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**SOLVENT-BASED TO WATERBASED ADHESIVE-COATED SUBSTRATE  
RETROFIT - VOLUME IV: FILM AND LABEL MANUFACTURING CASE STUDY:  
FLEXCON COMPANY, INCORPORATED**

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## FOREWORD

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The National Risk Management Research Laboratory is the Agency's center for investigation of technological and management approaches for reducing risks from threats to human health and the environment. The focus of the Laboratory's research program is on methods for the prevention and control of pollution to air, land, water, and subsurface resources; protection of water quality in public water systems; remediation of contaminated sites and groundwater; and prevention and control of indoor air pollution. The goal of this research effort is to catalyze development and implementation of innovative, cost-effective environmental technologies; develop scientific and engineering information needed by EPA to support regulatory and policy decisions; and provide technical support and information transfer to ensure effective implementation of environmental regulations and strategies.

This publication has been produced as part of the Laboratory's strategic long-term research plan. It is published and made available by EPA's Office of Research and Development to assist the user community and to link researchers with their clients.

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National Risk Management Research Laboratory

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## ABSTRACT

FLEXcon Company Incorporated (FLEXcon), a pressure-sensitive adhesive (PSA) coater, was selected for a site visit to collect information on the pollution prevention opportunities and barriers associated with waterbased adhesives. The purpose of the visit to FLEXcon was to gather information on its product manufacturing processes and to identify and discuss, with input from the plant personnel, any opportunities for preventing emissions related to the use of solvents and solvent-based adhesives. Specific objectives of the trip were to collect information necessary to characterize FLEXcon's market profile, plant layout, manufacturing supplies, manufacturing process profile, environmental issues, and waterbased adhesive coating experience, as well as the limitations of water-based adhesive coatings and opportunities for waterbased adhesives at FLEXcon. This case study includes six chapters. Chapter 2 includes the market profile and overall plant description. Chapter 4 discusses environmental issues associated with process conversion. Chapter 5 describes FLEXcon's waterbased adhesive formulation experience. Finally, Chapter 6 identifies the opportunities for future use of waterbased and other adhesives at FLEXcon.

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## ACRONYMS

BACT	Best Available Control Technology
EPA	U.S. Environmental Protection Agency
FLEXcon	FLEXcon Company Incorporated
IR	infrared
MEK	methyl ethyl ketone
PSA	pressure-sensitive adhesive
SIC	Standard Industrial Classification
VOC	volatile organic compound

## CONVERSION FACTORS

To Convert From	To	Multiply by
<b>LENGTH</b>		
feet (ft)	meters (m)	0.3048
meters (m)	feet (ft)	3.281
inches (in)	centimeters (cm)	2.54
<b>MASS OR WEIGHT</b>		
pounds (lb)	kilograms (kg)	0.454
pounds (lb)	tons	0.0005
tons	pounds (lb)	2,000
tons	kilograms (kg)	907.2
<b>VOLUME</b>		
gallons (gal)	liters (l)	3.785
gallons (gal)	cubic inches (in <sup>3</sup> )	231
gallons (gal)	fluid ounces (oz)	128
gallons (gal)	cubic meters (m <sup>3</sup> )	0.00379
liters (l)	gallons (gal)	0.2642
<b>TEMPERATURE</b>		
Fahrenheit (°F)	Celsius (°C)	subtract 32, then multiply by 0.5556
Celsius (°C)	Fahrenheit (°F)	multiply by 1.8, then add 32

## CHAPTER 1

### INTRODUCTION

#### 1.1 Background

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 assessing the potential for waterbased adhesive coatings as replacements for solvent-based adhesive coatings in the adhesives-coated and laminated substrate industry. TRC Environmental Corporation (TRC) is supporting EPA in this effort by investigating the manufacturing barriers and opportunities associated with process conversions to waterbased adhesives under Work Assignment Number 1/017, EPA Contract Number 68-D2-0181.

For the purposes of this report, the term "solvent" is used to refer to volatile organic compound (VOC) containing materials used as carriers for adhesive solids and as cleaning agents in the adhesive coating process. Common examples of solvents used in these ways are methyl ethyl ketone (MEK), toluene, cyclohexanone, and acetone, although a number of other organic liquids are used in these capacities as well. Although water is a solvent, for the purposes of clarity these other VOC containing liquids are referred to as solvents in this report.

FLEXcon Company Incorporated (FLEXcon), a pressure-sensitive adhesive (PSA) coater, was selected for a site visit to collect information on the pollution prevention opportunities and barriers associated with waterbased adhesives. The purpose of the visit to FLEXcon was to gather information on its product manufacturing processes and to identify and discuss, with input from the plant personnel, any opportunities for preventing emissions related to the use of solvents and solvent-based adhesives. Specific objectives of the trip were to collect information necessary to characterize FLEXcon's market profile, plant layout, manufacturing supplies, manufacturing process profile, environmental issues, and waterbased adhesive coating experience, as well as the limitations of water-based adhesive coatings and opportunities for waterbased adhesives at FLEXcon.

This case study includes six chapters. Chapter 2 includes the market profile and overall plant description. Chapter 3 provides a general process description. Chapter 4 discusses



environmental issues associated with process conversion. Chapter 5 describes FLEXcon's waterbased adhesive formulation experience. Finally, Chapter 6 identifies the opportunities for future use waterbased and other adhesives at FLEXcon.

## **CHAPTER 2**

### **MARKET PROFILE AND PLANT DESCRIPTION**

FLEXcon began operating one coating plant in Spencer, Massachusetts in 1955. Five plants in the Spencer area have been added since that time as increased capacity has been required. Additional production facilities are located in Connecticut and Minnesota and have just started in Nebraska. Warehousing facilities are located in six different locations throughout the United States and Canada. FLEXcon operates within Standard Industrial Classification (SIC) code 3081 (Unsupported Plastics Film and Sheet). In 1993, FLEXcon had approximately \$220,000,000 in sales. Overall, the company has been experiencing sales growth at a steady rate of ten percent per year.

FLEXcon employs approximately 1,100 people company wide. Of those, 800 are located in the Spencer complex including 600 production staff. Normal operating schedules are two 12-hour shifts per day seven days per week. FLEXcon has over 15 coating lines in Spencer and more than 20 company wide. Spencer alone has approximately 570,000 square feet (53,000 square meters) of production space. FLEXcon considers its annual throughput to be confidential, so the volume of products manufactured was not obtained during the facility visit. FLEXcon manufactures six main categories of pressure-sensitive products: graphic films, packaging labels, electronic printing labels, microembossed films, medical films and labels, and custom-performance products.

FLEXcon is a batch operation producing thousands of film constructions on its coating lines. The company coats various types of films and many of its end-products require high performance standards such as humidity and corrosive resistance. For these reasons, FLEXcon considers itself a high performance (specialty) pressure-sensitive film manufacturer.

FLEXcon's Spencer complex is composed of six plants. Some plants are coating plants and others are finishing plants. These six plants differ in age, capacity, and end-products manufactured. Plant #4 was toured during TRC's facility visit.

FLEXcon's experience with waterbased adhesives began 20 years ago with existing equipment designed for solvent-based coating. A dedicated waterbased coating line was purchased in 1987. Since then, four new coating machines have both water and solvent

capabilities using Best Available Control Technology (BACT). The two new lines in Nebraska also have dual capabilities.

FLEXcon made an effort to convert some of its solvent-based coating lines to waterbased in 1983. This effort, which is discussed in Section E, was abandoned shortly after its inception. FLEXcon's current waterbased product lines are not replacements for solvent-based products, but are new product lines aimed at different market segments. While waterbased product lines have been growing at an annual rate of 30 to 35 percent per year in the last few years, waterbased adhesives currently account for approximately 25 to 50 percent of FLEXcon's operations (by volume).

## CHAPTER 3

### GENERAL PROCESS DESCRIPTION

#### 3.1 Raw Materials

FLEXcon uses three main raw materials in its pressure-sensitive film production: release-coated liners, films, and coatings. The release-coated liners are either paper or polyester. Some of these liners are purchased pre-coated while others are coated at its Connecticut facility and shipped to Spencer. No release coatings are applied in the Spencer facility. The various films used for its customers' converting operations include vinyl, polyester, acrylic, acetate, polyethylene, polypropylene, and polystyrene. Specific films used for products are determined by the end-use requirements of FLEXcon's customers.

Three types of coatings are used at FLEXcon: a release coat, an adhesive coat, and a topcoat. Nearly all of FLEXcon's end products use each coating, although a topcoat may not be required for some customers. To manufacture pressure-sensitive films, a solvent-based or waterbased adhesive is first coated on the release liner, dried/cured, then laminated (transfer-coated) to a film. FLEXcon currently uses approximately 30 solvent-based adhesives and 10 to 15 waterbased adhesives. The adhesive coating must provide the necessary adhesion to the expected end-use substrates for film. FLEXcon officials estimated that the company coats 4,000 to 5,000 gallons (15,100 to 18,900 liters) of adhesives per week. Most of FLEXcon's waterbased adhesives are solvent-free (*i.e.*, no VOC), although a few contain solvents to allow for better performance and easier application. FLEXcon considers the composition of its coatings to be confidential.

A relatively thin layer of topcoat is normally added to FLEXcon's films to raise the surface energy of the film and assist its customers in converting (mainly printing) operations. Most of FLEXcon's topcoats are waterbased materials, although they normally contain some solvent.

## **3.2 Manufacturing Process Profile**

### **3.2.1 General Process Description**

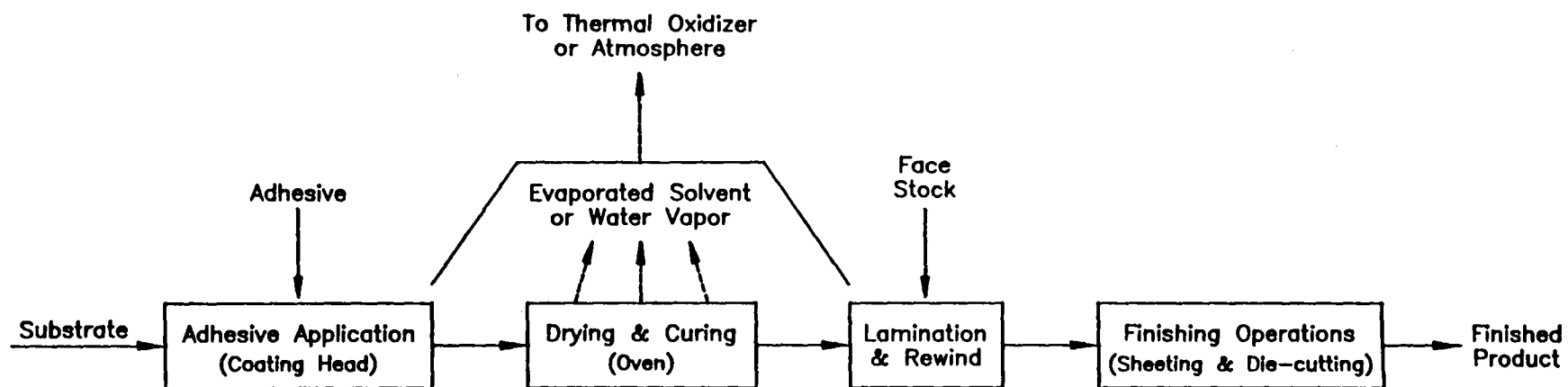
FLEXcon has three general steps in its pressure-sensitive film manufacturing: adhesive storage and transfer, film coating and laminating, and finishing operations (topcoat application, slitting, and sheeting). Adhesives are brought into each plant and stored until transferred directly to the coating line. Adhesive coatings are then applied to a release liner, dried or cured, and then laminated to their respective films. Following lamination, the film is re-wound and transferred to another coating line for topcoat application and finally to finishing operations. The topcoat operation may be bypassed if not required by the customer.

### **3.2.2 Adhesive Storage and Transfer**

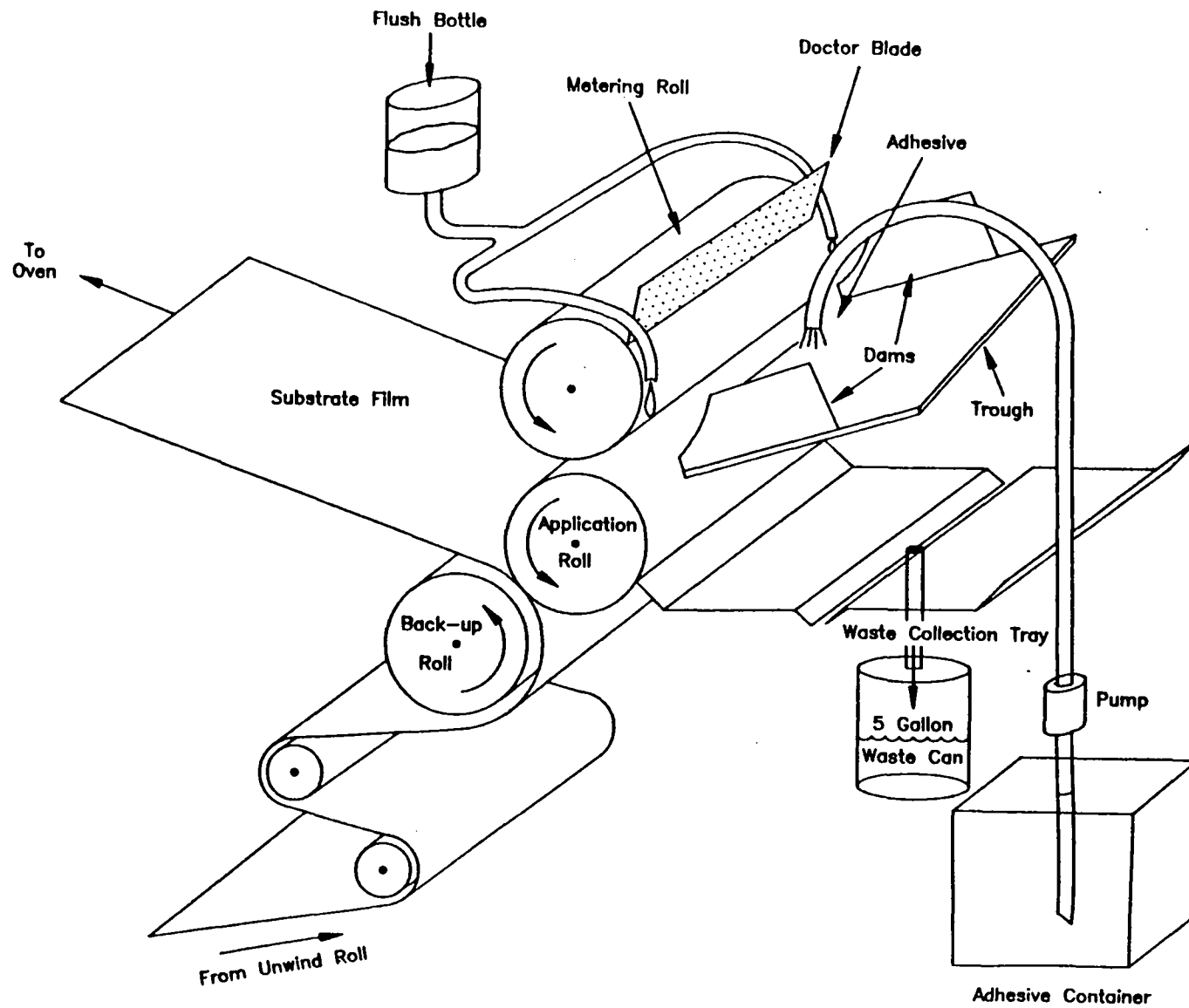
FLEXcon does not formulate its adhesives onsite, but instead works closely with its adhesive suppliers to develop the best possible formulations for its applications. Waterbased adhesives are brought into the plant in 275-gallon (1,040-liter) tote bins. After coating, these containers are cleaned with water by production personnel and then reused by the supplier. The wastewater generated in this cleaning is treated at an onsite treatment unit before it is released to the sewer. Solvent-based adhesives are delivered in 55-gallon (208-liter) drums and stored near the waterbased adhesives. Other coatings are delivered, stored, and transferred in a similar manner to the adhesives.

### **3.2.3 Film Coating and Laminating**

A typical coating line operation at FLEXcon is illustrated in Figure 3-1. The basic elements of the process are substrate unwind, coating application, drying/curing, lamination (transfer coating), and wind-up. Initially, release-coated paper or polyester is delivered in roll form to the coating line and unwound into the coating head. FLEXcon employs reverse roll coating heads which are composed of a metering roll, applicator roll, and back-up roll. Typical



**Figure 3-1. Coating Line Operation**



**Figure 3-2. Adhesive Application Equipment**

adhesive application equipment for FLEXcon is shown in Figure 3-2. Adhesives are delivered to the respective coating lines and pumped into an enclosed trough with dams located on both sides. Solvent-based adhesives employ diaphragm pumps, while waterbased adhesives use air cylinder pumps. Adhesive is picked up by the applicator roll and subsequently reduced in thickness by squeezing through the gap between the applicator roll and the metering roll. The metering roll is constantly wiped clean of adhesive by the doctor blade to provide a consistently smooth surface for contacting the adhesive layer. The applicator roll then transfers the adhesive layer to the substrate, which is travelling in the opposite direction. A back-up roll supports the substrate during the application process. This coating method is termed reverse roll coating.

Prior to product changeover at FLEXcon, all relevant coating equipment is cleaned to remove residue from the previous adhesive. Pumps, pipes, troughs, and coating heads are cleaned with either solvent or water. Troughs are lined with plastic which is removed and replaced during product changeover. Changeover times vary depending on the coating type changed. Waterbased to waterbased or solvent-based to solvent-based changes typically require less than one hour. Sometimes solvent-based to solvent-based changeovers require little or no cleanup. Waterbased to solvent-based changes (and vice versa) typically require one to two hours.

After adhesive application, the coated substrate is sent through a gas-fired oven for drying or curing. FLEXcon stated that most of its ovens are used for drying only; however, a few solvent-based adhesives are also cured. Oven exhaust is located at the end of the oven where evaporated carrier is either incinerated (for solvent-based adhesives) or released to the atmosphere (for waterbased adhesives). Once dried, a solvent-based product typically contains less than 0.5 percent solvent by weight, while a dried waterbased product contains less than 0.5 percent water by weight. Upon drying/curing, the adhesive is transfer-coated to film via lamination with nip rollers and either sent to a topcoat applicator or to other finishing operations.

#### **3.2.4 Finishing Operations (Topcoat Application, Slitting, and Sheeting)**

Topcoat application employs mainly waterbased coatings which contain some solvent. Prior to topcoat application, the laminated film may be corona pre-treated to raise its surface



energy, allowing for easier topcoat application and easier printing for customers. The topcoat operation employs a gravure coating head which coats a relatively thin layer of topcoat as compared to adhesive (typically four to twelve ten-thousandths of an inch). The topcoat application line is schematically similar to an adhesive coating line, although the coating line and oven are significantly shorter in length.

In finishing operations at FLEXcon, the large rolls of product are first cut into smaller rolls on slitting machines. These smaller rolls are then either sheeted or sent directly to the backing department. FLEXcon estimates that it ships approximately 30 to 40 percent of its product in sheet form and the remainder in roll form.

### **3.2.5 Differences Between Waterbased and Solvent-based Processes**

The coating processes and machinery used at FLEXcon to coat waterbased and solvent-based adhesives are very similar, although there are some significant differences. Since FLEXcon has not converted any of its coating lines from solvent-based to waterbased adhesives, the relative differences discussed in this section are based on operating lines that have dual coating capability.

A significant difference between solvent-based and waterbased adhesive-coated product manufacturing at FLEXcon is that waterbased adhesives are not well suited for short production runs due to the amount of time and excess substrate required to start-up a waterbased product. Waterbased adhesives need closer control of process variables and coater conditions must be optimum before process speeds can be increased. Solvent-based adhesives are well suited for short runs since they have greater processing latitude.

In general, waterbased adhesives at FLEXcon allow faster line speeds due to the lower coating weights required with waterbased adhesives. Waterbased adhesive solids content is generally higher than solvent-based adhesives, so waterbased adhesives have lower coating thicknesses. Solvent-based adhesives are often coated in the range of two to three one-thousandths of an inch thick while waterbased adhesives can be one to two one-thousandths of an inch thick at application. The lower coating weights and faster line speeds allow FLEXcon to lower its end-product cost to customers for waterbased products. FLEXcon officials noted the

company's waterbased coating lines are currently operating at maximum line speed with reverse roll coating technology. In order to increase line speeds, FLEXcon will have to switch coating methods to gravure or slot die.

Another difference between the production of solvent-based and waterbased adhesive-coated product is oven operation. The temperature configuration for waterbased materials is generally flat throughout the oven zones at a temperature of approximately 250°F (125°C). Solvent-based adhesives' oven temperatures range from an initial zone temperature of 100°F (38°C) to a final zone temperature of approximately 200°F (94°C). In addition, waterbased adhesives employ infrared (IR) heaters located in the oven zones to assist in evaporating the water carrier. The IR heaters are not used for solvent-based adhesive coatings. Finally, located at the oven exit is a system designed to re-moisturize the waterbased-coated paper substrates to reduce curl and ease laminating, topcoating, and finishing operations.

FLEXcon reported that clean-up operations are much more difficult with waterbased adhesives. Clean-up time, labor requirements, and wastewater generation are substantially greater for waterbased adhesives than for solvent-based adhesives.

## **CHAPTER 4**

### **ENVIRONMENTAL ISSUES**

There are significant differences among the environmental impacts associated with waterbased and solvent-based adhesive coating. The most important environmental impacts associated with solvent-based adhesives are evaporation, incineration, and disposal of solvents. For waterbased adhesives, the most important environmental issues are the disposal of waste adhesive and adhesive-coated paper.

FLEXcon uses a number of solvents in its solvent-based adhesives. Toluene, MEK, ethyl acetate, heptane, isopropyl alcohol, and xylene are all used in various adhesives. Solvent-based adhesives arrive at FLEXcon pre-formulated in 55-gallon drums. The adhesives are kept in a drum storage room in the drums until transferred to the coating head. A pump is connected directly to the drum of adhesive, and piping is run directly into the coating head to transfer adhesive. This technique allows for very limited evaporation of solvent into the plant atmosphere.

The coating heads on all machines are fully enclosed and are ventilated to the oven's oxidizers. Oven vapors are also ventilated to the oxidizers which have an estimated destruction efficiency of 98 percent. FLEXcon estimated that, due to improved emission controls, its annual solvent emissions are approximately 180 tons, down from approximately 1,350 tons at its maximum in the 1980s. These figures are for emissions controlled by thermal oxidation.

There are significant operating costs associated with FLEXcon's oxidizers. Natural gas is the main cost. The oxidizers operate at 1400°F. FLEXcon must also constantly monitor and report the performance of its oxidizers. Monitoring and reporting costs, while not easily quantifiable, are considered by FLEXcon to be significant costs of producing solvent-based adhesive-coated products.

FLEXcon produces some solvent wastes from the coating process which must be disposed of as hazardous wastes. These wastes are stored in 55-gallon drums onsite until disposal by an off-site contractor. While production levels of solvent-based adhesive-coated materials have increased over the years, the volume of hazardous waste generated by FLEXcon has remained

relatively constant. There are significant efforts to reduce and/or recycle waste. FLEXcon is a member of EPA's 33/50 Program.

Waterbased adhesives also have significant environmental costs associated with use. FLEXcon produces waterbased adhesive waste in its manufacturing process which is treated by FLEXcon's wastewater treatment system. This waste is generated during cleaning operations, including coating head cleaning and waterbased container cleaning. FLEXcon also generates solid waste because some unusable coated paper is generated during setup of waterbased adhesive-coated product runs.

To process waterbased adhesive wastes, FLEXcon runs the waste through its on-site wastewater treatment system which removes water and concentrates the waste into a solid sludge. The wastewater treatment system is capable of processing 50 gallons (760 liters) of untreated waterbased adhesive waste per hour. The system operates by first adding lime to the wastewater to raise its pH. The wastewater is then acidified to force the solids out of the sludge in a diatomaceous earth filter. The recovered water can then be re-used in cleaning operations. Both concentrated sludge and waste-coated paper are shipped to a municipal incinerator.

FLEXcon officials indicated that the volume of wastewater sludge and waste-coated paper produced by waterbased adhesives is approximately one-half the volume of hazardous solvent waste it produces with solvent-based adhesives. FLEXcon estimated that the total annual disposal cost of the sludge and solid waste is much less than the total annual disposal cost of its hazardous solvent wastes.

## **CHAPTER 5**

### **WATERBASED FORMULATION EXPERIENCE**

#### **5.1 Waterbased Adhesive Use**

FLEXcon began production of a waterbased adhesive-coated product approximately 20 years ago, using existing equipment. FLEXcon experimented with a large number of waterbased adhesive coatings before selecting two products to introduce in 1984. Since 1984, FLEXcon has steadily increased the number of waterbased adhesive-coated products it manufactures.

FLEXcon uses a total of approximately 50 adhesive-coating formulations in manufacturing its products. Approximately ten of these are waterbased adhesives, while the remainder are solvent-based adhesives. Waterbased adhesive-coated product sales currently account for approximately 25 to 50 percent of FLEXcon's total annual sales by unit area.

Five of FLEXcon's 19 adhesive coating machines in the Spencer, Massachusetts plant are capable of coating waterbased adhesive formulations.

The first step in the 1984 conversion process was to find two waterbased adhesives that could approach the performance of two of the largest solvent-based adhesives. End use performance of these products was initiated for existing applications. FLEXcon manufactured these two waterbased adhesive-coated products and offered them to its clients as alternative products to solvent-based adhesive-coated products. Since waterbased adhesive-coated products were less expensive to produce than competing solvent-based adhesive-coated products, FLEXcon was able to offer the waterbased adhesive-coated products at lower prices. However, the waterbased adhesives did not perform at expected levels and thus did not receive a positive response from clients.

FLEXcon's production of waterbased product has risen at a 25-percent annual rate in the last few years. However, almost all of FLEXcon's increases in waterbased production have been due to new products, not replacements for solvent-based adhesive-coated products.

FLEXcon is currently exploring a conversion of some of its solvent-based products to waterbased adhesives. FLEXcon personnel indicate three primary factors for considering this conversion. First, a waterbased adhesive has been found which meets the required performance

levels. Second, waterbased adhesive-coated products are much less expensive to produce than solvent-based products. Third, the process speeds for waterbased products are higher. These three factors give waterbased adhesive-coated products a market advantage over solvent-based adhesive-coated products. However, despite lower production costs, some waterbased adhesive-coated products exhibit lower profit margins due to the intense competition that has developed in the waterbased adhesive coating market.

FLEXcon is not currently contemplating any additional waterbased adhesives as replacements for current solvent-based adhesives. However, the company actively pursues improvements in waterbased adhesives that will allow it to develop new products to expand waterbased adhesive usage in the future.

## **5.2 Limitations of Waterbased Adhesive Coatings**

FLEXcon personnel indicated that significant adhesive performance issues must be addressed before waterbased adhesives can be fully utilized in its market segments. According to FLEXcon, there are currently no waterbased adhesive formulations that can match the total performance requirements of FLEXcon's clients. The main limitations of waterbased adhesives are:

1. Lower peel strength than solvent-based adhesives at room temperatures.
2. Lower shear strength at high temperatures.
3. Less flexibility in adhesion to a broad range of substrates.
4. Lower tolerance to humidity changes.
5. Limited products that can be used for direct skin contact.

Many of FLEXcon's products are exposed to relatively extreme temperature and humidity, rain, and ultra-violet radiation. Its products are used in direct skin contact applications, high stress conditions, and low energy surface applications. FLEXcon manufactures adhesive-coated products for use in the electronics industry, which must meet rigorous performance standards. FLEXcon's adhesive products designed for medical applications must also meet exacting

performance characteristics. The current spectrum of available waterbased adhesive coatings does not encompass the breadth of environmental conditions to which FLEXcon's products are subject.

In the remainder of this section, difficulties in the processing of waterbased adhesives are discussed. While these difficulties are significant when considering waterbased adhesive use at FLEXcon, it should be noted that the most important factor which limits waterbased adhesive use at FLEXcon is lower performance characteristics.

FLEXcon's market profiles complicate total conversion to waterbased adhesives. FLEXcon manufactures adhesive-coated products for six general market segments, which are discussed in Section 2 of this report. FLEXcon manufactures over 10,000 end products in these six market segments which are sold to a broad assortment of clients. As detailed in Section 3 of this report, FLEXcon employs a batch manufacturing system. This system allows a wide variety of products to be manufactured, and gives FLEXcon the capability to produce a relatively small number of products in a short time.

While the batch manufacturing system is necessary for FLEXcon to satisfy its clients' often time-critical production requests, it does not favor use of waterbased adhesives. FLEXcon must spend more time and materials to engage a run of waterbased adhesive-coated product than is required for a run of solvent-based adhesive-coated product. A waterbased adhesive-coated product must be run at least approximately 2,500 yards (2,300 meters) in substrate length to allow FLEXcon to make a profit on the production run. For solvent-based adhesive-coated products, production runs of approximately 250 yards (230 meters) may be performed profitably and without complications.

There are two factors that cause longer production times with waterbased adhesives. First, waterbased adhesives require additional equipment cleaning time. When waterbased adhesive-coated products are manufactured, more time is required to clean the coating head and other equipment than when solvent-based adhesive-coated products are manufactured. Occasionally, one solvent-based adhesive can be switched to another on the coating line without extensive cleaning. However, when switching from one waterbased adhesive to another, the coating head must be cleaned thoroughly. In addition, the coating heads must always be cleaned thoroughly when switching between waterbased and solvent-based adhesives.

The second factor causing longer production times with waterbased adhesives is that these adhesives take some time to equilibrate on the substrate during a production run. As a result, a portion of coated paper must be wasted before the coating head produces marketable products. For solvent-based adhesive coated products, a 50-yard (46-meter) production run is possible without coating problems.



## **CHAPTER 6**

### **OPPORTUNITIES FOR WATERBASED AND OTHER ADHESIVES AT FLEXCON**

For FLEXcon to adequately service the needs of its current client base, it must continue to use solvent-based adhesives. For most high-performance applications, there are no available substitutes for solvent-based adhesives. Waterbased and hot melt adhesives are currently better suited for lower performance applications. Radiation-cured adhesives can achieve high performance levels, but have a limited flexibility. Two-part reactive adhesive coatings are also limited in current applications.

Although FLEXcon personnel noted that it would currently be impossible to eliminate solvent-based adhesive use without drastically altering its client base and market segments, there are many opportunities available for waterbased adhesive use at FLEXcon in the future. As the performance characteristics of waterbased adhesives continue to improve, new markets are becoming accessible. FLEXcon continually searches for these new markets in which to sell waterbased adhesives. FLEXcon does not see similar opportunities for solvent-based adhesives. For FLEXcon, sales of solvent-based adhesive-coated products have stayed fairly constant. As a result, FLEXcon is increasing production of waterbased adhesive-coated products while maintaining current production levels of solvent-based adhesive-coated products.

In addition to sales of waterbased adhesives aimed toward new applications in existing markets, FLEXcon hopes to expand into new market segments. There may be further opportunities for conversion of current FLEXcon products (like shelf labels) from solvent-based to waterbased adhesives in the future. Many of FLEXcon's products have performance characteristics that cannot be matched with current waterbased adhesives. However, there may be solvent-based adhesives used at FLEXcon which could be replaced with a combination of waterbased adhesives. If the performance needs and market requirements of all FLEXcon's current solvent-based adhesive-coated products were analyzed, it is possible that some candidates for replacement would be found.

In the future, there will be more opportunities at FLEXcon to use waterbased adhesives with both current products and new products. Other adhesive technologies, like radiation-cured and two-part reactive adhesives, might also achieve performance breakthroughs allowing for

additional replacement of solvent-based adhesives. A key factor for a radiation cured system would be a breakthrough in cost for radiation sources and the lowering of toxicity in the chemicals. FLEXcon personnel predicted that performance levels of these various adhesive technologies might be high enough to warrant replacement of many high-performance solvent-based adhesives within ten years. As the performance and marketability of waterbased and other adhesives continue to increase, FLEXcon personnel believe that the company will be able to achieve significant conversions from solvent-based adhesives.

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16. ABSTRACT This volume discusses a visit to a site operated by Flexcon Company Incorporated, a pressure-sensitive adhesive coater, to collect information on the pollution prevention opportunities and barriers associated with waterbased adhesives. The purpose of the visit to Flexcon was to gather information on its products manufacturing processes and to identify and discuss, with input from plant personnel, any opportunities for preventing emissions related to the use of solvents and solvent-based adhesives. Objectives of the trip were to collect information necessary to characterize Flexcon's market profile, plant layout, manufacturing supplies, manufacturing process profile, environmental issues, and waterbased adhesive coating experience, as well as the limitations of waterbased adhesive coatings and opportunities for water-based adhesives at Flexcon. The case study includes six chapters. Chapter 2 includes the market profile and overall plant description. Chapter 3 provides a general process description. Chapter 4 discusses environmental issues associated with process conversion. Chapter 5 describes Flexcon's waterbased adhesive formulation experience. Chapter 6 identifies the opportunities for future use waterbased and other adhesives at Flexcon.		
17. KEY WORDS AND DOCUMENT ANALYSIS		
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pollution	Pollution Prevention	13B
Films	Stationary Sources	11C, 07D
Labels	Water-based adhesives	13D
Solvents		11K
Substrates		11D
Equipment		14G
Cleaning		13H
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