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EPA Office of Compliance Sector Notebook Project

Profile of the Rubber and Plastics Industry

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LIST OF ACRONYMS

AFS - AIRS Facility Subsystem (CAA database)
AIRS - Aerometric Information Retrieval System (CAA database)
BIFs - Boilers and Industrial Furnaces (RCRA)
BOD - Biochemical Oxygen Demand
CAA - Clean Air Act
CAAA - Clean Air Act Amendments of 1990
CERCLA - Comprehensive Environmental Response, Compensation and Liability Act
CERCLIS - CERCLA Information System
CFCs - Chlorofluorocarbons
CO - Carbon Monoxide
COD Chemical Oxygen Demand
CSI - Common Sense Initiative
CWA - Clean Water Act
D&B - Dun and Bradstreet Marketing Index
ELP - Environmental Leadership Program
EPA - United States Environmental Protection Agency
EPCRA Emergency Planning and Community Right-to-Know Act
FIFRA - Federal Insecticide, Fungicide, and Rodenticide Act
FINDS - Facility Indexing System
HAPs - Hazardous Air Pollutants (CAA)
HSDB - Hazardous Substances Data Bank
IDEA - Integrated Data for Enforcement Analysis
LDR - Land Disposal Restrictions (RCRA)
LEPCs - Local Emergency Planning Committees
MACT - Maximum Achievable Control Technology (CAA)
MCLGs - Maximum Contaminant Level Goals
MCLs - Maximum Contaminant Levels
MEK - Methyl Ethyl Ketone
MSDSs - Material Safety Data Sheets
NAAQS - National Ambient Air Quality Standards (CAA)
NAFTA - North American Free Trade Agreement
NCDB - National Compliance Database (for TSCA, FIFRA, EPCRA)
NCP - National Oil and Hazardous Substances Pollution Contingency Plan
NEIC - National Enforcement Investigation Center
NESHAP - National Emission Standards for Hazardous Air Pollutants
NO_2 - Nitrogen Dioxide
NOV - Notice of Violation

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LIST OF ACRONYMS (CONT'D)

NO_X - Nitrogen Oxide
NPDES - National Pollution Discharge Elimination System (CWA)
NPL - National Priorities List
NRC - National Response Center
NSPS - New Source Performance Standards (CAA)
OAR - Office of Air and Radiation
OECA - Office of Enforcement and Compliance Assurance
OPA - Oil Pollution Act
OPPTS - Office of Prevention, Pesticides, and Toxic Substances
OSHA - Occupational Safety and Health Administration
OSW - Office of Solid Waste
OSWER - Office of Solid Waste and Emergency Response
OW - Office of Water
P2 - Pollution Prevention
PCS - Permit Compliance System (CWA Database)
POTW - Publicly Owned Treatments Works
RCRA - Resource Conservation and Recovery Act
RCRIS - RCRA Information System
SARA - Superfund Amendments and Reauthorization Act
SDWA - Safe Drinking Water Act
SEPs - Supplementary Environmental Projects
SERCs - State Emergency Response Commissions
SIC - Standard Industrial Classification
SO_2 - Sulfur Dioxide
TOC - Total Organic Carbon
TRI - Toxic Release Inventory
TRIS - Toxic Release Inventory System
TCRIS - Toxic Chemical Release Inventory System
TSCA - Toxic Substances Control Act
TSS - Total Suspended Solids
UIC - Underground Injection Control (SDWA)
UST - Underground Storage Tanks (RCRA)
VOCs - Volatile Organic Compounds

RUBBER AND MISCELLANEOUS PLASTICS PRODUCTS (SIC 30)

I. INTRODUCTION TO THE SECTOR NOTEBOOK PROJECT

I.A. Summary of the Sector Notebook Project

Environmental policies based upon comprehensive analysis of air, water, and land pollution are an inevitable and logical supplement to traditional single-media approaches to environmental protection. Environmental regulatory agencies are beginning to embrace comprehensive, multi-statute solutions to facility permitting, enforcement and compliance assurance, education/outreach, research, and regulatory development issues. The central concepts driving the new policy direction are that pollutant releases to each environmental medium (air, water, and land) affect each other, and that environmental strategies must actively identify and address these inter-relationships by designing policies for the "whole" facility. One way to achieve a whole facility focus is to design environmental policies for similar industrial facilities. By doing so, environmental concerns that are common to the manufacturing of similar products can be addressed in a comprehensive manner. Recognition of the need to develop the industrial "sector-based" approach within the EPA Office of Compliance led to the creation of this document.

The Sector Notebook Project was initiated by the Office of Compliance within the Office of Enforcement and Compliance Assurance (OECA) to provide its staff and managers with summary information for eighteen specific industrial sectors. As other EPA offices, States, the regulated community, environmental groups, and the public became interested in this project, the scope of the original project was expanded. The ability to design comprehensive, common sense environmental protection measures for specific industries is dependent on knowledge of several inter-related topics. For the purposes of this project, the key elements chosen for inclusion are: general industry information (economic and geographic); a description of industrial processes; pollution outputs; pollution prevention opportunities; Federal statutory and regulatory framework; compliance history; and a description of partnerships that have been formed between regulatory agencies, the regulated community, and the public.

For any given industry, each topic listed above could alone be the subject of a lengthy volume. However, in order to produce a manageable document, this project focuses on providing summary information for each topic. This format provides the reader with a synopsis of each issue, and references where more in-depth information is available. Text within each profile was researched from a variety of sources, and was usually condensed from more detailed sources pertaining to specific topics. This approach allows for a wide coverage of activities that can be further explored based upon the citations and references listed at the end of this profile. As a check on the information included, each notebook went through an external review process. The Office of Compliance appreciates the efforts of all those that participated in this process and enabled us to develop more complete, accurate, and up-to-date summaries. Many of those who reviewed this notebook are listed as contacts in Section IX and may be sources of additional information. The individuals and groups on this list do not necessarily concur with all statements within this notebook.

I.B. Additional Information

Providing Comments

OECA's Office of Compliance plans to periodically review and update the notebooks and will make these updates available both in hard copy and electronically. If you have any comments on the existing notebook, or if you would like to provide additional information, please send a hard copy and computer disk to the EPA Office of Compliance, Sector Notebook Project, 401 M St., SW (2223-A), Washington, DC 20460. Comments can also be uploaded to the Enviro$ense Bulletin Board or the Enviro$ense World Wide Web for general access to all users of the system. Follow instructions in Appendix A for accessing these data systems. Once you have logged in, procedures for uploading text are available from the on-line Enviro$ense Help System.

Adapting Notebooks to Particular Needs

The scope of the existing notebooks reflect an approximation of the relative national occurrence of facility types that occur within each sector. In many instances, industries within specific geographic regions or States may have unique characteristics that are not fully captured in these profiles. For this reason, the Office of Compliance encourages State and local environmental agencies and other groups to supplement or re-package the information included in this notebook to include more specific industrial and regulatory information that may be available. Additionally, interested States may want to supplement the "Summary of Applicable Federal Statutes and Regulations" section with State and local requirements. Compliance or technical assistance providers may also want to develop the "Pollution Prevention" section in more detail. Please contact the appropriate specialist listed on the opening page of this notebook if your office is interested in assisting us in the further development of the information or policies addressed within this volume.

If you are interested in assisting in the development of new notebooks for sectors not covered in the original eighteen, please contact the Office of Compliance at 202-564-2395.

II. INTRODUCTION TO THE RUBBER AND MISCELLANEOUS PLASTICS PRODUCTS INDUSTRY

This section provides background information on the size, geographic distribution, employment, production, sales, and economic condition of the Rubber and Plastics Products industry. The type of facilities described within the document are also described in terms of their Standard Industrial Classification (SIC) codes. Additionally, this section contains a list of the largest companies in terms of sales.

II.A. Introduction, Background, and Scope of the Notebook

The rubber and miscellaneous plastics products industry, as defined by the Standard Industrial Classification (SIC) code 30, includes establishments that manufacture products from plastic resins, natural and synthetic rubber, reclaimed rubber, gutta percha, balata, and gutta siak. The production of the rubber mixture is commonly performed in facilities manufacturing rubber products and is covered under SIC 30; however, the production of plastic resins is not covered under SIC 30 because the majority of plastics product facilities manufacture products from pre-made resins purchased from plastic resin (polymer and resin) manufacturing facilities (SIC 28).

Although this SIC code covers most rubber and plastics products, some important rubber and plastics products are classified elsewhere. These products include boats, which are classified under SIC 37 (Transportation Equipment), and buttons, toys, and buckles, which are classified under SIC 39 (Miscellaneous Manufacturing Industries). Buttons, toys, and buckles are grouped according to the final product rather than by process because not all of these products are made out of rubber or plastic. The rubber and miscellaneous plastics products industry does include tire manufacture; however, because of the somewhat different processes involved, the recapping and retreading of automobile tires are classified under SIC 7534 and are not discussed in this profile.

Although SIC 30 groups rubber and plastics products together under some of the three-digit industry codes (e.g., rubber and plastic footwear under SIC 302), the majority of economic and process information separates plastic and rubber products. In addition, because tire manufacture accounts for such a large portion (almost 50 percent) of all rubber product manufacture, tire process and economic information is often discussed separately from that of other rubber products. Therefore, for the purposes of this industry profile, plastics products, rubber products, and rubber tires are often discussed separately.

II.B. Characterization of the Rubber and Miscellaneous Plastics Products Industry

The following sections contain information about the size and distribution of rubber and miscellaneous plastics products facilities as well as information about the types of products produced by these facilities. Also included is a discussion of the current and projected economic trends for the rubber and miscellaneous plastics products industry.

II.B.1. Industry Size and Geographic Distribution

Variation in facility counts occur across data sources due to many factors, including reporting and definitional differences. This document does not attempt to reconcile these differences, but rather reports the data as they are maintained by each source.

The Bureau of the Census estimates that in 1987, 597,900 people were employed by the plastics products industry and 231,700 were employed by the rubber products industry of which the tire industry employed 65,400. The value of shipments (revenue associated with product sales) totaled $61.6 billion in 1987 for the plastics products industry and $24.8 billion for the rubber products industry of which the tire industry contributed $10.5 billion. 1992 Census Data for SIC 30 was not available at the time of this printing.

Plastic

Because of the wide range of products produced, plastics products are manufactured in all parts of the country. According to the 1987 Census of Manufacturers, the total number of plastics products establishments (with 20 or more employees) was 5,999. Of these facilities, approximately 72 percent have fewer than 50 employees and only one percent have more than 500 employees (see Exhibit 1). Although these facilities are not concentrated in any particular region, a few States account for a large percentage of the facilities. These States include California, Ohio, Texas, Illinois, New York, Pennsylvania, New Jersey, and Michigan (see Exhibit 2).

Exhibit 1
Facility Size Distribution of Plastics Products Industry

Employees per Facility	Number of Facilities	Percentage of Facilities
1 to 4	2473	20
5 to 9	1581	13
10 to 19	1991	16
20 to 49	2729	23
50 to 99	1688	14
100 to 249	1190	10
250 to 499	301	3
500 to 999	80	1
1,000 to 2,499	10	0 (0.08)
2,500 or more	1	0 (0.008)
Total	12,044	100

Source: 1987 Bureau of the Census data.

Exhibit 2
Geographic Distribution of Plastics Products Industry

Source: 1987 Bureau of the Census data.

Rubber

Like the plastic industry, the rubber industry produces a wide range of products. Rubber product manufacturing establishments are located all across the country. According to the 1987 Census of Manufacturers, the total number of establishments (with 20 or more employees) was 1,204. Of these facilities, approximately 70 percent have fewer than 50 employees, and only three percent have more than 500 employees (see Exhibit 3). Although these facilities are not concentrated in any particular region, a few States account for a large percentage of the facilities. These States include California, Ohio, North Carolina, Indiana, Michigan, Illinois, Massachusetts, and Texas (see Exhibit 4).

Exhibit 3
Facility Size Distribution of the Rubber Products Industry

Employees per Facility	Number of Facilities	Percentage of Facilities
1 to 4	451	19
5 to 9	335	14
10 to 19	390	16
20 to 49	505	21
50 to 99	306	13
100 to 249	228	9
250 to 499	117	5
500 to 999	36	2
1,000 to 2,499	12	1
Total	2,380	100

Source: 1987 Bureau of the Census data.

Exhibit 4
Geographic Distribution of the Rubber Products Industry
Source: 1987 Bureau of the Census data.

Tires

Labor costs currently represent about 30 percent of the cost of tire and tube production for U.S. manufacturers. To keep these labor costs as low as possible, tire manufacturing plants are located primarily in southern States where labor rates are lower than the national average.

Exhibit 5
Facility Size Distribution of the Tire Industry

Employees per Facility	Number of Facilities	Percentage of Facilities
1 to 4	31	19
5 to 9	17	10
10 to 19	18	11
20 to 49	19	12
50 to 99	8	5
100 to 249	20	12
250 to 499	13	8
500 to 999	9	6
1,000 to 2,499	23	14
2,500 or more	5	3
Total	163	100

Source: 1987 Bureau of the Census data.

There are 47 tire manufacturing plants in the United States. These plants are located in 20 states. States that account for a large percentage of facilities include Alabama, Illinois and Tennessee.

Exhibit 6
Geographic Distribution of the Tire Industry
Source: 1987 Bureau of the Census data.

The two largest producers of tires, Goodyear and Michelin, accounted for approximately 55 percent of tire production in 1992. The five largest producers, Goodyear, Michelin, Bridgestone/Firestone, Continental/General Tire, and Cooper, accounted for 84 percent of production, while the eight largest companies produced 97 percent of the domestic product (see Exhibit 7).

Exhibit 7
North American Tire Sales

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Source: Tire Business 1993 Annual Report

II.B.2. Product Characterization

The Bureau of the Census' SIC 30 divides the rubber and miscellaneous plastics products into industry groups according to the type of product manufactured. The following is a list of all the three digit industry groups under SIC 30:

SIC 301 - Tires and Inner Tubes
SIC 302 - Rubber and Plastic Footwear
SIC 305 - Gaskets, Packing, and Sealing Devices and Rubber and Plastic Hose and Belting
SIC 306 - Fabricated Rubber Products, Not Elsewhere Classified
SIC 308 - Miscellaneous Plastics products

Several of these three digit classifications group rubber and plastics products. However, the four digit classifications clearly segregate the two industries. The following are four digit SIC code breakdowns of the plastic and rubber products industries. In the plastic industry, Plastics products, Not Elsewhere Classified (NEC) (SIC 3089) account for approximately 55 percent of all plastic product production. Unsupported Plastic Film and Sheet (SIC 3081) account for approximately 13 percent; Plastic Foam Products (SIC 3086) account for approximately 11 percent; Plastic Bottles (SIC 3085) account for approximately five percent; Plastic Pipe (SIC 3084), Unsupported Plastic Profile Shapes (SIC 3082), and Custom Compounding of Purchased Plastic Resins (SIC 3087) account for approximately four percent each; Laminated Plastic Plate, Sheet, and Profile Shapes (SIC 3083) account for approximately three percent; and Plastic Plumbing Fixtures (SIC 3088) for approximately one percent (see Exhibit 8).

Exhibit 8
Diversity of Plastics Products Industry

Source: 1987 Bureau of the Census data.

In the rubber industry, Tire and Inner Tube (SIC 3011) manufacture accounts for approximately 42 percent of all rubber product production. Fabricated Rubber Products Not Elsewhere Classified (SIC 3069) account for approximately 21 percent; Molded, Extruded, and Lathe-Cut Mechanical Rubber Goods (SIC 3061) account for approximately 15 percent; Rubber and Plastic Hose and Belting (SIC 3052), and Gaskets, Packing, and Sealing Devices (SIC 3053) account for approximately 10 percent; and Rubber and Plastic Footwear (SIC 3021) account for two percent (see Exhibit 9).

Exhibit 9
Diversity of the Rubber Products Industry

Source: 1987 Bureau of the Census data.

II.B.3. Economic Trends

Plastic

Consumption of plastics products is highest in the electronics, health care, construction, transportation, automotive, and food packaging industries. According to the 1994 U.S. Industrial Outlook, shipments of miscellaneous plastics products are expected to grow by five percent in 1994, largely as a result of stronger consumer confidence and spending, and expected increases in demand from the electronics and health care sectors. Highest growth is expected to be for molded and extruded products.

In 1992, U.S. exports of plastics products (approximately $4.5 billion) slightly exceeded imports (approximately $4.3 billion). The bulk of U.S. imports in 1993 came from Canada, Taiwan, China, and Japan. The value of the total trade turnover (sum of imports plus exports) amounted to approximately 13.5 percent of total industry shipments, domestic and foreign, in 1993. U.S. plastics products exports compete favorably against lower cost producers in many third-country markets. [Note: This data excludes the bottles and plumbing equipment/parts sectors of the industry.]

Rubber

The value of all products and services sold in the rubber products industry is forecasted to grow three percent in 1994, largely reflecting expected increases in the tire manufacturing sector's use of fabricated rubber products, as well as higher consumer spending. Higher than average growth is expected for automobiles (i.e., hoses, belts, etc.).

Trading patterns reflect the U.S. rubber industry's position as a moderately competitive producer; the U.S. is both a major exporter to industrialized nations and an importer of lower-cost products from industrializing countries. Imports continue to make inroads in the domestic market and stand at a nearly 2:1 ratio to exports. Two-way trade relative to total industry shipments remains stable, at about one-fifth of total industry shipments.

Tires

The tire industry shows signs of stabilizing after undergoing a period characterized by massive restructuring, the effects of recession in the domestic market, and consistently high levels of imports. With tire durability pushed to what many consider the practical limit, industry strategy has shifted to servicing the fast-growing emerging markets for high-performance, light truck, and recreational vehicle (RV) tires.

The tire industry grew at an average rate of 2.5 percent until 1990, at which point there was a slight decrease in growth. Industry shipments reached record levels in 1994, with higher than average growth expected for the high-performance, truck, and light truck tires and little or no growth projected for passenger tires installed on new cars.

Imports continued to outpace exports in the tire industry at a ratio of nearly 2:1 in 1993. However, since 1989, a steady growth of exports has slowly cut into this negative net trade position. The foreign trade sector of the industry is stable, as evidenced by several consecutive years when the ratio of combined exports and imports to overall industry shipments remained relatively constant. Canada is now the U.S.' largest trading partner, absorbing 40 percent of total U.S. exports, while supplying approximately 30 percent of imports in 1992. The two other top recipients of U.S. exports are Mexico and Japan, while Japan, South Korea, and Canada, produce the majority of tires imported by the United States.

During the 1980's, corporate restructuring and mergers and acquisitions resulted in the globalization of the tire industry. Almost one-half of domestic production capacity is now owned by foreign-based tire manufacturers, mainly European and Japanese. Among the advantages realized by the surviving companies are increased resources for research and development, and economies of scale across procurement, manufacturing, distribution, and service.

All four of the major tire producers in the U.S. are involved in the production of the synthetic rubber used in tire production, and two of these producers own and operate natural rubber plantations. More than 80 percent of the sales revenue of the four major producers (both foreign and domestic) is derived from tires and related transportation products such as rubber belts and hoses.

III. INDUSTRIAL PROCESS DESCRIPTION

This section describes the major industrial processes within the Rubber and Miscellaneous Plastics industry, including the materials and equipment used, and the processes employed. The section is designed for those interested in gaining a general understanding of the industry, and for those interested in the inter-relationship between the industrial process and the topics described in subsequent sections of this profile -- pollutant outputs, pollution prevention opportunities, and Federal regulations. This section does not attempt to replicate published engineering information that is available for this industry. Refer to Section IX for a list of reference documents that are available.

This section specifically contains a description of commonly used production processes, associated raw materials, the byproducts produced or released, and the materials either recycled or transferred off-site. This discussion, coupled with schematic drawings of the identified processes, provide a concise description of where wastes may be produced in the process. This section also describes the potential fate (air, water, land) of these waste products.

III.A. Industrial Processes in the Rubber and Miscellaneous Plastics Products Industry

The production of plastics products, both solid and foam, is a relatively diverse industry. Simpler processes consist of: (1) imparting the appropriate characteristics to the plastic resin with chemical additives; (2) converting plastic materials in the form of pellets, granules, powders, sheets, fluids or preforms into either intermediate or final formed plastic shapes or parts via molding operations; and (3) finishing the product (see Exhibit 10).

There are also several methods of reacting plastic resin and catalyst materials to form a thermoset plastic material into its final shape. (see Exhibit 11).

Plastic

Additives are often mixed with the plastic materials to give the final product certain characteristics (some of these additives can also be applied to the shaped product during the finishing process). These plastic additives and their functions, in terms of their effect on the final product, are listed below.

- **Additive Lubricants** assist in easing the flow of the plastic in the molding and extruding processes by lubricating the metal surfaces that come into contact with the plastic.
- **Antioxidants** inhibit the oxidation of plastic materials that are exposed to oxygen or air at normal or high temperatures.

- **Antistats** impart a minimal to moderate degree of electrical conductivity to the plastic compound, preventing electrostatic charge accumulation on the finished product.
- **Blowing Agents (foaming agents)** produce a cellular structure within the plastic mass and can include compressed gases that expand upon pressure release, soluble solids that leach out and leave pores, or liquids that change to gases and in the process develop cells.
- **Colorants** impart color to the plastic resin.
- **Flame Retardants** reduce the tendency of the plastic product to burn.
- **Heat Stabilizers** assist in maintaining the chemical and physical properties of the plastic by protecting it from the effects of heat such as color changes, undesirable surface changes, and decreases in electrical and mechanical properties.
- **Impact Modifiers** prevent brittleness and increase the resistance of the plastic to cracking.
- **Organic Peroxides** initiate or control the rate of polymerization in thermosets and many thermoplastics.
- **Plasticizers** increase the plastic product's flexibility and workability.
- **Ultraviolet Stabilizers (UV light absorbers)** absorb or screen out ultra-violet radiation thereby preventing the premature degradation of the plastic product.

Exhibit 10
Plastics Products Manufacturing Process

After adding the necessary additives to the plastic pellets, granules, powders, etc., the plastic mixture is formed into intermediate or final plastics products. A variety of molding processes are used to form solid plastics products. These processes include injection molding, reaction injection molding, extrusion, blow molding, thermoforming, rotational molding, compression molding, transfer molding, casting, encapsulation, and calendering. Foamed plastics products are made using slightly different processes then those used to make solid plastics products. The choice of which plastic forming process to use is influenced by economic considerations, the number and size of finished parts, the adaptability of particular plastic to a process (various plastic will mold, process, etc., differently) and the complexity of the post-forming operations. Below are brief descriptions of the most common molding and forming processes for creating solid plastics products.

Injection Molding: In the injection molding process, plastic granules or pellets are heated and homogenized in a cylinder until they are fluid enough to be injected (by pressure) into a relatively cold mold where the plastic takes the shape of the mold as it solidifies. Advantages of this process include speed of production, minimal post-molding requirements, and simultaneous multi-part molding. The reciprocating screw injection machine is the dominate technology used in injection molding. The screw acts as both a material plasticizer and an injection ram. The buildup of viscous plastic at the nozzle end of a cylinder forces the screw backwards as it rotates. When an appropriate charge is accumulated, rotation stops and the screw moves forward, thereby becoming an injection ram, forcing the melt (liquefied plastic) into the mold. The screw remains forward until the melt solidifies and then returns to repeat the cycle (see Exhibit 11).

Exhibit 11
Injection Molding

Source: McGraw-Hill Encyclopedia of Science and Technology.

Reaction Injection Molding: In the reaction injection molding process, two liquid plastic components, polyols and isocyanates, are mixed at relatively low temperatures (75 - 140 degrees F) in a chamber and then injected into a closed mold. Reaction Injection Molding requires far less energy than other injection molding systems because an exothermic reaction occurs when the two liquids are mixed. Reaction injection molding is a relatively new processing method that is quickly becoming common in the industry.

Extrusion: In the extrusion process, plastic pellets or granules are fluidized, homogenized, and formed continuously as the extrusion machine feeds them through a die (see Exhibit 12). The result is a very long plastic shape such as a tube, pipe, sheet, or coated wire. Extruding is often combined with post extruding processes such as blowing, thermoforming, or punching. Extrusion molding has an extremely high rate of output, for example, pipe can be formed at a rate of 2000 lb/hr (900 kg/hr).

Exhibit 12
Extrusion
Source: McGraw-Hill Encyclopedia of Science and Technology.

Blow Molding: Blow molding describes any forming process in which air is used to stretch and form plastic materials. In one method of blow molding, a tube is formed (usually by extrusion molding) and then made into a free-blown hollow object by injecting air or gas into the tube. Blow molding can also consist of putting a thermoplastic material in the rough shape of the desired finished product into a mold and then blowing air into the plastic until it takes the shape of the mold, similar to blowing up a balloon.

Thermoforming: In the thermoforming process heat and pressure are applied to plastic sheets which are then placed over molds and formed into various shapes. The pressure can be in the form of air, compression, or a vacuum (see Exhibit 13). This process is popular because compression is relatively inexpensive.

Exhibit 13
Thermoforming

*Source: **McGraw-Hill Encyclopedia of Science and Technology**.*

Rotational Molding: In the rotational molding process, finely ground plastic powders are heated in a rotating mold to the point of either melting and/or fusion. The inner surface of the rotating mold is then evenly coated by the melted resin. The final product is hollow and produced scrap free.

Compression and Transfer Molding: In the compression molding process, plastic powder or a preformed plastic part is plugged into a mold cavity and compressed with pressure and heat until it takes the shape of the cavity. Transfer molding is similar, except that the plastic is liquefied in one chamber and then injected into a closed mold cavity by means of a hydraulically operated plunger (see Exhibit 14). Transfer molding was developed to facilitate the molding of intricate plastics products which contain small deep holes or metal inserts because compression molding often ruins the position of the pins which form the holes and the metal inserts.

Exhibit 14
Transfer Molding

Source: McGraw-Hill Encyclopedia of Science and Technology.

Casting and Encapsulation: In the casting process, liquid plastic is poured into a mold until it hardens and takes the shape of the mold. In the encapsulation or potting process, an object is encased in plastic and then hardened by fusion or a chemical reaction (see Exhibit 15).

Calendering: In the calendering process, plastic parts are squeezed between two rolls to form a thin, continuous film.

The manufacture of foamed plastics products involves slightly different forming processes than those described above. The three types of foam plastic are blown, syntactic, and structural. Blown foam is an expanded matrix, similar to a natural sponge; syntactic foam is the encapsulation of hollow organic or inorganic micro spheres in the plastic matrix; and structural foam is a foamed core surrounded by a solid outer skin. All three types of foam plastic can be produced using processes such as injection, extrusion, and compression molding to create foam products in many of the same shapes as solid plastics products. The difference is that creating foam products requires processes such as the addition of chemical blowing agents, different mixing processes which add air to the plastic matrix, or a unique injection molding process used to make structural plastic.

Exhibit 15
Encapsulation

Source: McGraw-Hill Encyclopedia of Science and Technology.

The following are some basic processes which occur in conjunction with the standard molding and forming operations to produce blown foam plastic and syntactic foam plastic:

- A chemical blowing agent that generates gas through thermal decomposition is incorporated into the polymer melt;
- Gas which is under pressure is injected into the melt and then expands during pressure relief;
- A low-boiling liquid (e.g., HCFC's or hydrocarbons) is incorporated into the plastic compound and volatilized through the exothermic heat of reaction;
- Non-chemical gas-liberating agents (adsorbed gas on finely divided carbon) are added to the resin mix and released during heating;
- Air is dispersed by mechanical means within the polymer (similar to whipping cream); or
- The external application of heat causes the expansion of small beads of thermoplastic resin containing a blowing agent.

Structural foam plastic is made by injection molding liquid resins that contain chemical blowing agents. Less mixture is injected into the mold than is needed to mold a solid plastic part. At first the injection pressure is very high, causing the blowing agent mixture to solidify against the mold without undergoing expansion. As the outer skin is formed, the pressure is reduced and the remaining resin expands to fill the remainder of the mold. Structural foam plastic parts have a high strength-to-weight ratio and often have three to four times greater rigidity than solid plastic molded parts of equal weight that are made of the same material.

After the solid or foam plastic shape is created, post forming operations such as welding, adhesive bonding, machining, applying of additives, and surface decorating (painting and metalizing) are employed to finish the product.

To produce a thermoset plastic material, liquid resins are combined with a catalyst. Resins used for thermoset plastic products include urethane resins, epoxy resins, polyester resins, and acrylic resins. Fillers are often added to the resin-catalyst mixture prior to molding to increase product strength and performance and to reduce cost. Most thermoset plastic products contain large amounts of fillers (up to 70% by weight). Commonly used fillers include mineral fibers, clay, glass fibers, wood fibers, and carbon black. After the thermoset material is created, a final or intermediate product can be molded.

Various molding options may be employed to create the intermediate or final thermoset product. These processes include vacuum molding, press molding, rotational molding, hand lamination, casting and encapsulation, spray-up lamination, resin transfer molding, filament winding, injection molding; reaction injection molding, and pultrusion.

Rubber

Rubber product manufacture is as diverse as the number of rubber products produced. Even with this diversity, several basic, common processes are identifiable. This profile will focus on these basic processes: (1) mixing; (2) milling; (3) extruding; (4) calendering;
(5) building; (6) vulcanizing; and (7) finishing (see Exhibit 16).

The rubber product manufacturing process begins with the production of a rubber mix from polymers (i.e., raw and/or synthetic rubber), carbon black (the primary filler used in making a rubber mixture), oils, and miscellaneous chemicals. The miscellaneous chemicals include processing aids, vulcanizing agents, activators, accelerators, age resistors, fillers, softeners, and specialty materials. The following is a list of these miscellaneous chemicals and the functions they perform:

- **Processing Aids** modify the rubber during the mixing or processing steps, or aid in a specific manner during the extrusion, calendering, or molding operations.
- **Vulcanizing Agents** create cross links between polymer chains.
- **Activators**, in combination with vulcanizing agents, reduce the curing time by increasing the rate of vulcanization.
- **Accelerators** form chemical complexes with activators and thus aid in obtaining the maximum benefits from the acceleration system by increasing vulcanization rates and improving the final product's properties.
- **Age Resistors** slow down the deterioration of the rubber products that occurs through reactions with materials that may cause rubber failure (i.e., oxygen, ozone, light, heat, radiation, etc.).
- **Fillers** reinforce or modify the physical properties of the rubber, impart certain processing properties, and reduce costs by decreasing the quantity of more expensive materials needed for the rubber matrix.

Exhibit 16
Rubber Manufacturing Process

- **Softeners** either aid in mixing, promote greater elasticity, produce tack, or extend (replace) a portion of the rubber hydrocarbon (without a loss in physical properties).

- **Specialty Materials** include retarders, colorants, blowing agents, dusting agents, odorants, etc. Specialty materials are used for specific purposes, and are not required in the majority of rubber compounds.

Rubber mixes differ depending upon the desired characteristics of the product being manufactured. Production of the rubber mixture involves weighing and loading the appropriate ingredients into an internal mixer known as a "Banbury" mixer which is used to combine these ingredients. The area where the chemicals are weighed and added to the banbury is called the compounding area. The polymers and miscellaneous chemicals are manually introduced into the mixer hopper, while carbon black and oils are often injected directly into the mixing chamber from bulk storage systems. The mixer creates a homogeneous mass of rubber using two rotors which shear materials against the walls of the machine's body. This mechanical action also adds considerable heat to the rubber.

The mixed rubber mass is discharged to a mill or other piece of equipment which forms it into a long strip or sheet. The hot, tacky rubber then passes through a water-based "anti-tack" solution which prevents the rubber sheets from sticking together as they cool to ambient temperature. The rubber sheets are placed directly onto a long conveyor belt which, through the application of cool air or cool water, lowers the temperature of the rubber sheets. The process of rubber mixing includes all of these steps - Banbury mixing, milling (or other means of sheeting), anti-tack coating, and cooling.

After cooling, the sheets of rubber are sent through another mill. These mills are used to "warm up" the rubber for further processing on extruders and calenders. Some extruders can be "cold fed" rubber sheets, making this milling step unnecessary.

Extruders transform the rubber into various shapes or profiles by forcing it through dies via a rotating screw. Extruding heats the rubber and the rubber remains hot until it enters a water bath or spray conveyor where cooling takes place. Calenders receive hot strips of rubber from mills and squeeze them into reinforcing fibers or cloth-like fiber matrices, thus forming thin sheets of rubber coated materials. Calenders are also used to produce non-reinforced, thickness controlled sheets of rubber.

Extruded and calendered rubber components are combined (layered, built-up) with wire, polyester, aramid, and other reinforcing materials to produce various rubber products. Adhesives, called cements, are sometimes used to enhance the bonding of the various product layers. This assembling, reinforcing, pre-curing, and bonding process is referred to as building.

All rubber products undergo vulcanization (curing). Vulcanization is accomplished in heated compression molds, steam heated pressure vessels (autoclaves), hot air and microwave ovens, or various molten and fluidized bed units. During the curing process, the polymer chains in the rubber matrix cross-link to form a final product of durable, elastic, thermoset rubber. Increasing the number of cross-links in the rubber matrix gives rubber its elastic quality. One way to visualize this is to think of a bundle of wiggling snakes in constant motion. If the bundle is pulled at both ends and the snakes are not entangled, then the bundle comes apart. The more entangled the snakes are (like the rubber matrix after vulcanization), the greater the tendency for them to bounce back to their original shape.

Finishing operations may include grinding, printing, washing, wiping, and buffing.

As initially indicated, due to the diversity of products and facilities, not all of the processes shown in Exhibit 16 are necessary for every product. For example, many plants do not mix rubber but purchase uncured rubber from other facilities.

Exhibit 17 illustrates the processes used to manufacture the following rubber products:

Belts - A typical belt plant will not have an extruder but will use many layers of calendered material assembled on a lathe type builder to produce a rubber cylinder from which individual belts can be cut.

Hoses - A hose plant will use an extruder to produce a tube which is reinforced with cord or wire and covered with a layer of rubber applied by an extruder. The same extruder may be used to produce the initial tube and then to extrude the final "cover" layer onto the reinforced tube.

Molded Products - A molded products plant will use extruded material to feed compression molds, or may cut strips directly from the mixing process to feed the molds.

Roofing - Roofing manufacturers will process rubber through mills and calenders to produce the necessary sheeting.

Exhibit 17
Processes Used to Manufacture Various Rubber Products

Sealing - Sealing, gasket like materials, will use extrusion and continuous vulcanization in hot air ovens.

Tires

The tire manufacturing process is similar to that of other rubber products. The main difference between the rubber product manufacturing process and the tire manufacturing process is that the building process is generally more complex because there are many rubber components.

The tire production process in its most basic form consists of: (1) compounding and mixing elastomers, carbon blacks, pigments, and other chemicals such as vulcanizing agents, accelerators, plasticizers, and initiators; (2) extruding the rubber mixture between pairs of large rollers to prepare it for the feed mill, where it is slit into strips to take the shape of the tread and sidewall materials; (3) processing fabrics and coating them with rubber in a calendering operation; (4) processing bead wires and coating them with rubber in an extruding process; (5) cutting and cooling the various extruded and calendered outputs; (6) assembling all of the components (bead wires, coated fabrics, treads, etc.) on a tire-building machine; (7) lubricating the green tire (green tire spraying) (8) vulcanizing and molding the tire with heat and pressure; and (9) finishing the product (see Exhibit 18).

The main component of tire-building is the drum which is a collapsible cylinder shaped like a wide drum that can be turned and controlled by the tire builder. The building process begins when carcass plies, also known as rubberized fabric, are placed on a drum one at a time, after which the cemented beads (rubber coated wires) are added and the plies are turned up around them. Narrow strips of fabric are then cemented on for additional strength. At this stage the belts, tread, and sidewall rubber are wrapped around the drum over the fabric. The drum is then collapsed and the uncured (green) tire is coated with a lubricant (green tire spray) and loaded into an automatic tire press to be molded and cured. Prior to curing, the tire looks like a barrel that is open at both ends. The curing process converts the rubber, fabric, and wires into a tough, highly elastic product while also bonding the various parts of the tire into one single unit (see Exhibit 19). After curing, the tire is cooled by mounting it on a rim and deflating it to reduce internal stress. Finishing the tire involves trimming, buffing, balancing, and quality control inspection.

Exhibit 18
Tire Manufacturing Process

Exhibit 19
Tire Formation

Source: "Tire Materials and Construction" in Automotive Engineering, October, 1992.

III.B. Raw Material Inputs and Pollution Outputs in the Production Line

Plastic

There are four general types of pollution and resource material outputs that can occur at one or more stages of the plastics product manufacturing process. In addition, there are some plastics products disposal concerns. Manufacturing outputs include spills, leaks, and fugitive emissions of chemicals during the application of additives prior to molding or during finishing; waste water discharges during cooling and heating, cleaning, and finishing operations; plastic pellet releases to the environment prior to molding; and fugitive emissions from molding and extruding machines (see Exhibit 20). Each of these is discussed below.

Chemicals

One concern during the plastic product manufacturing process is the potential release of the additive chemicals prior to molding and during the finishing process. Releases could be in the form of spills during weighing, mixing, and general handling of the chemicals, in the form of leaks from chemical containers and molding machines, or in the form of fugitive dust emissions from open chemical containers. It should be noted that not all plastic product manufacturers use additives because many purchased pellets already contain the necessary additives, making this pollution output irrelevant for many facilities. The chemicals used in the plastic product manufacturing process are usually added in such small amounts that most manufacturers do not consider them to be a problem; however, some of the additives could be toxic and therefore even small amounts could present significant problems. According to a National Enforcement Investigations Center (NEIC) inspector, the plastic industry is currently looking into the characteristics of the additives and their releases for possible environmental or worker safety issues. The following is a list of some of the typical chemicals used as additives in the plastics products manufacturing process:

- **Lubricants** - stearic acid, waxes, fatty acid esters, and fatty acid amines
- **Antioxidants** - alkylated phenols, amines, organic phosphites and phosphates, and esters
- **Antistats** - quaternary ammonium compounds, anionics, and amines

Exhibits 20
Plastics Products Manufacturing Process Pollution Outputs

- **Blowing/foaming agents** - azodicarbonamide, modified azos, OBSH, and HTBA
- **Colorants** - titanium dioxide, iron oxides, anthraquinones, and carbon black
- **Flame Retardants** - antimony trioxide, chlorinated paraffins, and bromophenols
- **Heat Stabilizers** - lead, barium-cadmium, tin, and calcium-zinc
- **Organic Peroxides** - MEK peroxide, benzoyl peroxide, alkyl peroxide, and peresters
- **Plasticizers** - adipates, azelates, trimellitates, and DOP/DIOP/ DIDP
- **Ultraviolet Stabilizers** (UV light absorbers) - benzophenones, benzotriazole, and salicylates.

Waste Water

Contaminated waste water is another concern in the plastic product industry. EPA estimates that of the 10,260 plastic molding and forming plants in the U.S. (this figure includes establishments with less than 20 employees), 1,898 plants have 2,587 processes that use water (i.e., they are wet). The 1,898 wet plants have an estimated 810 wet processes with direct discharge, 1,145 processes with indirect discharge, and 632 wet processes with no discharge.

Water used in the plastic molding and forming processes falls into three main categories: (1) water to cool or heat the plastics products; (2) water to clean the surface of both the plastics products and the equipment used in production; (3) and water to finish the plastics products.

Cooling and heating water usually comes into contact with raw materials or plastics products during molding and forming operations for the purpose of heat transfer. The only pollutant found in some waste water discharged by contact cooling and heating in a treatable concentration is bis(2-ethylhexyl) phthalate (BEHP) and it is toxic. Many facilities do not process materials containing BEHP making this pollutant output irrelevant for many manufactures.

Cleaning water includes water that is used to clean the surface of the plastic product or the molding equipment that is or has been in contact with the formed plastic product. The types of pollutants found in cleaning water in treatable concentrations are biochemical oxygen demand (BOD5), oil and grease, total suspended solids (TSS), chemical oxygen demand (COD), total organic carbon (TOC), total phenols, phenol, and zinc.

Finishing water consists of water used to carry away waste plastic material or to lubricate the product during the finishing operation. TSS, bis(2-ethylhexyl) phthalate, di-n-butyl phthalate, and dimethyl phthalate are the pollutants identified in finishing water in treatable concentrations.

Of the pollutants found in all three types of process water, BOD5, oil and grease, TSS, and pH are considered conventional pollutants, TOC and COD are considered non-conventional pollutants, and bis (2-ethylhexyl) phthalate, di-n-butyl phthalate, dimethyl phthalate, phenol, and zinc are considered priority toxic pollutants.

Pellet Release

The third concern in the plastic product manufacturing industry is the release of plastic pellets into the environment. Plastic pellets and granules used to mold intermediate and final plastics products are often lost to floor sweepings during transport or while being loaded into molding machines, and may end up in waste water. Although they are inert, plastic pellets are an environmental concern because of the harm they can cause if runoff carries them to wetlands, estuaries, or oceans where they may be ingested by seabirds and other marine species. EPA storm water regulations classify plastic pellets as "significant materials," and therefore the discovery of a single pellet in storm water runoff is subject to Federal regulatory action.

Fugitive Emissions

Fugitive emissions from the molding processes may be an environmental concern because of the many additives, including cadmium and lead, which can be released during the application of high heat and pressure. Trade association officials (i.e., American Plastic Council and the Society of the Plastic Industry), are currently researching the composition of these emissions and their possible effects on worker safety and air quality.

Disposal

Plastics products also pose disposal concerns. Discarded plastics products and packaging make up a growing portion of municipal and solid waste. Because only a small percentage of plastic is recycled (less than one percent), virtually all disposed plastics products are put into landfills or incinerated. By the year 2000, the amount of disposed plastic will increase by 50 percent from present levels. Current estimates show that plastic constitutes 14 to 21 percent of the waste stream by volume and seven percent of the waste stream by weight. Because of its resistance to degradation, improper plastic disposal can have a particularly serious effect in the marine environment in terms of ecological risks and aesthetics.

In terms of landfill disposal, the slow degradation of plastic is not a significant factor in landfill capacity; research has shown that other constituents (e.g., paper, wood, food wastes) also degrade very slowly. However, the additives contained in plastic, such as colorants, stabilizers, and plasticizers, may include toxic constituents such as lead and cadmium which can leach out into the environment as the plastic degrades. Plastic contribute 28 percent of all cadmium found in municipal solid waste and approximately two percent of all lead. Data are too limited to determine whether these and other plastic additives contribute significantly to the leachate produced in municipal solid waste landfills. Plastic that contains heavy metal-based additives may also contribute to the metal content of incinerator ash.

Rubber

In the rubber product manufacturing industry, the primary environmental concerns are fugitive emissions, solid wastes, waste water, and hazardous wastes. Each of these is discussed below.

Fugitive and VOC Emissions

The compounding area, where dry chemicals are weighed and put into containers prior to mixing, can be a source of fugitive emissions, and possibly spills and leaks. Because additives must be pre-weighed, in some facilities the chemicals sit in big open bins on the scales or waiting to get on the scales, thus increasing the potential for significant fugitive dust emissions. Most mixing facilities have eliminated this problem by purchasing their chemicals in small, pre-weighed, sealed polyethylene bags. The sealed bag is put directly into the banbury mixer thus eliminating a formerly dusty operation. If chemicals are not in pre-weighed bags,

Exhibit 21
Rubber Products Manufacturing Process Pollution Outputs

fugitive emissions are also produced as the chemicals are loaded into the mixer. Emissions from the internal mixers are typically controlled by baghouses. Exhausts from the collection hoods are ducted to the baghouses for control of particulate and possibly particle-bound semi-volatiles and metals. The following is a list of the major chemicals used in the rubber compounding and mixing processes which can constitute these fugitive emissions:

- **Processing Aids** - zinc compounds
- **Accelerators** - zinc compounds, ethylene thiourea, and diethanolamie
- **Activators** - nickel compounds, hydroquinone, phenol, alphanaphthylamine, and p-phenylenediamine
- **Age Restorers** - selenium compounds, zinc compounds, and lead compounds
- **Initiator** - benzoyl peroxide
- **Accelerator Activators** - zinc compounds, lead compounds, and ammonia
- **Plasticizers** - dibutyl phthalate, dioctylphthalate, and bis(2-ethylhexyl adipate)
- **Miscellaneous Ingredients** - titanium dioxide, cadmium compounds, organic dyes, and antimony compounds.

VOC emissions are also an environmental concern in the rubber product manufacturing process. A 1994 RMA Emissions Factors study analyzed data on VOC emissions resulting from the mixing, milling, extruding, calendering, vulcanizing, and grinding processes. Although the findings showed extremely low VOC emissions for each pound of rubber process, large facilities processing great quantities of rubber face the potential of significant VOC emissions. For example, a facility must process 100,000 pounds of rubber to produce 10 pounds of VOCs during the mixing process. These emissions may add up, however, at large tire facilities producing 50,000 tires a day. The following are the finalized RMA VOC emissions factors for the various processes:

- **Mixing**: 1×10^{-4} lb VOC/lb rubber mixed (uncontrolled, i.e., before the control device)
- **Milling**: 8×10^{-5} lb VOC/lb rubber processed
- **Extruding**: 1×10^{-5} lb VOC/lb rubber processed

- **Calendering**: 3×10^{-5} lb VOC/lb rubber processed
- **Vulcanizing**: 4×10^{-4} lb VOC/lb rubber processed
- **Grinding (during finishing)**: 6×10^{-3} lb VOC/lb rubber removed (controlled, i.e., after the control device).

The RMA VOC emissions factors have been sent to EPA for review and possible inclusion in AP-42.

Solvent evaporation is another source of VOC emissions. Solvents are used in various capacities during the rubber product manufacturing process. For example, solvents are used to degrease equipment and tools and as a type of adhesive during building. Typically, releases of solvents occur either when the spent solvent solutions are disposed as hazardous wastes or when degreasing solvents are allowed to volatilize. In some facilities, mold release compounds, sprayed onto the cavities of compression molds, produce significant fugitive emissions. Solvents are becoming less of an issue as water, silicon, and non-solvent based release compounds are now common.

Solid Waste

Solid wastes are also an issue at rubber product manufacturing facilities. Surface grinding activities that generate dust and rubber particles are typically controlled by a primary cyclone and a secondary baghouse or electrostatic precipitator. This baghouse-captured particulate matter (chemicals, ground rubber, etc.) from compounding areas, banburys, and grinders is a source of solid waste. Used lubricating, hydraulic, and process oils are also prevalent at most manufacturing facilities.

Scorched rubber from mixing, milling, calendering, and extruding is a major solid waste source within the rubber product manufacturing facilities, as is waste rubber produced during rubber molding operations. Waste rubber can be classified into three categories: (1) uncured rubber waste; (2) cured rubber waste; (3) off-specification products. Currently, much of the uncured rubber waste is recycled at the facility. Cured rubber waste is either recycled at the facility or sold to other companies who use it to make products such as mud flaps and playground mats. Off-specification products can be sold to other companies who make products from shredded or scrap rubber or it can be disposed. These practices are discussed further in the section on pollution prevention.

Waste Water

Waste water from cooling, heating, vulcanizing, and cleaning operations is an environmental concern at many facilities. Contaminants can be added to waste water in direct contact cooling applications such as extruder cooling conveyors and from direct contact steam used in vulcanizing operations. The residual in adhesive dispensing containers and contaminated adhesives can also be sources of contaminated waste water.

Zinc is of particular concern as a constituent of storm water for the facilities involved in manufacturing and processing rubber products. A study by the RMA identified several processes through which zinc might be introduced into storm water. Inadequate housekeeping is considered to be the primary source of zinc. Inefficient, overloaded, or malfunctioning dust collectors and baghouses are another source of zinc. Facilities that grind rubber usually create dust. This dust, composed partially of zinc, can go untreated (no dust collector) and be released into the atmosphere through ventilation fans. The ventilation fans, which are typically located in the ceilings, deposit the dust on the roof where it is exposed to rain and hence to storm water. Some facilities use zinc stearate slurry to prevent sticking between rubber products and have indicated that the slurry frequently drips to the floor and eventually drains to a storm water outlet.

Like plastic products, the leaching potential of rubber products disposed in landfills poses a potential environmental concern. This is a concern for rubber product manufacturing facilities which may have to dispose of scrap rubber that they are unable to sell. The RMA assessed the levels of chemicals, if any, leached from waste rubber products using EPA's June 13, 1986 proposed Toxicity Characterization Leaching Procedure (TCLP). TCLP tests were performed on 16 types of rubber products to assess the leaching potential of over 40 different chemicals which included volatile organics, semi-volatile organics and metals. Results of the TCLP study indicate that none of the rubber products tested, cured or uncured, exceeded proposed TCLP regulatory levels. Most compounds detected were found at trace levels (near method detection limits) from ten to one hundred times less than proposed TCLP regulatory limits. The TCLP regulatory levels adopted after June 13, 1986 were even less stringent than the original proposal.

Tires

The resource material and pollution outputs from the tire manufacturing process include all of the outputs discussed above in the rubber product manufacturing process. There is however an emphasis on the VOC emissions which result from cementing and spraying operations (see Exhibit 22) and on scrap tire disposal.

VOC Emissions

VOC emissions from the rubber tire manufacturing process are caused by solvent application to the different tire components before, during, and after the building process (these VOC emissions can also result from the manufacture of other rubber products that require cementing or gluing). The principal VOC emitting processes affected by NSPS regulations are undertread cementing operations, sidewall cementing operations, tread end cementing operations, bead cementing operations, green tire spraying operations, Michelin-B operations, and Michelin-C automatic operations. Michelin-B and -C operations are confidential and cannot be revealed to the public. They are however known and regulated by EPA. All cementing operations refer to the system used to apply cement to any part of the tire. The green tire spraying operation refers to the system used to apply a mold release agent and lubricant to the inside and/or outside of green tires to facilitate the curing process and to prevent rubber from sticking to the curing press. VOC-emissions also occur in limited amounts from operations where rubber is heated. Such operations include mixing, milling, extruding, calendering, vulcanizing, and grinding.

Scrap Tires

Probably the biggest environmental concern with respect to rubber tires is the disposal of scrap tires. In 1992, it was estimated that the U.S. had approximately two billion scrap tires, with annual additions of 200 to 250 million tires. These tires pose three environmental threats. The first being that tire piles are a fire hazard and burn with an intense heat which gives off dense black smoke. These fires are extremely difficult to extinguish in part because tire casings form natural air pockets that supply the oxygen which feeds the flames. The second threat is that the tires trap rain water which serves as a nesting ground for various insects such as mosquitoes, and in areas where there are scrap tire piles there tend to be severe insect problems. The third and most important environmental threat associated with scrap tires is that discarded tires are bulky, virtually indestructible, and when buried tend to work their way back to the surface as casings compressed by the dirt slowly spring back into shape and "float" the tire upward. This problem has led to either extremely high tipping fees for scrap tires in landfills - at least twice the fee for municipal solid waste - or total bans on whole tires in landfills. As discussed above, the RMA has conducted testing to verify that tires are not hazardous wastes based on TCLP analysis. The many efforts underway to address this problem are discussed in the pollution prevention section of this profile.

Exhibits 22
Tire Manufacturing Process Pollution Outputs

III.C. Management of Chemicals in Wastestream

The Pollution Prevention Act of 1990 (EPA) requires facilities to report information about the management of TRI chemicals in waste and efforts made to eliminate or reduce those quantities. These data have been collected annually in Section 8 of the TRI reporting Form R. beginning with the 1991 reporting year. The data summarized below cover the years 1992-1995 and is meant to provide a basic understanding of the quantities of waste handled by the industry, the methods typically used to manage this waste, and recent trends in these methods. TRI waste management data can be used to assess trends in source reduction within individual industries and facilities, and for specific TRI chemicals. This information could then be used as a tool in identifying opportunities for pollution prevention compliance assistance activities.

While the quantities reported for 1992 and 1993 are estimates of quantities already managed, the quantities reported for 1994 and 1995 are projections only. The EPA requires these projections to encourage facilities to consider future waste generation and source reduction of those quantities as well as movement up the waste management hierarchy. Future-year estimates are not commitments that facilities reporting under TRI are required to meet.

Exhibit 23 shows that the rubber and miscellaneous plastics industry managed about .53 billion pounds of production-related waste (total quantity of TRI chemicals in the waste from routine production operations) in 1993 (column B). Column C reveals that of this production-related waste, 31 percent was either transferred off-site or released to the environment. Column C is calculated by dividing the total TRI transfers and releases by the total quantity of production-related waste. In other words, about 70 percent of the industry's TRI wastes were managed on-site through recycling, energy recovery, or treatment as shown in columns D, E and F, respectively. The majority of waste that is released or transferred off-site can be divided into portions that are recycled off-site, recovered for energy off-site, or treated off-site as shown in columns G, H, and I, respectively. The remaining portion of the production-related wastes (23.8 percent), shown in column J, is either released to the environment through direct discharges to air, land, water, and underground injection, or it is disposed off-site.

From the yearly data presented below it is apparent that the portion of TRI wastes reported as recycled on-site has decreased and the portions treated or managed through energy recovery on-site have increased between 1992 and 1995 (projected).

Exhibit 23
Rubber & Misc. Plastics
Source Reduction and Recycling Activity for SIC 30

A	B	C	D	E	F	G	H	I	J
	Production Related Waste	% Reported as Released	**On-Site**			**Off-Site**			**Remaining Releases**
Year	**Volume (10^6 lbs.)***	and Transferred	% Recycled	% Energy Recovery	% Treated	% Recycled	% Energy Recovery	% Treated	**and Disposal**
1992	543	31%	55.04%	2.97%	11.61%	3.05%	1.63%	0.94%	32.52%
1993	534	31%	55.91%	2.83%	11.00%	3.19%	1.95%	1.26%	23.87%
1994	414	—	44.27%	2.94%	15.49%	5.16%	2.49%	1.74%	27.91%
1995	307	—	27.35%	6.02%	20.92%	5.89%	2.66%	2.34%	34.82%