2 Liquid Waste Streams

Spent cleaning solvents are the largest liquid waste produced by coated and laminated substrate manufacturers. Many of these solvents are recoverable through distillation and can be incorporated in a coating, however they may also be sent off-site for disposal. A second liquid waste stream consists of excess or off-specification coating.

Another source of liquid wastes may be the control equipment. Facilities using carbon adsorption systems (usually associated with controls on dryers or ovens) have the potential to discharge contaminated water from the steam used to desorb the carbon beds. Facilities typically have three options for disposing of this waste: (1) use the water for boiler feed; (2) use the water for cooling tower purposes; or (3) discharge the water into a wastewater treatment facility or local sewer for further treatment.

Facilities are responsible for the environmental impacts their water may have on a sewer or water system. A facility must always consider the effects of a new liquid waste stream on plant wastewater treatment (WWT) operations or on the Publicly Owned Treatment Works (POTW). Some cleaners may reduce toxicity, hazardous waste, and air emissions, but create excursions in effluent limitations.

2.9.3 Solid Wastes

Solid wastes from the manufacturing operations may be classified into three areas: cleaning waste, waste substrate, and solidified coating waste. Solid waste from cleaning includes items such as rags, floor coverings, machinery coverings, and coating filters. The disposal of waste substrate (from the edge of paper rolls, at the beginning and ending of a run, and from cutting and packaging operations) is dependent on local/state regulations. The characteristics of the solvent on the paper affect its classification as solid waste.

In addition, solid waste may be created by emissions control equipment. Activated carbon from carbon adsorption systems must be replaced periodically, presenting a solid waste disposal problem. The remains from incineration or catalytic oxidation must be disposed of as solid waste. The carbon may be able to be re-used for fuel or recycling for other uses. Waste from incineration or oxidation may also have alternative uses.

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CHAPTER 3
QUESTIONNAIRE RESULTS

3.1 GENERAL

A questionnaire is frequently used to obtain industrial process information that cannot be gathered through literature searches. With the exception of actual facility visits, questionnaire distribution is often the best method for gathering specific facility data. Questionnaire distribution may either be via paper or disk mail-outs. Limited information gathering may also be conducted by telephone contacts. It is important to conduct a preliminary phone or mail questionnaire prior to facility site visits to help identify willing participants, to obtain general knowledge of facility products and processes, and to inform industrial personnel of EPA's project objectives. As discussed in Chapter 1, the responses to several targeted questionnaires provided much of the background for the *Improved Equipment Cleaning for Coated and Laminated Substrate Manufacturing Facilities* research project. Preliminary questionnaire development began under a previous EPA effort. Initially, the questionnaire was to be conducted by phone. However, because of the quantity of information required, two separate mail-out questionnaires were developed. The poor response rate led to the development of revised questionnaires which were mailed and then followed by phone contacts. This chapter summarizes questionnaire development and industry responses. The last section in this chapter identifies pollution prevention trends within the industry, as identified through responses to questionnaire efforts.

3.2 DESCRIPTION OF ORIGINAL QUESTIONNAIRE

The initial project plan, under a previous EPA effort, included the development of a brief telephone questionnaire to be used to prepare a cursory industry characterization and to select potential demonstration sites for Phase II activities. Because of the number of industry unknowns, including the variety of industrial processes, products, cleaning technologies, and associated emissions, a more thorough written questionnaire was developed. This questionnaire requested information on product type and manufacturing capacity, processes and coatings, equipment cleaning techniques, solvent consumption and recycling, and pollution prevention research efforts. Prior to the distribution of this questionnaire, it was reviewed by several industry and trade association personnel including representatives of Anchor Continental and Shuford Mills.

The original 14 recipients of the two written questionnaires, were identified through a search of the TRIS database and through leads obtained from members of the October 1991 Industry Focus Group.[1] Separate questionnaires were prepared for manufacturers operating under SIC 2672 and SIC 2641. Prior to distribution of the questionnaire by mail, each anticipated recipient was contacted by phone to assess willingness to cooperate in the questionnaire effort. Of the approximately fourteen questionnaires mailed, only four industries responded. Many of the non-respondents indicated that confidentiality was a concern. They believed that answering the questions would lead to the disclosure of confidential business information (CBI).

Facilities not responding to the initial questionnaire received follow-up phone calls. Although some of these calls were met with persistent industry reluctance to participate, some calls did result in the retrieval of valuable information. Several facilities did agree to host site visits and to consider continued participation as a demonstration site.

3.3 DESCRIPTION OF REVISED QUESTIONNAIRE

In an effort to receive input from a wider and more representative industry cross-section, a revised questionnaire was developed. The revised questionnaire tables were adapted from the initial questionnaire to include clarification of processes, products, and associated cleaning methods. The final questionnaire consisted of ten tables addressing the cleaning issues for each of four primary coating operations. Two tables (*i.e.*, one for process characteristics and a second for equipment cleaning techniques) were developed for each of the four coating processes (*i.e.*, adhesive, saturant, release, and other). Two additional tables summarized facility location, product line, and general pollution prevention research activity information.

An extensive list of facilities and potential questionnaire respondents operating within the SICs 2641, 2671, and 2672 was compiled. Facility names, addresses, phone numbers, and contacts were extracted from *Ward's Business Directory*, *Dun & Bradstreet Million Dollar Directory*, *Air Toxics & VOCs*, and *North Carolina Manufacturing Firms Directory*.[2,3,4,5] Facilities that agreed to review the questionnaire were sent a copy either by mail or by fax to ensure that the contact would have sufficient time to become acquainted with the questions asked and gather any specific data. A phone appointment to review and complete the tables was established with the facility contact. Several additional questions not amenable to the table format were also asked during the phone interview.

Approximately 51 facilities were contacted by phone to assess their interest in participating in the questionnaire effort or in hosting a site visit. These contacts included the 14 facilities that had already received the initial questionnaire. Over half of the facilities contacted were small, label printing operations claiming a variety of SICs. None of these small facilities were willing to complete the questionnaire or host a site visit. Within the timeframe allowed for this task, nine companies completed the questionnaire for ten facilities. (One company responded for two of its facilities.)

3.4 FINAL QUESTIONNAIRE SUMMARY AND CONCLUSIONS

The final questionnaire was developed to show the relationship between products, manufacturing processes, waste generation, and cleaning technologies. Responses are summarized according to the four primary coating application processes: saturation, release coating, adhesive application, and other processes. The results are discussed in the remainder of this chapter and summarized in Tables 3-1 through 3-4. These tables use the same format as those used to collect the data.

Table 3-1 provides an overview of the nine companies (and ten plants) that responded to the questionnaire. Facility size is represented by either number of employees or by square yards of product manufactured. A uniform parameter to characterize size was not possible as many of the facilities considered either number of employees or production volume confidential.

Table 3-2 identifies the manufacturing processes of each of the questionnaire respondents. Table 3-2 is organized by process (*i.e.*, saturation, release coating, adhesive application, and other processes) and by facility. Line numbers are indicated under the company name. A facility operating three lines using exactly the same process and equipment will have the number three. If the facility operates three lines with slightly different parameters, the line numbers will be listed individually (*i.e.*, 1, 2, 3). The Table 3-2 headings include coating technology, coating method, resin type, percent resin, carrier type, solvent percent solvent, solvent quantity, and

TABLE 3-1. QUESTIONNAIRE RESPONDENT PROFILES

Company	Product	SIC	Size
Plant A	Consumer and Painting Tapes	2672	12-100 million yd^2
Plant B Plant C	Printing and Drafting Films Drafting and Reproduction Films	2672	10 million yd^2 10 million yd^2
Plant D	Pressure Sensitive Labels	2671	380 Employees
Plant E	Pressure Sensitive Labels, Paper, and Film	2671, 3080, 3081	900 Employees
Plant F	Pressure, Sensitive Tape; Industrial Duct and Masking Tapes	2672	100 Employees
Plant G	Pressure Sensitive Tape for Industrial Applications	2672	75 Employees
Plant H	Pressure Sensitive Films and Screen Inks	2672	50 Employees $10 million in sales
Plant I	Pressure Sensitive Tape	2672	500 Employees
Plant J	Pressure Sensitive Labels	2672	200 to 300 million yd^2

percent solvent recycled. The coating technology category refers to the general coating formulation (*e.g.*, waterbased, solvent-based, two-part reactive, hot melt, or other). Coating method refers to either the method of coating application or the type of application roller. Resin type refers to the type of resin used in the coating formulation, while percent resin indicates the percent solids in the coating formulation. The carrier is the liquid portion of the coating that transfers the solid resin to the substrate. The quantity of solvent present in the coating formulation is represented by the percent solvent category, while the solvent quantity category indicates the volume of solvent used in the formulation during a specified time frame. The last category indicates the quantity of formulation solvent that is recycled on-site. Table 3-3 shows cleaning operations subdivided by the four process categories. Each sub-table describes the cleaning method, frequency, solvent, and waste streams generated/employed by the individual companies. This table is further subdivided according to equipment component. Table 3-4 summarizes the pollution prevention efforts undertaken by each of the questionnaire respondents. It was difficult to obtain every category of data from every respondent because of varying policies.

TABLE 3-2. PROCESS PROFILE

Process/ Company	Capacity	Coating Technology	Coating Method	Resin Type	Percent Resin	Carrier Type	Solvent	Percent Solvent	Solvent Quantity	Percent Solvent Recycled
Saturation										
Plant A		Solvent Water 2 part corrosion inhibitor	Metering bar	Protein latex	5-20	Solvent or Water	IPA	3-5		
Plant C		Solvent	Dip/squeeze	Methyl-styrene and oil	20-100	Solvent	MEK Heptane			0
Plant I										
1		Water	Knife/blade	Styrene-butadiene		Water	None			100
2		Water	Dip/squeeze	Styrene-butadiene		Water	None			100
Release										
Plant A	70 million yd^2									
1		Water	Metering bar							
2		Solvent, 2-part	Metering bar	Vinyl corrosion inhibitor			Toluene, Heptane			
3		Solvent, 2-part	Metering bar	Vinyl corrosion inhibitor			MEK, IPA			
4		Solvent, 2-part, water	Metering bar	Vinyl corrosion inhibitor				0-97	600 gal/wk	0

(Continued)

TABLE 3-2. PROCESS PROFILE (Continued)

Process/ Company	Capacity	Coating Technology	Coating Method	Resin Type	Percent Resin	Carrier Type	Solvent	Percent Solvent	Solvent Quantity	Percent Solvent Recycled
Plant D										
2		Silicone								
1		Water								
Plant F 3 lines		Solvent or water	Knife/blade	Nitrile butadiene and silicone						90-96
Plant I										
1		Water	Knife/blade	Vinyl acetate		Water	None			N/A
2		Water	Applicator roll	Latex		Water	None			N/A
3		Water	Knife	Latex		Water	None			N/A
Plant J	200 to 300 million yd^2	Solvent, 2-part	Gravure	Silicone	2-100	Solvent	Toluene, Xylene, Heptane	50-98	4200 gal/yr	0-90
Adhesive										
Plant A 2 lines	12 million yd^2	Water	Metering bar	Latex	30-60	Water				
Plant B		Solvent	Extrusion die	Acrylics	25-30	Solvent	Toluene MEK		15,000 gal/yr	0
Plant D										
2 lines (1 can convert to H_2O		Solvent	Metering bar	Starch base			Toluene	50-75	2-3 thous gal/yr	50
2 lines		Water	Reverse roll	Acrylics	100		Water			
1 line		Water	Reverse roll	Starch base	100		Water			
1 line		Hot melt	Metering bar	Plastic resin	100					

(Continued)

TABLE 3-2. PROCESS PROFILE (Continued)

Process/ Company	Capacity	Coating Technology	Coating Method	Resin Type	Percent Resin	Carrier Type	Solvent	Percent Solvent	Solvent Quantity	Percent Solvent Recycled
Plant D (con't)										
1 line		Wax coater		Wax petroleum						
1 line		Hot melt								
Plant E	136 million yd^2									
8 lines		Solvent	Knife, rev. roll, gravure	Acrylic rubber, styrene-butadiene, nitrile-butadiene	35-60 avg. = 40	Solvent	Toluene, ethylacetate, hepane, hexane, IPA, xylene	40-65 avg. = 60	5,417 gal/mo	20 reuse or recycle
1 line		Water	3 reverse roll			Water				
4 lines		Solvent or water	Knife, rev. roll, gravure			Solvent or water				
Plant G	49.8 million yd^2						Toluene, MEK		825 gal/mo	
1		Solvent or water	Knife/blade	Acrylic, urethane and others	15-65	Solvent, water or mixed	Acetone, ethylacetate,	35-85		0
2		Solvent or water	Reverse roll	Acrylic, urethane and others	15-65	Solvent, water or mixed	Heptane, hexane	35-85		0
3		Hot melt	Hot melt	Nitrile-butadiene	100		N/A			
4		Solvent or water	Knife/blade	Acrylic, urethane and others	15-65	Solvent, water or mixed	Ethanol	35-85		0

(Continued)

TABLE 3-2. PROCESS PROFILE (Continued)

Process/ Company	Capacity	Coating Technology	Coating Method	Resin Type	Percent Resin	Carrier Type	Solvent	Percent Solvent	Solvent Quantity	Percent Solvent Recycled
Plant H	500 lbs/hr	Solvent	Knife	Acrylic	25-45	Solvent	Ethylacetate toluene	55-75		0
Plant I 4 lines			Reverse roll	Nat. synthetic rubber			Toluene	40, 55-57		
Plant J 2 lines	200 to 300 million yd^2	Solvent or water	Reverse roll, gravure, metering bar	Styrene-butadiene Nitrile-butadiene acrylic	30-60	Solvent or water	Toluene, Heptane	40-70	1320 gal/yr	0-90
Surface Web Coating										
Plant B		Solvent	Metering bar	Acrylics, cellulose, esters	15-30	Solvent	Toluene, MEK, Alcohol			0
Plant C		Solvent	Metering bar	Acrylics, cellulose, esters	20-35	Solvent	Toluene, MEK, Alcohol			90

TABLE 3-3a. SATURATION PROCESS EQUIPMENT CLEANING

Company/Product	Rollers	Troughs	Dams	Floors	Mixing Vessels
Method					
Plant A	Scrub brush, wipe, spray	Scrub brush, wipe, spray	Scrub brush, wipe, spray	Scrub brush, wipe, spray	Scrub brush, wipe, spray
Plant C	Wipe	Dip			Bath
Plant I	Wipe	Wipe	Wipe	Wipe	Wipe
Frequency					
Plant A	Product change	Product change	Product change	Product change	Product change
Plant C	Daily and product change	Daily and product change	Daily and product change	Daily and product change	Daily and product change
Plant I	1/week	1/week	1/week	1/week	1/week
Solvent					
Plant A	Water	Water	Water	Water	Water
Plant C	Heptane, 5 gal/event	Heptane, 5 gal/event	Heptane, 5 gal/event	Heptane, 5 gal/event	Heptane, 5 gal/event
Plant I	Toluene	Toluene	Toluene	Toluene	Toluene
Waste Type					
Plant A	Water 50 gal/wk water	Water 50 gal/wk water	Water 50 gal/wk water	Water 50 gal/wk water	Water 50 gal/wk water
Plant I	Rags	Rags	Rags	Rags	Rags

TABLE 3-3b. RELEASE PROCESS EQUIPMENT CLEANING

Company/ Product	Rollers	Troughs	Dams	Floors	Mixing Vessels
Method					
Plant A	Putty knife, scrub brush, wipe, spray	Putty knife, scrub brush, wipe, spray	Putty knife, scrub brush, wipe, spray	Putty knife, scrub brush, wipe, spray	Putty knife, scrub brush, wipe, spray
Plant D					
Silicone	Solvent run through process	Solvent run through process	Solvent run through process	Solvent run through process	Solvent run through process
Waterbased emulsion	Wipe	Wipe	Wipe	Wipe	Wipe
Plant F	Wipe, scrub brush, putty knife	Wipe, scrub brush, putty knife	Wipe, scrub brush, putty knife	Wipe	Run Dry
Plant J	Wipe, dip, bath, scrub brush	Wipe, dip, bath, scrub brush	Wipe, dip, bath, scrub brush	Wipe, dip, bath, scrub brush	Wipe, dip, bath, scrub brush
Plant I	Wipe	Wipe	Wipe	Wipe	Wipe
Frequency					
Plant A	Product change	Product change	Product change	Product change	Product change
Plant D					
Silicone and Waterbased emulsion	Product change and weekly	Product change and weekly	Product change and weekly	Weekly	Product change and weekly
Plant F	Product Change	Product Change	Product Change	Daily	When empty or product change
Plant I	Product change	Product change	Product change	Product change	Product change
Plant J	Product change and upset conditions	Product change and upset conditions	Product change and upset conditions	Product change and upset conditions	Product change and upset conditions

(Continued)

TABLE 3-3b. RELEASE PROCESS EQUIPMENT CLEANING (Continued)

Company/ Product	Rollers	Troughs	Dams	Floors	Mixing Vessels
Solvent					
Plant A	Toluene	Toluene	Toluene	Toluene	Toluene
Plant D Silicone and Waterbased Emulsion	Citrus based mineral spirits (Previously TCA)	Citrus based mineral spirits (Previously TCA)	Citrus based mineral spirits (Previously TCA)	Citrus based mineral spirits (Previously TCA)	Citrus based mineral spirits (Previously TCA)
Plant F	MEK	MEK	MEK	MEK	MEK
Plant I	Toluene	Toluene	Toluene	Toluene	Toluene
Plant J	Toluene and TCA	Toluene and TCA	Toluene and TCA	Toluene and TCA	Toluene and TCA
Waste Type					
Plant A	Solvent, 600/gal/wk Water, 350 gal/wk				
Plant D Silicone Waterbased emulsion	Spent cleaner Rags	Spent cleaner Rags	Spent cleaner Rags	Spent cleaner Rags	Spent cleaner Rags
Plant F	Rags	Rags	Rags	Rags	Rags
Plant I	Rags				

TABLE 3-3c. ADHESIVE PROCESS EQUIPMENT CLEANING

Company/Product	Rollers	Troughs	Dams	Floors	Mixing Vessels
Method					
Plant A	Putty knife	Putty knife		Scraper	Putty knife
Plant B	Wipe	Dip			Dip
Plant D	Wipe/scrape	Wipe/scrape	Wipe/scrape	Wipe/scrape	Wipe/scrape
Plant E	Wipe	Wipe	Soak	Blades are soaked	
Plant G	Wipe, dip, and bath	Dip, bath, and putty knife	Wipe, bath, and putty knife		
Plant H	Wipe		Wipe	Wipe	Spray
Plant I	Run dry/putty knife/wipe	Run dry/putty knife/wipe	Run dry/putty knife/wipe	Run dry/putty knife/wipe	Run dry/putty knife/wipe
Plant J	Wipe, dip, bath, scrub brush, spray	Wipe, dip, bath, scrub brush, spray	Wipe, dip, bath, scrub brush, spray	Wipe, dip, bath, scrub brush, spray	Wipe, dip, bath, scrub brush, spray
Frequency					
Plant A	Product change	Product change and every 1-2 weeks			Product change
Plant B	Daily	Daily			Daily
Plant E	1-2/day	1-2/day	1-2/day		
Plant G	Product change	Product change	Product change	Daily	
Plant H					
1	1/mo		1/day	2/yr	1/yr
2	1/day		3/day	2/yr	1/wk
3	1/wk		9/day	2/yr	1/day
Plant I	Product change	Product change	Product change		
Plant J	Product change, upset conditions, continual	Product change, upset conditions, continual	Product change, upset conditions, continual		
Solvent					
Plant A	Water	Water	Water	Water	Water
Plant B	Toluene, 15,000 gal/yr	Toluene, 15,000 gal/yr	Toluene, 15,000 gal/yr	Toluene, 15,000 gal/yr	Toluene, 15,000 gal/yr

(Continued)

TABLE 3-3c. ADHESIVE PROCESS EQUIPMENT CLEANING (Continued)

Company/Product	Rollers	Troughs	Dams	Floors	Mixing Vessels
Plant C					
Acrylics, plastic resin	Mono methyl butyl ether	Mono methyl butyl ether	Mono methyl butyl ether	Mono methyl butyl ether	Mono methyl butyl ether
Starch	Hot water	Hot water	Hot water	Hot water	Hot water
Solvent	Toluene	Toluene	Toluene	Toluene	Toluene
Hot melt	Citrus based cleaner (90% VOC content)	Citrus based cleaner (90% VOC content)	Citrus based cleaner (90% VOC content)	Citrus based cleaner (90% VOC content)	Citrus based cleaner (90% VOC content)
Plant E	Toluene, MEK, Ethylacetate	Toluene, MEK, Ethylacetate	Toluene, MEK, Ethylacetate	Toluene, MEK, Ethylacetate	Toluene, MEK, Ethylacetate
Plant G	MEK, xylene	MEK, xylene	MEK, xylene	MEK, xylene	MEK, xylene
Plant H	PM Acetate™ (25%), Cyclohexane (25%), API 100 Aromatic™ (50%)	PM Acetate™ (25%), Cyclohexane (25%), API 100 Aromatic™ (50%)	PM Acetate™ (25%), Cyclohexane (25%), API 100 Aromatic™ (50%)	PM Acetate™ (25%), Cyclohexane (25%), API 100 Aromatic™ (50%)	PM Acetate™ (25%), Cyclohexane (25%), API 100 Aromatic™ (50%)
Plant I	Toluene	Toluene	Toluene	Toluene	Toluene
Plant J	Toluene, TCA	Toluene, TCA	Toluene, TCA	Toluene, TCA	Toluene, TCA
Waste Type					
Plant A	350 gal water/wk	350 gal water/wk	350 gal water/wk	350 gal water/wk	350 gal water/wk
Plant B	Rags	Rags	Rags	Rags	Rags
Plant D	Rags	Rags	Rags	Rags	Rags
Plant E	Rags	Rags	Rags	Rags	Rags
Plant G	Fugitives, rags, cardboard tray liners	Fugitives, rags, cardboard tray liners	Fugitives, rags, cardboard tray liners	Fugitives, rags, cardboard tray liners	Fugitives, rags, cardboard tray liners

(Continued)

TABLE 3-3c. ADHESIVE PROCESS EQUIPMENT CLEANING (Continued)

Company/Product	Rollers	Troughs	Dams	Floors	Mixing Vessels
Plant H					
1 & 2	100 gal/yr	100 gal/yr	100 gal/yr	100 gal/yr	100 gal/yr
3	1540 gal/yr	1540 gal/yr	1540 gal/yr	1540 gal/yr	1540 gal/yr
Plant I	Wastepaper and salvage ends	Wastepaper and salvage ends	Wastepaper and salvage ends	Wastepaper and salvage ends	Wastepaper and salvage ends
Plant J	toluene wash, 150 gal/mo TCA, 200 gal/mo	toluene wash, 150 gal/mo TCA, 200 gal/mo	toluene wash, 150 gal/mo TCA, 200 gal/mo	toluene wash, 150 gal/mo TCA, 200 gal/mo	toluene wash, 150 gal/mo TCA, 200 gal/mo

TABLE 3-3d. OTHER PROCESS EQUIPMENT CLEANING

Company/Product	Rollers	Troughs	Dams	Floors	Mixing Vessels
Method					
Plant B	Wipe	Dip			Bath
Plant C	Wipe	Dip			Bath
Frequency					
Plant B	Daily	Daily			Daily
Plant C	Daily and product change	Daily and product change			Daily and product change
Solvent					
Plant B	MEK, 10,000 gal/yr	MEK, 10,000 gal/yr	MEK, 10,000 gal/yr	MEK, 10,000 gal/yr	MEK, 10,000 gal/yr
Plant C	Toluene, MEK, alcohols (500 gal/mo total)	Toluene, MEK, alcohols (500 gal/mo total)	Toluene, MEK, alcohols (500 gal/mo total)	Toluene, MEK, alcohols (500 gal/mo total)	Toluene, MEK, alcohols (500 gal/mo total)

TABLE 3-4. GENERAL POLLUTION PREVENTION RESEARCH

Company	WB[a] Y/N	Years WB[a] in Use	Level of Research	Limitations	Low Solvent Research	General Pollution Prevention Efforts Description	Research Impacts on Cleaning
Plant A	Y	27 yrs	Minimal	High cost Poor curing lusters	Moderate	Higher solids adhesives; Investigated distillation	
Plant B	N		Minimal	Product specifications	Minimal	Scheduling product runs Reuse cleaning solvent	
Plant C	N		Moderate	Product specifications	None		
Plant D	Y	58 yrs	Extensive	High cost, Waterbased coatings unable to provide required tack	Moderate	Trying mineral spirit/ terpene mix	
Plant E	Y	15-20 yrs	Extensive	Tack Waterbased coatings unable to provide required tack		Run jobs together; Dilute toluene drip bottle with nontoxic solvent; Distillation of waste solvent	On-site water treatment
Plant F	Y	5 yrs	Moderate to Extensive	Waterbased cleaners do not remove adhesives adequately from rollers	Moderate to Extensive	Scans technical literature	Non VOC products are not effective
Plant G	Y	10 yrs	Minimal	Waterbased coatings unable to provide required tack	Minimal	Designing process line to accept UV curing equipment in the future; Operator training; Run similar adhesive jobs together	
Plant H							
Waterbased PSAs	Y	1 yr	High	Poor physical properties			
UV-Curable Coatings	N		Moderate	High cost, Poor physical properties			

(Continued)

TABLE 3-4. GENERAL POLLUTION PREVENTION RESEARCH (continued)

Company	WB[a] Y/N	Years WB[a] in Use	Level of Research	Limitations	Low Solvent Research	General Pollution Prevention Efforts Description	Research Impacts on Cleaning
Plant I	Y	20+ yrs	Extensive	High cost Slower line speeds	Minimal	Backsizing line(s) use cellophane-like plastic as roller covers	Mineral spirits don't clean effectively; Solvent recycling.
Plant J	Y	10+ yrs	Extensive	Slow line speeds Slow drying time	None	Replacement of all solvent-based products by 1994	Investigating non-VOC cleaning products

[a]WB = Waterbased coatings (saturants, release coats, and/or adhesives)

3.4.1 Saturation Processes

Only three companies manufacture products requiring saturation process lines. Plant A process lines may operate with solvent, water, or two-component reactives. Plant C operates with solvent-based materials. Plant I uses waterbased saturants exclusively. Coating methods used on the saturation process lines include blade, dip and squeeze, and metering rod. Latex and styrene-based resins are formulated with isopropyl alcohol (IPA), MEK, and heptane solvent carriers.

Cleaning of saturation process lines is primarily accomplished by wiping the equipment components with solvent-soaked rags, as indicated in Table 3-3a. While Plant A uses waterbased cleaners, Plant C and Plant I use heptane and toluene, respectively. The three companies clean on a variety of schedules including after product changes, daily, or weekly. Rags and spent cleaning solutions are the primary waste generated from equipment cleaning.

3.4.2 Release Backing Processes

Due to confidentiality concerns of some respondents, the information presented in Tables 3-2 and 3-3b is not complete. Five of the nine responding companies operate 13 release backing process lines. As the tables indicate, waterbased formulations are used extensively in release backings. Plant F's process lines may be run either with water- or solvent-based release coatings. Plant I uses waterbased emulsions exclusively. Plant A and Plant J use a mixture of solvent and two-part reactive coatings. Vinyl- and silicone-based resins are common in release backing formulations. Plant F and Plant J recycle at least 90 percent of the solvent.

As indicated in Table 3-3b, equipment cleaning methods employed for release backing process lines include preliminary residue scraping followed by wiping the equipment components with solvent-soaked rags. Almost exclusively, the respondents clean only after product changes or on a weekly basis. Toluene is by far the most common cleaning solvent, followed by MEK and 1,1,1-trichloroethane (TCA). One company uses citrus based materials to clean silicone release backing lines. Rags and spent solvent are the primary wastes generated from the cleaning of equipment.

3.4.3 Adhesive Coating Processes

As indicated in Table 3-2, 33 adhesive coating lines are operated by the companies receiving questionnaires. Only one facility does not contain an adhesive application station. Facility adhesive-coating capacities range from 12 million to 300 million square yards per year. A diverse mixture of coating application methods and equipment was represented, including reverse roll, gravure, knife-over-roll, metering rod, hot melt, and extrusion die. While most of the facilities operate lines dedicated to the coating of either solvent-based or waterbased adhesives, two companies (*i.e.*, Plant G and Plant J) are able to use either solvent- or waterbased adhesives on the same coating line.

A variety of coating formulation resins (*e.g.*, acrylic, natural and synthetic rubber, nitrile, styrene butadiene, urethane, and starch) were identified by industry respondents. Although several resin types were reported, this variety does not appear to impact the coating method or technology employed for the process.

Commonly used solvents include toluene, ethyl acetate, MEK, heptane, and hexane, with toluene being the most commonly used vehicle solvent in adhesive formulations among questionnaire respondents. Cleaning with water is possible on water- and starch-based adhesive lines. Solvent vehicles used did not depend on the types of resins in the formulations. The solvent content in the adhesives formulations ranged from 35 to 85 percent.

Although the questionnaire recipients employ a variety of processes, the reported cleaning of all adhesive-coating process equipment is similar, as indicated in Table 3-3c. Again, the preferred cleaning method is wiping the equipment with solvent-soaked rags. A putty knife or scraper is often used on difficult-to-clean areas to loosen dried coating materials. No trends in cleaning frequency were identified among the companies or equipment components. Daily cleaning or cleaning after a product change are common. The primary wastes generated during cleaning are solvent soaked rags and waste solvent.

3.4.4 Other Processes

As shown in Tables 3-2 and 3-3d, the only other coating process identified by the questionnaire respondents is surface web coating (*i.e.*, printing and drafting and reproduction films) at Plant B and Plant C. Acrylic, cellulose- or ester-based resin formulations formulated with toluene, MEK, and alcohol are applied by metering rods. Plant C recycles approximately 90 percent of their solvent. Equipment cleaning techniques used by Plant B and Plant C on their web coating lines do not differ from those described earlier.

3.4.5 General Pollution Prevention Industry Trends

Some of the equipment cleaning pollution prevention techniques identified by the questionnaire recipients include job scheduling, operator awareness training, and equipment retrofits to accommodate both water or UV-curable coatings as indicated in Table 3-4. Several companies have taken steps to reduce the amount of solvent used to clean equipment by consecutively scheduling production runs using adhesives or coatings with similar formulations. While many companies dedicate equipment lines to specific products, the majority of companies do not dedicate products to certain process lines. Water- and solvent-based formulations are frequently dedicated to particular process lines. Very few companies coat both water and solvent formulations on the same process lines. Product specifications generally mandate whether waterbased formulations are applicable to a particular job. Certain coating properties are possible with waterbased coatings, while others are not.

Other solvent reduction techniques include dilution of solvents with non-toxic cleaning compounds, and use of roller covers, such as cellophane-like materials or teflon coatings which prevent the coating from adhering to the roller.

Although there is much emphasis on reducing cleaning solvent consumption and waste generation, most facilities still give their operators free access to cleaning solvents. Safety cans, filled with solvent, are often located near the application equipment. Large solvent storage drums (*i.e.*, 55 gallons) are located in a central storage area with no monitoring or access restrictions. Additionally, few companies take advantage of waste solvent recycling.

Two waste reduction methods identified through industry questionnaires, that do not directly involve equipment cleaning involve equipment retrofit opportunities. One company is investigating reducing solvent consumption by designing new process lines and retrofitting current lines to accept UV curing equipment retrofits. Another potential retrofit of equipment involves waterbased materials. The general level of waterbased coatings research conducted by facilities in the questionnaire is "moderate." Many of the companies conduct research or adhesive formulation in on-site research and development laboratories. Other facilities have reported that they would consider using waterbased formulations if a coating supplier would produce a "reliable" material. Plants A, E, I, and J have all used waterbased coatings in some coating applications (*e.g.*, saturants and release coats) for at least twenty years. These companies cite the reduced ability to meet customer product specifications, lack of adhesiveness and luster, and high cost as the primary drawbacks of waterbased coatings. Some of the same complaints were noted for waterbased cleaners. According to questionnaire respondents, low-VOC or non-VOC cleaning products do not effectively clean the equipment.

3.4.6 Conclusions

In conclusion, equipment cleaning techniques for solvent-based coating formulations do not seem to be dependent upon the type of process or product. Rather, the same cleaning materials and methods appear to be used across the wide range of products and processes reported by the questionnaire recipients. One universal waste reduction method would be limiting operator access to solvent storage areas, however, increased recycling and recovery efforts will also provide reduced solvent waste generation benefits. Non-stick roller covers, protective wrappings on other equipment components, and regulated solvent spray or drip systems may also offer effective alternatives to current cleaning techniques.

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CHAPTER 4

POLLUTION PREVENTION ALTERNATIVES

4.1 GENERAL

This chapter provides an overview of the pollution prevention alternatives for the coated and laminated substrate manufacturing industry. The chapter is divided into eight sections: (1) General, (2) Cleanup Avoidance, (3) Best Practices, (4) Recycling of Solvents and Cleaning Materials, (5) Alternative Cleaning Materials, (6) Equipment Modifications, (7) Alternative Cleaning Technologies, and (8) Waterbased Adhesives. The cleanup avoidance section addresses job scheduling, and running the equipment dry. The best practices section discusses the impacts of best operating practices on the reduction of emissions associated with equipment cleaning. The recycling section focuses on the benefits associated with recycling. The alternative cleaning materials section addresses the use of mineral spirits, citrus based cleaners, and di-basic esters in equipment cleaning. The equipment modifications section discusses changes that can be made to existing equipment to reduce waste generation. Alterative cleaning technologies focuses on the use of ultrasonic cleaning and its impact on equipment cleaning. The final section discusses the impact of converting from solvent-based adhesives to waterbased adhesives on equipment cleaning.

4.2 CLEANUP AVOIDANCE

4.2.1 Job Scheduling/Production Campaigning

Efficient production scheduling can be a very effective way to reduce the need for equipment cleaning in any industry. In job scheduling, similar products are run together. For the coated and laminated substrate industry, products with similar coatings would be run in sequence. Proper scheduling will reduce the need to clean reservoirs, application rollers, and other pieces of equipment that require large amounts of cleaning solvent. Job scheduling requires prior planning with production needs balanced against reduced cleaning.[1]

Job scheduling can cause some cross-contamination between batches of adhesives. However, this problem is often solved with the use of makeready substrate. Makeready substrate involves the disposal of the cross-contaminated end of one run and the beginning of the subsequent run of substrate.

4.2.2 Run Dry

Running the coating line dry is an operating technique, occurring at the end of a production run, that involves adding only enough coating to the application trough to coat the length of the remaining web. This allows the substrate web and the coating to end at approximately the same time. In some facilities, the excess coating, following a run dry step, is drained from the troughs and coating lines and put back into storage drums for future use. Both of these methods require considerable operator planning and attention.[2]

4.3 BEST PRACTICES

4.3.1 Storage of Cleaning Solvents

Many facilities store cleaning solvents close to the production areas to provide easy worker access. Most facilities have small containers (*e.g.*, 3 to 5 gallon safety cans) at or near the production machinery, larger containers in the production area for exchange of solvents, and a storage area for delivery and pickup of the solvent barrels or tanks. Occupational Safety and Health Act (OSHA) regulations provide guidance on storage and movement of drums and containers within a facility. Restricting operator access to these solvents is discussed in the next section.

4.3.2 Use and Accessibility of Cleaning Materials

Coated and laminated substrate facilities typically do not restrict operator access to cleaning solvents. Consequently, in many cases, operators dispense more cleaning material than actually needed to achieve the desired level of cleaning.

Additionally, if an operator has a choice of cleaning materials, the material with the greatest solvency and cutting power (and consequently the highest VOC content) is often selected. Although the management may provide and encourage the use of alternative cleaners, this use may not be enforced.

4.3.3 Mechanical Pre-Cleaning

Dry cleaning techniques can be used to remove coating material that has adhered to the sides of mix tanks, coating application heads, application rollers, troughs, dams, and equipment housings. These techniques typically consist of using fiber or metal brushes, squeegees, or putty knife-type scrapers to mechanically remove excess coating prior to wet cleaning processes.

An alternative to full solvent wiping may consist of an initial dry scraping, followed by a solvent wipe, followed by a second mechanical scraping step. In this case, most of the coating is removed prior to any wet cleaning. The solvent-wipe step serves only to loosen and break the bond between the coating and the equipment, not to completely dissolve and remove the coating. Actual coating removal is achieved by the second dry step.

4.3.4 Disposal of Spent Cleaning Materials

Waste cleaning materials include spent rags, cleaning solvents, and wash water. Solvent-soaked rags are typically considered solid hazardous waste and must be shipped off-site for disposal. One facility reported being able to incinerate rags and filters used with Varsol in their boiler. Depending upon State regulations, this may be an option available to many facilities. One facility distilled TCA for use in the mixing area for solvent-based adhesives. Spent mineral spirits were recycled by another facility to be used as a paint thinner for facility painting applications. Additionally, washwater and the high pressure water used to clean large pieces of equipment were determined to be hazardous waste at facilities using solvents to clean spills.

4.3.5 Centralization of Major Cleanup

Several facilities have centralized cleaning areas for parts which can be removed from the machinery and cleaned. The creation of a centralized area may allow a facility to control air emissions from the cleaning process by using a ventilation system to collect the solvent-saturated air. The centralized cleaning area also reduces the possibility of a large spill of solvent occurring on the process line.

Exterior sections of large vats may be cleaned by hand while the interior may have a mop bath cleaning. Roller and other similar sized parts may be scrapped, bathed, and hung to dry. Smaller parts may simply be bathed or dipped. Facilities may also have stages of cleaning. The parts may be dipped in a less concentrated bath or dirty cleaner as an initial first step. Then, the part may move to a intermediate bath where it is bathed and wiped by hand. The third bath area may apply a clean solvent for a final cleaning and then drying.

4.4 RECYCLING OF SOLVENTS AND CLEANING MATERIALS

4.4.1 Solvent Recovery

Some facilities recover solvent using a batch distillation unit. A batch distillation system consists of four components: a spent solvent collection tank, a heated boiling chamber, a condenser, and a clean solvent collection tank. Once an operator has cleaned a piece of equipment, the spent solvent is stored in a small container which is later sent to the solvent distillation system to be reclaimed.

As the spent solvent is added to the collection tank, a filter removes the large particles. When the tank is full, the solvent is transferred by a pumping system to the heat chamber. As the solvent is heated to a specific vaporization temperature, the low boiling point constituents are vaporized and collected in a condenser. The unusable residue that collects at the bottom of the heat chamber is referred to as still bottoms. These still bottoms are considered hazardous waste and are disposed of off-site.

The vapors in the condenser are quickly cooled to promote optimum condensation. The condensate is now nearly 100 percent solvent that is drained off and collected in containers to be reused.[3]

4.4.2 Extension of Solvent Life/Countercurrent Rinsing

One source identifies the need to blend additives and/or stabilizers into the recovered solvents to increase their useful life. Some cleaning solvents (*e.g.*, TCA and MEK), however, are not considered well suited to on site re-stabilization as the process may be too time-consuming, labor intensive, and expensive for many facilities to pursue.[4]

Countercurrent rinsing is another method for extending the life of cleaning solvents. Countercurrent rinsing uses spent cleaning solvent to complete an initial cleaning of the equipment. This step is then followed by rinsing the surface with clean solvent (either recycled or virgin) to remove the remaining soils.[5]

4.4.3 Cleaning Rags

Frequently, the recycling of cleaning rags is dependent upon the chemical used. Rags contaminated with solvents such as TCA, toluene, MEK, or heptane are treated as hazardous wastes and require proper disposal. Most facilities visited allow operators to decide when a rag's useful life has been reached. Those facilities using non-halogenated cleaners may be able to clean rags either in-house or at a commercial cleaning operation. However, recycling cleaning rags may introduce lint and dirt into the coatings which can cause a quality problem, and the cost of cleaning the solvent-coated rags may be prohibitive.

4.5 ALTERNATIVE CLEANING MATERIALS

4.5.1 Mineral Spirits

Mineral spirits is a volatile, colorless petroleum solvent with a petroleum odor. A commonly used mineral spirit derivative is Varsol, a branded petroleum solvent blend manufactured by Exxon. A list of physical and chemical properties for Varsol is provided in Section 2.8.3 of this document.

In limited cases, Varsol has been found to be an effective cleaning solvent replacement for toluene and MEK. Although Varsol does tend to leave a residue on the equipment being cleaned, which can become a quality issue (*e.g.*, leaving a film or leaving a tacky surface), some facilities indicated that the amount of residue left on the rollers was minimal and would either dry or be removed by the makeready substrate as it passed over the rollers.[6]

4.5.2 Citrus Based Cleaners and Terpenes

In recent years, the use of citrus based and terpene cleaners has received some attention from the coated and laminated substrate manufacturing industry. Citrus based and terpene cleaners are solutions of such chemicals as d-limonene and methylpyrrolidone. These cleaners are not regulated under Title III of the Clean Air Act Amendments as hazardous air pollutants. In most cases, these cleaners are also exempt from Title I regulations for VOCs.[7]

Some facilities have tried citrus based cleaners as replacements for toluene and MEK. However, these facilities commented that the citrus based cleaners were expensive, did not clean well, and produced a strong, undesirable odor. Another drawback is that the spent citrus cleaner may still be considered hazardous waste due to the coatings that are being removed and therefore must be disposed of properly.

4.5.3 Di-Basic Esters (DBEs)

Di-basic esters are chemical combinations of the refined methyl esters of adipic, glutaric, and succinic acids. A typical mixture of DBE consists of 17 percent dimethyl succinate, 17 percent dimethyl adipate, and 66 percent dimethyl glutarate.[8] DBE is a combustible mixture which may contribute to smog. When heated it decomposes and emits an irritating odor and fumes.[8] Because DBE is not an air toxic or a VOC and is less toxic than many currently used cleaning materials, it may be an effective alternative cleaner. It is reported to be effective in cleaning equipment used to coat products with polyurethane adhesives, however its use as a cleaner within the coated and laminated substrate industry is not documented.[4]

4.6 EQUIPMENT MODIFICATIONS

4.6.1 Improved Shielding

Many facilities have modified process equipment to reduce the possibility of splashes and spills. These modifications include the addition of edge guards and shields over application areas. By reducing the amount of coating splashed on the outside of equipment or spilled on the floor surrounding the equipment, the frequency of cleaning is reduced. However, the addition of guards and shields can limit operator access to certain areas of the equipment, making repairs more difficult.

4.6.2 Surface Coating

Many facilities coat rollers with a nonstick materials such as teflon, silicone, or plasma-coatings. These nonstick coatings allow the adhesive-coated substrate to pass over the roller without sticking or leaving adhesive on the roller, thus reducing the required cleaning frequency.

One difficulty associated with coated rollers is durability. When the coating is nicked or scraped, it loses its effectiveness. This is particularly a problem with silicone-coated rollers. Ceramic/plasma-coated rollers also have drawbacks: static buildup on these rollers can ignite if sparked and the entire line can catch fire. One solution is to avoid placing the plasma coated rollers in series, which will prevent static buildup.[9]

4.6.3 Surface Wrapping

Another technique used to avoid cleaning is the application of a surface wrapping to the outside of the equipment. One facility covers the coating line equipment with foil. This facility reduced its equipment cleaning by removing the wrapping, disposing of it, and reapplying a new wrap. Other facilities apply this same principle to the floors surrounding the coating line equipment. Floors may be covered with off-specification substrate material which would otherwise be waste or with absorbent felt mats (which must be purchased, but require fewer changeovers than off-specification substrates). In any of these cases, it is important to evaluate the quantity of solid waste (equipment wraps or covers) generated in relation to reduced cleaning emissions.

Another surface wrapping technique is the application of tetrafluoroethylene (TFE) film tape to rollers to prevent the coatings from sticking to the rollers. However, TFE film tape is one of the most expensive film tapes and its use could be cost prohibitive.

4.6.4 Substrate Edge Guides

The installation of pneumatic or electronic substrate edge guides can also assist in reducing material waste and cleanup. The guides are often placed at several locations on a coating line to regulate the movement of the web and to prevent the web from sliding back and forth along the rollers. In keeping the web straight, the guides also ensure that the coating is applied to the web without running past the edges and onto the floor or equipment.

4.7 ULTRASONIC CLEANING

Ultrasonic cleaning is a technology currently used to clean metal parts. It was developed as a possible replacement for solvent cleaning.[10] Ultrasonic cleaning involves the use of sound waves in an aqueous solution to create tiny bubbles which implode and "scrub" the part clean. This method of cleaning is used in a variety of industries required to clean metal parts, including limited applications within the coated and laminated substrate industry. The benefits of an ultrasonic cleaning system include rapid cleaning, low operating cost, and high levels of cleanliness. From an environmental perspective, the use of aqueous ultrasonic cleaning solutions reduces the VOC emissions associated with equipment cleaning and reduces the hazardous waste generated by the facility.[11]

Ultrasonic energy uses sound waves above the range of human hearing (generally above 18,000 kilohertz). The ultrasonic waves are produced by a generator which creates high frequency electrical current and a transducer which transforms the electrical current into mechanical waves. The vibrations are transmitted to the cleaning liquid, which then contacts the surfaces to be cleaned.[12]

Once the waves have reached a significant amplitude, cavitation occurs. Cavitation is defined as the formation and collapse of vapor cavities in a flowing liquid.[13] The result is the production of thousands of extremely small, high-intensity shock waves that penetrate and "clean" the dirty part. A benefit of ultrasonic cleaning is that the size of the bubbles allows cleaning the most intricate part without having to disassemble it.[12]

Several properties of the cleaning fluid can influence the effectiveness of ultrasonic cleaning, temperature, dissolved gas in the liquid, surface tension, viscosity, ultrasonic power, ultrasonic frequency, and part exposure. Temperature has the most significant effect on ultrasonic cleaning. As temperature increases for most cleaning fluids, the cavitation intensity increases, providing better cleaning. However, if the liquid reaches its boiling point, cavitation will not occur. Dissolved gas in the cleaning fluid decreases the cavitation intensity because the gas pocket provides a cushion that will not allow the full cavitation intensity to reach the part to be cleaned. Cleaning fluids with high surface tension will create higher cavitation intensity due to the greater energy that is released when the bubbles implode. The higher the viscosity of the cleaning fluid the more energy required to cavitate. The ultrasonic power that is used to generate the sound waves can become too strong and damage the parts to be cleaned. Identifying the sufficient amount of power is very important. Maintaining the proper ultrasonic frequency is also important. As the frequency is increased, more power is needed to produce the same cavitation intensity. The final variable in the cleaning process is part exposure: it is very important for parts to be placed correctly in the bath to prevent air pockets from forming and reducing the efficiency of the cleaning.[12]

An ultrasonic cleaning system is shown in Figure 4-1. The system contains three basic elements: a generator, a transducer, and a tank filled with the cleaning solution. The generator

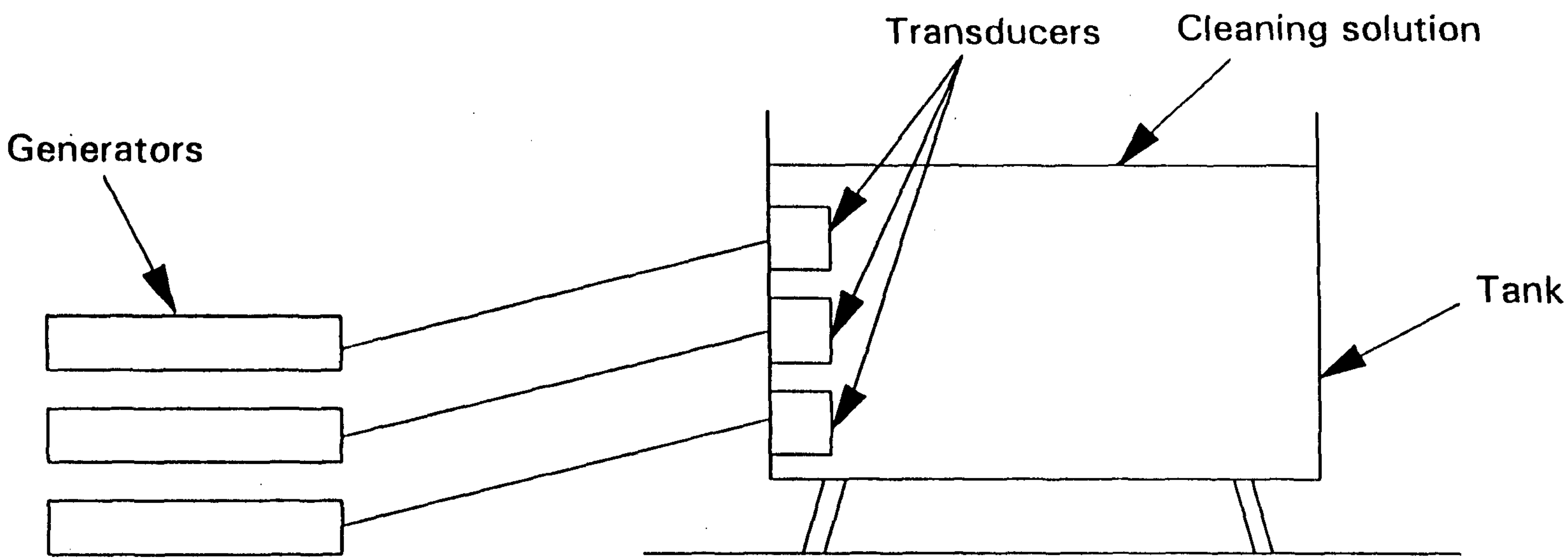

Figure 4-1. Ultrasonic Cleaning System.

produces the high frequency electrical current. The transducer converts the current into mechanical vibrations. Some cleaning systems also include rinsing and drying stations.[10] The capital costs of such a system range from $10,000 to $150,000, depending mainly on tank size.[11]

The application of ultrasonic cleaning to equipment associated with the coated and laminated substrate manufacturing industry requires carefully selecting the cleaning solution. Typical cleaning solutions used in the metal parts cleaning systems have limited applicability to the removal of adhesives from the rollers, carriages, application heads, and other pieces of coating equipment. One facility tested over 200 different cleaning solutions before finding a cleaner capable of removing the wide variety of coatings.

4.8 WATERBASED ADHESIVES

The substitution of waterbased adhesives for solvent-based adhesives has been a subject of interest with the coated and laminated substrate industry due to the reduction in VOC emissions associated with the adhesive. Simplified equipment cleaning is another benefit of waterbased adhesives. While still wet, waterbased adhesives can be cleaned with warm water or a soap solution. However, if the adhesive is allowed to dry, the equipment cleaning methods would be the same as those for a solvent-based adhesive.[14]

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CHAPTER 5

SUMMARY AND EVALUATION OF DEMONSTRATION OPPORTUNITIES

5.1 GENERAL

The objective of Phase I of the *Improved Equipment Cleaning in the Coated and Laminated Substrate Manufacturing Industry* project is to identify both potentially demonstrable pollution prevention technologies and criteria characteristic of a facility in which the technologies could be applied. This section outlines characteristics of such potential demonstration technologies and sites. The information that is presented is based on data collected through several sources including literature searches, industry questionnaires, plant visits, pollution prevention experts, and industry and trade association personnel.

5.2 TECHNOLOGY SELECTION CRITERIA

The selection and overall effectiveness of a demonstrable pollution prevention technique depends on several factors including potential environmental impact, cost, applicability, availability, and longevity. This section applies these criteria to several of the pollution prevention alternatives discussed in Chapter 4. Table 5-1 presents a summary of the potential demonstration technologies.

5.2.1 Potential Environmental Impact

"Pollution prevention is any practice which reduces the amount of any hazardous substance, pollutant, or contaminant entering the waste stream or otherwise released to the environment (including fugitive emissions) prior to recycling, treatment, or disposal; and reduces the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants."[1] Pollution prevention includes equipment or technology modifications, process or procedure modifications, reformulation or redesign of products, raw material substitution, and improvements in housekeeping, maintenance, training or inventory control. However, when considering implementing any of these technologies, it is necessary to evaluate the potential

TABLE 5-1. TECHNOLOGY SELECTION CRITERIA

Pollution Prevention Alternatives	Impacted Media			Technology Cost		Applicability and Longevity		Availability
	Air	Water	Land	Capital	Annual Operating	Segment	Longevity	
Cleanup Avoidance								
Job Scheduling/Production Campaigning	+	+	+	None	Facility Dependent	Dedicated Line	Immediate and Indefinite	Yes
Run Dry	+	+	+	None	Facility Dependent	All	Immediate and Indefinite	Yes
Best Practices								
Solvent Storage Techniques	+			Minimal	Minimal	All	Immediate and Indefinite	Yes
Cleaning Materials Accessibility	+	+	+	Minimal	Minimal	All	Immediate and Indefinite	Yes
Mechanical Pre-Cleaning	+	+	-	Minimal	Minimal	All	Immediate and Indefinite	Yes
Cleanup Centralization	+	+	+	High	High	All	Immediate and Indefinite	Facility Dependent
Recycling								
Solvent Recovery	+	+	+,-	High	Moderate	Large Mfgs	Immediate and Indefinite	Facility Dependent
Countercurrent Rinsing	+	+	+	High	Moderate	Centralized Cleaning	Immediate and Indefinite	Facility Dependent
Alternative Cleaning Materials								
Mineral Spirits	+	+	+	Minimal	Minimal	Facility Dependent	Facility Dependent (upon Product Testing)	Facility Dependent
Citrus Based Cleaners	+	-	+	Minimal	Minimal	Facility Dependent	Facility Dependent (upon Product Testing)	Facility Dependent
Dibasic Esters	+	-	+	Minimal	Minimal	Facility Dependent	Facility Dependent (upon Product Testing)	Facility Dependent

(Continued)

TABLE 5-1. TECHNOLOGY SELECTION CRITERIA (Continued)

Pollution Prevention Alternatives	Impacted Media			Technology Cost		Applicability and Longevity		Availability
	Air	Water	Land	Capital	Annual Operating	Segment	Longevity	
Equipment Modifications								
Improved Shielding	+	+	+	Moderate	None	Facility Dependent	Immediate and Indefinite	Facility Dependent
Surface Coating	+	+	-	Moderate	Minimal	Facility Dependent	Immediate and Indefinite	Facility Dependent
Surface Wrapping	+	+	-	Moderate	Minimal	Facility Dependent	Immediate and Indefinite	Facility Dependent
Alternative Technologies								
Ultrasonic Cleaning	+	+	+	High	Moderate	Centralized Cleaning	Immediate and Indefinite	Facility Dependent

environmental impacts (*i.e.*, possible effects) on all media (*i.e.*, air, water, and land). For example, one must evaluate the relative environmental benefits (or disadvantages) achieved by reducing air emissions from equipment cleaning by moving from aromatic or ketone cleaners to aqueous cleaners, which will result in additional pollutant loading to the facility wastewater stream.

One way to assess potential environmental impacts is through the development of a life cycle analysis (LCA) which looks at the product/production process from the extraction of the raw materials to the product's ultimate recycle or reuse. In this sense, an LCA is a "cradle-to-cradle" approach, rather than the Resource Conservation and Recovery Act's (RCRA's) "cradle-to-grave" approach. LCAs involve project definition, data gathering, model development, result analysis and reporting, and result interpretation. Although an LCA for the pollution prevention technologies discussed in Chapter 4 is beyond the scope of this project, some general observations can be made. The impacted media are presented in Table 5-1.

5.2.2 Technology Cost

The cost of implementing a pollution prevention technology includes total capital investment and total annual operating costs. Total capital investment includes costs required to purchase equipment, costs of labor and materials for installing that equipment, costs for site preparation and buildings, and other costs referred to as indirect installation costs (*e.g.*, engineering and construction and field expenses). If the technology is an adjustment to a current installation, then the costs are referred to as retrofit costs.

Total annual costs include raw material expenses, operating labor, maintenance, utilities, replacement parts, waste treatment and disposal, capital recovery, and overhead.[2] For the purpose of this report, the cost section of Table 5-1 is divided into capital and annual costs. Specific cost categories are listed in the appropriate cost columns.

5.2.3 Applicability and Longevity

Applicability refers to the range/segments of the coated and laminated substrate industry to which the technology applies. For example, the technology may be applicable to masking tape plants but not to label facilities, or the technology may be applicable to large facilities, but not to small, toll coating plants. Longevity refers to the length of time required to achieve initial results and the length of time during which the technology will be applicable. For example, a facility may implement a technology which will achieve results within one year and will be appropriate for four years based on the current manufacturing equipment and methodologies practiced at the plant. Table 5-1 identifies the industry segment (*i.e.*, dedicated line or toll coating facility) for which the technology is most applicable. Table 5-1 also indicates the anticipated useful life of the technology.

5.2.4 Availability

Technology availability includes the ability of facilities to purchase, or otherwise acquire and implement, the desired technology within a reasonable period of time (*e.g.*, one year). One commonly used example of availability is that of add-on control devices such as incinerators. Some industry segments that have recently been required to install incinerators are facing a six-month waiting time from placement of order to receipt of equipment. This backlog is based on the ability of the equipment manufacturing firms to make and ship a desired product.

5.3 SITE SELECTION CRITERIA

Selection criteria exist for potential demonstration sites as well as for pollution prevention technologies. Facility selection criteria include industry segmentation (*i.e.*, size of facility and product and process diversity), available resources, location, and timing. This section will identify the characteristics of facilities likely to participate as demonstration host sites.

5.3.1 Industry Segmentation

As discussed in Chapter 2, industry segmentation is determined by facility size and product diversity. Generally, facilities within the coated and laminated substrate manufacturing industry operate in one of two different segments. The first segment consists of large facilities operating coating lines dedicated to one type of product, such as masking tape or label stock. For example, one coating line at one facility produces 16 grades of filament tape. The differences between the grades are based on the type of film (*e.g.*, polyester or polypropylene), the type and number of nylon or rayon strands per square inch, and the thickness of the coating applied. The second industry segment consists of the batch-processor, or those plants that manufacture comparatively small batches of a wide variety of products (usually with a high value-added component). This category includes plants that make and market their own line of products, and batch-processors that offer contract coating services. For example, one coating line at a batch facility may process short-run, wide-width products including dry photo masking agents and reproduction materials. Batch facilities are often small, employing less than 50 people.

Both segments of the coated and laminated substrate manufacturing industry use essentially the same cleaning methods even though the segments differ substantially in the range of substrates, coatings, and application equipment used at the plants. As a review of the information presented in Chapter 2, the primary differences between the cleaning conducted at a dedicated line facility and a batch plant are frequency and degree of cleaning. Dedicated line facilities may run their lines 24 hours per day, 7 days per week, and 52 weeks per year. Lines are typically shut down one shift per week for preventative maintenance and cleaning. In contrast, batch processors generally do not clean equipment on any specific schedule. Due to the relatively short production runs and the custom nature of the specialty products that these facilities manufacture, cleaning between each job or product changeover is critical.

For the reasons presented above, demonstrations should be conducted at one facility operating in each of the two industry segments. The focus at the dedicated line facility might include the implementation and evaluation of a cleaning solvent substitute, improved operating practices, and process modifications. The focus at the batch coating facility would be geared toward improving the efficiency of cleaning operations by reducing the amount of cleaning solution necessary to achieve the required degree of cleanliness. A second objective at this facility would be to identify better methods of administering the cleaning solution. A demonstration within each of the industry segments will assist not only dedicated line facilities and batch processors, but also those facilities that have characteristics of each.

5.3.2 Resource Availability

In order to conduct a successful demonstration, the host facilities must be willing to commit company resources (*e.g.*, time, labor, capital, and equipment) to the project. A demonstration team will spend approximately one week at the host site facility. Demonstration preparation will be approximately two days, the actual demonstration will be completed within the remaining three days and training, and follow-up will require approximately one day during a separate trip. The demonstration and training segments are expected to occur during first shift operations, while preparation may include activities during all normal operating hours (*e.g.*, three shifts, if applicable). Additionally, the host facilities will be expected to spend time coordinating with the demonstration team.

The host facilities will be expected to provide the technical oversight necessary to prepare for, conduct, and follow-up on the demonstration. The labor component will consist of production operator cooperation and oversight during on-site operations, as well as a technical coordinator for both on-site and off-site operations. Another critical labor component will consist of management commitment to the success of the demonstration. It is also assumed that the host facilities will purchase and install any necessary equipment to complete the demonstration.

Another resource component necessary to ensure success of the demonstration will be the willingness of the host facility to work with the federal, State, and regional branches of EPA and industrial trade associations to disseminate the demonstration results. Result dissemination will include facility publicity and access to costing figures, raw material (*e.g.*, cleaning solvent purchase records), equipment specifications, and production and maintenance records.

5.3.3 Timing

The preparation and demonstration phases of this project will be conducted during June, July, and August of 1993.

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APPENDIX A

COATED AND LAMINATED SUBSTRATE INDUSTRIES WITH ANNUAL SALES GREATER THAN $1 MILLION

TABLE A-1. COATED PAPER, PACKAGING FACILITIES (SIC 2671) WITH 1992 ANNUAL SALES GREATER THAN $1 MILLION

Name	Address	Sales in $ Millions
Bemis Company Inc.	625 Marquette Ave, Minneapolis MN 55402	1,128
Consolidated Papers Inc.	PO Box 8050, Wisconsin Rapids WI 54495	949
Instrument Systems Corp.	100 Jericho Quadrangle, Jericho NY 11753	459
Printpack Inc.	PO Box 43687, Atlanta GA 30378	302*
DataCard Corp.	PO Box 9355, Minneapolis MN 55440	300
Arrow Industries Inc.	PO Box 810489, Dallas TX 75381	185
Minnesota Mining and Manufacturing Co., Medical Imaging Systems	8124 Pacific Ave, White City OR 97503	120
Cellu-Craft Inc.	1403 4th Ave, New Hyde Park NY 11040	65
Milprint Inc.	9045 N Deerwood Dr, Milwaukee WI 53223	65
Shields Bag and Printing Co.	PO Box 9848, Yakima WA 98909	60
Star Tex Corp.	PO Box 1089, Lakeville MN 55044	42
Consolidated Papers Inc., Stevens Point Div.	PO Box 227, Stevens Point WI 54481	40*
Central Products Co.	531 N Stiles St, Linden NJ 07036	36
Packaging Industries Inc.	2450 Alvarado St, San Leandro CA 94577	36
Papercon Inc.	2700 Apple Valley NE, Atlanta GA 30319	35
Daubert Industries Inc.	1 Westbrook Corporate, Westchester IL 60154	32
Bonar Plastics Ltd, Bonar Packaging Inc.	PO Box 818, Tyler TX 75710	30
Placon Corp.	PO Box 8246, Madison WI 53708	30
Ideal Tape Company Inc.	1400 Middlesex St, Lowell MA 01851	30
Burrows Paper Corp. Packaging Div.	1722 53rd St, Fort Madison IA 52627	30
Superpac Inc.	PO Box 189, Southampton PA 18966	25
Adchem Corp.	625 Main St, Westbury NY 11590	25
Worthen Industries Inc.	3 E Spit Brook Rd, Nashua NH 03060	24
Jefferson Smurfit Corp., Laminating and Coating Co.	1228 E Tower Rd, Schaumburg IL 60173	24
Western Summit Manufacturing Corp.	9120 Juniper St, Los Angeles CA 90002	20
Clear Lam Packaging Inc.	1950 Pratt Blvd, Elk Grove Village IL 60007	19*
American Biltrite Inc., Tape Products Div.	105 Whittendale Dr, Moorestown NJ 08057	18*

(continued)

TABLE A-1. COATED PAPER, PACKAGING FACILITIES (SIC 2671) WITH 1992 ANNUAL SALES GREATER THAN $1 MILLION (continued)

Name	Address	Sales in $ Millions
Minnesota Mining and Manufacturing Co., Packaging Systems Div.	PO Box 5517, Greenville SC 29606	17*
Release Technologies Inc.	1400 Harvester Rd, West Chicago IL 60185	16*
Flex Products Inc.	2793 Northpoint Pkwy, Santa Rosa CA 95407	11*
Kleartone Inc.	695 Summa Ave, Westbury NY 11590	11
Norpak Corp.	70 Blanchard St, Newark NJ 07105	10
Tapecon Inc.	10 Latta Rd, Rochester NY 14612	9
Pioneer Paper Corp.	50 Triangle Blvd, Carlstadt NJ 07072	9
Peacock Papers Inc.	273 Summer St, Boston MA 02210	9
Tolas Health Care Packaging Corp.	114 Pheasant Run, Newtown PA 18940	6
Zorn Packaging Inc.	1315 Hwy 34, Farmingdale NJ 07727	6
Lustreprint Corp.	622 Northumberland, Buffalo NY 14215	6
SuBastion Industries Inc., Prescotech	PO Box 4362, Evansville IN 47711	4*
Foxon Packaging Corp.	235 W Park St, Providence RI 02901	3
Arcon Coating Mills Inc.	PO Box 486, Oceanside NY 11572	3*
Hobar Company Inc.	PO Box 2363, South San Francisco CA 94080	3
Creative Environments Inc.	33 W 54th St, New York NY 10019	1*

* Indicates an estimated financial figure.

Source: Gale Research, Inc. *Ward's Business Directory of U.S. Private and Public Companies*, Volume 5. Detroit, MI. 1992.

TABLE A-2. COATED AND LAMINATED PAPER, NEC FACILITIES (SIC 2672) WITH 1992 ANNUAL SALES GREATER THAN $1 MILLION

Name	Address	Sales in $ Millions
Minnesota Mining and Manufacturing Co.	3M Ctr, St Paul MN 55144	13,021
Boise Cascade Corp., White Paper Div.	PO Box 50, Boise ID 83728	2,610*
Appleton Papers Inc.	PO Box 359, Appleton WI 54912	775
Nashua Corp.	PO Box 2002, Nashua NH 03061	590
PLC Enterprises Inc.	300 Plaza Dr, Vestal NY 13850	260
Mosinee Paper Corp.	1244 Kronenwetter Dr, Mosinee WI 54455	210
International Paper Co., Bleached Board Div.	PO Box 7069, Pine Bluff AR 71611	160*
Anchor Continental Inc.	PO Drawer G, Columbia SC 29250	110
Simpson Plainwell Paper Co.	200 Allegan St, Plainwell MI 49080	100*
Avery Dennison Corp., Fasson Roll Div.	7670 Auburn Rd, Painesville OH 44077	99*
American Tape Co.	317 Kendall Ave, Marysville MI 48040	92
Shuford Mills Inc., Tape Div.	PO Drawer 1530, Hickory NC 28603	91*
James River Corporation of Virginia, Riegel Packaging Div.	Frenchtown Rd, Milford NJ 08848	90
Tesa Tuck Inc.	1 Le Fevre Ln, New Rochelle NY 10801	74
James River Corporation of Virginia, Otis Div.	PO Box 10, Jay ME 04239	73
Fortifiber Corp.	4489 Bandini Blvd, Los Angeles CA 90023	70
Fitchburg Coated Products Inc.	PO Box 1106, Scranton PA 18510	70
Minnesota Mining and Manufacturing Co., Tape Manufacturing Div.	Hwy 71 S, Nevada MO 64772	63*
Manco Inc.	830 Canterbury Rd, Westlake OH 44145	60
Wheeler Group Inc.	PO Box 2945, Hartford CT 06104	53*
Avery International Corp., Fasson Specialty Div.	9292 9th St, Rancho Cucamonga CA 91730	50
Bomarko Inc.	PO Box K, Plymouth IN 46563	49

(continued)

TABLE A-2. COATED AND LAMINATED PAPER, NEC FACILITIES (SIC 2672) WITH 1992 ANNUAL SALES GREATER THAN $1 MILLION (continued)

Name	Address	Sales in $ Millions
MPI Label Systems	PO Box 70, Sebring OH 44672	48
Hazen Paper Co.	PO Box 189, Holyoke MA 01041	46
James River Corporation of Virginia, Wyomissing Div.	PO Box 742, Reading PA 19603	42
Kanzaki Specialty Papers Inc.	PO Box 2002, Ware MA 01082	40
Holland Manufacturing	15 Main St, Succasunna NJ 07876	39
Phomat Reprographics Inc.	29350 Stephenson Hwy, Madison Heights MI 48071	35
James River Corporation of Virginia, Premold Div.	Box 6001, West Springfield MA 01090	34
Devon Tape Corp.	1511 Tonnelle Ave, North Bergen NJ 07047	28
Custom Tapes Inc.	7125 W Gunnison St, Harwood Heights IL 60656	28
Tape Inc.	PO Box 11067, Green Bay WI 54307	27
Drug Package Inc.	901 N Service Rd, O'Fallon MO 63366	26*
Crowell Corp.	PO Box 3227, Newport DE 19804	25
ADM Corp.	100 Lincoln Blvd, Middlesex NJ 08846	24
TimeMed Labeling Systems Inc.	144 Tower Dr, Burr Ridge IL 60521	21
Riverside Paper Corp.	PO Box 179, Appleton WI 54911	20
DRG Medical Packaging Inc.	4101 Lien Rd, Madison WI 53704	20*
Temple-Inland Inc., Rexford Paper Company Div.	PO Box 411, Milwaukee WI 53201	20
Data Documents Inc., Label Div.	3403 Dan Morton Dr, Dallas TX 75236	19*
Label Art Inc.	1 Riverside Way, Wilton NH 03086	18
M and C Specialties Co.	90 James Way, Southampton PA 18966	18
Tidi Products Inc.	PO Box 2150, Rialto CA 92376	17
Sun Process Converting Inc.	505 Bonnie Ln, Elk Grove Village IL 60007	15
Topflight Corp.	160 E 9th St, York PA 17405	15*
Hamilton Hybar Inc.	4123 Carolina Ave, Richmond VA 23222	14*
Excello Specialty Co.	4495 Cranwood Pkwy, Cleveland OH 44128	13

(continued)

TABLE A-2. COATED AND LAMINATED PAPER, NEC FACILITIES (SIC 2672) WITH 1992 ANNUAL SALES GREATER THAN $1 MILLION (continued)

Name	Address	Sales in $ Millions
American Cyanamid Co., Engineered Materials Dept.	21444 Golden Triangle, Saugus CA 91350	13*
Shamrock Scientific Systems Inc.	34 Davis Dr, Bellwood IL 60104	13*
Highland Supply Corp.	1111 6th St, Highland IL 60104	12
Salem Label Company Inc.	PO Box 39, Salem OH 44460	12
Betham Corp.	87 Lincoln Blvd, Middlesex NJ 08846	12
Best Label Company Inc.	13260 Moore St, Cerritos CA 90701	12
Permalite Repromedia Corp.	230 E Alondra Blvd, Gardena CA 90248	10
Paper Coating Co.	3536 E Medford St, Los Angeles CA 90063	8*
Handy Wacks Corp.	PO Box 26, Sparta MI 49345	8
Fibre Leather Manufacturing Corp.	686 Belleville Ave, New Bedford MA 02745	7
Laminated Papers Inc.	54 Winter St, Holyoke MA 01040	6*
Fast Coast Finishing Co.	Box 39, Fairview NJ 07022	6*
International Tape Products Co.	5 Lawrence St, Bloomfield NJ 07003	6
Graphic Arts Finishers	32 Cambridge St, Charlestown MA 02129	5
Litton Industrial Automation Systems Inc., Identification Products	6750 S Belt Circle Dr, Bedford Park IL 60638	5
East-West Label Company Inc.	1000 E Hector St, Conshohocken PA 19428	5
Universal Label Printers Inc.	12521 McCann Dr, Santa Fe Springs CA 90670	5
Avon Tape Inc.	PO Box 1423, Brockton MA 02403	5
Salinas Valley Wax Paper Company Inc.	PO Box 68, Salinas CA 93902	5
Alfax Paper and Engineering Co.	35 Washington St, Westborough MA 01581	5
Dielectric Polymers Inc.	218 Race St, Holyoke MA 01040	5
Dura-Process Co.	4000 Winnetka Ave N, Minneapolis MN 55427	4
Keystone Packaging Service	555 Warren St, Phillipsburg NJ 08865	4
Quikstik Label Manufacturing Co.	210 Broadway, Everett MA 02149	4
Blue Ribbon Label Corp.	241 Hudson St, Hackensack NJ 07601	4

(continued)

TABLE A-2. COATED AND LAMINATED PAPER, NEC FACILITIES (SIC 2672) WITH 1992 ANNUAL SALES GREATER THAN $1 MILLION (continued)

Name	Address	Sales in $ Millions
Penmar Industries Inc.	1 Bates Ct, Norwalk CT 06854	4
Alcop Adhesive Label Co.	826 Perkins Ln, Beverly NJ 08010	3
Mask-Off Company Inc.	PO Box 1148, Monrovia CA 91017	3
Markel Finishing Corp.	400 Bostwick Ave, Bridgeport CT 06605	3*
Hurst Label Co.	PO Box 6903, Burbank CA 91510	3
Thomas Tape Co.	PO Box 207, Springfield OH 45501	3
JL Darling Corp.	2212 Port Tacoma Rd, Tacoma WA 98421	2
Dermi-Klene Company Inc.	1901 S Bon View Ave, Ontario CA 91761	1
Keller Ticket Co.	554 36th St, Union City NJ 07087	<1*

* Indicates an estimated financial figure.

Source: Gale Research, Inc. *Ward's Business Directory of U.S. Private and Public Companies*, Volume 5. Detroit, MI. 1992.

APPENDIX B

COATED AND LAMINATED SUBSTRATE FACILITIES AND ASSOCIATED TRIS EMISSIONS

TABLE B-1. SIC 2671 - COATED PAPER, PACKAGING

Facility	Parent Company Name	Total Air Release in lbs/yr	MEK Release in lbs/yr	Toluene Release in lbs/yr
3M	3M	75,875	5,200	43,600
3M, BRISTOL PLANT	3M	2,280,115	26,250	1,900,250
3M CENTER	3M	84,267		
ADHESIVES RESEARCH INC.	NA	92,455	6,100	37,600
ALUSUISSE FLEXIBLE PACKAGING INC.	NA	91,540	66,476	1,608
AMERICAN NATIONAL CAN CO.	NA	384,278	73,402	292,828
AMERICAN NATIONAL CAN CO.	NA	321,837	128,574	186,795
AMERICAN NATIONAL CAN CO.	NA	299,606	207,355	68,783
AMERICAN NATIONAL CAN CO.	NA	142,185	91,450	53,373
AMERICAN NATIONAL CAN CO.	NA	118,251	45,455	72,796
AMERICAN NATIONAL CAN CO.	NA	86,049	28,261	23,754
AMERICAN NATIONAL CAN CO.	NA	20,134		20,134
AMERICAN NATIONAL CAN CO.	NA	9,270		9,270
AMERICAN NATIONAL CAN CO.	NA	1,680	1,680	
AMERICAN TAPE CO.	NA	3,258,683		3,258,683
AMERY TECHNICAL PRODUCTS INC.	NA	14,390	14,390	
ARLON INC., FLEXIBLE TECHNOLOGIES DIV.	NA	69,000	69,000	
AVERY LABEL BASE MATERIALS	AVERY INTERNATIONAL	182,380		
BOMARKO INC.	NA	205,000		55,000
CELLU-CRAFT MIDWEST INC.	NA	11,179		
CELLU-CRAFT PRODUCTS CO.	NA	41,857	15,436	
CELLU-CRAFT SOUTH	NA	16,488		16,488
CONSOLIDATED ALUMINUM CORP.	NA	456,249	120,612	85,652
DELUXE PACKAGES	NA	23,084		
DENNISON MFG. CO.	AVERY DENNISON	478,317	8,819	469,493
DIXICO INC.	NA	304,995		300,984
DIXICO INC.	NA	62,126		60,608
DRG MEDICAL PACKAGING INC.	NA	51,250		51,250
FASSON MERCHANT PRODUCTS DIV.	AVERY DENNISON	105,832		105,832

(Continued)

TABLE B-1. SIC 2671 - COATED PAPER, PACKAGING (Continued)

Facility	Parent Company Name	Total Air Release in lbs/yr	MEK Release in lbs/yr	Toluene Release in lbs/yr
HARGRO FLEXIBLE PACKAGING	NA	214,680		198,000
HARGRO FLEXIBLE PACKAGING CORP.	NA	74,797	1,909	
HARGRO INDUSTRIAL PKG.	NA	18,524	11,410	7,114
INTERNATIONAL PAPER CO.	INTERNATIONAL PAPER	70,500		13,000
JAITE PACKAGING INC.	NA	91,100	65,400	
JAMES RIVER CORP.	NA	178,000		42,000
JAMES RIVER CORP.	NA	152,000		152,000
JAMES RIVER II INC.	NA	9,178		
JAMES RIVER II INC., COATED PRODUCTS DIV.	NA	54,070		26,300
J.S.C.-SMURFIT LAMINATIONS	NA	11,800		
KLEARTONE INC.	NA	1,663		
LABELON CORP.	NA	138,770	66,060	5,330
LEPAGE'S INC.	NA	44,215		42,324
LITHOGRAPHIC INDUSTRIES INC.	NA	6,613	6,613	
LITHOTYPE CO.	NA	15,800		
MANVILLE FOREST PRODUCTS PLANT 20	MANVILLE CORP.	66,780	17,240	49,540
PACQUET ONEIDA INC.	NA	3,152		
PILLSBURY GREEN GIANT FILM CONVERTING	NA	52,851	27,107	25,744
RITRAMA DURAMARK	NA	164,000		164,000
R. J. REYNOLDS TOBACCO CO. WHITAKER PARK 641	NA	9,978	9,465	513
STRAUBEL PAPER CO.	NA	11,327		
TENNESSEE PRESS INC.	NA	48,000	11,000	14,000
WESTVACO ENVELOPE DIV.	NA	32,800		5,400
ZIMMER PAPER PRODUCTS INC.	NA	32,535		32,535
	GRAND TOTAL	10,791,505	1,124,664	7,892,581

Source: TRIS 1990
NA - Not Available/Applicable

TABLE B-2. SIC 2672 - COATED AND LAMINATED PAPER, NEC

FACILITY	PARENT COMPANY NAME	TOTAL AIR RELEASE IN LBS/YR	MEK RELEASE IN LBS/YR	TOLUENE RELEASE IN LBS/YR
3M	3M	419,050		22,250
3M CENTER	3M	84,267	33,000	16,000
3M, CV & AP CONSUMER PRODUCTS PLANT	3M	20,106,008	11,747,612	7,469,813
3M TAPE MFG. DIV.	3M	2,554,780	70,000	676,000
ACME STEEL CO., PITTSBURG WEST PLANT	ACME STEEL CO.	25		
ADCHEM CORP.	ADCHEM CORP.	27,150	5,600	18,200
ADCHEM INDUSTRIES INC.	ADCHEM INDUSTRIES INC.	9,900	1,850	6,050
ANCHOR CONTINENTAL INC.	LINCOLN GROUP	3,374,938		3,359,653
APPLETON PAPERS INC.	APPLETON PAPERS INC.	45,889		
APPLETON PAPERS INC. HARRISBURG PLANT	WIGGINS TEAPE APPLETON	724		
ARLON INC.	BAIRNCO CORP.	44,250	12,161	11,426
AVERY DENNISON BUILDING 3	AVERY DENNISON	831,874	71,400	678,000
AVERY DENNISON BUILDING 7	AVERY DENNISON	756,300	69,000	337,800
AVERY DENNISON FASSON FILMS DIV.	AVERY DENNISON	15,595	495	14,250
AVERY DENNISON FASSON ROLL DIV.	AVERY DENNISON	690,200		650,000
AVERY DENNISON M & PF DIV.	AVERY DENNISON	1,901,670	1,863,000	11,800
AVERY DENNISON SPECIALTY TAPE DIV.	AVERY DENNISON	9,180	3,080	6,400
AVERY LABEL BASE MATERIALS	AVERY INTERNATIONAL	182,380		
CAMVAC INTERNATIONAL INC.	BOWATER INDUSTRIES PLC.	30,406	18,422	11,984
CENTRAL PRODUCTS CO.	ALCO STANDARD CORP.	2		
COMPAC INDUSTRIES INC.	COMPAC CORP.	8,364		8,364
CORONET PAPER CORP.	NA	3,450		3,450
DAUBERT COATED PRODUCTS INC.	DAUBERT INDUSTRIES INC.	334,300	12,300	322,000
DECORA MFG., DECORA DIV.	UTILITECH INC.	43,005	25,339	15,114
EASTERN FINE PAPER INC.	SHELBURNE HOLDING CORP.	23,158	2,166	19,935
ESSELTE DYMO HIGHLAND PLANT	ESSELTE PENDAFLEX CORP.	125,110	40,175	
FASSON MERCHANT PRODUCTS DIV.	AVERY DENNISON	105,832	9,589	122344 (a)

(Continued)

TABLE B-2. SIC 2672 - COATED AND LAMINATED PAPER, NEC (Continued)

FACILITY	PARENT COMPANY NAME	TOTAL AIR RELEASE IN LBS/YR	MEK RELEASE IN LBS/YR	TOLUENE RELEASE IN LBS/YR
GRAPHIC CONTROLS CORP.	GRAPHIC CONTROLS CORP.	186,590		151,535
GRAPHICS TECHNOLOGY INTERNATIONAL INC.	SPECIALTY COATINGS GROUP, INC.	450,000		450,000
HOOD COATINGS INC.	NA	51,621		51,621
INTERNATIONAL PAPER CO., MOSS POINT MILL	INTERNATIONAL PAPER	339,303		
IVEX COATED PRODUCTS CORP.	IVEX CONVERTED PRODUCTS CORP.	339,710	18,200	305,000
KANZAKI SPECIALTY PAPERS	KANZAKI USA INC.	9,000		
LAMOTITE	REXHAM	1,159,704	44,963	51,693
LITHO COLOR PRINTING CORP.	NFC PARTNERS	177,409	150,144	27,265
LITTLE FALLS COLOR PRINT	SULLIVAN PAPER CO.	24,196		24,196
LUDLOW CORP.	TYCO LABORATORIES INC.	236,015		236,015
LUDLOW TECHNICAL PAPERS	TYCO LABORATORIES INC.	2,350		4,170
MANVILLE SALES CORP.	MANVILLE CORP.	7,698		6,255
MASK-OFF CO. INC.	NA	24,095	3,750	8,450
MEYERCORD INTERNATIONAL INC.	MEYERCORD CO.	2,700		2,700
MOORE BUSINESS FORMS & SYSTEMS DIV.	MOORE BUSINESS FORMS INC.	422,695		
MORGAN ADHESIVES CO. (MACTAC)	BEMIS CO. INC.	766,525	5,123	759,302
NASHUA CORP. CPD	NASHUA CORP.	301,426		292,404
NASHUA CORP. LABEL DIV.	NASHUA CORP.	1,162,500		717,000
NORESIN INC.	NA	145,329		
NORESIN INC.	NA	41,105		
NORTHERN ENGRAVING CORP.	NA	50,531		50,531
ORCHARD DECORATIVE PRODUCTS	BORDEN INC.	6,373		5,373
OREGON OVERLAY DIV.	SIMPSON INVESTMENT CO.	1,119,270		
PEARL BOOKBINDING CO. INC.	NA	500		

(Continued)

TABLE B-2. SIC 2672 - COATED AND LAMINATED PAPER, NEC (Continued)

FACILITY	PARENT COMPANY NAME	TOTAL AIR RELEASE IN LBS/YR	MEK RELEASE IN LBS/YR	TOLUENE RELEASE IN LBS/YR
PERMALITE REPROMEDIA CORP.	NA	113,310		98,307
PRECISION COATINGS INC.	NA	776,200	150,000	290,000
REICHHOLD CHEMICALS INC.	REICHHOLD, INC.	489,972		
REYNOLDS METALS CO., PLANT #1	REYNOLDS METALS CO.	39,520	24,950	14,570
ROCK-TENN PAPERBOARD PRODUCTS	ROCK TENN CO.	160,920		
SANCAP LINER TECHNOLOGY INC.	NA	64,000		
SIMPSON PAPER CO.	SIMPSON INVESTMENT CO.	25,400		
STRAUBEL PAPER CO.	NA	11,327		
SULLIVAN PAPER CO.	NA	45,229		45,229
THILMANY	INTERNATIONAL PAPER CO.	1,069,100		370,000
W. H. BRADY COATED PRODUCTS DIV.	W. H. BRADY CO.	423,050	53,350	302,300
	GRAND TOTAL	41,972,480	14,435,669	18,044,749

Source: TRIS 1990
NA - Not Available (Applicable)
NEC - Not Elsewhere Classified
(a) Emissions are summed from SICs 2671 and 2672

TABLE B-3. MISCELLANEOUS COATED AND LAMINATED SUBSTRATE MANUFACTURING FACILITIES

FACILITY	PARENT COMPANY NAME	TOTAL AIR RELEASE IN LBS/YR	MEK RELEASE IN LBS/YR	TOLUENE RELEASE IN LBS/YR
SHUFORD MILLS, HICKORY, NC	SHUFORD MILLS, INC.	1,931,324		1,931,324
FLEXCON, SPENCER, MA	FLEXCON	194,492	32,319	132,473
COATING SCIENCES, INC., BLOOMFIELD, CT	COATING SCIENCES, INC.	33,985	3,342	20,052
THE OCTOBER COMPANY, EASTHAMPTON, MA	THE OCTOBER COMPANY	18,945		18,945
TESATUCK, MIDDLETOWN, NY	TESATUCK, INC.	228,750		228,750
REXHAM, MATTHEWS, NC	REXHAM INDUSTRIAL	614,515	300,970	299,968

Source: 1990 TRIS

APPENDIX C

TRIP REPORTS

TRC
Environmental Solutions through Technology

TRC Environmental Corporation
100 Europa Drive, Suite 150
Chapel Hill, NC 27514
☎ (919) 968-9900 Fax (919) 968-7557

Date: January 8, 1993

Subject: Site Visit - Anchor Continental Incorporated
Pressure Sensitive Tape Manufacturer
EPA Contract 68-D9-0173, Work Assignment Number 3/309
TRC Reference No. 1637309

From: Geary D. McMinn and David D. Ocamb
TRC Environmental Corporation

To: Mike Kosusko
Organics Control Branch
Air and Energy Engineering Research Laboratory (MD-61)
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

I. Purpose

As part of the overall effort by the U.S. Environmental Protection Agency (EPA) to identify areas for preventing the creation of pollution associated with manufacturing entities, EPA is currently reviewing the pollution prevention opportunities associated with equipment cleaning in the adhesives-coated and laminated paper industry. TRC Environmental Corporation (TRC) is supporting EPA in this effort by developing prevention strategies for laminated paper equipment cleaning under Work Assignment Number 3/309, EPA Contract Number 68-D9-0173.

Anchor Continental Incorporated (Anchor), a pressure sensitive tape manufacturing facility, was selected for a site visit to collect information on the pollution prevention opportunities available for this industry segment. The focus of pollution prevention efforts in this industry is on emissions of volatile organic compounds (VOCs) and air toxics. The purpose of the visit to Anchor was to gather information on their pressure sensitive tape manufacturing processes and to identify, with input from the plant experts, any opportunities for preventing VOC emissions resulting from the cleaning of equipment. Specific objectives of the trip were to collect information necessary to characterize the plant production processes, equipment cleaning requirements and practices, and cleaning solvent recovery and disposal methods; and to witness first-hand any pollution prevention opportunities for pressure sensitive tape equipment cleaning operations.

This trip report includes four sections. Section II identifies the location of the Anchor facility. Section III presents the individuals who participated in the site visit. Section IV includes the technical information compiled during the site visit. In addition, the attached Appendix presents facility plot plans for the various Anchor production processes.

II. Place and Date

Anchor Continental Incorporated
2000 South Beltline Boulevard
Columbia, SC 29250
(803) 376-5468

December 18, 1992

III. Attendees

Anchor Continental Incorporated

Rick G. Carnell, Environmental Affairs Manager

TRC Environmental Corporation

David D. Ocamb, Senior Environmental Engineer
Geary D. McMinn, Environmental Scientist

IV. Discussion

The discussion began with the purpose of the visit, addressing EPA's goals for pollution prevention analysis for pressure sensitive tape manufacturing, and future preventive activities. During this meeting the following major areas were considered:

- The general plant description
- Manufacturing and site activities at the Columbia plant including adhesives mixing, paper tape manufacturing, reinforced tape manufacturing, cloth tape manufacturing, and stencil products manufacturing
- Equipment cleaning practices
- General emissions information
- Pollution prevention opportunities specific to the Anchor facility
- Prevention opportunities that may be applied to the overall industry (*e.g.*, reformulation of adhesives and changes in cleaning)

The meeting was followed by a tour of the production operations. Each specific topic addressed in the meeting is discussed in detail below.

A. Anchor History and General Plant Description

Anchor Continental began manufacturing pressure sensitive tapes approximately sixty years ago. Anchor currently operates two plants, one in Covington, Ohio, and the headquarters plant in Columbia, South Carolina. The Columbia facility operates 5 days per week, 24 hours per day, and produces four types of pressure sensitive products:

- Paper Tapes
- Duct (Cloth) Tapes
- Reinforced (Film) Tapes
- Stencil Products

Although specific product characteristics (*e.g.*, adhesive strength or color) vary according to customer specifications, there are general product characteristics for each of the different product groups.

Anchor manufactures several types of saturated paper tapes including masking tapes and some packaging tapes. The VOC content of the coatings in these tapes (*i.e.*, saturant, release coat, and adhesive), and the resulting VOC emission rate, varies viscosity and with the desired performance characteristics. For instance, a product, such as automotive tape, which must withstand elevated temperatures for an extended period of time tends to be manufactured with natural rubber. When dissolved in a solvent such as toluene, natural rubber results in a high viscosity (high solids, low solvent) material. Other materials (*e.g.*, synthetic rubbers) result in low solids formulations and yield high VOC coating contents and high VOC emission rates.

Duct or cloth tapes are laminates of cloth and a polyethylene film. While the 100 percent solids adhesive on such tapes contains no solvents, the release coat does contain a solvent. Solvent vapors from the release coat station and oven are destroyed in a catalytic oxidation unit. Duct tape, as its name applies, is used in ducting insulation and carpet pad splicing.

Reinforced (film) tapes are manufactured in the same manner as paper tape except that the saturated paper substrate of the paper tape is replaced with a polyester film. The film contains glass fiber strands which provide superior strength. Film tapes have become popular in packaging and box sealing, electrical, and pipe wrapping applications.

Stencil products are manufactured using a calendered, solvent-based adhesive coating process. An adhesive-coated film and a rubber sheet are laminated and wound into a roll. The stencil products are used in a variety of etching (*e.g.*, glass) and sand blast (*e.g.*, monument) applications. The solvent vapors resulting from the drying of the adhesive coat are destroyed by catalytic oxidation.

Figure A in the Appendix shows the layout of the Anchor - Columbia facility. The tape and stencil products are manufactured on a total of five process lines in either the production building, the rubber division building, or the latex saturator building. Adhesives and release coats are formulated in the mixing area. The mixed adhesives and release coats are transferred to the area storage vessels for use in the various tape production processes. In addition, a centralized equipment cleaning room is located at the south end of the production building. The majority of the movable equipment used throughout the production facility (*e.g.*, rollers, dip trays, and knives) is directed to this central room for dedicated cleaning.

As shown on the plot plan in the Appendix Figure B, the main production building contains three of the five facility process lines as well as other specialized processes. Line 1 is a low VOC line regulated by New Source Performance Standards (NSPS). Line 2 is grandfathered from NSPS regulations, has fewer restrictions on the VOC content in the processing materials, and, therefore, can run tapes that produce higher emissions. Line 3 runs only reinforced and paper tape. The main production building also houses an intermediate coating line which saturates raw paper with polyurethane to provide the paper with greater tensile strength.

The remaining two tape process lines are located in the rubber division as shown in Appendix Figure C. Duct (cloth) tape and stencil products are manufactured on dedicated process lines. The rubber division contains two small scale banburys (rubber mixing units) which are used to mix the rubber substrate and mill/extrude the rubber sheeting and adhesive stocks.

Appendix Figure D shows the layout of the saturator building. This building contains a hot-melt line and an intermediate coating line used to manufacture latex-saturated tape backing for paper tapes. In the latex-saturation process, raw paper is saturated with latex to provide greater tensile strength. The saturating process involves passing the paper through a latex saturant bath and then drying the saturated paper in drying ovens. The saturated paper is then directed to other tape process lines for production of the desired tape product. The hot-melt uses a solventless thermoplastic adhesive to produce specialty tapes.

B. <u>Adhesive Mixing</u>

Adhesive mixing is a basic manufacturing requirement for the solvent-based adhesives used in the tape products produced by Anchor. Anchor mixes adhesives to meet tight tolerances dictated by customer specifications. Figure 1 is a flow diagram representing the Anchor process for adhesive mixing. As shown, adhesive mixing begins with stock preparation. Stock is prepared by blending natural and synthetic rubbers, hydrocarbon resins, oils, and fillers in a banbury. The banbury output is then directed to mills where a sheet of adhesive stock is extruded, cut, and then palletized for further processing.

The pallet sheets are then sent to the mixing department where they are loaded into mixers approximately 10,000 gallons in size. Toluene is added to dissolve the stock. Heptane is also used with toluene for manufacturing certain stencil adhesives. The solvent is pumped into the mixers with additional resins, rubber (self polymerizing), and oils to complete the adhesive formulation. Table 1 presents a breakdown of the adhesive ingredients employed by Anchor. The actual mix ratios are considered confidential.

Once an adhesive is formulated, the finished material is pumped to storage tanks in the appropriate manufacturing building or transferred via tote vessels to specific process lines for future use. In order to ensure the proper adhesive quality, Anchor uses in-line filtration. Filter bags separate remaining suspended solids (the natural and synthetic rubber) from the coating mixture. The filter bags are changed once per shift for each coating line.

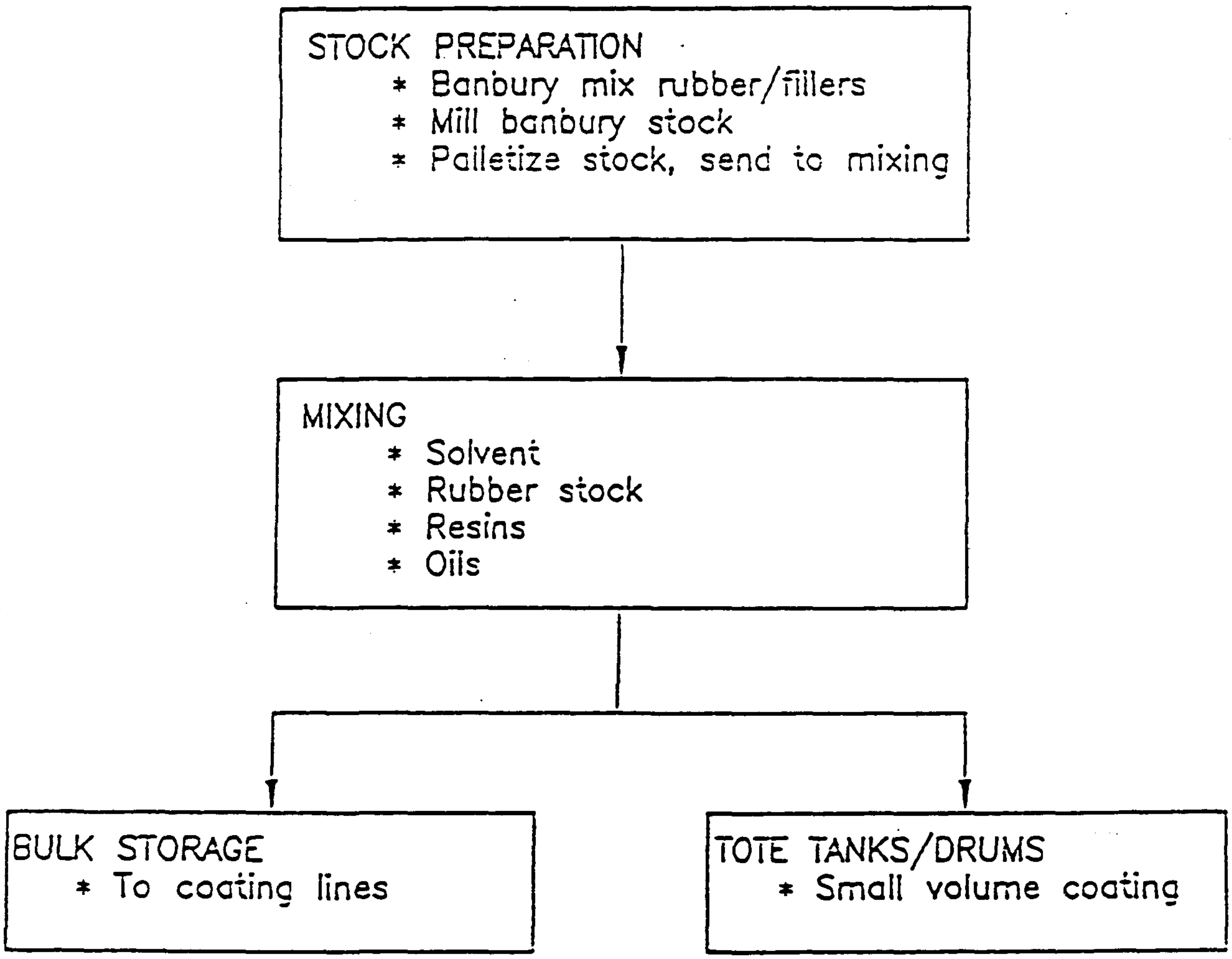

Figure 1. Adhesives Mixing Flow Diagram.

TABLE 1. ANCHOR ADHESIVES RAW MATERIALS

Chemical Name	Chemical Name
Styrene/butadiene copolymer	Petroleum hydrocarbon resin
Zinc dibutyl dithiocarbonate	Heptane
Tetrakis (methylene(3,5-Di-tert-butyl-4-hydroxyhydrocinnamate))	Styrene-isoprene-styrene block copolymer
Polyterpene resin	Aliphatic hydrocarbon resin
Zinc oxide	Zinc isopropyl xanthate
Mineral oil	Natural rubber
Polyalphamethyl styrene	Sodium aluminum silicate
Diphenylmethane diisocyanate	Toluene
Ground limestone	Hydrated amorphous silica
Ground silica	Zinc dibutyl dithiocarbonate

C. Paper Tape Manufacturing

A process flow diagram for paper tape manufacturing is presented in Figure 2. To manufacture paper tape, the raw paper is bought from a vendor either as latex saturate or polyurethane saturate. The compositions of the purchased saturates are presented in Table 2. If a desired color and/or bond (tie) is required, the paper is processed in an intermediate coating area before applying a release and adhesive coat. A tie coat improves the bond of the adhesive to the paper.

After color and/or tie coats are applied, the release coat is applied to the non-bonding surface of the product. The composition of the release coat is presented in Table 3. The release coat is applied by passing the paper through a roller system containing a release coat. The release coat is transferred from the roller to the top side of the paper. The roller system maintains the tension of the paper to ensure even coating application. A doctor blade, a long knife-like piece of metal, removes any excess coating from the paper. The removed coating returns to the coating bath for reuse. The release coat is pumped from the release coat storage tanks on the process line which are fed from the larger storage tanks located in the mixing area. The tape passes through multi-stage natural gas-fired dryers to dry the release coat.

Adhesive, pumped from bulk storage tanks located in the mixing area, is applied after the release agent. After exiting the release coat dryers, the paper passes through rollers to maintain the tension for applying the adhesive. A large roller dipping into a "bath" of adhesive comes into contact with the clean, non-release coat, side of the papercoated paper. A doctor blade is used to remove excess adhesive from the paper after contacting the roller. The adhesive-coated paper then

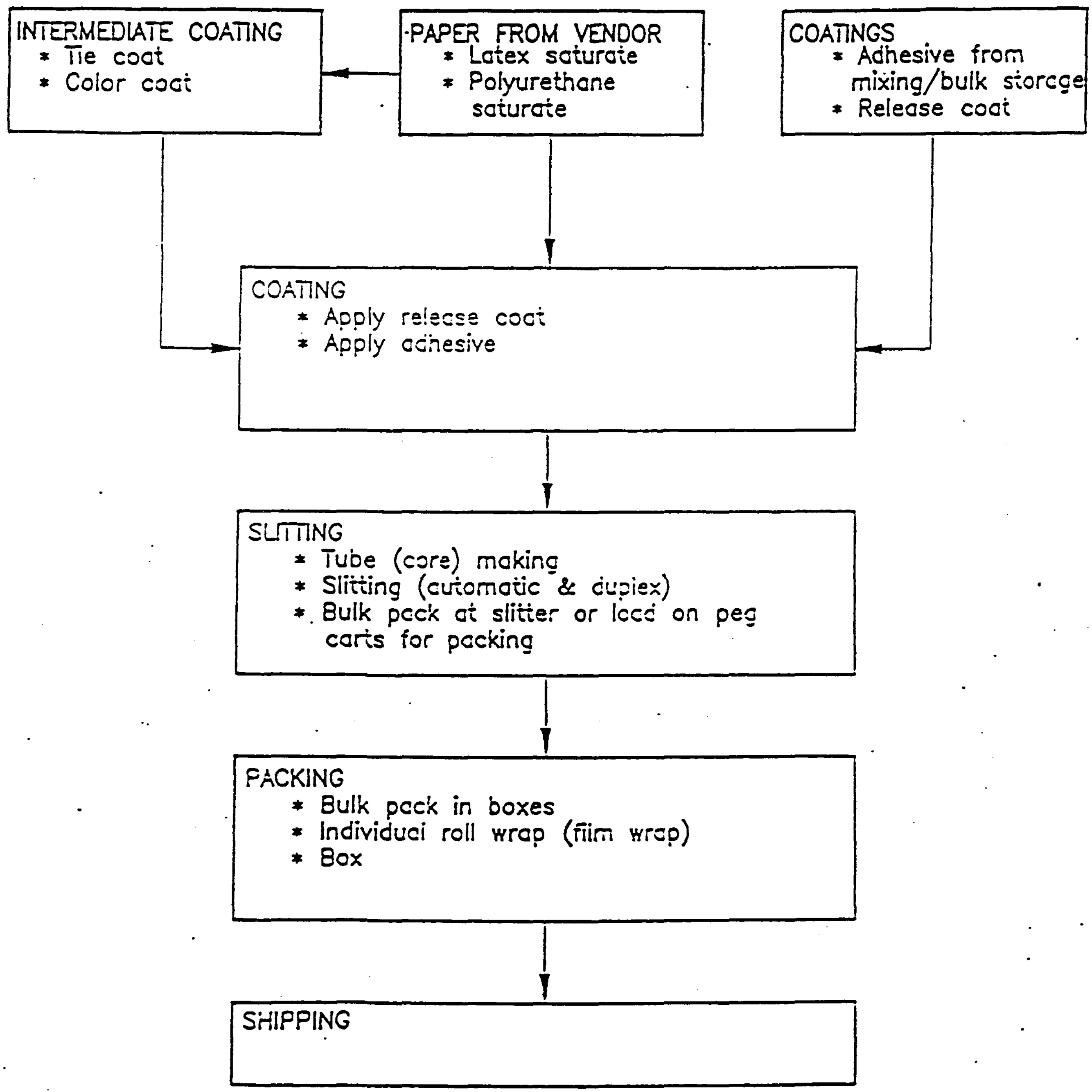

Figure 2. Paper Tape Manufacturing Process Flow Diagram.

TABLE 2. ANCHOR PURCHASED SATURANTS COMPOSITION

Saturant Type	Chemical Name
Latex Saturant	Carboxy-modified butadiene/styrene polymer emulsion
Polyurethane Saturant	Toluene diisocyanate
	Toluene
	Hydrocarbon resin
	Polyether blend

TABLE 3. ANCHOR RELEASE COAT RAW MATERIALS

Chemical Name	Chemical Name
Acrylic ester copolymer	Isopropyl alcohol
Silicone catalyst	Silicone solution
Polyamide resin	Toluene

proceeds through another set of dryers. The paper tape is then ready for Quality Assurance Inspection, slitting, roll-up, and packaging for distribution.

D. Reinforced Tape Manufacturing

Other types of tapes have the same basic process flow as paper tapes but are manufactured using slightly different raw materials and substrates. The general process flow diagram for reinforced tape manufacturing is presented in Figure 3. In general, reinforced tapes have a polyester backing instead of saturated paper backing. Fiberglass strands are incorporated to give superior strength compared to paper tape. These strengtheners are tie-coated or laminated, to the polyester film. The release coat is applied on the opposite side of the tie-coat with the adhesive being placed over the reinforcing threads. The remaining processing activities for reinforced tape include drying, Quality Assurance Inspection, slitting, roll-up, and packaging for distribution.

E. Duct (Cloth) Tape Manufacturing

Figure 4 presents the process flow diagram for duct tape manufacturing. Duct tape manufacturing is similar to paper tape manufacturing except that the adhesive is calendered in a solid form to join together to the laminate, the polyethylene film and the cloth substrate. The result is a cloth and film web which then has the release coat applied on the film side. No solvent is present

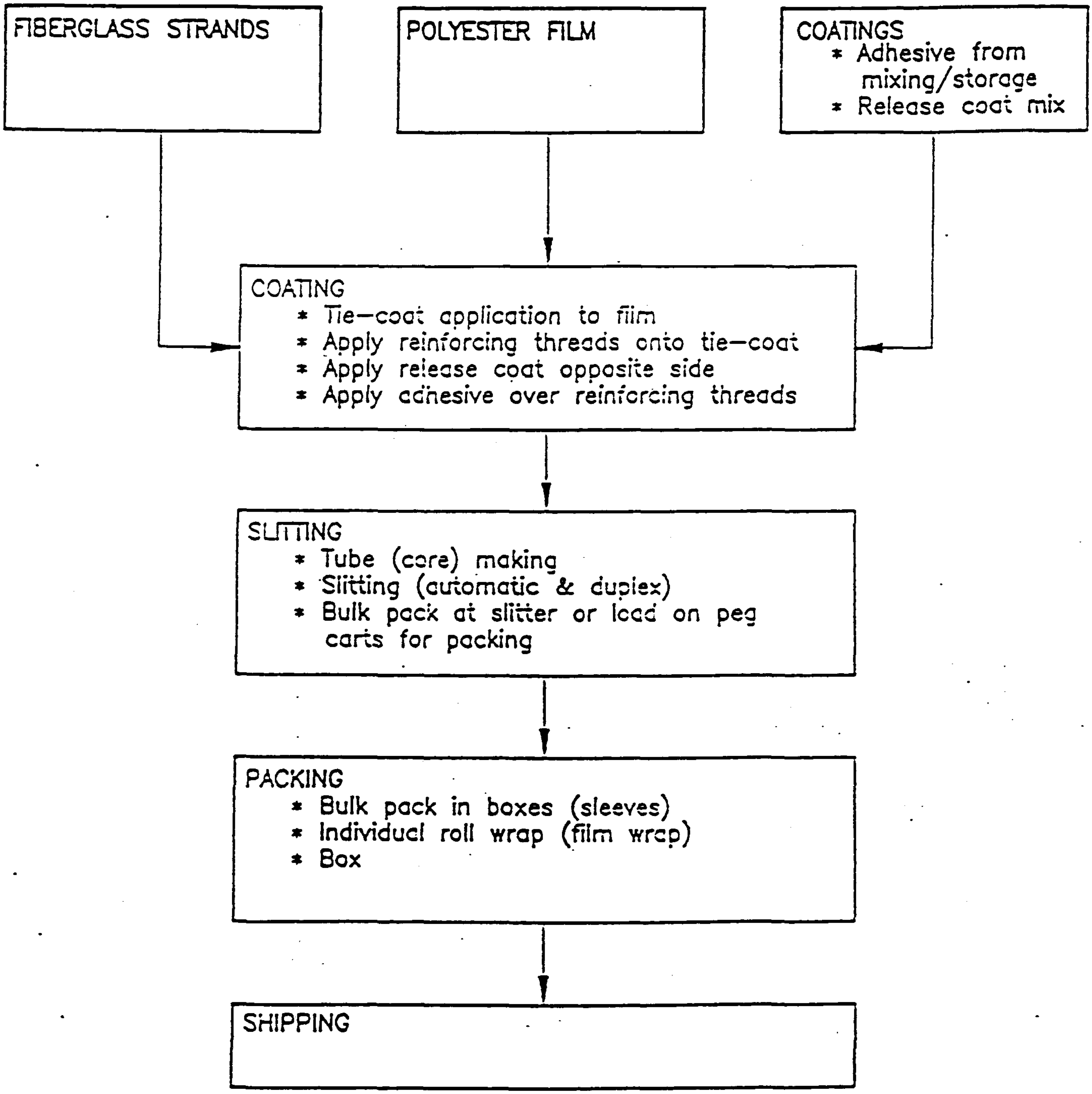

Figure 3. Reinforced Tape Manufacturing Process Flow Diagram.

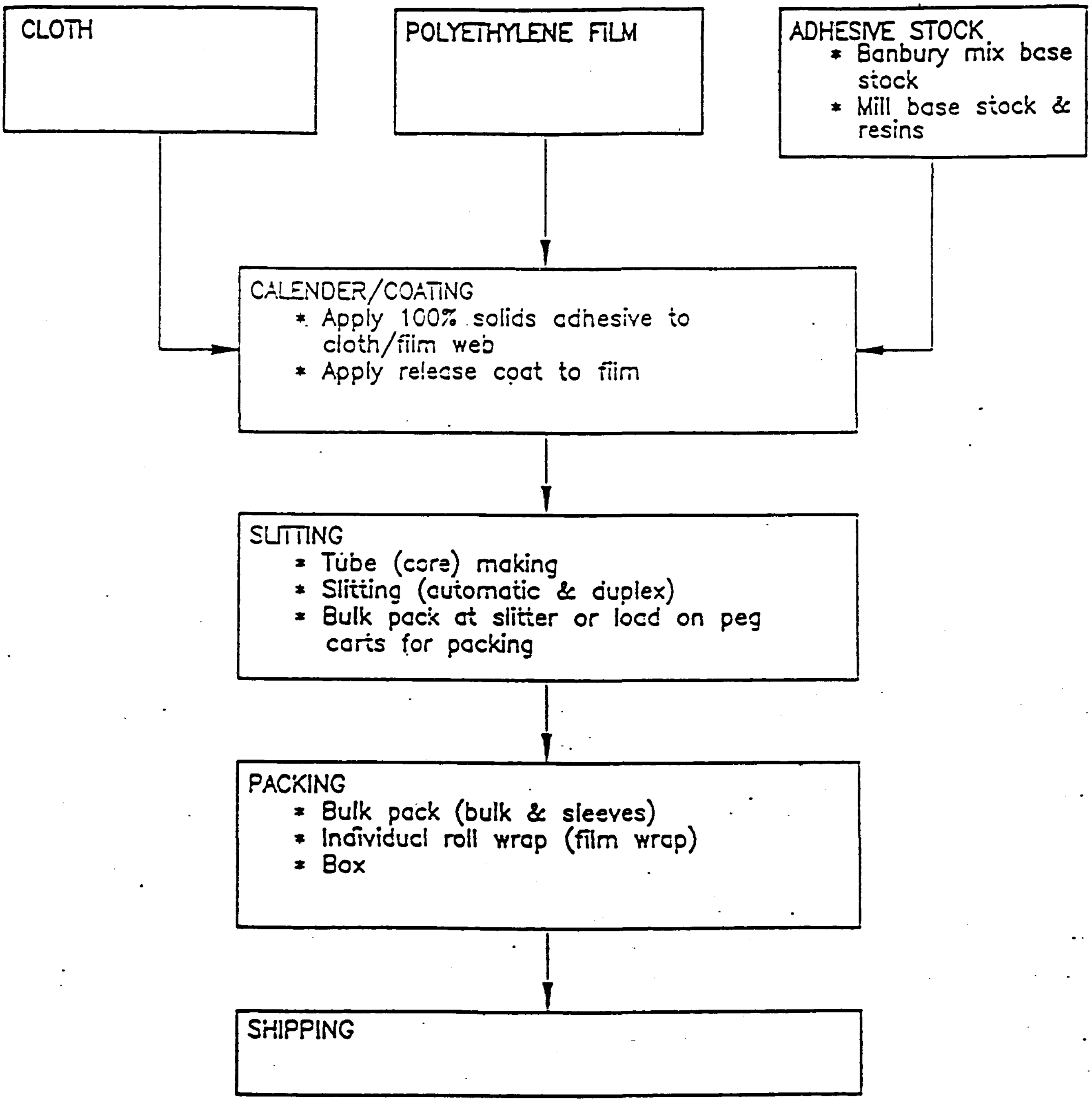

Figure 4. Duct (Cloth) Tape Manufacturing Process Flow Diagram.

in the duct tape adhesive which is 100 percent solids. However, toluene is present in the release coat. Anchor employs a catalytic oxidizer to destroy any toluene or other emissions generated during drying.

F. Stencil Products Manufacturing

The process for manufacturing stencil products is different from tape manufacturing. The stencil products process flow diagram is presented on Figure 5. The process begins by blending rubber stock in a banbury and then milling and calendering the banbury output to create rubber sheets. The sheets are placed on a conveyor for cooling. Adhesive is transferred from the mixing area by tote vessels. The adhesive is applied to a release liner. This adhesive-coated release liner is then laminated with the rubber sheets, trimmed to proper size, and wound in rolls. The stencil products are then finished in the same way as other Anchor tape products.

G. General Equipment Cleaning Practices

Anchor does not perform equipment cleaning on any specific schedule. When a process is down, the equipment is disassembled (that which can be), moved to the centralized equipment cleaning room attached to the main production building, and given a toluene bath. Process equipment is soaked and cleaned in one of two 100-gallon toluene vats in the cleaning room. The vats are filled with toluene as needed; the toluene is changed once per week. Toluene is pumped off and recycled as part of the overall adhesive mixing process. Approximately 180 gallons are recycled. Anchor estimates using mass balance that 20 gallons per week of toluene are lost as waste and fugitive emissions. Further discussion of the reclamation process can be found in Section H of this report.

Stationary equipment (*e.g.*, rollers) that cannot be moved to the centralized cleaning room is cleaned in a two-step process. First, the equipment is wiped down with a dry rag. Next, it is cleaned with a toluene-soaked rag. Drip trays are located under the adhesive coaters on each coating line. In addition to catching excess adhesive, these trays contain toluene which is used for spot cleaning. Scrapers, similar to putty knives, are dipped into toluene in the drip tray or solvent safety can and then used to remove dried adhesive from the process equipment rollers.

The toluene-soaked rags and excess toluene are collected in five-gallon safety cans located near the machinery. The safety cans are sealed, grounded containers which hold the toluene and toluene rags to prevent spills and reduce emissions. Once these cans are full, the operator is required to take them to a 55-gallon drum located in the disposal area (located in the mix area). Toluene-contaminated rags and toluene that cannot be reclaimed are sent off-site for disposal. Any other spent solvents (*e.g.*, heptane) and waste, solvent-based coatings used in the facility are sent off-site for disposal.

In the past, Anchor attempted to use Varsol, a mineral spirits solvent substitute, for general equipment cleaning in an attempt to reduce toluene use and resulting emissions from clean up. However, Anchor found Varsol to be less effective than toluene for equipment cleaning. Anchor

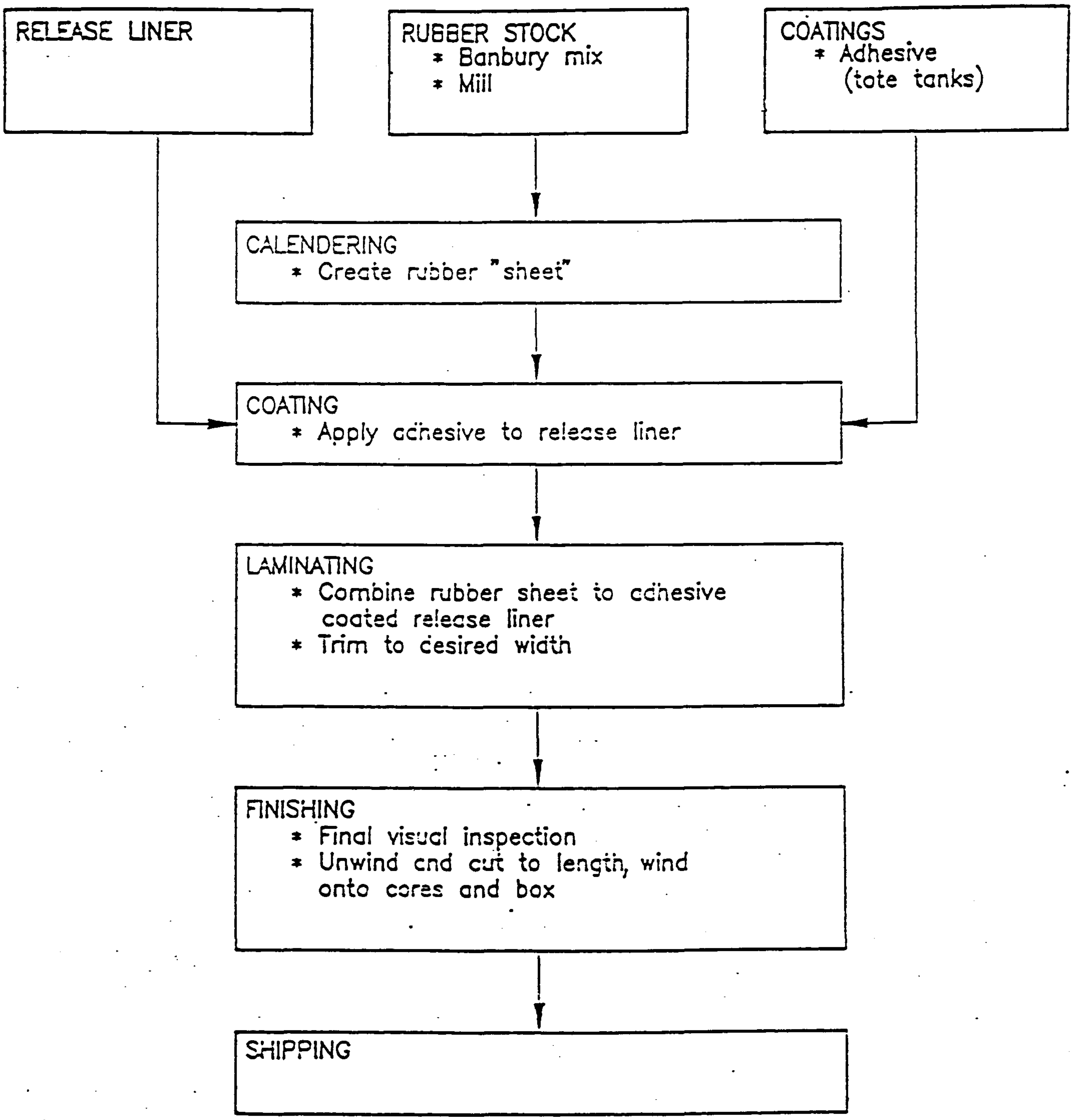

Figure 5. Stencil Products Manufacturing Process Flow Diagram.

believes that Varsol is inappropriate for the production line because it leaves a film on the adhesive and release coat rollers which reduces the uniformity of the applied coats and subsequently prevents the adhesive from attaching to the tape. Varsol is currently used to clean spills and leaks on floors and machinery in the packaging department. It is also used for daily floor cleaning. The Varsol-soaked cleaning rags (not classified as hazardous waste) are disposed of in the facility (burned in the plant boiler) according to Anchor's South Carolina Department of Health and Environmental Control (DHEC) permit. The permit prohibits burning toluene-soaked rags.

H. General Emissions Information

Toluene is used as a solvent in the mixing of the adhesives and in cleaning the process equipment. Toluene is released from the centralized cleaning room as well as from the "on-the-spot" cleaning applications within the facility. These releases are predominantly fugitive emissions. Cleaning equipment involves wiping the excess adhesives with a rag, scraping the equipment component if necessary, and then wiping the area with a toluene-soaked rag.

Anchor employs both a toluene recycle/reclamation and an off-site disposal program. The containers holding toluene and toluene-soaked rags are a source of fugitive emissions. After cleaning parts and removing sludge, the centralized cleaning room, which houses the two 100-gallon vats, recycles approximately 180 gallons per week of toluene. In addition, an average of 148 gallons of sludge per month is sent off-site for disposal. Approximately 200 gallons per month of toluene are reused while only 20 gallons per week are non-reusable. Roughly 88 gallons of toluene per week from other sources are reusable. Approximately six drums per year of toluene rags are sent off-site for disposal.

Spent Varsol is sent off-site for disposal while rags contaminated with Varsol are burned in the boilers. Approximately 125 gallons of Varsol per week are generated from plant wide sources. Varsol rags are burned at the rate of two drums per week. Varsol is also used to wash filter bags which become contaminated with adhesive on the production lines. Filter bags are incinerated at the rate of one drum per week.

I. Pollution Prevention Opportunities

Potential pollution prevention opportunities include: (1) replacement of all toluene cleaning with Varsol; (2) identification of a cleaning solvent substitute to replace toluene; (3) elimination of the toluene/adhesive drip trays on the coating lines, and (4) using sealed cleaning solvent buckets for on-the-spot cleaning.

The most effective technique for Anchor to reduce emissions would be to eliminate toluene as a cleaning solvent. Even though Anchor has previously replaced a large portion of the toluene with Varsol, complete replacement of toluene by Varsol is unreasonable since Varsol has a limited application for cleaning in the pressure sensitive tape industry. As mentioned earlier, Varsol can leave a film on the coating rollers which reduces the effectiveness of the adhesive application. As such, identification of a new cleaning solvent to use in conjunction with Varsol remains the only viable opportunity for reducing toluene usage and emissions from equipment cleaning. To pursue this preventive opportunity, the cleaning solvent suppliers could be surveyed to determine if an effective toluene replacement exists in the market place today. One consideration in using a solvent-substitute is subsequent disposal of the aqueous waste.

An additional pollution prevention (and emissions reduction) opportunity available at Anchor would be to replace the toluene/adhesive drip trays and provide the operators with sealed cleaning solvent buckets for on-the-spot cleaning. Process operators generally use putty-like cleaning knives to spot clean areas on calenders, mills, and coating rollers. The operators generally have a drip tray present where a small volume of toluene is maintained. The putty knives are dipped into the tray to moisten the knife prior to the on-the-spot cleaning. By using a small, sealed cleaning bucket in place of toluene in an open drip tray, the operators can use toluene for spot cleaning while simultaneously reducing fugitive emissions.

Additional measures such as using a toluene dilution (*e.g.*, 75 percent toluene and 25 percent water) could have an impact on emissions from the cleaning process. Alternative technologies such as using a mist sprayer rather than a continual toluene drip may reduce the amount of adhesive lost in the application process and reduce the amount of toluene needed for clean up. Finally, a combination of the above techniques may be applied to reduce the emissions of toluene from the pressure sensitive tape industry.

APPENDIX

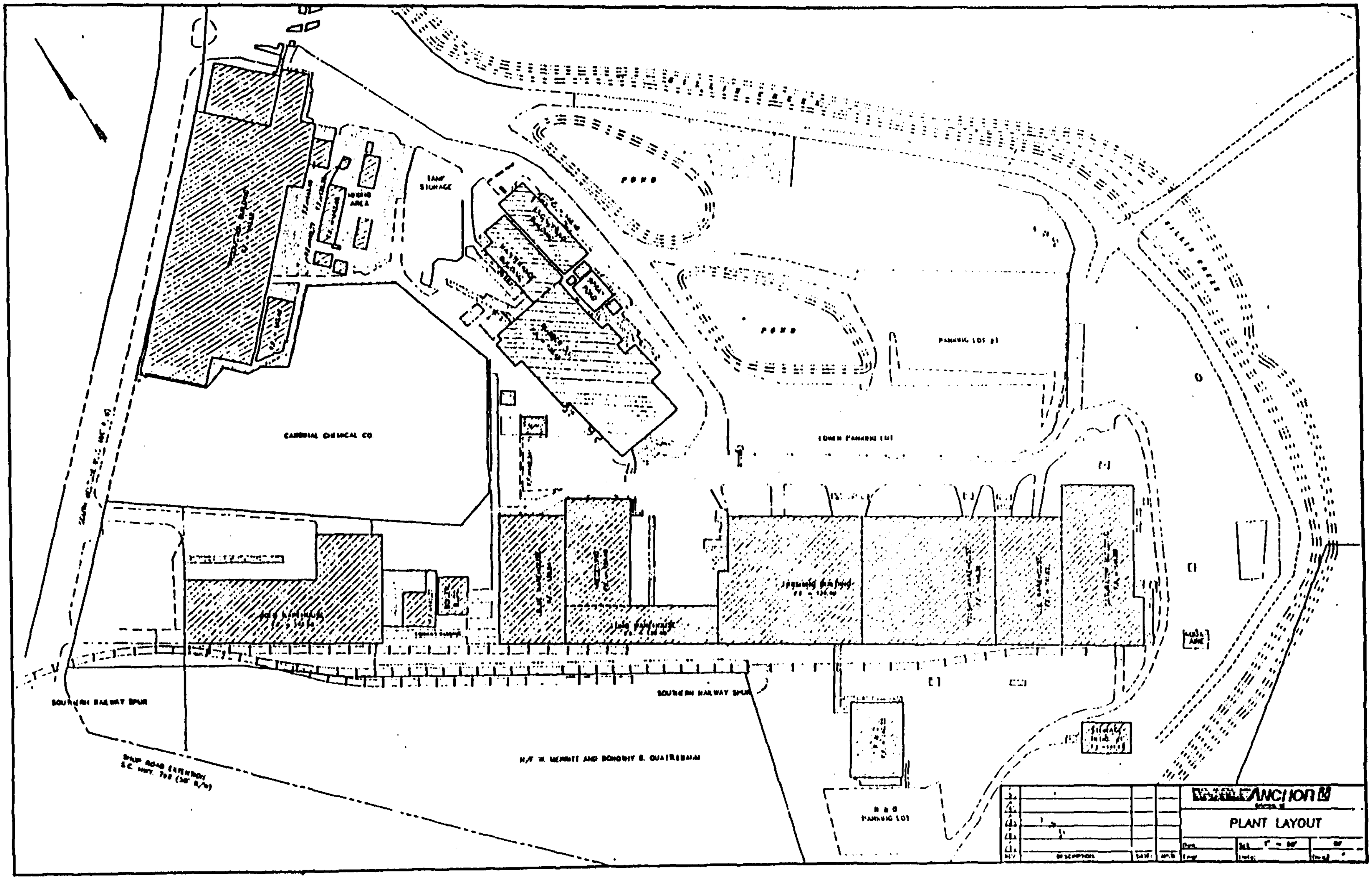

Figure A. Site Plan for the Anchor Continental Incorporated Columbia, South Carolina Facility

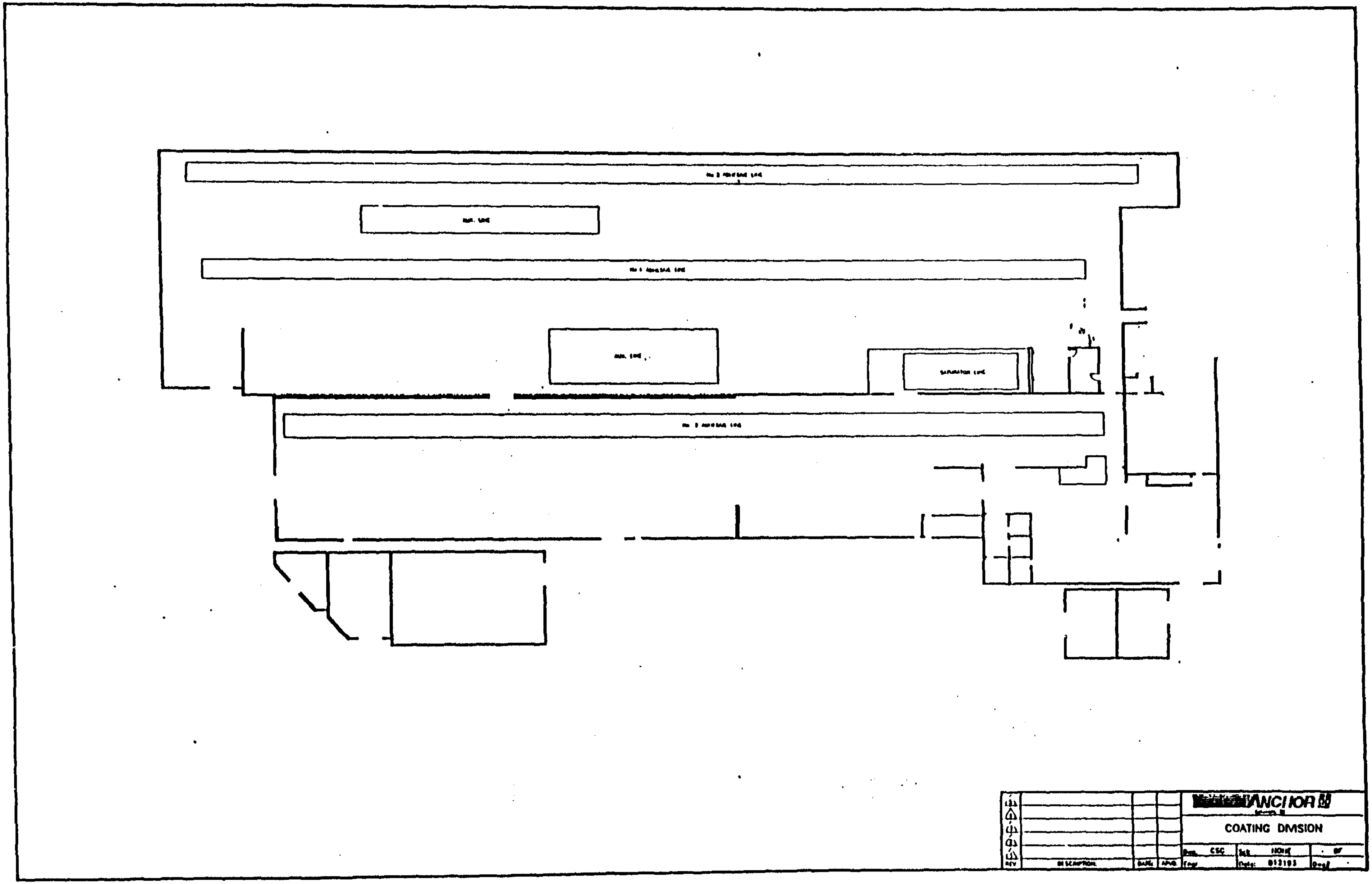

Figure B. Anchor Production Building Plot Plan

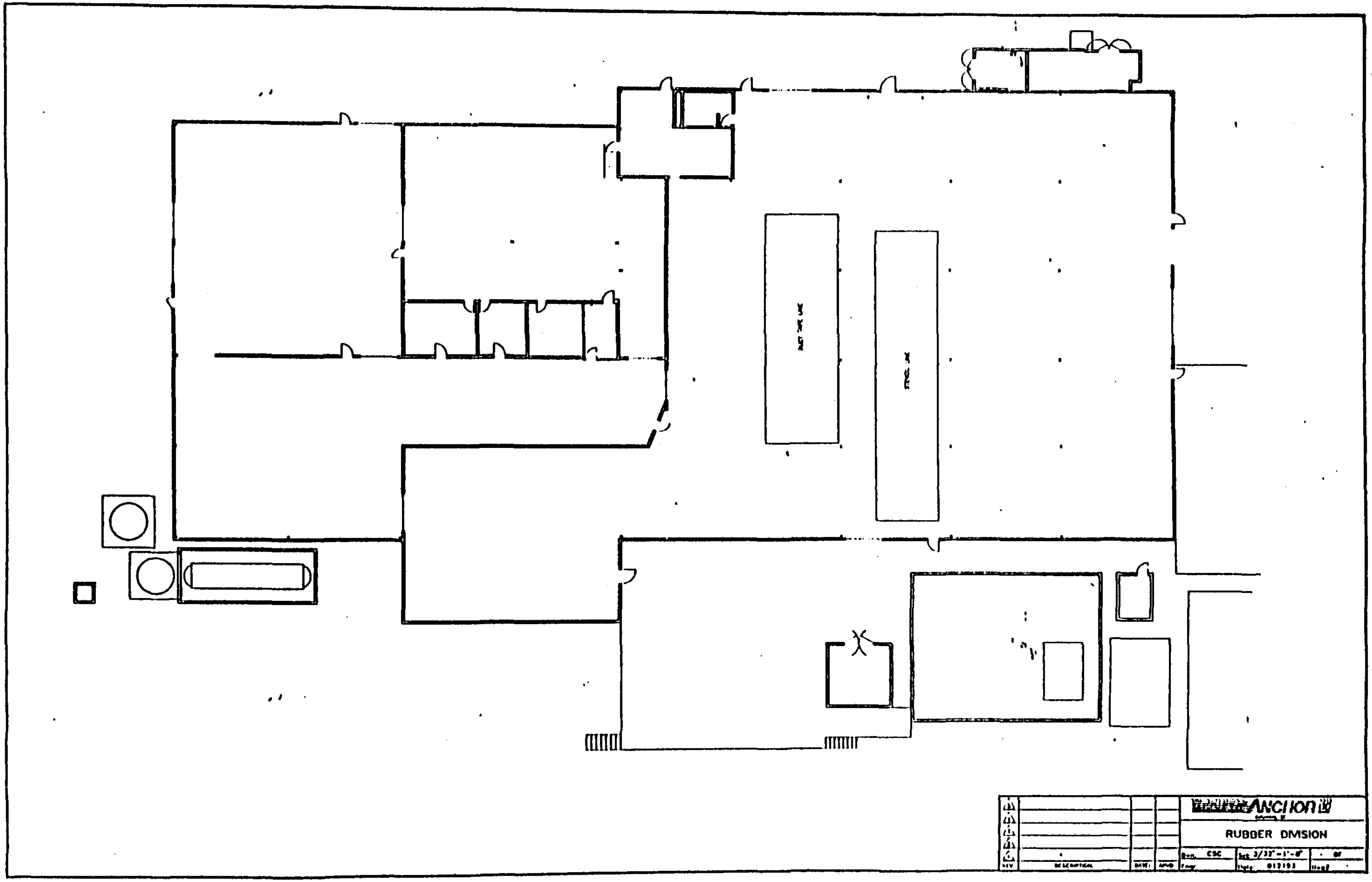

Figure C. Anchor Rubber Division Building Plot Plan

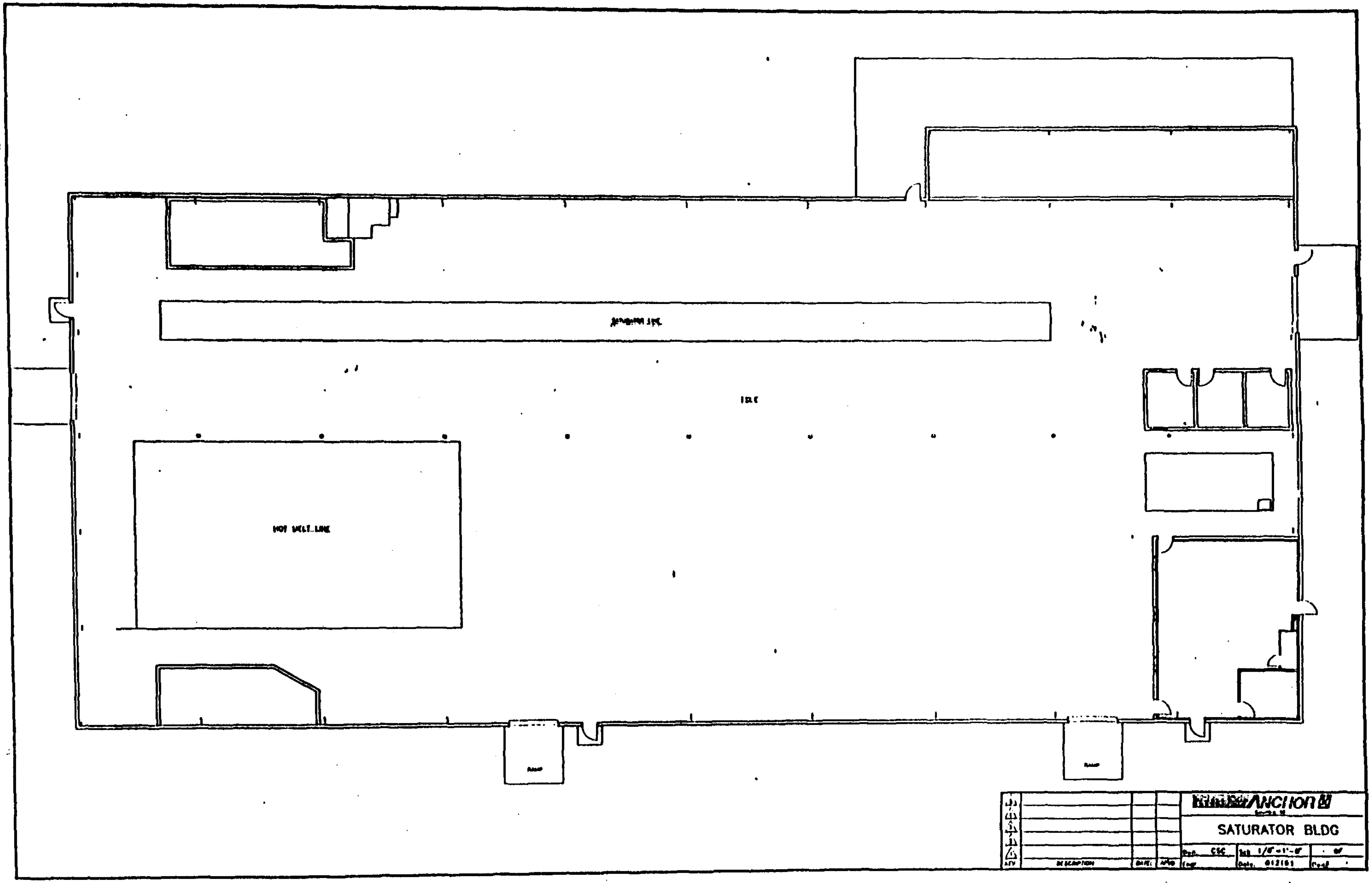

Figure D. Anchor Saturator Building Plot Plan

TRC

Environmental Solutions through Technology

TRC Environmental Corporation
100 Europa Drive, Suite 150
Chapel Hill, NC 27514
☎ (919) 968-9900 Fax (919) 968-7557

Date: March 31, 1993

Subject: Site Visit - 3M Company
Pressure Sensitive Tape Manufacturer
EPA Contract 68-D9-0173, Work Assignment Number 3/309
TRC Reference Number 1637309

From: Beth W. McMinn and Jill B. Vitas
TRC Environmental Corporation

To: Mike Kosusko
Organics Control Branch
Air and Energy Engineering Research Laboratory (MD-61)
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

I. Purpose

As part of the overall effort by the U.S. Environmental Protection Agency (EPA) to identify areas for preventing the creation of pollution associated with manufacturing entities, EPA is currently reviewing the pollution prevention opportunities associated with equipment cleaning in the adhesives-coated and laminated paper industry. TRC Environmental Corporation (TRC) is supporting EPA in this effort by developing pollution prevention strategies for laminated paper equipment cleaning under Work Assignment Number 3/309, EPA Contract Number 68-D9-0173.

The Minnesota Mining and Manufacturing Company (3M) in Bristol, Pennsylvania, a pressure sensitive tape manufacturing facility, was selected for a site visit to collect information on the pollution prevention opportunities available for this industry segment. The primary focus of pollution prevention efforts in this industry is on emissions of volatile organic compounds (VOCs) and air toxics. The purpose of the visit to 3M was to gather information on their pressure sensitive tape manufacturing processes and to identify, with input from the plant experts, any opportunities for preventing pollution resulting from the cleaning of equipment. Specific objectives of the trip were to collect information necessary to characterize the plant production processes, equipment cleaning requirements and practices, and cleaning solvent recovery and disposal methods; and to witness first-hand any pollution prevention opportunities for pressure sensitive tape equipment cleaning operations.

This trip report includes four sections. Section II identifies the location of the 3M facility. Section III presents the individuals who participated in the site visit. Section IV includes the technical information compiled during the site visit.

II. Place and Date

3M Company
Green Lane
Bristol, PA 19007
(215) 945-2800

February 11, 1993

III. Attendees

3M Company

Belinda M. Wirth, Environmental Engineer
Bob McKinnell, RCRA Coordinator

TRC Environmental Corporation

Beth W. McMinn, Project Manager
Jill B. Vitas, Task Leader

IV. Discussion

The discussion began with TRC describing the purpose of the visit, addressing EPA's goals for pollution prevention analysis for pressure sensitive tape manufacturing and future preventive activities. During this meeting the following areas were discussed:

- Market Profile
- Manufacturing Supplies
- Manufacturing Process Profile
- Equipment Cleaning Experience
- Emissions Reduction and Control Experience
- Pollution Prevention Experience

The meeting was followed by a tour of the production operations. Each topic addressed in the meeting is discussed in detail below.

A. 3M History and Market Profile

3M Company has approximately 70 plants in the United States, 14 of which manufacture pressure sensitive tapes and labels (*i.e.*, operate under Standard Industrial Classification codes 2671 and 2672). In total, the company employs nearly 50,000 people in the United States. 3M is the largest pressure sensitive tape manufacturer with almost 85 percent of the market share and 1991 sales of nearly $13 billion.

The 3M Bristol facility, whose primary Standard Industrial Classification (SIC) code is 2672 (Coated and Laminated Paper, Not Elsewhere Classified), began operation in 1948 when 3M Company purchased the central building and land. Since that time, 3M has expanded, adding both buildings and land, to reach its current 70-acre site as shown on Figure 1. The Bristol plant is now operating with both a facility and employee cap. The facility's primary product has always been pressure sensitive tape. The Bristol plant currently operates within 3M's Masking and Packaging Division and produces film and filament packaging tapes for both consumer and industrial markets. Nearly 90 percent of the plant's output is sold to industrial markets. Additional plants in this division are located in Bedford Park, Illinois and Greenville, South Carolina. Approximately 40 percent of the tapes produced at the Bristol facility contain solvent-based adhesives, while the remaining 60 percent contain hot melt adhesives and typically a solvent-based release coat. In addition to manufacturing tapes, the Bristol plant makes fire retardant and marine caulks.

B. Manufacturing Supplies

The 3M Bristol plant uses more than 200 raw materials in their manufacturing processes. While the majority of these compounds are used in the caulk formulations, over 120 materials are used in primers, release coatings, and adhesive blends. The 3M facility uses toluene and mineral spirits to clean the equipment and floors.

C. Manufacturing Process Profile

The manufacturing process at the Bristol facility begins with the formulation of the coatings. A release coating prevents an adhesive from sticking to a surface. For tapes, the release coating prevents the adhesive-coated surface from sticking to the backside of the tape during manufacturing and winding. 3M uses a release coating step in the manufacture of film and filament packaging tapes. These low solids coatings are composed of resins, solvents, and additives. The release coatings are manufactured in fixed or portable agitated mix tanks and transferred via a dedicated manifold system to the release coating application head.

3M also manufacturers primers which bond the natural rubber based adhesive to the film substrate. Raw materials in the primers include rubbers, solvents, and additives. The primers are manufactured by the same process as the release coatings.

The 3M Bristol facility compounds both hot melt and rubber based (natural and synthetic) adhesives. The adhesives are made in blenders and high-speed shear dispersers, called moguls, and then transferred via dedicated transfer lines to the applicable coating heads. The adhesive manufactured for the filament tape line uses natural or synthetic rubber dissolved in solvent mixtures for the specified viscosity. Adhesive for the film tape line has a synthetic rubber (hot melt) base.

The 3M Bristol plant operates two coating lines. The 5W line is dedicated to the manufacture of filament tape, while the 6W line produces colored film tapes. The Bristol plant is the only 3M plant in the United States that makes filament tape, a type of heavy-duty polyester or polypropylene packaging tape reinforced with filament strands. The 5W line operates 24 hours a day, 6 days a week, and 40 weeks per year with a maximum capacity of 115 yards per minute and an average

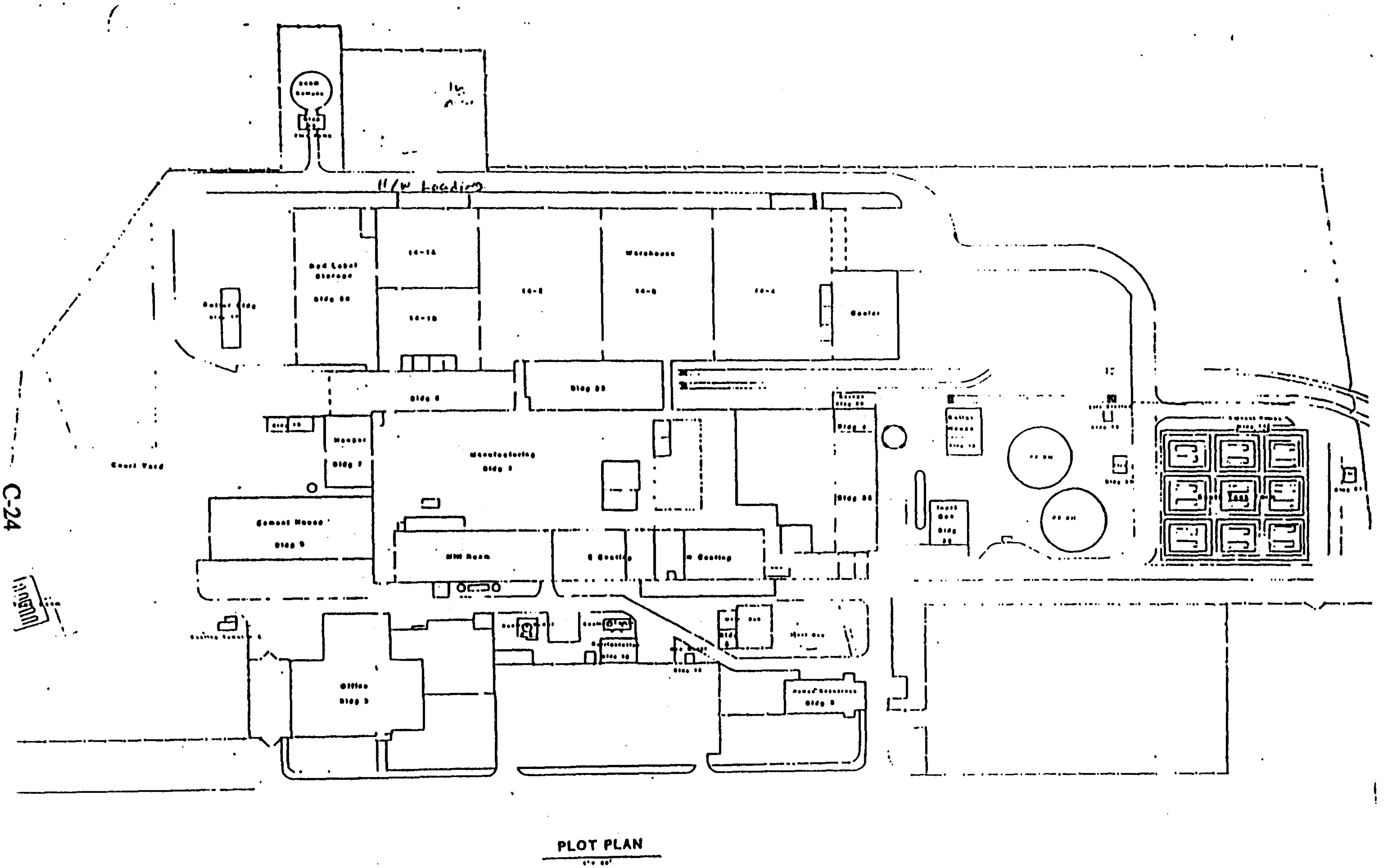

Figure 1. 3M Bristol Facility Plot Plan.

capacity of 80 square yards per minute. The line is typically shut down on Fridays for preventive maintenance and cleaning. Sixteen different grades of tape are manufactured on the 5W line. The differences between these grades are based on the type of film (*i.e.*, polyester or polypropylene), the type and number of nylon or rayon strands per square inch, and the thickness of the coating applied. The highest grade (and profit margin) products are produced in the greatest quantity (*e.g.*, 3.8 million square yards per year).

The general process flow for the 5W line follows. Rolls of polyester or polypropylene film are placed on an unwinder. The film passes through a gravure coater that applies a solvent-based primer which averages 98 percent VOC (5.9 pounds VOC per gallon of coating less water). Solvents used in the 5W coating formulations include xylene, toluene, heptane, ethanol, and cyclohexylamine. After the film substrate is primed, it passes through a hot air impingement dryer with an airflow of 6,000 scfm. The exhaust from this primer oven is released to the atmosphere. The dry, primed film is then release coated with a gravure roller (96 percent VOC and 6.9 pounds VOC per gallon of coating less water) and moved through a second hot air impingement dryer. The exhaust from the release coat oven is also released to the atmosphere. The film then moves to a primary adhesive application stage where an adhesive averaging 4.9 pound VOC per gallon (81 to 82 percent VOC) is applied. Following the adhesive coating, the film enters a two-stage oven equipped with inert gas solvent recovery. Once dry, the film and nylon or rayon filament strands are laminated and adhesive coated. The second adhesive coating step is followed by a pass through two stages of a six zone oven also equipped with an inert gas solvent recovery system, a third adhesive coating application, and a final pass through the remaining four stages of the oven. Solvent recovery in the adhesive ovens on the 5W line is estimated to be 83 to 86 percent efficient. The product is then wound, followed by slitting and packaging.

The 6W line operates 24 hours a day, 7 days a week, and 45 weeks per year with a line capacity of 425 yards per minute. The line is typically shut down for four to eight hours on Tuesdays for preventive maintenance and cleaning. The 6W line is capable of manufacturing 50 to 60 varieties of film tape products. Products are distinguished by film type, color, and film thickness. Eighty percent of the films run on the 6W line are polypropylene, 18 percent are polyester, 1 percent is polyvinyl chloride (PVC), and the remaining 1 percent are made with miscellaneous substrates (*e.g.* kraft paper, cellophane, etc.). The polypropylene and polyester film tapes and kraft paper tapes are used in box sealing applications. Tapes made with cellophane and PVC films are used for specialty applications such as taping clothing bags. All of the products produced on the 6W line are sold to industrial customers. Two of 3M's other facilities located in Greenville, South Carolina and Cynthiana, Kentucky make the same product for consumer markets using similar equipment configurations.

Coating stations on the 6W line consist of two precoaters and one functional adhesive applicator. The configuration of this line allows 3M personnel to use any combination of these three coating stations. A brief description of the 6W line and its current operating parameters follows (see Figure 3). Clear or colored films are loaded onto an unwinder. The film is guided by idling rolls to Station 1, an enclosed coating operation, where a gravure roller is used to apply primers. This coating station operates on average one day (*i.e.*, 24 hours) per month. Waterbased primers are applied 16 to 20 hours each month while solvent-based coatings account for the remaining 4 to 8 hours of operation. The solvent-based (*e.g.*, toluene, xylene, heptane, and isopropanol) coating formulations are typically pigmented and are used to change the properties of the film. From Station 1, the web moves into an enclosed release coat (low adhesive backsize - LAB) application station (Station 2). This station also uses a gravure roller. Station 2 is used 100 percent of the time that the line is operating. Each of these two precoat stations (*i.e.*, the primer and the LAB) is followed by a single stage oven. The next coating application station applies the functional hot melt adhesive using die application. The coated film is then wound and moved to the slitting operations. No emissions control device is used on this line as the hot melt formulation contains no solvents. Exhaust from both of the ovens is vented directly to the atmosphere.

D. Emission Reduction and Control Experience

Emission control devices used by the 3M Bristol facility include the following:

- Inert gas solvent recovery ovens following adhesive application on the 5W filament tape line
- Baghouses in the rubber compounding and milling areas
- Baghouses in the converting area for detackifying operations
- Condensers on the release and primer blenders

The solvent (*i.e.*, heptane) that is recovered from the two adhesive solvent recovery ovens is recycled back into the adhesive. 3M has also installed (but is not operating) duct work to capture the air stream from the open web area (prior to the web entering zones seven and eight of the inert gas solvent recovery oven) on Line 5W to improve the capture efficiency resulting in an overall control efficiency of over 90 percent. Plant officials hope to route the flash-off stream to the facility's boiler for heat recovery. The facility is currently waiting on permission from the State of Pennsylvania.

In addition, 3M Company has plans to transfer the LAB coating of polypropylene that occurs at Station 2 on Line 6W to another facility with a sophisticated solvent recovery unit. The Bristol facility would then receive primed and LAB coated polypropylene films from a sister facility and apply only the hot melt adhesive on the 6W line. The elimination of these steps at the Bristol plant would allow the facility to reduce solvent emissions originating at the 6W line. Emissions at the other 3M facility would not be significantly affected by the added coating application processes. Table 1 shows the Bristol facility's 1991 reportable Toxic Release Inventory (TRI) emissions. Table 2 shows 1992 VOC emissions broken down by coating line.

E. Equipment Cleaning Experience

Because the 3M Bristol facility operates coating lines dedicated to one product category (individual products may have different coating formulations), extensive cleaning is limited to production downtime or significant product changeovers. Normally, downtime, which consists of scheduled downtime for preventative maintenance (*i.e.*, Tuesdays for 6W and Fridays for 5W),

TABLE 1. 3M BRISTOL FACILITY 1991 TRI EMISSIONS

Chemical	Quantity (pounds/year)	Source
Toluene	910,000	Stack
Xylene	12,000	Stack
Ethylbenzene	1,200	Stack
Cyclohexane	102,605	Stack
Methyl Ethyl Ketone	1,400	Stack
Methanol	7,600	Stack
Zinc Compounds	11 to 499	Fugitive

TABLE 2. 3M BRISTOL FACILITY 1992 VOC EMISSIONS (TONS)

Coater	1st Qtr.	2nd Qtr.	3rd Qtr.	4th Qtr.	Total
5W	202.5	172.4	202.7	135.5	713.1
6W	79.6	97.7	96.9	110.6	384.8
Total	**282.1**	**270.1**	**299.6**	**246.1**	**1,097.9**

downtime due to lack of line utilization, or quality imposed line shutdowns, is 1 percent of operating time. Production is scheduled to run compatible batches in sequence. When a product change is to occur, the production operator will add only enough coating to the application troughs to coat the length of film remaining on the substrate web. This allows the substrate web and the coating to end at approximately the same time. As the first web finishes, the second web is threaded and new coating formulations are added to the application troughs. In some cases, excess coating is drained from the application pans and coating lines back into storage drums. The drummed material is retained for future use. Although there is some product contamination with either scenario, the substrate coated with the mixed coatings is the last portion of the first roll or the first part of the succeeding web. In either case this portion of the web, the makeready substrate, is discarded. Makeready is generated regardless of substrate and coating. This method of process changeover, characteristic of large facilities running dedicated production lines, minimizes coating waste and, consequently, minimizes required cleanup. For example, the 6W line often runs pigmented adhesives. Production jobs are scheduled to run from white to darker colors. These changeovers may generate several thousand yards of makeready film, most of which (*i.e.*, all of the polypropylene) is sold as scrap.

More significant product changeovers require more cleaning. In some cases, lines are stopped, application rolls are wiped down, and application trays are removed and replaced with clean trays. The removed trays are then cleaned with toluene and made ready for the next product changeover. In-process cleaning is done as needed when coatings, especially adhesives, spill or splash onto equipment housings.

Cleaning operations at the Bristol facility may be separated into three primary categories (*i.e.*, in-process equipment cleaning, centralized parts cleaning, and miscellaneous cleaning) using three types of cleaning solvents (*i.e.*, mineral spirits, toluene, and heptane). The type and method of process equipment cleaning is based on the adhesive or coating formulation rather than on the type of film or substrate. The coating application rollers on both the 5W and the 6W lines are cleaned using similar methods. The cleaning frequency, however, is slightly different. Adhesive application rollers are the most frequently cleaned piece of equipment, followed by the LAB application rollers. All of the coating rollers on the 5W line and the prime coat application roller on the 6W line are wiped with a non-static rag soaked in toluene and then cleaned with a caustic solution. Spot equipment cleaning (*e.g.*, sides of dams and troughs and coating application heads) on both lines is done with toluene-soaked rags. Larger jobs, including the cleaning of piping, pumps, ovens, and equipment housings, are done with rags and mineral spirits. If material has solidified on the equipment, toluene may be used instead of mineral spirits. The hot melt adhesive roller on the 6W line is cleaned using dry methods such as mechanical scraping.

The Bristol facility operates four centralized parts cleaning areas. One area is dedicated to the cleaning of pressure tanks, mix tanks, and tote tanks. These large pieces of equipment are transferred into the cleaning room equipped with exhaust fans and an air make-up fan. The outside of the equipment is manually cleaned with rags, brushes, and mineral spirits, while internal tank components are cleaned manually with heptane, mops, and squeegees. The other centralized cleaning areas use parts washers and are used to clean coating application heads, coating troughs, material piping, and miscellaneous equipment parts. The parts to be cleaned are placed in the solvent bath, soaked, and then scrubbed with brushes. Two of these stations use mineral spirits and the third uses toluene. All of the solvent employed in parts cleaning operations is used for a period ranging from three days to three weeks. Once they are no longer usable, the spent solvents are combined, declared waste, and transferred to drums which are sent off-site for fuel blending. (The waste solvent has a BTU value of 18,500). Cleaning rags that are no longer usable are also combined and sent off-site as hazardous waste.

Miscellaneous cleaning includes the cleaning of product and raw material storage tanks, process lines, and floors. Routine floor cleaning is performed as needed using mineral spirits. In general, storage tanks and process lines are dedicated and, therefore, do not require cleaning. The Bristol facility has been using high pressure water for these difficult and occasional (yearly) cleaning jobs. A licensed contract facility, OHM, uses a solution of high pressure (12,000 psi) water, heptane, isopropyl alcohol, and salts to clean dry adhesives from process equipment, storage tanks, floors, and other equipment parts. The wash water is contained and disposed of as hazardous waste (D001, Waste Flammable Liquid). Because this type of service is rather expensive (*i.e.*, approximately $800 per day) and because it is costly to dispose of the waste (due to the low BTU value), 3M plans to discontinue this method of cleaning. No replacement cleanup methods have been identified.

In 1990, the Bristol plant generated 1,366,000 pounds of solid hazardous waste (*e.g.*, rags and adhesive/coating waste) and 847,000 pounds of waste cleaning solvent. Projected 1993 figures are 23,800 pounds of solid hazardous waste and 26,000 pounds of waste solvent.

F. Pollution Prevention Experience

Much of 3M's pollution prevention experience at the Bristol plant consists of avoiding cleanup and following "best management" practices. The facility uses centralized cleaning areas which limits operator access to cleaning solvents. In addition, 3M recovers the solvent that volatilizes in the 5W ovens and recycles it back into the adhesive formulation.

The Bristol facility has attempted to use citrus based cleaners in slitting and packing operations. Although the cleaners performed well and resulted in no quality problems, they were cost prohibitive. The Bristol facility has not attempted to use citrus based cleaners on the coating lines.

The Bristol facility has experimented with silicon-coated, non-stick rollers, but due to durability problems, these rollers have not been used in the production process. An alternative for silicone, which the Bristol plant does use, is flame-applied plasma coatings which prevent adhesive buildup on winding, idling, and tension rollers. Adhesive remaining on these rollers can be easily removed by hand. One difficulty that the Bristol facility faces with plasma-coated rollers is that they tend to encourage static buildup. The buildup of static is a concern because if there is a spark the entire line could catch on fire. To avoid this dilemma, 3M configures the equipment so that plasma-coated rollers are not in series. Thick films are more susceptible to static than are thin films.

The 3M research and development laboratories in St. Paul, Minnesota are currently developing and evaluating low VOC coatings. The Bristol facility recently replaced the heptane-based precoat on the 6W line with a waterbased acrylate for a short production-scale run. Although the coating did meet the production specification, it resulted in several manufacturing difficulties. Foam formed in the application pan. Some of the foaming effects which resulted from agitation caused by the gravure coater could be eliminated with an alternative application method such as flow bar coating. Other difficulties include poor stability with heat and over time, increased dry temperatures, and inefficient material transfer.

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Environmental Solutions through Technology

TRC Environmental Corporation
100 Europa Drive, Suite 150
Chapel Hill, NC 27514
☎ (919) 968-9900 Fax (919) 968-7557

Date: April 14, 1993

Subject: Site Visit - TesaTuck, Inc.
Pressure Sensitive Tape Manufacturer
EPA Contract 68-D9-0173, Work Assignment Number 3/309
TRC Reference No. 1637309

From: Beth W. McMinn and Jill B. Vitas
TRC Environmental Corporation

To: Mike Kosusko
Organics Control Branch
Air and Energy Engineering Research Laboratory (MD-61)
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

I. <u>Purpose</u>

As part of the overall effort by the U.S. Environmental Protection Agency (EPA) to identify areas for preventing the creation of pollution associated with manufacturing entities, EPA is currently reviewing the pollution prevention opportunities associated with equipment cleaning in the adhesives-coated and laminated paper industry. TRC Environmental Corporation (TRC) is supporting EPA in this effort by developing prevention strategies for laminated paper equipment cleaning under Work Assignment Number 3/309, EPA Contract Number 68-D9-0173.

TesaTuck Incorporated (TTI), a pressure sensitive tape manufacturing facility, was selected for a site visit to collect information on the pollution prevention opportunities available for this industry segment. The focus of pollution prevention efforts in this industry is on emissions of volatile organic compounds (VOCs) and air toxics. The purpose of the visit to TTI was to gather information on their pressure sensitive tape manufacturing processes and to identify, with input from the plant experts, any opportunities for preventing VOC emissions resulting from the cleaning of equipment. Specific objectives of the trip were to collect information necessary to characterize the plant production processes, equipment cleaning requirements and practices, and cleaning solvent recovery and disposal methods; and to witness first-hand any pollution prevention opportunities for pressure sensitive tape equipment cleaning operations.

This trip report includes four sections. Section II identifies the location of the TTI facility. Section III presents the individuals who participated in the site visit. Section IV includes the technical information compiled during the site visit.

II. Place and Date

TesaTuck Incorporated
Crotty Road
Middletown, NY 10940
(914) 692-2826

February 12, 1993

III. Attendees

TesaTuck, Incorporated

Mark Harrison, Director of Environmental Affairs
Stanley Williams, Plant Manager

TRC Environmental Corporation

Beth McMinn, Project Manager
Jill Vitas, Task Leader

IV. Discussion

The discussion began with TRC reviewing the purpose of the visit and addressing EPA's goals for pollution prevention analysis for pressure sensitive tape manufacturing and future preventive activities. During this meeting the following major areas were considered.

- Market profile and general plant description
- Manufacturing supplies
- Manufacturing process profile
- Equipment cleaning experience
- Emission reduction and control experience
- Pollution prevention opportunities

The meeting was followed by a tour of the production operations. Each specific topic addressed in the meeting is discussed in detail below.

A. Market Profile and General Plant Description

TTI was bought by Tesa Incorporated, a German-owned company, in the 1970's. TTI owns the Middletown plant, and two others in the United States: one in Carbondale, Illinois and one in Sparta, Michigan. The Middletown facility was built in 1980 and the equipment that TTI currently uses was installed in 1986. Approximately 260 employees are located at this facility, of which 214 are production staff. The Middletown facility operates 6 days per week (the plant is closed every Saturday after 4:00 pm through Sunday), 24 hours per day.

At the Middletown facility, TTI manufactures both commercial and industrial grade masking and duct tapes. Industrial grade masking tapes (painting tapes) serve the original equipment manufacturer (OEM) and marine markets. Currently 70 percent of the products manufactured at the Middletown facility contain solvent-based coating, with the remaining 30 percent using waterbased coatings.

The Middletown facility is located on 37 acres within two connected buildings that total approximately 180,000 square feet. Masking tape is manufactured on two process lines; one that applies the saturant and release coatings and one that applies the adhesive. Adhesives and release coatings are formulated in the mixing area. The mixed adhesives and release coatings are transferred to the process lines via dedicated pipe/manifold systems. The duct tape process line is located in a separate building, where all mixing, coating, and packaging are done in one continuous process line.

B. Manufacturing Supplies

TTI uses a variety of hydrocarbon resins in their coating formulations. Toluene is the main solvent used in the adhesive formulations, although small amounts of heptane and isopropyl alcohol are also used. For cleaning, TTI uses mineral spirits, which can be incorporated into the formulation with no quality problems.

C. Manufacturing Process Profile

Adhesive Mixing

Adhesive mixing is a basic manufacturing requirement for the solvent-based adhesives used in the masking tape products manufactured at TTI. The adhesive provides the bond between the tape and the substrate. Adhesive mixing begins with stock preparation. Stock is prepared by blending natural and synthetic rubbers, hydrocarbon resins, oils, and fillers in a compounding tank. The output is then directed to a two-roll sheeting mill where a sheet of adhesive stock is extruded, cooled, cut, and chopped into pellets for further processing.

The pellets are then sent via conveyor to the mixing area where they are loaded into large mixers. Toluene, heptane, and spent mineral spirits are added to dissolve the stock into a slurry with 48 percent by weight solids. The solvent is pumped into the mixers with additional resins, rubber, and oils to complete the adhesive formulation.

The finished adhesive formulation is then either pumped into a storage tank for later use or pumped directly to the coating equipment through a manifold system.

Paper Tape Manufacturing

A coating block diagram is presented in Figure 1. To manufacture paper tape, the raw paper is bought from a vendor.

The waterbased saturant is applied to the raw paper by a reverse roll coater (*i.e.*, Coater 1). Once the saturant has been applied, the substrate web passes through a floating air oven. A thermal oxidizer is used to destroy any toluene or other emissions generated during the drying process. The web is dried to a specific weight. The waterbased release coat is then applied via a reverse gravure roller (*i.e.*, Coater 2). The web passes through another floating air oven which is also vented to the thermal oxidizer. At this point, the web is wound and transferred to the adhesive coating line where a solvent-based adhesive is applied by a heated reverse roll coater (*i.e.*, Coater 3). The fully coated web then passes through a final oven to dry.

Once the adhesive has been applied and dried the finished tape is allowed to cool, then slit and packaged to be sent to the warehouse for shipping.

Duct (Cloth) Tape Manufacturing

Duct tape manufacturing is similar to paper tape manufacturing except that the adhesive is calendared in a solid form to the laminated polyethylene film and cloth substrate. The result is a cloth and film web which has the release coat applied on the film side. No solvent is present in the duct tape adhesive, which is 100 percent solids. However, toluene is present in the release coat. TTI employs a thermal oxidizer to destroy the toluene or other emissions generated during drying of the release coat.

D. Equipment Cleaning Experience

TesaTuck regularly shuts down on Saturday at 4:00 p.m. During the shut down, operators thoroughly clean the equipment and floors surrounding the equipment. Where it is possible, the equipment is wiped down with a rag soaked with mineral spirits. TTI uses an aqueous detergent and water to clean the saturant head and drip tray. The gravure cylinders are sent to EZE Products in South Carolina to be ultrasonically cleaned every 6 months.

Mineral spirits has proved to be the best cleaner because of its low cost and ease of use. It is kept in small safety containers near the equipment so that the operator can access it easily. Spent mineral spirits is introduced back into the adhesive formulation. The film that is left on the equipment from the mineral spirits does not cause a quality problem because the first 20 feet of the run will remove it and will be discarded. This "makeready" substrate would be disposed of regardless of the substance used to clean the equipment. The spent mineral spirits from the duct tape line is recycled to the masking tape adhesive formulations. TTI uses approximately 1,000 gallons of mineral spirits per quarter. Due to the environmental impacts of the toluene, TTI strictly enforces the use of mineral spirits instead of toluene even though the toluene

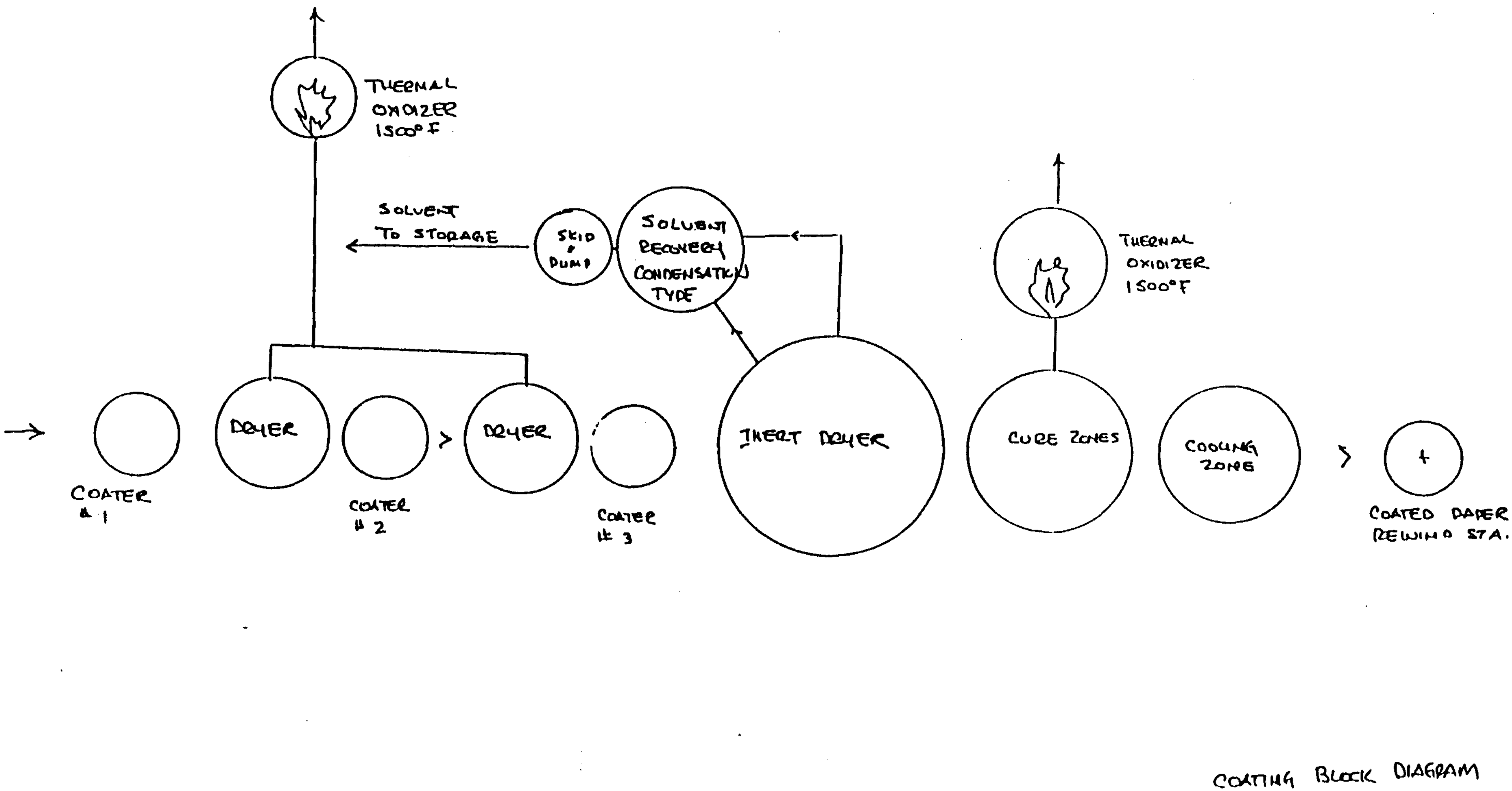

Figure 1. Tesa Tuck Coating Block Diagram.

provides better cleaning. Accumulated spent mineral spirits (that are not used in the adhesive) are distilled and used as paint thinner when the operators paint the floors and fences in and around the facility.

The equipment cleaned the most frequently at the facility is the saturator application head, which is cleaned continuously with water. The equipment that requires the most cleaning solvent (mineral spirits) is the adhesive coating application head and the calendar application head (duct tape line).

The process lines and adhesive mixing tanks are cleaned by flushing with toluene and using the spent cleaning solvent in the next batch. The paper tape reverse gravure roller is continuously and automatically cleaned with a water spray.

TTI has tried to use citrus based cleaners. Due to the high cost and poor cleaning power, they were not considered to be feasible. In addition, spent citrus based cleaners are considered to be hazardous waste.

E. Emission Reduction and Control Experience

Currently, TTI has three thermal oxidizers that control VOC emissions from the ovens on the three process lines. Hoods have been installed over the open web areas to provide for approximately 100 percent capture of the solvent emissions. Each of these hoods is ducted to the incinerators.

TTI is gradually reducing toluene usage by replacing it with heptane. TTI hopes to replace 50 percent of the toluene with heptane, since heptane is not a listed hazardous air pollutant and because heptane is less harmful to the environment.

F. Pollution Prevention Opportunities

Possible pollution prevention opportunities at TTI include the conversion to waterbased adhesive formulations and greater use of coated rollers.

In the discussion of waterbased adhesive formulations, TTI identified that production would decrease due to the length of time needed to dry the waterbased formulations. In order to maintain production at the current level, additional dryers would be needed.

The use of coated rollers for the idlers and take-up rollers in the process line has become industry standard. These rollers provide the necessary tension on the web while preventing the adhesive from sticking to the roller itself. TTI purchases their coated rollers from Plasma Coating Corporation in Waterbury, Connecticut.

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TRC Environmental Corporation
100 Europa Drive, Suite 150
Chapel Hill, NC 27514
☎ (919) 968-9900 Fax (919) 968-7557

DATE: April 1, 1993

SUBJECT: Site Visit - Nashua Corporation - Label Division
Label and Label Stock Manufacturer
EPA Contract 68-D9-0173, Work Assignment Number 3/309
TRC Reference No. 1637309

FROM: Geary McMinn and Scott Snow
TRC Environmental Corporation

TO: Mike Kosusko
Organics Control Branch
Air and Energy Engineering Research Laboratory (MD-61)
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

I. Purpose

As part of the overall effort by the U.S. Environmental Protection Agency (EPA) to identify pollution prevention opportunities associated with manufacturing entities, EPA is currently reviewing equipment cleaning practices in the adhesives-coated and laminated paper industry. TRC Environmental Corporation (TRC) is supporting EPA in this effort by developing alternative pollution prevention strategies for adhesive-coated and laminated paper equipment cleaning under Work Assignment Number 3/309, EPA Contract Number 68-D9-0173.

Nashua Corporation, a label and label stock manufacturing facility, was selected for a site visit to collect information on the pollution prevention opportunities for emissions of volatile organic compounds (VOCs) and air toxics available in this industry segment. The purpose of the visit to Nashua was to gather information on their label stock manufacturing processes and to identify and discuss, with input from the plant engineers, any opportunities for preventing emissions resulting from the cleaning of equipment. Specific objectives of the trip were to collect information necessary to characterize the plant production processes, equipment cleaning requirements and practices, use of waterbased adhesive technology, waterbased equipment retrofit considerations, and cleaning solvent recovery and disposal methods; and to identify any pollution prevention opportunities for label stock equipment cleaning operations.

This trip report includes four sections. Section II identifies the location of the Nashua facility. Section III presents the individuals who participated in the site visit. Section IV includes the technical information compiled during the site visit.

II. Place and Date

Nashua Corporation
Label Division
3838 South 108th Street
Omaha, Nebraska 68144
(402) 397-3600

February 12, 1993

III. Attendees

Nashua Corporation - Label Division

Dan Abraham, Process Engineer

TRC Environmental Corporation

W. Scott Snow, Mechanical Engineer
Geary D. McMinn, Environmental Scientist

IV. Discussion

The discussion began with TRC personnel stating the purpose of the visit, addressing EPA's goals for the pollution prevention analysis for pressure sensitive tape and label manufacturing, and identifying future preventive activities. During the meeting the following major topics were discussed:

- Market profile and general plant description
- Manufacturing supplies
- Manufacturing process profile
- Equipment cleaning practices
- Emission reduction and control experience
- Pollution prevention opportunities
- Waterbased formulation experience

The meeting was followed by a tour of the site. Each specific topic addressed in the meeting is discussed in detail in this report.

A. Nashua Market Profile and General Plant Description

Nashua Corporation began operating the Omaha, Nebraska, plant in 1966. The plant was originally built in 1959 and operated by the International Paper Company. The facility currently employs approximately 100 administrative and management personnel and 200 to 300 hourly production personnel. The unionized Omaha plant operates 24 hours per day, 5 to 7 days per week depending upon customer demand. The Omaha plant produces pressure sensitive labels, roll-stock, and custom label products. The Omaha facility, a tape plant in Albany, New York, and a coated products facility at the headquarters in Nashua, New Hampshire, all operate within Nashua's Coated Product's Group.

Figure 1 shows the layout of the Nashua - Omaha facility. There are three coating lines in the plant located in the coating room east of the glue filtering room. All three coating lines at the Omaha facility have been grandfathered from environmental regulations. Line 1 is an adhesive coater/laminator and currently coats with both solvent-based and waterbased adhesives. During 1991, Line 1 ran 100 percent solvent-based adhesives, however, it currently runs approximately 50 percent solvent-based and 50 percent waterbased products. Nashua engineers expect that by the end of 1993, Line 1 will function with 100 percent waterbased products. Line 2 is the release coating machine and presently applies both a solvent-based release coating and a 100 percent solid-catalyzed silicone release coating. Line 3 is another adhesive coater/laminator and currently runs 100 percent waterbased coatings that contain ammonia as a pH stabilizer (concentration of less than 1.0 percent in solution). Nashua currently collects and recovers solvent vapors from the drying ovens of Line 1 with a carbon adsorption system at approximately 80 percent efficiency.

Raw paper, the material used to manufacture label stock, was identified by Nashua as the highest cost item used in the manufacturing process at approximately $0.50 to $0.75 per pound depending on grade and specification. The raw paper which is saturated with release coating is called label stock. Adhesive, which provides tack for the labels, is then applied to the label stock and a laminated backing is added. Adhesive costs approach $1 per wet pound or $2 per dry pound. Nashua indicated that approximately 0.33 pounds of adhesive is typically applied per pound of paper. After lamination, the label material is ready for either shipment as a final product or further processing in the label-converting area. The majority of business for the Omaha plant is label stock manufacturing.

B. Manufacturing Supplies

Nashua considers the chemical composition of their coatings and supplies confidential. They indicated that their 100 percent solids release coating contains no VOCs and the solid is considered the carrier. For the solvent-based silicone release coating, silicone is diluted with tolusol, a heptane/toluene blend, which is considered the carrier. Their waterbased adhesive coatings also contain no VOCs and water is the carrier. Nashua identified that there is no direct correlation between VOC content of their adhesives and bond strength; however, a small amount of water or solvent remains in the cured coating to prevent the product from becoming too dry

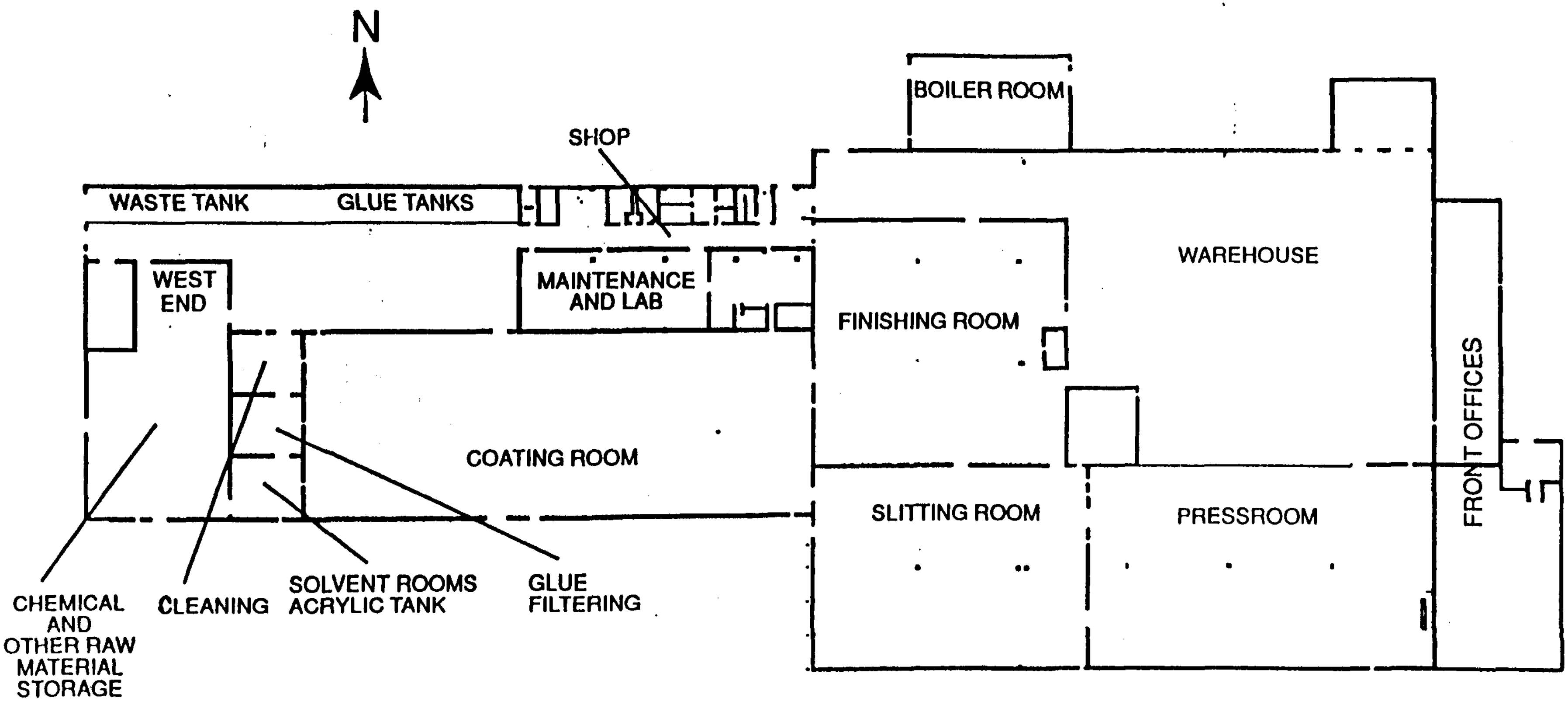

Figure 1. Nashua Plant Layout

(thus lowering the tack). Nashua indicated that after drying, a small amount of water is added to their waterbased products by a mist system to prevent the loss of tack.

C. Manufacturing Process Profile

General Process Description

The manufacturing of labels at Nashua - Omaha consists of three basic steps: adhesive mixing, label stock manufacturing, and label converting. When the desired end-product does not require converting, the last step in this process is omitted. Adhesives are brought into the plant, mixed, and stored in process holding tanks. Figure 2 presents a flow diagram of the label and label stock production processes. Master rolls of raw paper are first coated with a silicone release liner and adhesive, and then are laminated with face stock. After these steps, the label stock is cut and sized in the slitting room and is either sent to warehousing and shipping or processed in the label converting operations. The Omaha facility produces between 200,000,000 to 300,000,000 square yards per year of label stock and release backing. The facility receives and exports materials by both rail and truck.

Adhesive Mixing

The purpose of label adhesives is to provide a bond between the substrate and the label stock. Nashua indicated that they use a variety of adhesives in their manufacturing process. The formulation of their solvent-based adhesives involves combining adhesive stock, natural rubbers, acrylic products, and other materials in large steel mixing tanks. Solvents used in their solvent-based adhesives include toluene and heptane. Waterbased adhesives are mixed in tanks with a fiberglass lining which promotes easier stripping and cleaning. After mixing, the adhesives are pumped through stainless steel canister filters to process holding tanks.

In order to achieve the proper level of initial tack, Nashua strives to manufacture a final product that contains less than 3 percent water for waterbased adhesives or less than 1 percent solvent for solvent-based adhesives. Ammonia, which elevates the pH and serves as a stabilizer, is also present in small quantities (less than 1 percent) in waterbased adhesives.

Label Stock Manufacturing

The first step in label stock manufacturing is to create a coated release liner. The solids silicone or the silicone-tolusol mixture is applied to master rolls of raw paper on the Line 2 coating machine. The coated release liner is then dried in an oven heated by steam coils for approximately 5 to 10 seconds. Any vaporized solvent is vented by the oven exhaust systems to the atmosphere. After drying, the coated release liner is wound onto rolls and transported to either Line 1 or Line 3 for coating/lamination. Excess silicone can be frozen in air tight containers for future use.

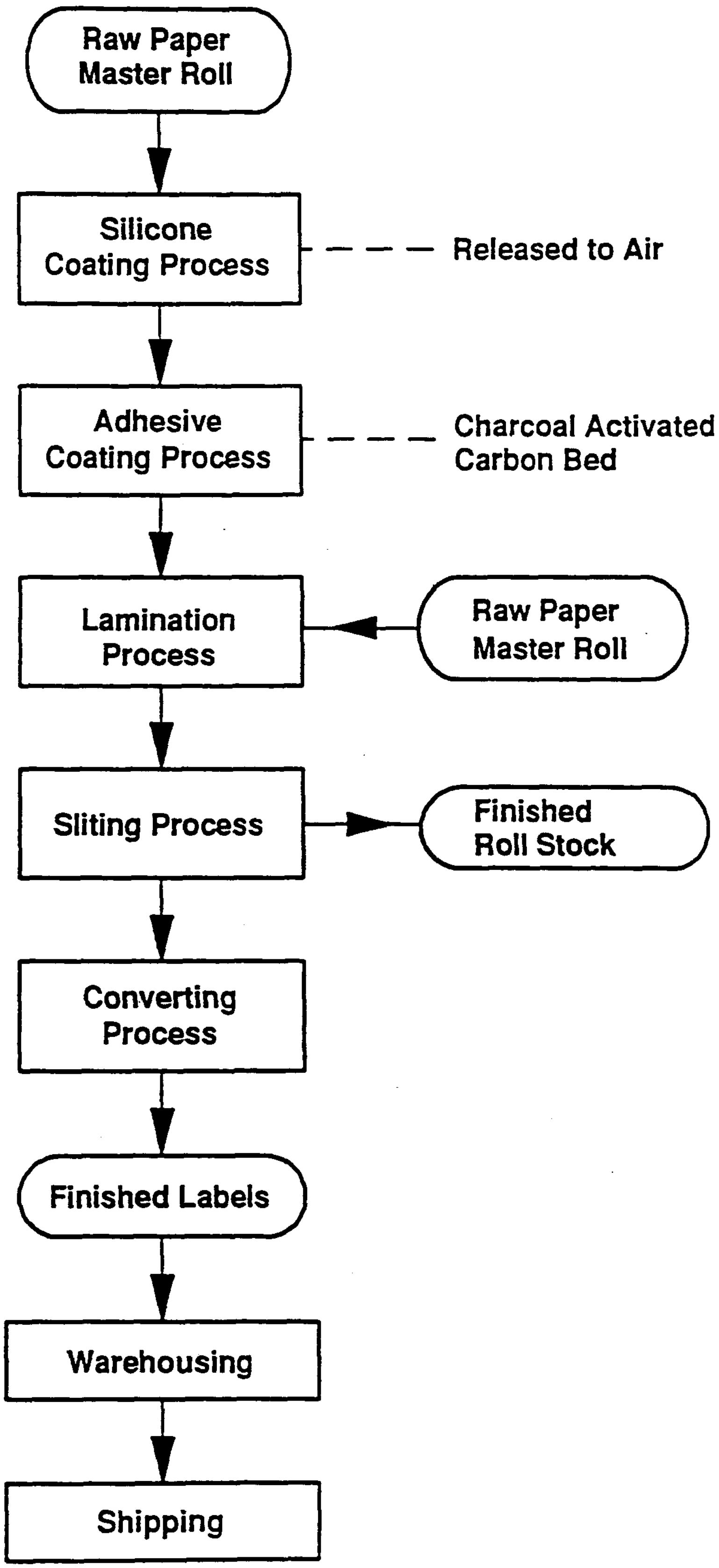

Figure 2. Finished Label Production Process.

Nashua stated that their process lines run either solvent-based or waterbased adhesives, but typically require a downtime of approximately 24 hours to setup the coating heads when converting adhesives. Line 1 uses solvent-based adhesives consisting of natural rubber and resins dissolved in toluene or waterbased adhesives. Line 3 uses only waterbased adhesives which are purchased ready to use. Nashua adds some ingredients to improve the initial tack of these adhesives.

The release liner is unwound and the silicone-coated surface is coated with an adhesive and cured in an oven. The drying ovens on Line 1 are similar to Line 2's except that the emissions are ducted to a carbon adsorption system. The reclaimed solvent can then be re-used in compounding adhesives. Line 3 dryers use direct fired burners and cannot process solvent-based adhesive products. As the coated paper travels out of the oven, it is moisturized by a water spray mist and then laminated under pressure rollers with the label face stock creating a three-layer lamination (face stock, adhesive, and release liner). Wind and unwind rollers are wrapped with double-sided tape to help the product stick to the rollers.

Once the product has finished drying and been rewound, it is transferred to the slitting room for cutting and sizing. Nashua has several high-speed slitting machines which cut the rolls of paper into narrow widths for use on its own printing presses or for shipment as finished product. Excess edge portions of the paper known as off-cuts are removed by a trim system which conveys the cut-offs to a cyclone separator, and ultimately to a dumpster for transport to the city landfill. The special cut rolls are moved to the pressroom for custom orders or the finish room (if the product is being sold to competitors or other processors) for packaging before warehousing and shipment as a finished product. The warehouse holds custom orders and stock label products awaiting shipment.

Label Converting Operations

The slit laminate which is to be processed further is moved to the pressroom. In the pressroom, the laminate is loaded onto label presses where it may be die cut, perforated, and/or printed. The waste matrix from the die cut is removed, rolled, and sent to the city landfill. The inks used in the printing presses are waterbased. A printing plate is required for use with the press. Nashua uses a photochemical etching process to make these plates in the preparation department. This process uses a perchloroethylene/butanol mixture as the etching solvent. Nashua reclaims this solvent with a distillation unit.

After converting, the printed labels are wound into rolls or fan-folded into sheets and boxed. The finished products are sent to the warehouse for storage and shipping.

D. Equipment Cleaning Practices

The function of an equipment cleaning product in the adhesives-coated and laminated paper industry is to break the bond between the adhesive and the metal (or other surface) being cleaned. Water solutions alone are normally ineffective for cleaning purposes. Nashua has found that products such as mineral spirits, 1,1,1-trichloroethane (TCA), and toluene successfully break the adhesive bonds. Nashua has also tested many other materials for equipment cleaning, including mineral oils, xylenes, and citrus products. Table 1 provides a summary chart of cleaning products Nashua is currently using and has proposed to use to clean process equipment. The VOC content of cleaning products is estimated by the manufacturer and Nashua accepts these estimates for emissions calculations.

Nashua is currently trying to replace toluene in their cleaning operations in order to reduce toxic emissions. Toluene is not recycled by Nashua due to its fire and explosive risk, evaporation, and low purchase cost. TCA, another effective cleaner, which costs approximately $3 to $4 per gallon, is recycled on site using a distillation unit. Approximately 2,268 gallons of TCA are recycled a year. Nashua will be replacing TCA due to the phase out requirements of the Montreal Protocol. Nashua has found that citrus based products are costly (up to $10 per gallon), do not effectively clean acrylic-based adhesives, and exude a strong, undesirable odor.

Nashua uses several techniques to satisfy their various cleaning requirements. Equipment is not cleaned on any specific time schedule, however, when lines are down for changeover, the rollers, filters, and other equipment are normally cleaned. Larger parts (such as application rollers and adhesive filters) are cleaned in the glue rooms (Figure 1). The cleaning solvents Nashua uses are stored in tanks and drums on site. Dip cans containing cleaning solvent are located in the plant near the machinery which they service. Most cleanup involves a wipe down using solvent-ladened cleaning rags. Nashua indicated that their operators have full access to the cleaning solvent storage areas.

The fiberglass adhesive mixing tanks are cleaned by cutting the adhesive residue with a high-pressure water blaster. The blaster cuts pieces of the adhesive off the tank wall which are then peeled away a section at a time. The adhesive residue is collected at the bottom of the tank and removed for shipment to the landfill. The mixing tank cleaning system also uses a pit located under the tanks that captures the blaster water and transfers it to a special holding tank for delivery to the city water treatment system. During the mixing of adhesives in the fiberglass tanks, layers of different adhesives are deposited on the tank walls. Within these layers, microscopic "bugs" grow. According to Nashua, the "bugs" present no product contamination and are welcomed at the city landfill due to their ability to breakdown waste material.

Nashua uses dedicated lines to transport the adhesives from the mixing tanks to the process holding tanks. The waterbased adhesive lines are never exposed to air, therefore, the adhesive does not harden in them as quickly as it does in the solvent-based lines. These waterbased lines normally operate until a significant reduction in flow is identified, at which time they are replaced rather than cleaned. Polyvinyl chloride (PVC) piping was chosen for these

TABLE 1. SUMMARY OF CLEANING PRODUCTS USED AND PROPOSED AT NASHUA - OMAHA

Area Cleaned	Cleaning Products Used	Proposed
Water-based adhesive mixing tanks	W	
Solvent-based adhesive mixing tanks	Tol	Tol
Water-based coating lines	H_2O	
Solvent-based coating lines	Tol	
Rollers (all)	Tol, TCA	MS
Drip on edge of paper	TCA	MO, MS
Dryers (Water- and solvent-based lines)	MS	
Filters (stainless steel)	Tol, TCA	MS
Floor cleaning in production/mixing area	MS	H_2O
Press plate etching	Perch	O
Press roller cleaning	IPA	

Description of Terms:

H_2O - Hot water and scrapper
IPA - Isopropyl Alcohol - (solution is approximately 10 percent IPA)
MO - Mineral Oil
MS - Mineral Spirits
O - Octusol (Dupont replacement for Perch)
Perch - Perchloroethylene/Butanol mixture
Tol - Toluene
TCA - Trichloroethane
W - High pressure water wash

lines due to removal convenience and low cost. Nashua stated that some PVC piping has been replaced after approximately three years in operation.

Nashua indicated that their largest daily cleaning problem is the metallic filters used to filter the adhesive when transferred from the mixing tank to the process holding tanks. These filters are removed from the lines and cleaned in a toluene bath using a scrub brush. The baths are changed approximately once every two weeks and the waste toluene is sent off site for disposal. Eventually, Nashua plans to have mineral spirits or another viable product replace the toluene in the cleaning bath. The product that does the best cleaning job on the filters will also be used to clean the application roller. The process holding tanks for the solvent-based adhesives are flushed with solvent. This remaining solvent and any dissolved adhesive remain in the tank and mix with the next batch of adhesive. No product quality problems have been noted with this cleaning procedure.

Nashua uses a putty knife and a hot water spray to clean splashes and spills on the machinery that applies waterbased adhesives. Waste adhesive which contains less than 20 percent water is sent to the landfill. Splashes and spills on the solvent-based adhesive machinery are cleaned with a putty knife and TCA soaked rags. A TCA drip is used on the edges of the application roller to prevent adhesive from flowing over the paper edge. In the future, mineral spirits or a viable alternative will be used as an alternative to TCA.

Mineral spirits are used to mop the floor of the mixing and production areas and are also used to clean the solvents trapped in the dryer oven hoods. In the pressroom, TCA and toluene are used to remove dried, waterbased inks and adhesive from the presses and tooling. Isopropyl alcohol (approximately 600 gallons a year) is also used to remove inks from the rollers.

E. Emissions Reduction and Control Experience

Nashua intends to replace the toluene and TCA used for cleaning processes by the end of 1993. Most emissions of toluene are fugitive and Nashua does not control or recycle toluene because of the explosive and fire hazards, the high cost of capturing toluene emissions, and the relatively low cost of virgin toluene solvent. Approximately 3,000 gallons of toluene are used on an annual basis with 1,800 gallons being sent off site for disposal as hazardous waste.

Nashua currently reclaims TCA by a distillation system. Approximately 2,268 gallons (2,160 gallons from release coat and 108 gallons from adhesive line cleaning) of a total 2,520 gallons of TCA are recycled annually with 200 gallons shipped off site as hazardous waste. Nashua indicated that approximately 10 gallons of TCA are used for cleaning process holding tanks after every product changeover. Approximately 600 gallons per year of isopropyl alcohol are used to clean the printing press lines.

Solid waste from the Nashua facility includes paper waste from the cutting and slitting processes, which is compacted and sent to the landfill. Hazardous waste shipped off site includes approximately 3,500 pounds per month of waste adhesive, silicone, paper, TCA, oil from machines, and perchloroethylene still bottoms (used in etching printing plates). Rags and absorbent socks (called "pigs") contaminated with VOC solvents are considered hazardous waste and disposed of properly, while those containing no VOCs are sent to the landfill.

Nashua's city sewer discharge limit allows for 100 ppm of total recoverable petroleum hydrocarbons in their wastewater discharge. Nashua conducts tests once per month at the plant outfall to assure compliance. Normally, the concentration ranges from 20 to 30 ppm. In the past, adhesive mixes clogged the discharge system, however, to avoid this, the wastewater is currently stored in special tanks and shipped by truck to the city treatment facility, where it can be treated and sold as fertilizer. By the end of 1993, Nashua predicts that 95 percent of their wastewater will be disposed of at the city treatment facility.

Nashua indicated that they recycle approximately 10 to 15 percent of total raw paper input. Once the paper has been coated with silicone or adhesive, it cannot be recycled and is transported to the landfill.

Other control experiences at Nashua - Omaha include floor vents, special coated application and non-application rollers, and plant boilers. For proper ventilation, floor vents are used in the adhesive holding area and equipment cleaning area to collect and evacuate indoor air to the atmosphere. Also, Nashua is currently testing different types of coated rollers (*e.g.*, teflon, plasma, graphite) for the adhesives application and non-application processes. These rollers are designed to simplify the equipment cleaning process by employing a less sticky surface. Finally, the plant boilers are located at the north end of the plant and are the only equipment in the plant requiring air emissions permits.

F. Pollution Prevention Opportunities

Potential pollution prevention opportunities include the replacement of all toluene and TCA cleaning with a viable non-VOC solution.

Nashua is currently in the process of converting their adhesive coatings to 100 percent waterbased solutions. Since these products contain water and not solvents as carriers, most of the process emissions from the coating lines should be eliminated. However, equipment cleaning of these waterbased lines will remain a potential TCA fugitive emissions source. To prepare for this changeover, alternative cleaning solutions have been, and are currently being, tested at Nashua. These include products such as mineral spirits, mineral oils, and citrus based products. At the time of this site visit, no viable alternative had been found to completely replace the toluene and TCA used in equipment cleaning.

Nashua's emissions reduction programs are extensive. Any safety cans which contain toluene or TCA located next to the production equipment are spring closed. Also, tank cleaning baths are covered and allow enough room for large equipment pieces to avoid overfilling the tanks. Nashua encourages its operators to scrape equipment before using chemicals as a final wipe. Finally, mats are provided around machinery to capture any spills which may exceed the capacity of the drip tanks, thus avoiding extensive floor cleanup. An outside service is employed to clean these mats.

G. Waterbased Formulation Experience

As previously mentioned, Nashua - Omaha has extensive experience in waterbased adhesives and plans to phase out all solvent-based coatings by the end of 1993. The major reason for this is to comply with requirements of the Clean Air Act of 1990. Other reasons include fewer permitting/paperwork requirements, less restrictions by New Source Review or New Source Performance Standards, and elimination of most hazardous waste regulatory requirements.

Equipment additions were needed to change from solvent-based to waterbased adhesives. First, a different configuration of rollers and a different gravure set-up are required on the coating machines. The application roller must be designed to allow a greater thickness of waterbased adhesive to remain on the substrate. Waterbased coatings do not penetrate most substrates as well as solvent-based coatings and therefore must be thicker to penetrate any given substrate. Coating speeds must be reduced to accommodate the longer drying times required by waterbased adhesives. All mixing tanks, holding tanks, filters, pumps, and piping must be retrofitted to prevent contamination from previously used solvent-based adhesives. Nashua has also coated the waterbased adhesive tanks with fiberglass to allow for cleanup with high-pressure (3,000 to 5,000 psi) water. Pumps used to transport waterbased adhesives must have lower horsepower and compression rates due to the lower viscosity and higher surface tensions of waterbased adhesives.

Nashua does not anticipate losing much business due to the solvent-to-water adhesive changeover because they have been able to find or formulate new waterbased adhesives to replace most of the solvent-based products. However, some products require certain characteristics of natural rubber that waterbased adhesives have been unable to provide (*e.g.*, extremely cold bonding, wet bonding, and peel and re-peel ability).

Economic and environmental incentives are the primary reasons for Nashua's conversion from solvent-based to waterbased adhesives. Although waterbased adhesives cost more than solvent-based adhesives (more specialized adhesives may double the cost), adhesives costs are not the driving costs: raw paper costs drive the end-product cost. Nashua expects the increased adhesive cost to have some effect on their cost to customers. Although the adhesives changeover would result in possibly changing waste streams by increasing water usage or by adding waterbased products, the overall effect should be a reduction in total waste. The reduced waste disposal costs and permitting costs are two economic benefits. Nashua advised that any facility wishing to switch to waterbased adhesives must first set goals and then invest the time and research to attain them.

TRC
Environmental Solutions through Technology

TRC Environmental Corporation
100 Europa Drive, Suite 150
Chapel Hill, NC 27514
☎ (919) 968-9900 Fax (919) 968-7557

Date: March 19, 1993

Subject: Site Visit - Rexham Industrial
Coated and Laminated Substrate Manufacturer
EPA Contract 68-D9-0173, Work Assignment Number 3/309
TRC Reference No. 1637309

From: Beth W. McMinn and Jill B. Vitas
TRC Environmental Corporation

To: Mike Kosusko
Organics Control Branch
Air and Energy Engineering Research Laboratory (MD-61)
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

I. Purpose

As part of the overall effort by the U.S. Environmental Protection Agency (EPA) to identify areas for preventing the creation of pollution associated with manufacturing entities, EPA is currently reviewing the pollution prevention opportunities associated with equipment cleaning in the adhesives-coated and laminated paper industry. TRC Environmental Corporation (TRC) is supporting EPA in this effort by identifying and developing prevention strategies for coated and laminated substrate equipment cleaning under Work Assignment Number 3/309, EPA Contract Number 68-D9-0173.

Rexham Industrial (Rexham), a coated and laminated substrate manufacturing facility, was selected for a site visit to collect information on the pollution prevention opportunities available for this industry segment. The focus of pollution prevention efforts in this industry is on emissions of volatile organic compounds (VOCs) and air toxics. The purpose of the visit to Rexham was to gather information on their coated and laminated substrate manufacturing processes and to identify, with input from the plant experts, any opportunities for preventing VOC emissions resulting from the cleaning of equipment. Specific objectives of the trip were to collect information necessary to characterize the plant production processes, equipment cleaning requirements and practices, and cleaning solvent recovery and disposal methods; and to witness first-hand any pollution prevention opportunities for coated and laminated substrate equipment cleaning operations.

This trip report includes four sections. Section II identifies the location of the Rexham facility. Section III presents the individuals who participated in the site visit. Section IV includes the technical information compiled during the site visit.

II. Place and Date

Rexham Industrial
P.O. Box 368
Matthews, NC 28106-7003
(704) 847-9171

March 5, 1993

III. Attendees

Rexham Industrial

Gordon Miller, Manager of Safety and Environmental Affairs

U.S. Environmental Protection Agency

Michael Kosusko, EPA Work Assignment Manager

TRC Environmental Corporation

Beth W. McMinn, Project Manager
Jill B. Vitas, Task Leader

IV. Discussion

The opening conference began with EPA and TRC discussing the purpose of the visit, the background of the coated and laminated substrate manufacturing project, EPA's goals for pollution prevention analysis, the handling of confidential business information, and the resulting trip report. The opening meeting then proceeded with a question and answer period during which time EPA and TRC discussed the following topics:

- Market profile and general plant description
- Manufacturing supplies
- Manufacturing process profile
- Equipment cleaning experience
- Emission reduction and control experience
- Pollution prevention opportunities

The meeting was followed by a tour of the production operations. Each specific topic addressed in the meeting is discussed in detail below.

A. Rexham Market Profile and General Plant Description

Rexham is a wholly owned subsidiary of Bowater PLC of England. They currently own/operate 34 facilities in North America. Rexham sees a strong health, safety, and environmental compliance record as a competitive advantage. Their customers seem to be looking for "green" suppliers.

Rexham is made up of four divisions: Industrial Films, Printing and Packaging, Plastics, and Medicals. The Matthews facility is the Industrial Films Division Headquarters. The facility is considered a custom converter, producing coated and laminated products in four categories: electronics/photographics, miscellaneous products, graphic arts, and medical supplies. One of Rexham's electronic products is a dry photo masking agent. Photographic products consist of masking agents and photographic substrates. Balloon hull material, a seven-ply laminate, is one example of products included in the miscellaneous category. The graphic arts products include materials for reproductions and proofs. The main products in the medical supplies category are surgical barriers.

The Matthews facility began operation in 1963. Since that time it has increased its operating schedule to an anticipated 7 days per week, 24 hours per day, 360 days per year in 1993. Rexham currently employs 275 people at the Matthews facility, of which 160 are production staff involved in the manufacturing of the coated products. Figure 1 shows the layout of the facility.

B. Manufacturing Supplies

Rexham's primary raw materials consist of coating formulations, solvents, and substrates. Rexham can work with many different coating formulations with a variety of resin bases, including but not limited to, acrylics, urethanes, and polyesters. The majority of the formulating and cleaning solvents used at the facility consists of methyl ethyl ketone (MEK) and toluene, with smaller quantities of tetrahydrofuran, some esters, and some alcohols.

The Rexham facility has the capability of handling a variety of substrates, including films, paper, foils, and foam. Currently, about 90 percent of Rexham's products are manufactured with plastic film substrates, 9 percent with paper substrates, and the remainder is with foils and foam.

Rexham cleans process equipment with the solvent that is incorporated in the coating formulation. For those processes that include mixtures of different solvents, Rexham typically will clean with the solvent in the highest concentration in the formulation.

C. Manufacturing Process Profile

Although specific steps vary by product type, Rexham's general manufacturing process includes the following steps. Incoming dry raw materials are stored in their original shipment containers (*e.g.*, bags and fiber drums) in Warehouse 1 or 2. Wet raw materials are stored in designated drum storage or staging areas located throughout the plant. These materials are moved, as necessary, to the central mix room where the required coating formulation materials are blended

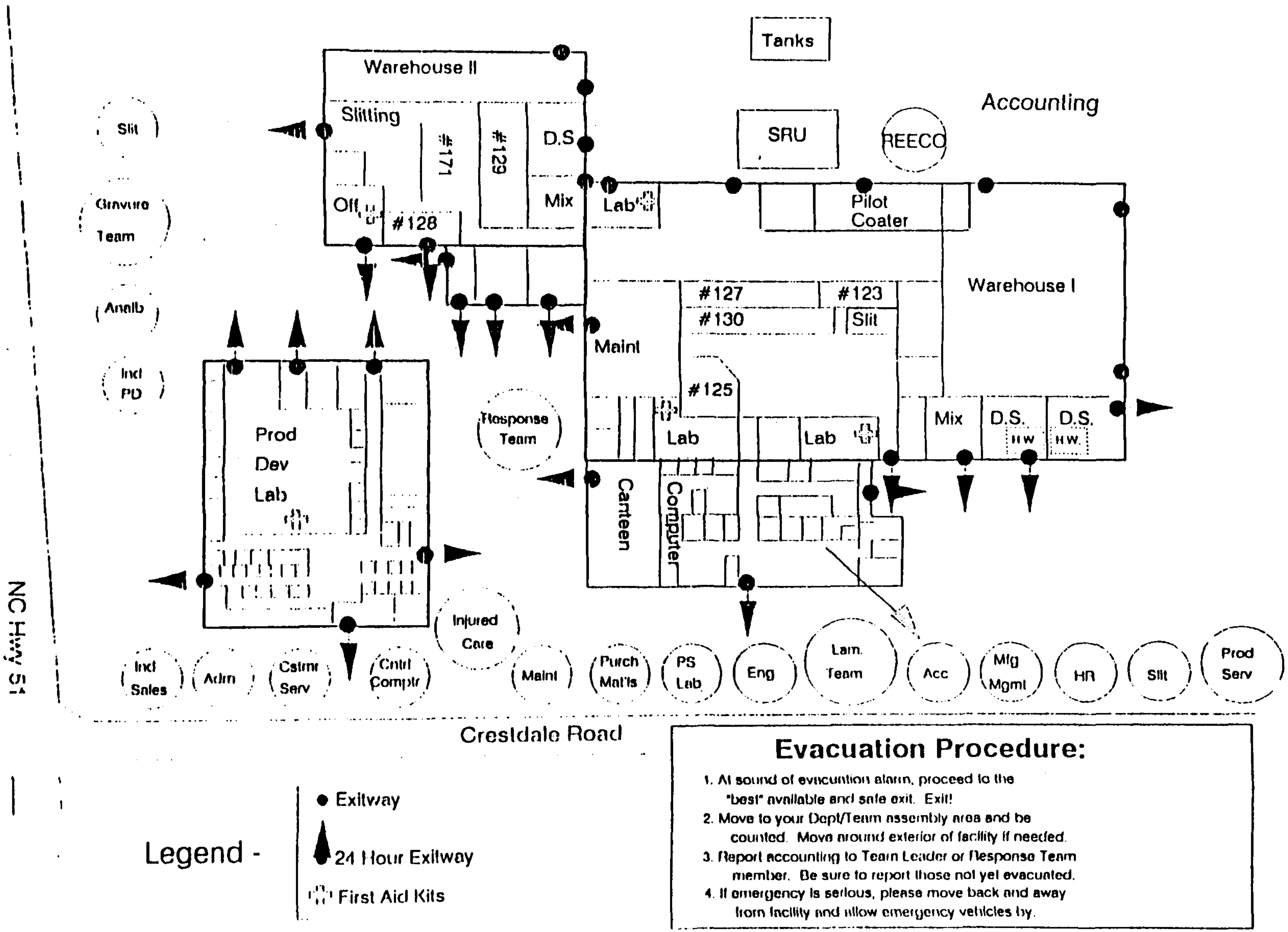

Figure 1. Rexham facility layout.

with variable-speed dispersers in mix tanks or drums. Due to the large number of products it manufactures, Rexham's mixing process can be very simple or very complex, and is modified to satisfy customer needs. Approximately 50 percent of the coatings used at the Matthews facility are premixed by a supplier, 10 to 15 percent are mixed in-house from raw materials, and the remainder are purchased blends that Rexham modifies by adding performance enhancing chemicals. Rexham's equipment is capable of handling coatings of any chemical composition (*i.e.*, 100 percent solids, waterbased, solvent-based, ultra-violet formulations).

The mixed coatings are then pumped from 55-gallon drums or mix tanks through a manifold system to the coating application system. Substrate webs are also moved to the coating lines. The coating is applied to the substrate web by an application roller. Once the coating has been applied, it enters a zoned oven which allows for uniform drying. After the substrate is dried, it passes through a nip roller where it is laminated (if needed). If multiple coatings are necessary the previous steps are repeated. The product is then wound, slit according to customer requirements (if necessary), and then packaged and sent to Warehouse 1 or 2 for shipping. Rexham operates on a "just-in-time" inventory concept, which allows for production of an order within 28 days of receipt.

Rexham operates eight coating lines, each configured to run a particular type of product. Table 1 contains a general description of each of the configurations Rexham uses.

TABLE 1. REXHAM COATING LINE CONFIGURATIONS

Number of Machines	Machine Width	Run Length	Number of Coatings
1	narrow	short	1
1	wide	short	1
2	wide	long	1
1	wide	long	2
2	wide	long	multiple
pilot coater	multiple configurations		

D. Equipment Cleaning Experience

Rexham does not perform equipment cleaning on any specific schedule. However, due to the relatively short production runs and the custom nature of the specialty products that Rexham manufactures, cleaning between jobs is critical. Therefore, at the end of each job, all application equipment is thoroughly cleaned. Typically the coating line operator requests a drum of either virgin or reclaimed cleaning solvent (*e.g.*, primarily MEK or toluene - See Section B) from the mix room. Although Rexham has attempted to use alternative cleaners, such as mineral spirits, it describes the cleaning results as "inadequate." The cleaning solvent drum is brought to the coating line equipment and the operator pumps a small amount into a bucket. The operator wets a rag in the bucket and then wipes down the equipment. The used rag is discarded in a hazardous waste drum which is sent off-site for disposal. The spent cleaning solvent is transferred to a "dump" drum which is either sent to the on-site still for recycling or sent off-site for disposal as hazardous waste. The Rexham still currently reclaims solvent at the rate of 50 gallons per hour, 24 hours per day, 5 days per week.

A machine that is anticipated to be idle for several days undergoes a cleaning regime similar to the process described for cleaning between jobs. This cleaning job, however, is more thorough, involves the disassembling of equipment, the cleaning of pumps, equipment housings, and ovens, and requires approximately 30 man-hours (*e.g.*, five people each at six hours) to accomplish.

Rexham operates a central cleaning area with a solvent (MEK) bath and two ultrasonic cleaning units. The ultrasonic cleaners are used to clean the coating cylinders and very dirty adhesive reservoir pans and application roller carriages. Rexham tried many cleaning solutions in the ultrasonic cleaner before finding one which would remove all the coatings from the rollers.

Where it is possible, the floors around the coating lines are covered with off-specification film substrates. Although this film is normally mopped with cleaning solvent at the end of each shift, it does reduce the quantity of solvent that would otherwise be used to clean the floors. As the film floor coverings are ripped and become unprotective, they are disposed of as solid waste and replaced with another layer of off-specification film.

E. Emission Reduction and Control Experience

Rexham is aware of EPA's 33/50 program but has made a corporate decision not to formally participate. However, the company will meet the goals of the program over the next few years.

Solvents are used in the mixing of the coatings and in cleaning the process equipment. Solvent fugitive emissions result from the baths in the central cleaning area as well as from the "on-the-spot" cleaning applications within the facility.

The oven exhaust from two coating lines is currently ducted to a 4-bed carbon absorber. The removal efficiency of the carbon absorber is reported to be greater than 92 percent. Oven exhaust from two additional lines is ducted to a REECO™ regenerative thermal oxidizer (RTO), rated at 20,000 standard cubic feet per minute, and achieving a destruction efficiency reported to be 96 percent. This control system achieves the Lowest Achievable Emission Rate (LAER) recognized by EPA. The remaining four lines are ducted to a direct-fire incinerator, considered by EPA to be Reasonably Available Control Technology (RACT) for the industry.

Rexham is planning to install total enclosures on all of their coating lines to capture and control all VOC emissions from the process. Total enclosures will also reduce operator exposure. With the enclosure design that Rexham will construct, Rexham does not anticipate difficulties with operator access to lines and equipment.

F. Pollution Prevention Opportunities

Potential pollution prevention opportunities include: (1) reduction in the use of solvent to clean the floors, (2) reduction in amount of solvent used to clean the equipment, and (3) running the process line dry when possible.

The most effective preventive technique for Rexham would be to reduce or eliminate the use of solvent for floor cleaning. The operators currently cover the floor with off-specification film substrate, which is eventually disposed of as solid waste. Mopping the substrate-covered floors each shift with solvent may not be necessary.

Another opportunity for Rexham would be to optimize the amount of cleaning solvent needed to achieve the required cleaning specifications. Operators would be restricted to this amount of solvent. It is anticipated that the optimum amount of cleaning solvent would be considerably less than what is currently being used.

One additional pollution prevention technique would be to run the line dry. "Running dry" a line is an operating technique, occurring at the end of a production run, that involves adding only enough coating to the application troughs to coat the length of substrate remaining on the web. This allows the substrate web and the coating to end at approximately the same time. In some facilities, excess coating is drained from the application pans and coating lines back into storage drums. The drummed material is retained for future use. This production technique minimizes coating waste and, consequently, minimizes required cleanup. It also requires operator attention and planning.

Currently, Rexham uses waterbased formulations only at customer request. Rexham said that the industry is headed toward waterbased formulations to reduce emissions, but that phase-in of this approach will be gradual.

RADIAN
CORPORATION

M E M O R A N D U M

DATE: September 30, 1992

SUBJECT: Trip Report - Shuford Mills

FROM: John Keith and Trent Zirkle, Radian Corporation

TO: Improved Equipment Cleaning Project File

I. PURPOSE

The purpose of the visit to Shuford Mills was to learn about the methods of cleaning adhesives coating equipment and the resulting multi-media wastes generated from the cleaning. The visit was also intended to develop a working relationship between Shuford Mills and the U.S. Environmental Protection Agency (EPA), Air and Energy Engineering Research laboratory (AEERL) for potential demonstration projects.

II. PLACE AND DATE

Place: Shuford Mills
Hickory, North Carolina

Date: June 25, 1992

III. ATTENDEES

<u>Shuford Mills</u>

William Little
Andy Stimpson
Bob Hollieway

<u>Radian Corporation</u>

John Keith
Trent Zirkle

IV. DISCUSSION

1. Project Background

The U.S. EPA AEERL is conducting research and development projects for various industrial processes to identify, develop, and demonstrate applicable technologies that reduce waste generation (i.e., pollution prevention technologies). The adhesives and coated paper manufacturing industry has been selected for a pollution prevention research project focussed on reducing air emissions and multi-media waste generated by equipment clean-up. Three of the 17 targeted chemicals identified in the EPA's 33/50 Program; methyl ethyl ketone (MEK), toluene, and xylenes, are typically used as solvents during equipment clean-up in this industry. AEERL has contracted Radian to conduct the initial phase of the research project to; identify current cleaning methods, technologies, and generated wastes; identify current similar research efforts; and determine pollution prevention (alternative) technologies. Shuford Mills has expressed interest in participating in this research project.

2. Shuford Mills Background

The Shuford Mills Tape Division manufactures a variety of pressure sensitive tapes. Pressure sensitive tapes do not require water or heat to activate the adhesive; only a light rubdown pressure is required to make the tape stick. The major product at Shuford Mills' Hickory, North Carolina plant is masking tape. Approximately 500 to 600 people are employed at the Hickory plant.

3. Operation

At Shuford Mills' Hickory plant, manufacturing involves three distinct coating operations: saturation, backsizing or release coating, and adhesive coating. In the saturation step, a paper backing material is saturated with a water based liquid latex material. During backsizing, a water-based coating is applied to one side of the paper to prevent delamination and tearing, to provide water resistance, and to aid in unwinding and slitting. In the adhesive step, a solvent based adhesive is applied to the substrate on the opposite side of the backsize.

The three coating operations are sequential but not continuous. Each coating step is performed on a separate process line. However, each coating operation consists primarily of the same major processes. A roll of paper is unwound and the coating is applied. The coated paper then passes through a drying oven where most of the moisture and/or organic vapors are volatilized. For solvent based adhesives, the captured vapors are sent to a carbon adsorberfor recovery. The release coating is water based, and the water is emitted to the atmosphere during drying. After exiting the dryer, the coated paper is then re-wound onto a roll.

Shuford Mills has three saturation lines. As shown in Figure 1, raw paper is unwound and run through a trough of latex-based saturant. The saturated paper exits the trough and passes by a doctoring blade. The doctoring blade controls the thickness and quantity of saturant applied to the paper. The rollers and dams (or ears) are only cleaned during shutdown, about once per week. A toluene-soaked rag is used to wipe the equipment clean. The toluene is stored in covered, five gallon buckets next to the rollers. Toluene left on the rag either evaporates or is returned to the bucket where the rag is stored. Due to coating material that accumulates in the toluene cleaning solvent in the bucket, the toluene must be periodically replaced. The "spent" toluene is recycled as make-up solvent for the coatings formulations.

The second coating operation, backsizing, is shown in Figure 2. Coating is applied to the paper via a small coated roller. The roller contacts a bath of coating material and transfers the coating material to the paper as the roller

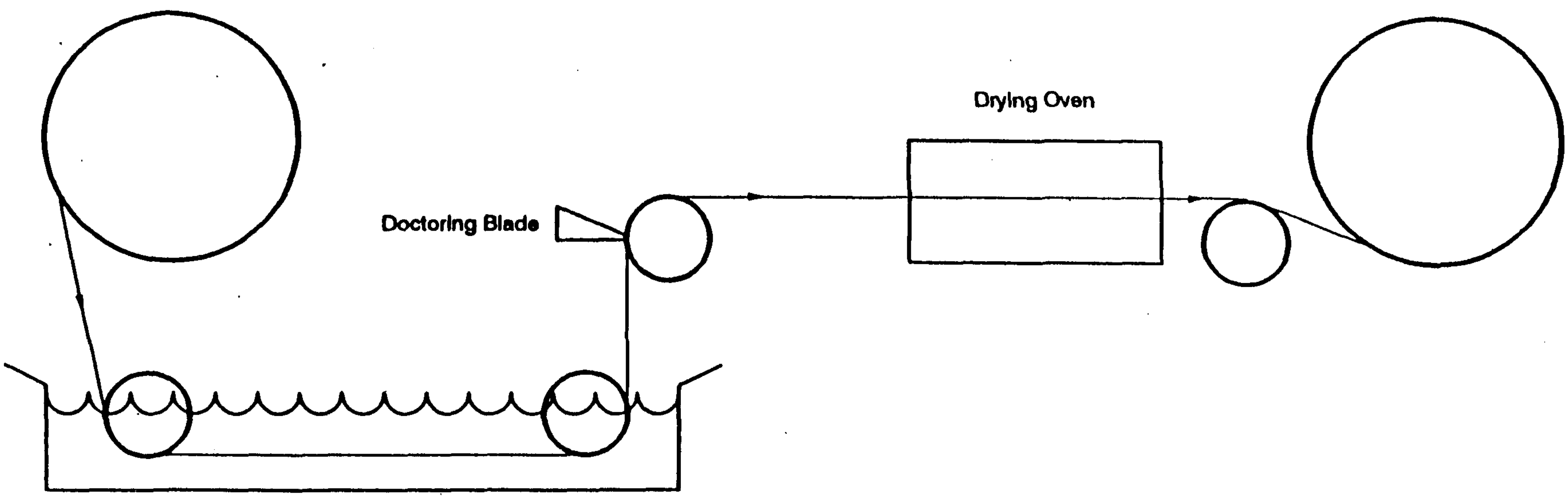

Figure 1. Saturation

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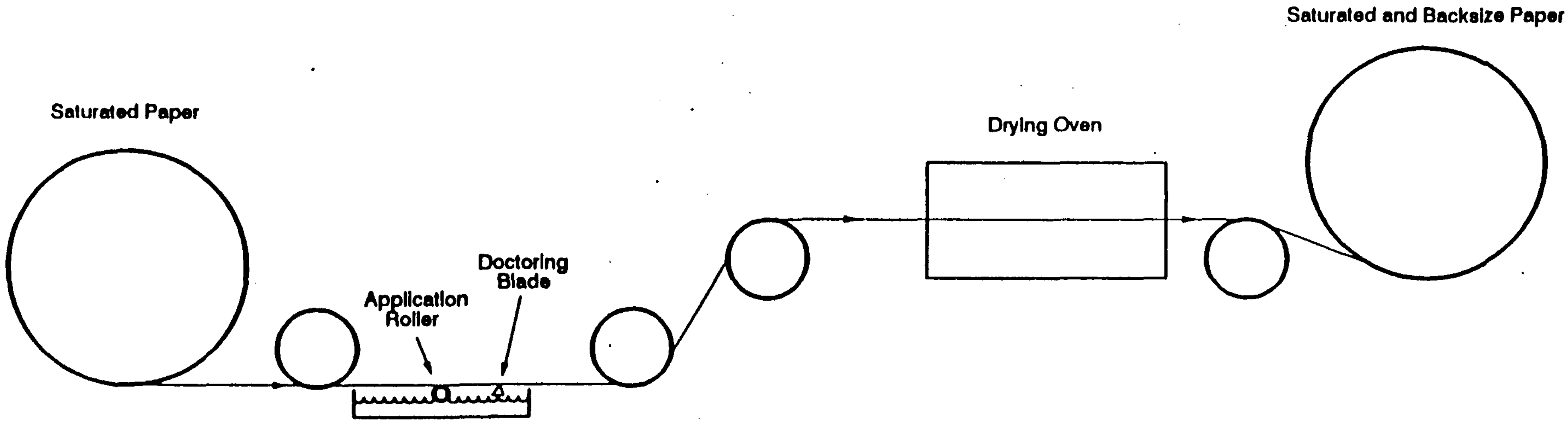

Figure 2. Backsizing

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rotates. A doctoring blade controls the thickness of the coating material applied. Any rollers that may come in contact with the coated side of the paper are wrapped with a thin cellophane-like plastic sheet. This sheet can be removed and discarded, instead of using solvent to clean the roller.

The coating material on a given backsize line may be changed up to ten times per week. When product quality allows, the rollers and troughs are not cleaned every time the coating material is changed. Flow of one coating material to the trough is stopped. Most of the coating material left in the trough is applied before flow of the next coating material starts. This results in a brief period when the coating material is "mixed."

When product quality dictates a more thorough cleaning to prevent the mixing of coating materials, a toluene-soaked rag is used to clean the application roller and trough. The toluene is handled in the same way as described for the saturation processes.

The third coating operation, adhesive coating, is shown in Figure 3. Adhesive is applied via a coated roller. The roller is coated by contact with adhesive from a holding trough. The tip of the trough is butted against the roller. A slow-rotating metering roller controls the thickness of the adhesive applied. As with backsizing, the adhesive on a given line may be changed up to ten times per week. When product quality allows, the equipment (rollers, trough, ears) are not cleaned every time the adhesive is switched. As with the backsize, brief periods of "mixed" adhesive will be applied.

When product quality dictates that no "mixed" adhesive be used, flow of the adhesive to the trough is stopped by closing a valve on the feed pipe to the adhesive header. Figure 4 shows the adhesive feed equipment and the trough. After the feed pipe is closed off, the valve from the header to the trough is closed. The adhesive left in the header is drained into a bucket and

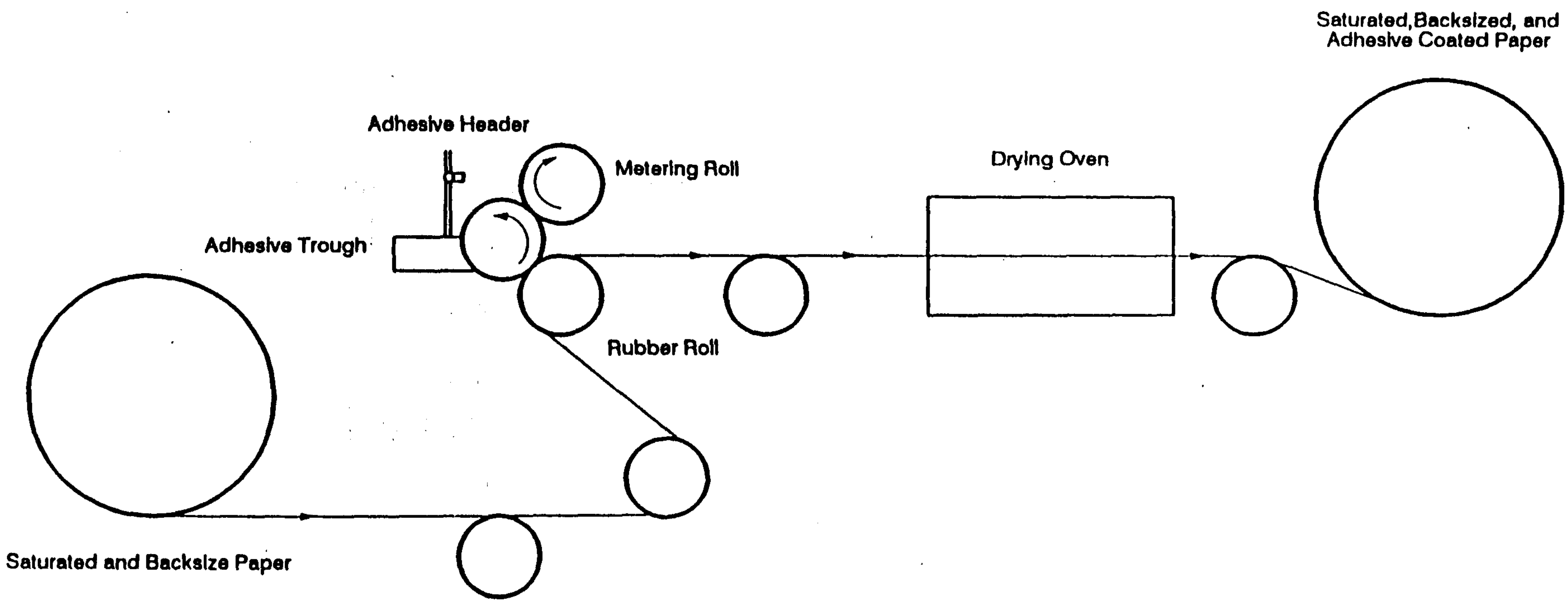

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Figure 3. Adhesive Coating

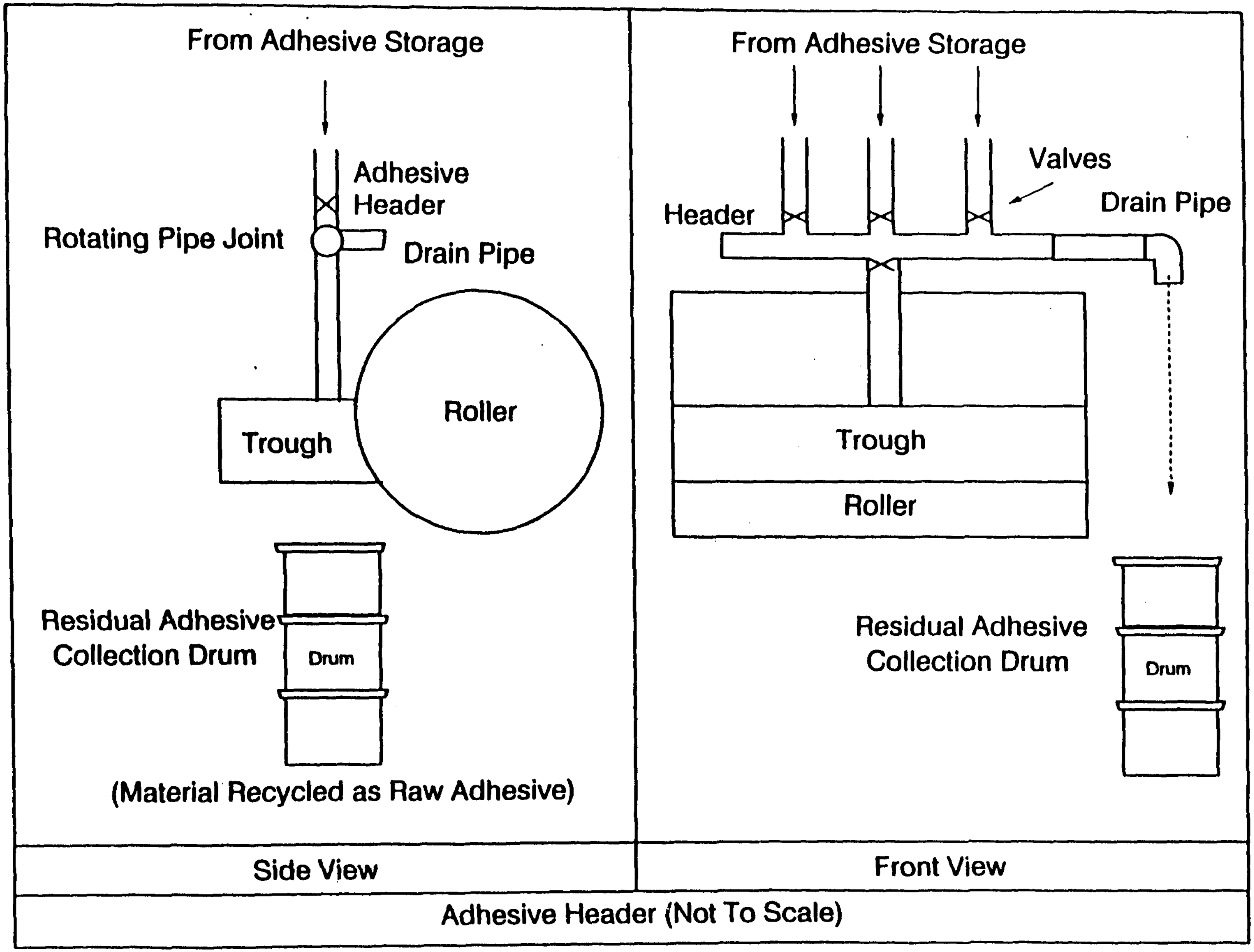

Figure 4. Blow-Up of Adhesive Header

recycled. While the paper is still being run through the rollers, a putty knife is used to scrape as much coating materialas possible from the trough and ears to the point where the trough and the roller meet. This allows the scraped coating material to be applied to the substrate. Finally, a toluene-soaked rag is used to wipe the equipment clean.

4. Solvent Usage

Toluene is the only cleaning solvent used at Shuford Mills. All spent toluene from cleaning is recycled as make-up solvent in product formulations. No estimate of the amount of toluene used for cleaning was made. Shuford Mills is planning to install a metering system to track where toluene is used. The largest cleaning use of toluene occurs when the substrate tears during the adhesive coating process. When this happens, coating materials get on a dry rubber roller. Approximately 2.5 to 3 gallons of toluene are needed to clean this roller. No estimate of how often the substrate tears was available.

RADIAN
CORPORATION

M E M O R A N D U M

DATE: September 30, 1992

SUBJECT: Trip Report - FLEXcon Company, Inc.

FROM: John Keith, Radian Corporation

TO: Improved Equipment Cleaning Project File

I. PURPOSE

The purpose of the visit to the FLEXcon Company, Inc. (FLEXcon) was to learn about the methods of cleaning adhesives coating equipment and the resulting multi-media wastes generated from cleaning. The visit was also intended to develop a working relationship between FLEXcon, U.S. Environmental Protection Agency, Air and Energy Engineering Research laboratory (AEERL), and the Massachusetts Office of Technical Assistance (MOTA) for potential demonstration projects.

II. PLACE AND DATE

Place: FLEXcon Company, Inc.
Spencer, Massachusetts

Date: May 4, 1992

III. ATTENDEES

U.S. EPA AEERL

Michael Kosusko

Mass OTA

Paul Richard, Jr.

FLEXcon

Darwin Irish
Charles Schultz

Radian Corporation

John Keith

IV. DISCUSSION

1. Project Background

The U.S. EPA AEERL is conducting research and development projects focussed on various industrial processes to determine, develop, and demonstrate applicable technologies that reduce waste generation (i.e., pollution prevention technologies) with special interest on air emissions of 17 targeted chemicals. The adhesives and coated paper manufacturing industry has been selected for a pollution prevention research project focussed on reducing air emissions and multi-media waste generated by equipment clean-up. Three of the 17 targeted chemicals; methyl ethyl ketone (MEK), toluene, and xylenes, are used as solvents during equipment clean-up. AEERL has contracted Radian to conduct the initial phase of the research project to; identify current cleaning methods, technologies, and generated wastes, identify current similar research efforts, and determine pollution prevention (alternative) technologies.

FLEXcon, through Mass OTA, has expressed interest in participating in this research project. MOTA is a State funded program that offers free technical assistance to industry.

2. FLEXcon Background

FLEXcon manufactures adhesive coated products. The substrates that the coatings are applied to are mostly paper, but include some synthetic plastic films. FLEXcon has 13 production lines in Spencer, Massachusetts, with additional production capability in Connecticut and Minnesota, and warehousing operations in Kansas. FLEXcon employs approximately 900 employees in Spencer, Massachusetts.

Massachusetts industries are subject to compliance with the Massachusetts Toxic Use Reduction Act (TURA). TURA mandates that industries monitor and reduce the generation of multi-media wastes prior to any control, capture, or recycling/reuse efforts. In response to TURA, FLEXcon has implemented a company wide pollution prevention program to reduce the generation of wastes. FLEXcon's program is modeled after their quality control program and uses employee teams made up of operations staff, management, maintenance, engineering, and research and development staff. The teams focus on different production areas to identify, monitor, and reduce multi-media waste generation.

FLEXcon's efforts to date include; tracking the amounts of solvents used and wastes generated during clean-up, working with adhesive vendors to identify alternative formulations or products that have reduced solvent content (e.g., water based adhesives) and investigation into a distillation unit to reclaim waste solvents for reuse.

3. Operations

A generic process schematic of an adhesives coating line is shown on Figure 1. The FLEXcon coating lines were the same, schematically. The substrate is run past the application roller where the coating is applied. The coated substrate then moves through an oven with different temperature zones. The coating dries, and, in the case of resin based coating, cures in the oven. Most of the solvents in the adhesive coating volatilize in the oven. The final coating on the product typically contains less than 0.5 percent solvent by weight. The coated product is pressed onto a silicone coated backing is rolled and moves to cutting and sheeting operations. In cutting and sheeting, the large rolls of product are rerolled and cut into smaller rolls or cut into sheets and stacked.

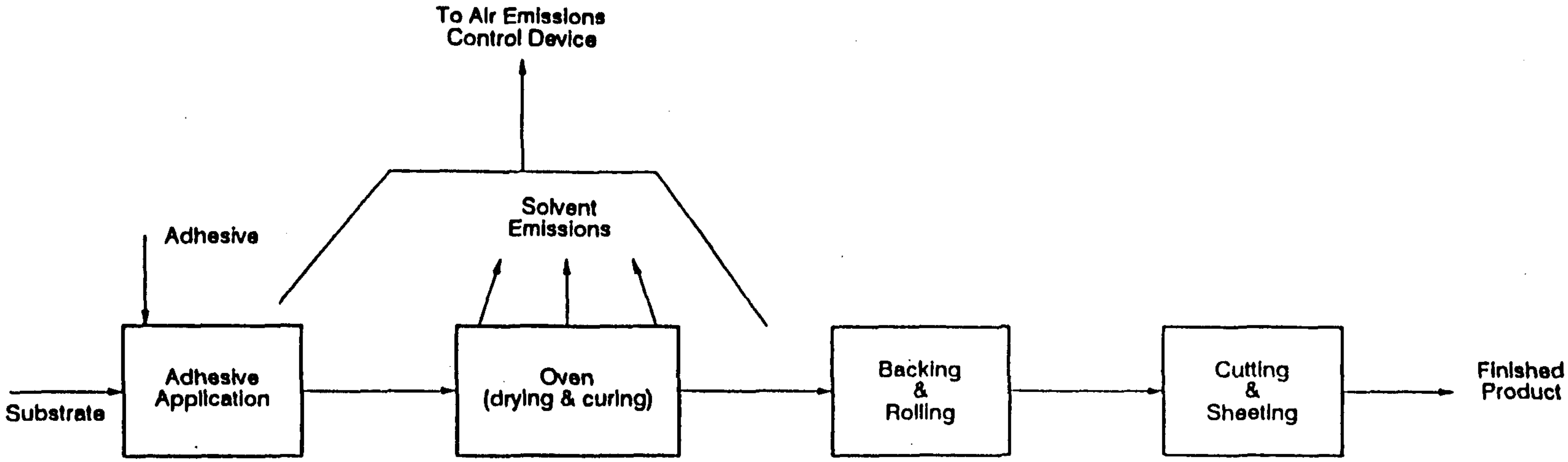

Figure 1. Schematic of Adhesives Coating Operation

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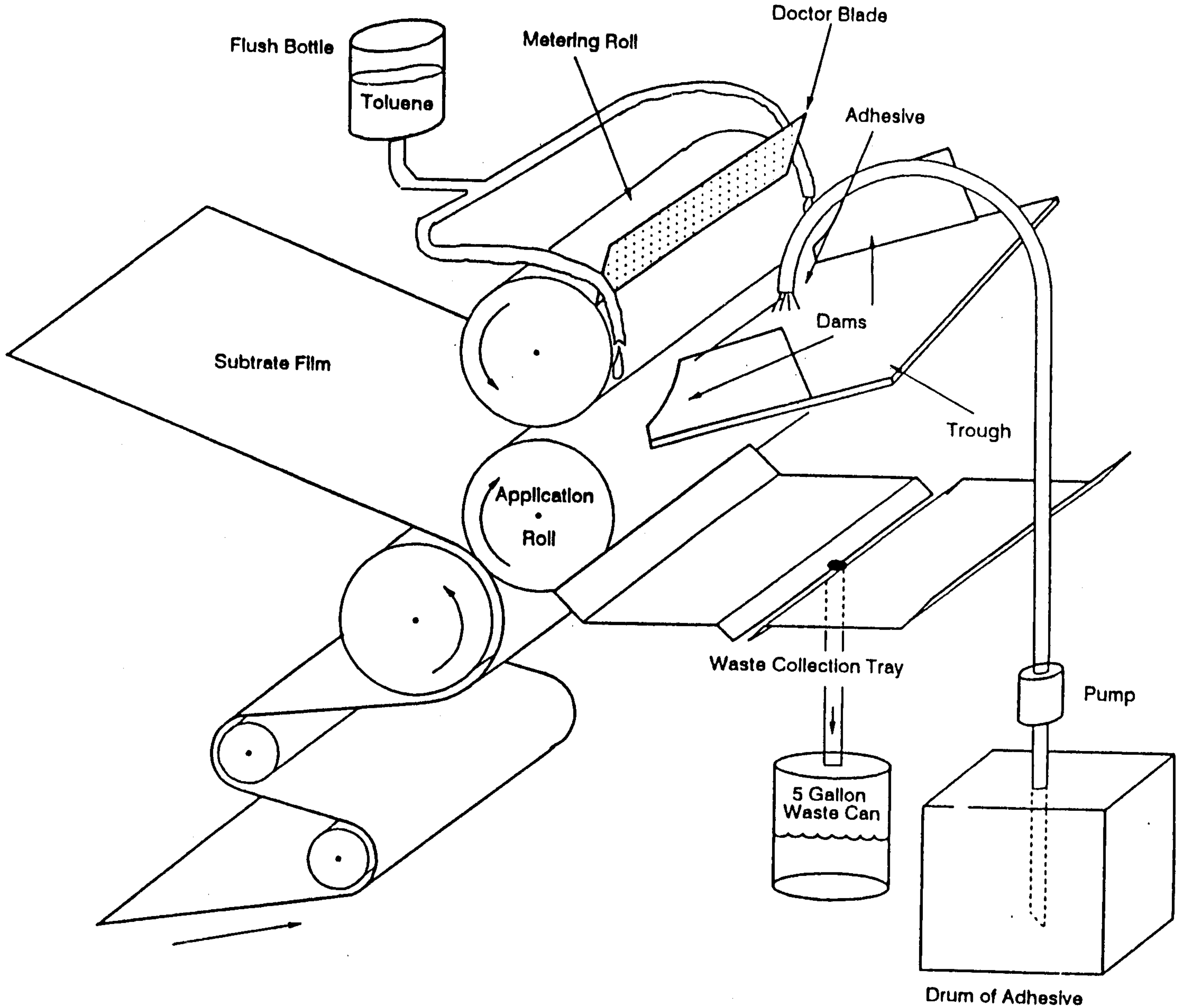

Figure 2. Adhesive Application Equipment Schematic

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For adhesive coated paper production, most equipment cleanup occurs at the application section of the coating line. Figure 2shows the configuration of the adhesive application equipment used at FLEXcon. The adhesive is pumped from a drum to a reservoir that allows the adhesive to contact each of the two rollers. The reservoir is made up of three pieces; the trough, and two dams. The positioning of the reservoir directly impacts the thickness of the adhesive applied. The space between the metering roll and application roll and the speed of the metering roll, application roll, and the substrate also control the thickness and quality of the coating. The doctor blade removes excess adhesive from the surface of the metering roll before emersion into the reservoir. The two flush bottles provide a continuous drip of toluene which dissolves and flushes away any adhesive at the dam a metering roll interface. Without the toluene flush adhesive builds up on the ends metering roll. Excessive build up of adhesives can force the rolls apart which impacts the thickness of the coating.

The wastes generated by cleaning are waste adhesive and toluene and associated emissions from the flush bottles, and the waste adhesive and MEK and associated emissions from cleaning the three reservoir components, rolls, doctor blade, pump, and hoses. Additionally, the waste collection tray is also cleaned during a "super" clean-up which occurs less frequently.

A clean-up was not conducted during the site visit so no specific details regarding clean-up can be presented. However, the general clean-up method was described after the tour.

The pump and hoses are cleaned by flushing them with MEK. The three reservoir components are removed and soaked in a MEK bath. The rolls and doctor blade are wiped with rags saturated with MEK. Clean-up generates approximately 15 gallons of MEK waste. During a super clean-up the waste collection tray is wiped down with MEK, and the doctor blade is removed and soaked in an MEK bath along with the three reservoir components.

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15. SUPPLEMENTARY NOTES AEERL project officer is Michael Kosusko, Mail Drop 61, 919/541-2734.

16. ABSTRACT The report gives results of a Phase I study to characterize current equipment cleaning practices in the coated and laminated substrate manufacturing industry, to identify alternative cleaning technologies, and to identify demonstrable technologies and estimate their emissions impacts. It presents information from sources including literature searches, industry questionnaires, plant visits, pollution prevention experts, and industry and trade association personnel. (NOTE: Phase II activities will be the actual demonstration of selected alternative technologies, and Phase III will be to transfer related technology by means of conference papers, journal articles, and newsletters, prepared and presented at industrial workshops, pollution prevention conferences, and other events where industrial application of pollution prevention technologies is discussed. Facilities within this industry tend to operate in one of two segments: (1) large facilities operating coating lines dedicated to one type of product, such as masking tape or label stock; or (2) batch processors or plants that manufacture comparatively small quantities of a wide variety of high value-added products. Both segments of the industry use essentially the same cleaning methods, even though the segments differ substantially in the range of substrates, coatings, and application equipment used at the plants.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Pollution	Solvents	Pollution Control	13B	11K
Cleaning	Polymers	Stationary Sources	13H	07D
Coatings			11C	
Laminates			11D	
Manufacturing			05C	
Emission			14G	

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