EPA/310-R-97-009

EPA Office of Compliance Sector Notebook Project:

Profile of the Textile Industry

September 1997

Office of Compliance
Office of Enforcement and Compliance Assurance
U.S. Environmental Protection Agency
401 M St., SW
Washington, DC 20460

This report is one in a series of volumes published by the U.S. Environmental Protection Agency (EPA) to provide information of general interest regarding environmental issues associated with specific industrial sectors. The documents were developed under contract by Abt Associates (Cambridge, MA), Science Applications International Corporation (McLean, VA), and Booz-Allen & Hamilton, Inc. (McLean, VA). This publication may be purchased from the Superintendent of Documents, U.S. Government Printing Office. A listing of available Sector Notebooks and document numbers is included on the following page.

All telephone orders should be directed to:

Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402
(202) 512-1800
FAX (202) 512-2250
8:00 a.m. to 4:30 p.m., EST, M-F

Using the form provided at the end of this document, all mail orders should be directed to:

U.S. Government Printing Office
P.O. Box 371954
Pittsburgh, PA 15250-7954

Complimentary volumes are available to certain groups or subscribers, such as public and academic libraries, Federal, State, and local governments, and the media from EPA's National Center for Environmental Publications and Information at (800) 490-9198. For further information, and for answers to questions pertaining to these documents, please refer to the contact names and numbers provided within this volume.

Electronic versions of all Sector Notebooks are available free of charge at the following web address: **www.epa.gov/oeca/sector**. Direct technical questions to the "Feedback" button at the bottom of the web page.

Cover photograph courtesy of American Textile Manufacturers Institute.

Sector Notebook Contacts

The Sector Notebooks were developed by the EPA's Office of Compliance. Questions relating to the Sector Notebook Project can be directed to:

Seth Heminway, Coordinator, Sector Notebook Project
US EPA Office of Compliance
401 M St., SW (2223-A)
Washington, DC 20460
(202) 564-7017

Questions and comments regarding the individual documents can be directed to the appropriate specialists listed below.

Document Number	Industry	Contact	Phone (202)
EPA/310-R-95-001.	Dry Cleaning Industry	Joyce Chandler	564-7073
EPA/310-R-95-002.	Electronics and Computer Industry*	Steve Hoover	564-7007
EPA/310-R-95-003.	Wood Furniture and Fixtures Industry	Bob Marshall	564-7021
EPA/310-R-95-004.	Inorganic Chemical Industry*	Walter DeRieux	564-7067
EPA/310-R-95-005.	Iron and Steel Industry	Maria Malave	564-7027
EPA/310-R-95-006.	Lumber and Wood Products Industry	Seth Heminway	564-7017
EPA/310-R-95-007.	Fabricated Metal Products Industry*	Scott Throwe	564-7013
EPA/310-R-95-008.	Metal Mining Industry	Jane Engert	564-5021
EPA/310-R-95-009.	Motor Vehicle Assembly Industry	Anthony Raia	564-6045
EPA/310-R-95-010.	Nonferrous Metals Industry	Jane Engert	564-5021
EPA/310-R-95-011.	Non-Fuel, Non-Metal Mining Industry	Rob Lischinsky	564-2628
EPA/310-R-95-012.	Organic Chemical Industry*	Walter DeRieux	564-7067
EPA/310-R-95-013.	Petroleum Refining Industry	Tom Ripp	564-7003
EPA/310-R-95-014.	Printing Industry	Ginger Gotliffe	564-7072
EPA/310-R-95-015.	Pulp and Paper Industry	Seth Heminway	564-7017
EPA/310-R-95-016.	Rubber and Plastic Industry	Maria Malave	564-7027
EPA/310-R-95-017.	Stone, Clay, Glass, and Concrete Industry	Scott Throwe	564-7013
EPA/310-R-95-018.	Transportation Equipment Cleaning Ind.	Virginia Lathrop	564-7057
EPA/310-R-97-001.	Air Transportation Industry	Virginia Lathrop	564-7057
EPA/310-R-97-002.	Ground Transportation Industry	Virginia Lathrop	564-7057
EPA/310-R-97-003.	Water Transportation Industry	Virginia Lathrop	564-7057
EPA/310-R-97-004.	Metal Casting Industry	Jane Engert	564-5021
EPA/310-R-97-005.	Pharmaceuticals Industry	Emily Chow	564-7071
EPA/310-R-97-006.	Plastic Resin and Man-made Fiber Ind.	Sally Sasnett	564-7074
EPA/310-R-97-007.	Fossil Fuel Electric Power Generation Ind.	Rafael Sanchez	564-7028
EPA/310-R-97-008.	Shipbuilding and Repair Industry	Anthony Raia	564-6045
EPA/310-R-97-009.	Textile Industry	Belinda Breidenbach	564-7022
EPA/310-R-97-010.	Sector Notebook Data Refresh-1997	Seth Heminway	564-7017
EPA/310-R-98-001.	Aerospace Industry	Anthony Raia	564-6045
EPA/310-R-98-002.	Agricultural Chemical, Pesticide, and Fertilizer Industry	Amy Porter	564-4149
EPA/310-R-98-003.	Agricultural Crop Production Industry	Ginah Mortensen	(913)551-7864
EPA/310-R-98-004.	Agricultural Livestock Production Ind.	Ginah Mortensen	(913)551-7864
EPA/310-R-98-005.	Oil and Gas Exploration and Production Industry	Dan Chadwick	564-7054
EPA/310-R-98-008.	Local Government Operations	John Dombrowski	564-7036

*Spanish translations available.

Page iv intentionally left blank.

TEXTILE INDUSTRY
(SIC 22)
TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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
NO_x - Nitrogen Oxides
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
SO_x -	Sulfur Oxides
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

I. INTRODUCTION TO THE SECTOR NOTEBOOK PROJECT

I.A. Summary of the Sector Notebook Project

Integrated environmental policies based upon comprehensive analysis of air, water and land pollution are a 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 originally 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 to its current form. 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 Environene World Wide Web for general access to all users of the system. Follow instructions in Appendix A for accessing this system. Once you have logged in, procedures for uploading text are available from the on-line Enviroene Help System.

Adapting Notebooks to Particular Needs

The scope of the industry sector described in this notebook approximates the national occurrence of facility types within the sector. In many instances, industries within specific geographic regions or states may have unique characteristics that are not fully captured in these profiles. 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 already covered, please contact the Office of Compliance at 202-564-2395.

II. INTRODUCTION TO THE TEXTILE INDUSTRY

This section provides background information on the history, size, geographic distribution, employment, production, sales, and economic condition of the textile industry. The facilities described within the document are described in terms of their Standard Industrial Classification (SIC) codes.

II.A. History of the Textile Industry

The textile industry is one of the oldest in the world. The oldest known textiles, which date back to about 5000 B.C., are scraps of linen cloth found in Egyptian caves. The industry was primarily a family and domestic one until the early part of the 1500s when the first factory system was established. It wasn't until the Industrial Revolution in England, in the 18th century, that power machines for spinning and weaving were invented. In 1769 when Richard Arkwright's spinning frame with variable speed rollers was patented, water power replaced manual power (Neefus, 1982).

In the early 17th century of colonial America, textiles were primarily manufactured in New England homes. Flax and wool were the major fibers used, however, cotton, grown primarily on southern plantations, became increasingly important (Wilson, 1979). In 1782 Samuel Slater, who had worked as an apprentice to Arkwright's partner, emigrated to America. In Blackstone River, Rhode Island, he started building Arkwright machines and opened the first English-type cotton mill in America (ATMI, 1997a). In the early nineteenth century, in Lowell, Massachusetts, the first mill in America to use power looms began operations. It was the first time that all textile manufacturing operations had been done under the same roof (Wilson, 1979 and ATMI, 1997a).

The twentieth century has seen the development of the first manmade fibers (rayon was first produced in 1910). Although natural fibers (wool, cotton, silk, and linen) are still used extensively today, they are more expensive and are often mixed with manmade fibers such as polyester, the most widely used synthetic fiber. In addition, segments of the textile industry have become highly automated and computerized (ATMI, 1997a).

The textile industry is characterized by product specialization. Most mills only engage in one process or raw material. For example, a mill may be engaged in either broadloom weaving of cotton or broadloom weaving of wool. Similarly, many mills specialize in either spinning or weaving operations, although larger integrated mills may combine the two operations. These large mills normally do not conduct their own dyeing and finishing operations. Weaving, spinning, and knitting mills usually send out their fabrics to one of the approximately 500 dyeing and finishing plants in the United States (EPA, 1996).

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

Broadly defined, the textile industry consists of establishments engaged in spinning natural and manmade fibers into yarns and threads. These are then converted (by weaving and knitting) into fabrics. Finally, the fabrics and in some cases the yarns and threads used to make them, are dyed and finished.

The manufacturing of textiles is categorized by the Office of Management and Budget (OMB) under Standard Industrial Classification (SIC) code 22. The Standard Industrial Classification system was established by OMB to track the flow of goods and services in the economy, by assigning a numeric code to these good and services. SIC 22 is categorized into nine three-digit SIC codes. Due to the large number of processes used in the textile industry and the limited scope of this notebook, the production of nonwoven synthetic materials and carpets is not discussed in detail. The primary focus of this notebook is on weaving and knitting operations, with a brief mention of processes used to make carpets.

OMB is in the process of changing the SIC code system to a system based on similar production processes called the North American Industrial Classification System (NAICS). In the NAIC system, textile mills (including fiber, yarn and thread mills, fabric mills, and textile and fabric finishing and coating mills) be classified as NAIC 313. Textile product mills (including furnishings, carpets, rugs, curtains, linens, bags, canvas, rope, twine, tire cord and tire fabric) will be classified as NAIC 314.

This notebook covers the textiles industry as defined by SIC 22. Less focus is given to SIC 229, Miscellaneous Textile Goods in the Industrial Process Descriptions Section because the processes used and products manufactured vary substantially within SIC 229. Products categorized under SIC 229 include coated fabrics, not rubberized, tire cord and fabrics, cordage and twine, and textile goods not elsewhere classified. It is important to note, however, that the Miscellaneous Textile Goods category is covered in Section II, Introduction to the Textile Industry; Section IV, Chemical Release and Transfer Profile; Section VIII, Compliance Activities and Initiatives; and other sections of this document. Industry sectors related to the textiles industry, but not categorized under SIC 22 (and thus, not in the scope of this notebook) include the manufacturing of clothing and apparel (SIC 23) and the manufacturing of rubber coated textile goods (SIC 3069).

II.C. Characterization of the Textile Industry

II.C.1. Product Characterization

Within the nine broad categories in the textile industry are 22 four-digit SIC codes which more narrowly define the different types of products made by textile manufacturers. The various SIC codes and their associated products are shown in Table 1.

Table 1: Standard Industrial Classifications within the Textile Industry (SIC 22)

3-digit SIC code	4-digit SIC Code
SIC 221- Broadwoven Fabric Mills, Cotton	SIC 2211 - Broadwoven Fabric Mills, Cotton
SIC 222- Broadwoven Fabric Mills, Manmade Fiber and Silk	SIC 2221 - Broadwoven Fabric Mills, Manmade Fiber and Silk
SIC 223- Broadwoven Fabric Mills, Wool (Including dyeing and finishing)	SIC 2231 - Broadwoven Fabric Mills, Wool (including dyeing and finishing)
SIC 224- Narrow Fabric Mills: Cotton, Wool, Silk, and Manmade Fiber	SIC 2241 - Narrow Fabric Mills: Cotton, Wool, Silk, and Manmade Fiber
SIC 225- Knitting Mills	SIC 2251 - Women's Full-Length and Knee-Length Hosiery, except socks SIC 2252 - Hosiery, not elsewhere classified SIC 2253 - Knit Outwear Mills SIC 2254 - Knit Underwear and Nightwear Mills SIC 2257 - Weft Knit Fabric Mills SIC 2258 - Lace and Warp Knit Fabric Mills SIC 2259 - Knitting Mills, not elsewhere classified
SIC 226- Dyeing and Finishing Textiles, except wool fabrics and knit goods	SIC 2261 - Finishers of Broadwoven Fabrics of Cotton SIC 2262 - Finishers of Broadwoven Fabrics of Manmade Fiber and Silk SIC 2269 - Finishers of Textiles, not elsewhere classified
SIC 227 - Carpets and Rugs	SIC 2273 - Carpets and Rugs
SIC 228- Yarn and Thread Mills	SIC 2281 - Yarn Spinning Mills SIC 2282 - Yarn Texturizing, Throwing, Twisting, and Winding Mills SIC 2284 - Thread Mills
SIC 229- Miscellaneous Textile Goods	SIC 2295 - Coated Fabrics, not rubberized SIC 2296 - Tire Cord and Fabrics SIC 2298 - Cordage and Twine SIC 2299 - Textile Goods, not elsewhere classified

Source: *Standard Industrial Classification Manual*, 1987, Office of Management and Budget, Washington, DC.

Manufacturing establishments within the textile industry are primarily involved in 1) fiber preparation and manufacture of yarn, thread, braids, twine, and cords; 2) manufacture of knit fabrics, broad and narrow woven fabrics, as well as carpets and rugs from yarn (Broad woven fabrics are generally greater than 12 inches in width, whereas narrow woven fabrics are less than 12 inches in width.); 3) dyeing and finishing fibers, yarns, fabrics, and knitted goods; 4) coating, waterproofing and treating fabrics; 5) integrated manufacture of knit apparel and other products from yarn; and 6) manufacture of felt, lace, nonwoven, and other miscellaneous textile products. More detailed information on the industrial processes used to produce the various textile products is provided in Section III.

II.C.2. Industry Size and Geographic Distribution

According to the *1992 Census of Manufacturers* for SIC 22 (the most recent census data available), there were a total of 5,584 establishments in the textile manufacturing industry. A large proportion of these were knitting mills (SIC 225) and yarn and thread mills (SIC 228), as shown in the shaded rows in Table 2. Together these categories accounted for almost 50 percent of the total number of establishments in the industry. They also accounted for the largest portion of the employment and value of shipments in the textile industry. The knitting and yarn and thread mills categories accounted for 46 percent of the 614,000 people employed in the industry, and 40 percent of the $70.5 million in value of shipments, in 1992. A summary of these statistics is shown in Table 2.

Table 2: Summary Statistics for the Textile Industry (SIC 22)

Industry SIC Code	Establishments (No.)[1]	Companies (No.)[2]	Employment (000's)	Value of Shipments (millions of dollars)[3]
SIC 221	323	281	55.9	5,814
SIC 222	422	321	87.4	8,793
SIC 223	99	87	13.7	1,612
SIC 224	258	224	16.8	1,314
SIC 225	2,096	1,911	193.3	16,968
SIC 226	481	440	50.8	7,077
SIC 227	447	383	49.4	9,831
SIC 228	598	372	92.2	11,277
SIC 229	1,160	1,071	54.5	7,829
Totals	5,584	5,090	614	70,518

Source: adapted from various 1992 *Census of Manufactures, Industry Series,* for SICs 2211 - 2299, U.S. Department of Commerce, Bureau of the Census, 1995.

Note: The shaded rows highlight the SIC codes which contain the largest number of establishments, employment, and value of shipments.

[1] An establishment is a physical location where manufacturing takes place. Manufacturing is defined as the mechanical or chemical transformation of substances or materials into new products.

[2] Defined as a business organization consisting of one establishment or more under common ownership or control.

[3] Value of all products and services sold by establishments in the industry sector.

Most textile mills are small, specialized facilities. A large percentage of establishments in the industry have fewer than 20 employees, as shown in the shaded column. The exceptions include yarn and thread mills (SIC 228) and manmade fiber and silk broadwoven fabric mills (SIC 222), which have 100 employees or more per establishment. Some of the larger 'integrated' mills may employ anywhere from hundreds to thousands of people. A summary of these statistics is shown in Table 3.

Table 3: Summary of Establishment Sizes within the Textile Industry (SIC 22)

Industry SIC Code	Percentage of Establishments[1] with 0-19 Employees	Percentage of Establishments with 20-49 Employees	Percentage of Establishments with 50-99 Employees	Percentage of Establishments with 100 or More Employees
SIC 221	64	4	4	28
SIC 222	40	8	6	46
SIC 223	45	22	9	23
SIC 224	49	14	14	22
SIC 225	44	21	14	21
SIC 226	32	22	15	31
SIC 227	53	12	9	26
SIC 228	24	11	13	52
SIC 229	58	18	11	12

Source: adapted from various 1992 *Census of Manufactures, Industry Series*, for SICs 2211 - 2299, U.S. Department of Commerce, Bureau of the Census, 1995.

Note: The shaded column highlights the large percentage of facilities that have fewer than 20 employees.
[1] An establishment is a physical location where manufacturing takes place. Manufacturing is defined as the mechanical or chemical transformation of substances or materials into new products.

The ten largest textile companies (in terms of sales) in the U.S. are listed in Table 4. The data shown is taken from the *Fairchild's Textile & Apparel Financial Directory*, 1996, which compiles financial data on U.S. textile companies. *Fairchild's* ranks each U.S. company by sales volume. Readers should note that (1) each company was assigned a 3- or 4-digit SIC code that most closely resembles the firm's principal industry using *Ward's Business Directory of U.S. Private and Public Companies*; and (2) sales figures include those of subsidiaries and operations (even those not related to textiles industry). Additional sources of company-specific financial information include Standard and Poor's *Stock Report Services*, Dun and Bradstreet's *Million Dollar Directory*, Moody's Manuals, and the companies' annual reports. In compiling Table 4, the top companies for the 3-digit SIC code categories in the textile industry were identified.

Table 4: Top U.S. Companies in the Textile Industry (SIC 22) and Corresponding Sector

Rank[a]	Company	1995 Sales (millions of dollars)	3-digit SIC code
1	Springs Industries, Fort Mill, SC	$2,233	221
2	Burlington Industries, Greensboro, NC	$2,209	223
3	WestPoint Stevens, West Point, GA	$1,650	221
4	Unifi, Greensboro, NC	$1,555	228
5	Dominion Textile, New York, NY	$1,429	221
6	Collins & Aikman Corp., Farmville, NC	$1,291	221
7	Triarc, New York, NY	$1,128	221
8	Fieldcrest Cannon, New York, NY	$1,095	221
9	Cone Mills, Greensboro, NC	$910	221
10	Guilford Mills, Greensboro, NC	$783	225

Source: This chart has been adapted from data in *Fairchild's Textile & Apparel Financial Directory*, 1996, with assistance from ATMI.

The geographic distribution of the textile industry in the U.S. is largely governed by its history in this country. The industry began in New England and moved to the South as cotton became the primary source of fibers. The five major states for employment in the textile industry are North Carolina, Georgia, South Carolina, Alabama, and Virginia. Though the majority of mills are located in the South, northern states such as Maine, Massachusetts, New York, New Jersey, Rhode Island, and Pennsylvania are still important to the textile industry. Many finishing and dyeing (SIC 226) operations are located in New Jersey. Narrow fabrics and manmade fiber mills (SIC 224) are more concentrated in Rhode Island and Pennsylvania. Knitting mills (SIC 225) and miscellaneous textile mills (SIC 229) are scattered through several southern and northern states. The leading states in terms of employment for the textile industry are shown by SIC code in Table 5.

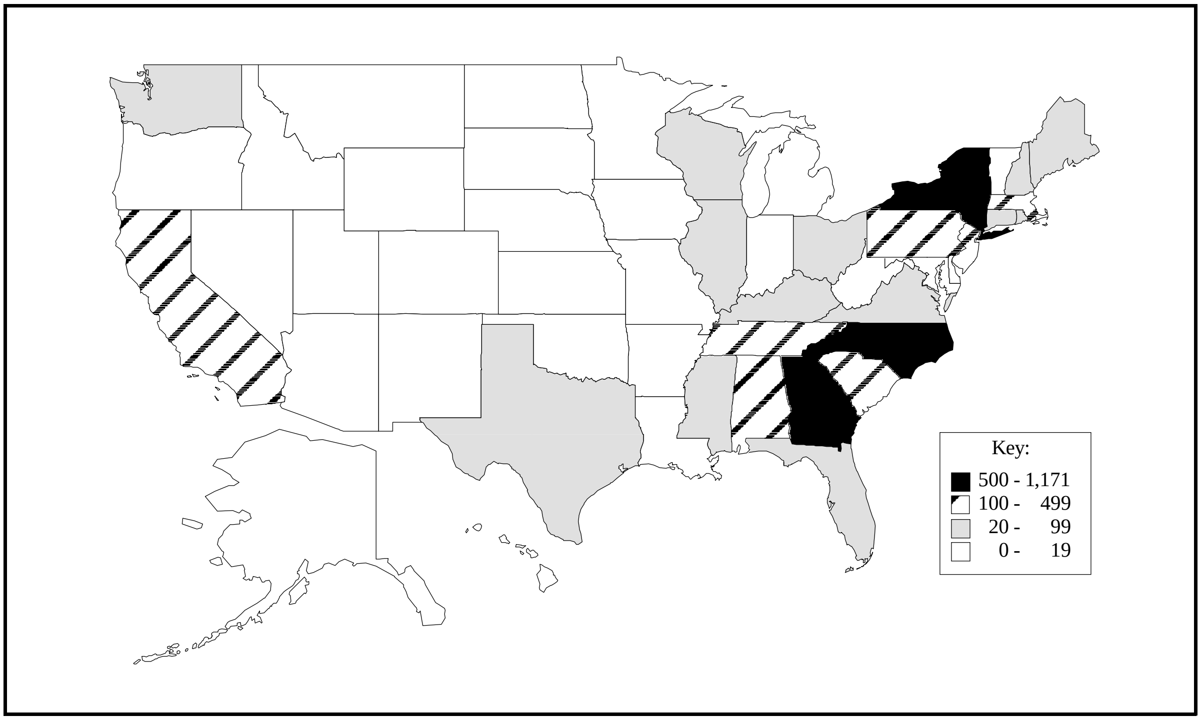
A map showing the number of textile establishments (based on census data) in each state follows the table (Figure 1).

Table 5: Geographic Distribution of Textile Mills in the United States

3-digit SIC code	Major states (based on employment)	approximate % of employment in 3-digit SIC code category, attributable to major states
SIC 221	NC, SC, GA, AL	87
SIC 222	SC, NC, GA, VA	79
SIC 223	VA, GA, ME, NC	69
SIC 224	NC, PA, RI, SC	52
SIC 225	NC, KY, LA, NY, GA, PA, TX, NJ	40
SIC 226	NC, SC, GA, NJ	63
SIC 227	GA	64
SIC 228	NC, GA, SC	70
SIC 229	NC, SC, GA, AL, TN, MA, OH, NY	40

Source: adapted from various 1992 *Census of Manufactures, Industry Series,* for SICs 2211 - 2299, U.S. Department of Commerce, Bureau of the Census, 1995.

Figure 1: Distribution of Textile Establishments in the U.S.



Source: 1992 *Census of Manufactures, Industry Series,* for SICs 2211 - 2299, U.S. Department of Commerce, Bureau of the Census, 1995.

II.C.3. Economic Trends

Throughout the 1990s, the textile industry indicators have shown improvements. The year 1994 was a peak year for all indicators including exports, capital expenditures, employment, and mill fiber consumption. In 1994, mill fiber consumption set a record with a 6 percent increase to 16.1 billion pounds. In 1995, fiber consumption decreased by 1.7 percent only to increase by 1 percent in 1996 (ATMI, 1997b). Both 1994 and 1996 were record years for fiber consumption and were a substantial improvement over the recession years in the early part of the decade. The industry has also experienced a shift towards increasing international trade with countries such as Canada and Mexico (ATMI, 1996).

Domestic Economy

"The textile industry spends four to six percent of sales on capital expansion and modernization, down from eight to ten percent during the expansionary phase of the 1960s and 1970s. Most recent capital expenditure has paid for mill modernization and factory automation" (EPA, 1996). According to the American Textile Manufacturers Institute (ATMI), the largest trade association for the industry, capital expenditures by domestic textile companies have increased in recent years reaching $2.9 billion in 1995 (ATMI, 1997b). The increase in capital expenditures has led to an increase in productivity. Between 1975 and 1995, loom productivity, measured in square yards of fabric per loom, increased by 267 percent and was up 10.5 percent in 1996 (ATMI, 1997b). In the same period, productivity of broadwoven fabric mills, measured by an index of output per production employee hour, increased by 105 percent, and productivity of yarn spinning mills increased by 88 percent (ATMI, 1996). Industry also reports spending more than $25 million each year on pollution and safety controls.

"Economies of scale in textile manufacturing are significant and limit entry into the market. The cost of a new fiber plant, for example, is approximately $100 million. Costs of raw materials are frequently volatile and typically account for 50 to 60 percent of the cost of the finished product. To hedge against supply shocks and to secure supply, many producers are vertically integrated backward into chemical intermediates (and in the case of companies such as Phillips and Amoco, all the way to crude oil). Forward integration into apparel and product manufacture (e.g. carpeting) also is not uncommon." (US EPA, 1996).

International Trade

Over the past five years, the textile industry has been increasingly influenced by international trade. In particular, with the signing of the North American Free Trade Agreement (NAFTA) in 1994, trade with Canada and Mexico has increased significantly. In 1996, 42 percent of U.S. textile exports were to Canada and Mexico alone. Canada, Mexico, and the Caribbean Basin Initiative (CBI) countries accounted for 50 percent of the total textile exports in 1996.

In 1996, U.S. exports increased by 8.6 percent over the previous year to $7.8 billion. The major export markets for the U.S. textile industry were, in order of decreasing export volumes, Canada, Mexico, United Kingdom, Japan, Hong Kong, Dominican Republic, Germany, Belgium, Saudi Arabia, and South Korea. Between 1995 and 1996, exports to all of these markets grew. Exports to Canada increased by 10 percent to $2.1 billion, to the European Union by 2 percent to $1.1 billion, to the Caribbean Basin Initiative (CBI) countries by 13 percent to $622 million, and to Japan by 8 percent to $299 million. Exports to Mexico increased by 28 percent to $1.2 billion (ATMI, 1997b).

Yarn, fabric, and made-ups (excluding apparel) imports into the United States also have been steadily increasing since 1978. In 1995, the major sources of imports into the U.S. were Canada, China, Pakistan, India, Mexico, Taiwan, South Korea, Thailand, Indonesia, and Japan. Although both exports and imports have risen, the textile trade deficit has widened. In 1996, the U.S. textile trade deficit fell to $2.4 billion (ATMI, 1997b).

Page 12 intentionally left blank.

III. INDUSTRIAL PROCESS DESCRIPTION

This section describes the major industrial processes in the textile 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 interrelationship 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. Note also that Section V, Pollution Prevention Opportunities, provides additional information on trade-offs associated with the industrial processes discussed in this section.

This section describes commonly used production processes, associated raw materials, the byproducts produced or released, and the materials either recycled or transferred off-site. This discussion identifies where in each process wastes may be produced. This section concludes with a description of the potential fate (via air, water, and soil pathways) of process-specific waste products.

III.A. Industrial Processes in the Textile Industry

Much of the following section is based upon "*Best Management Practices for Pollution Prevention in the Textile Industry,*" published by the U.S. EPA Office of Research and Development. Additional references are cited in the text.

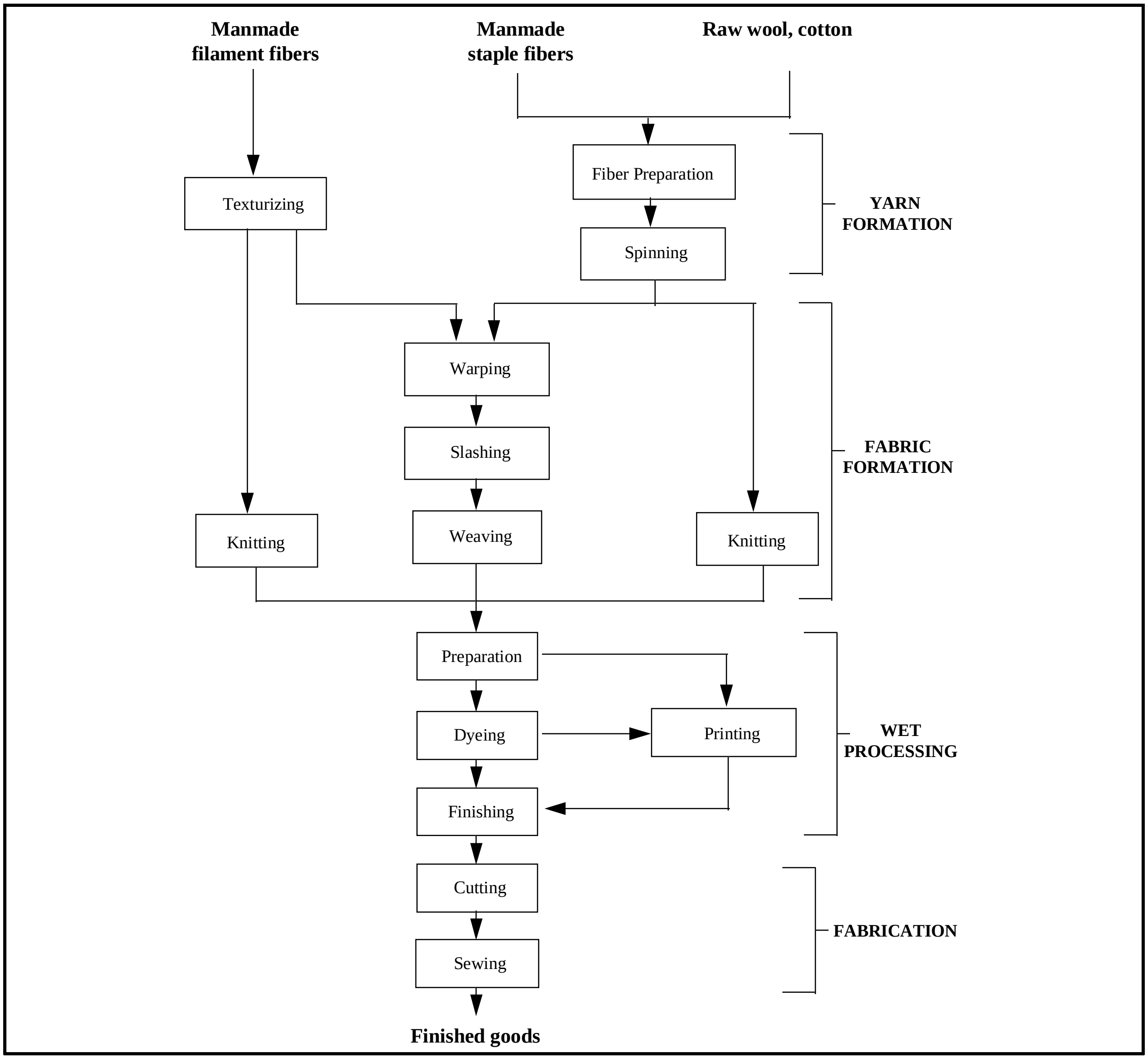
The textile industry is comprised of a diverse, fragmented group of establishments that produce and/or process textile-related products (fiber, yarn, fabric) for further processing into apparel, home furnishings, and industrial goods. Textile establishments receive and prepare fibers; transform fibers into yarn, thread, or webbing; convert the yarn into fabric or related products; and dye and finish these materials at various stages of production. The process of converting raw fibers into finished apparel and nonapparel textile products is complex; thus, most textile mills specialize. Little overlap occurs between knitting and weaving, or among production of manmade, cotton, and wool fabrics. The primary focus of this section is on weaving and knitting operations, with a brief mention of processes used to make carpets.

In its broadest sense, the textile industry includes the production of yarn, fabric, and finished goods. This section focuses on the following four production stages, with a brief discussion of the fabrication of non-apparel goods:

1) yarn formation
2) fabric formation
3) wet processing
4) fabrication

These stages are highlighted in the process flow chart shown in Figure 2 and are discussed in more detail in the following sections.

Figure 2: Typical Textile Processing Flow Chart

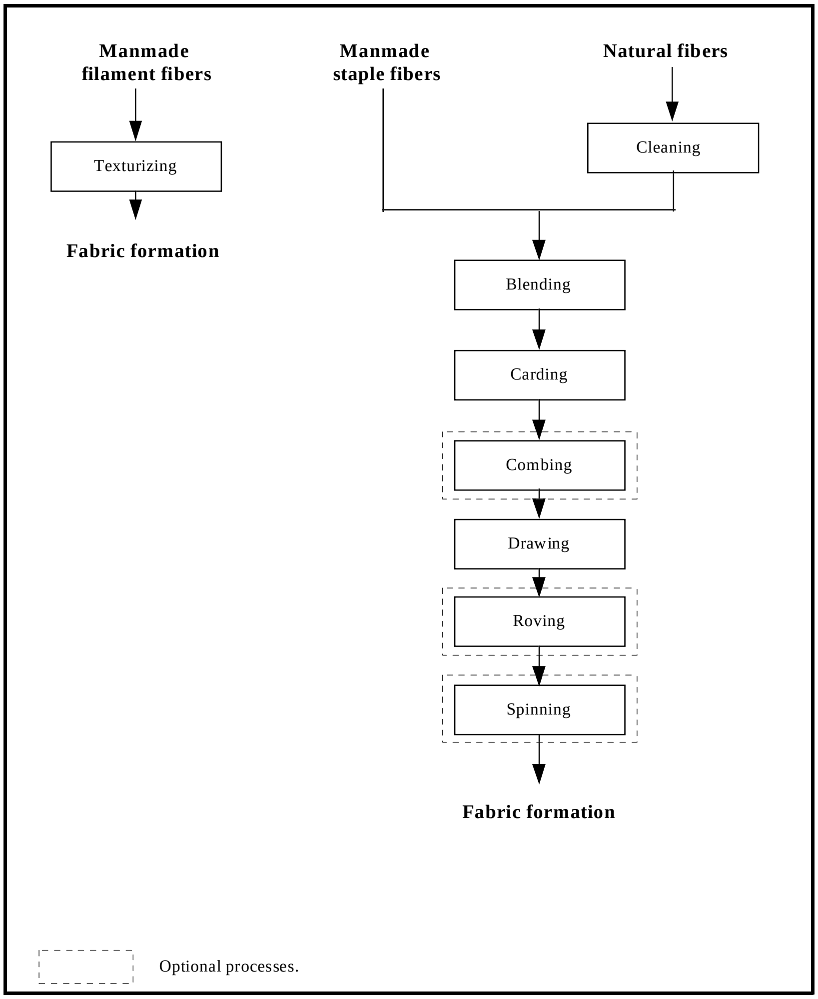


Source: ATMI, Comments on draft of this document, 1997b.

III.A.1. Yarn Formation

Textile fibers are converted into yarn by grouping and twisting operations used to bind them together. Although most textile fibers are processed using spinning operations, the processes leading to spinning vary depending on whether the fibers are natural or manmade. Figure 3 shows the different steps used to form yarn. Note that some of these steps may be optional depending on the type of yarn and spinning equipment used. Natural fibers, known as staple when harvested, include animal and plant fibers, such as cotton and wool. These fibers must go through a series of preparation steps before they can be spun into yarn, including opening, blending, carding, combing, and drafting.

Figure 3: Yarn Formation Processes



Source: ATMI, 1997.

Manmade fibers may be processed into filament yarn or staple-length fibers (similar in length to natural fibers) so that they can be spun. Filament yarn may be used directly or following further shaping and texturizing. The main steps used for processing natural and manmade fibers into yarn are below.

Natural Fibers

Yarn formation can be performed once textile fibers are uniform and have cohesive surfaces. To achieve this, natural fibers are first cleaned to remove impurities and are then subjected to a series of brushing and drawing steps designed to soften and align the fibers. The following describes the main steps used for processing wool and cotton. Although equipment used for cotton is designed somewhat differently from that used for wool, the machinery operates in essentially the same fashion.

- *Opening/Blending.* Opening of bales sometimes occurs in conjunction with the blending of fibers. Suppliers deliver natural fibers to the spinning mill in compressed bales. The fibers must be sorted based on grade, cleaned to remove particles of dirt, twigs, and leaves, and blended with fibers from different bales to improve the consistency of the fiber mix. Sorting and cleaning is performed in machines known as openers. The opener consists of a rotating cylinder equipped with spiked teeth or a set of toothed bars. These teeth pull the unbaled fibers apart, fluffing them while loosening impurities. Because the feed for the opener comes from multiple bales, the opener blends the fibers as it cleans and opens them.

- *Carding.* Tufts of fiber are conveyed by air stream to a carding machine, which transports the fibers over a belt equipped with wire needles. A series of rotating brushes rests on top of the belt. The different rotation speeds of the belt and the brushes cause the fibers to tease out and align into thin, parallel sheets. Many shorter fibers, which would weaken the yarn, are separated out and removed. A further objective of carding is to better align the fibers to prepare them for spinning. The sheet of carded fibers is removed through a funnel into a loose ropelike strand called a sliver. Opening, blending, and carding are sometimes performed in integrated carders that accept raw fiber and output carded sliver.

- *Combing.* Combing is similar to carding except that the brushes and needles are finer and more closely spaced. Several card slivers are fed to the combing machine and removed as a finer, cleaner, and more aligned comb sliver. In the wool system, combed sliver is used to make worsted yarn, whereas carded sliver is used for woolen yarn. In the cotton system, the term combed cotton applies to the yarn made from combed sliver. Worsted wool and combed cotton yarns are finer (smaller) than yarn that has not been combed because of the higher degree of fiber alignment and further removal of short fibers.

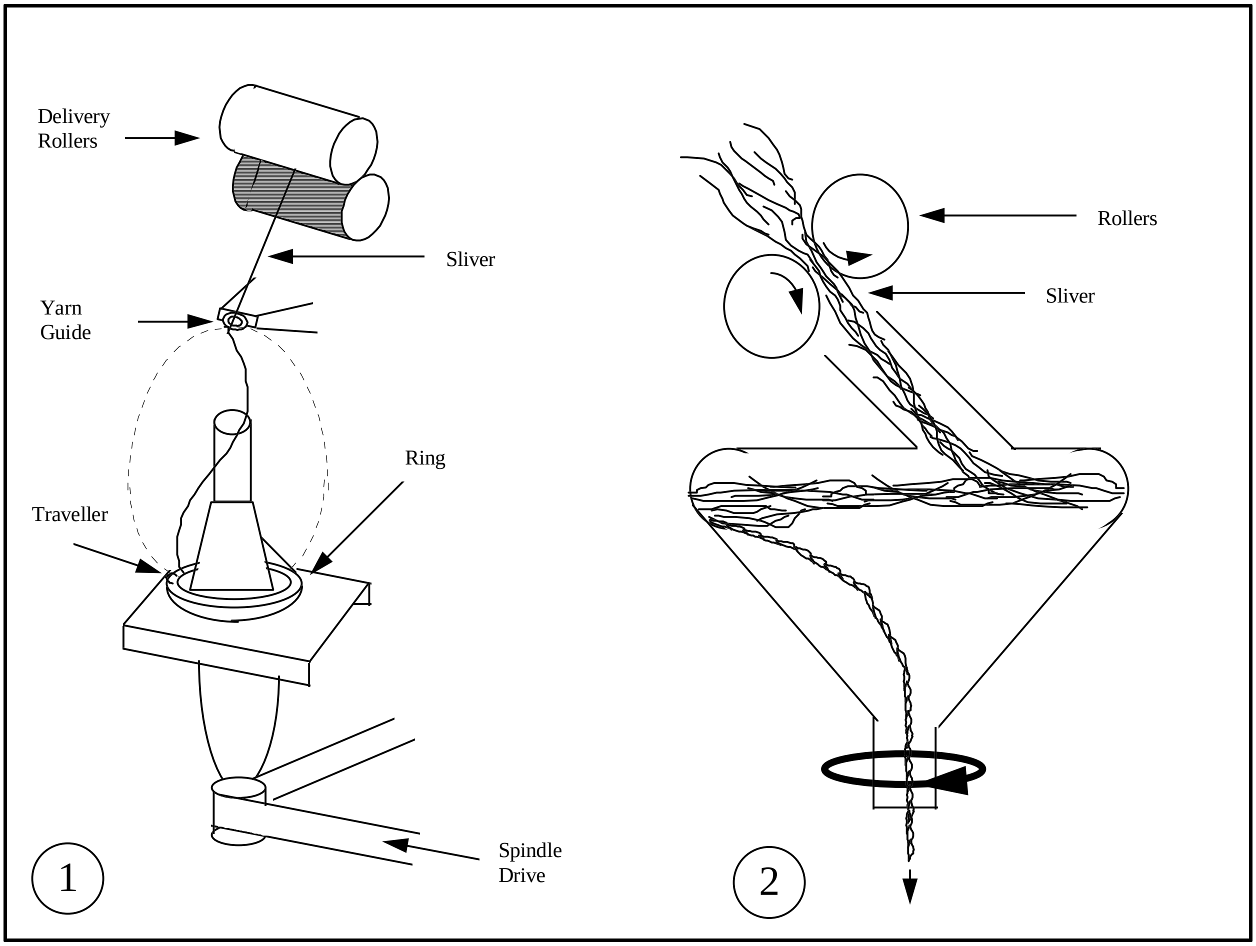
- *Drawing.* Several slivers are combined into a continuous, ropelike strand and fed to a machine known as a drawing frame (Wingate, 1979). The drawing frame contains several sets of rollers that rotate at successively faster speeds. As the slivers pass through, they are further drawn out and lengthened, to the point where they may be five to six times as long as they were originally. During drawing, slivers from different types of fibers (e.g., cotton and polyester) may be combined to form blends. Once a sliver has been drawn, it is termed a roving.

- *Drafting.* Drafting is a process that uses a frame to stretch the yarn further. This process imparts a slight twist as it removes the yarn and winds it onto a rotating spindle. The yarn, now termed a roving in ring spinning operations, is made up of a loose assemblage of fibers drawn into a single strand and is about eight times the length and one-eighth the diameter of the sliver, or approximately as wide as a pencil (Wingate, 1979). Following drafting, the rovings may be blended with other fibers before being processed into woven, knitted, or nonwoven textiles.

- *Spinning.* The fibers are now spun together into either spun yarns or filament yarns. Filament yarns are made from continuous fine strands of manmade fiber (e.g. not staple length fibers). Spun yarns are composed of overlapping staple length fibers that are bound together by twist. Methods used to produce spun yarns, rather than filament yarns, are discussed in this section. The rovings produced in the drafting step are mounted onto the spinning frame, where they are set for spinning. The yarn is first fed through another set of drawing or delivery rollers, which lengthen and stretch it still further. It is then fed onto a high-speed spindle by a yarn guide that travels up and down the spindle. The difference in speed of travel between the guide and the spindle determines the amount of twist imparted to the yarn. The yarn is collected on a bobbin.

  In ring spinning, the sliver is fed from delivery rollers through a traveler, or wire loop, located on a ring. The rotation of the spindle around the ring adds twist to the yarn. This is illustrated in Figure 4(1). Another method, shown in Figure 4(2), is open-end spinning, which accounts for more than 50 percent of spinning equipment used (ATMI, 1997b). In this method, sliver passes through rollers into a rotating funnel-shaped rotor. The sliver hits the inside of the rotor and rebounds to the left side of the rotor, causing the sliver to twist. Open-end spinning does not use rotating spindles since the yarn is twisted during passage through the rotor.

Figure 4: Comparison of Open-End and Ring Spinning Methods



Source: B.P. Corbman, *Textiles: Fiber to Fabric*, McGraw-Hill, Inc., 1975.

Yarn spinning is basically an extension of the preparation steps described above for natural fibers. Additional twisting of the yarn may occur, or multiple yarns may be twisted together to form plied yarns. Plying takes place on a machine similar to a spinning frame. Two or more yarns pass through a pair of rollers and onto a rotating spindle. The yarn guide positions the yarn onto the spindle and assists in applying twist. Plied yarns may be plied again to form thicker cords, ropes, and cables.

Manmade Fibers

Although not classified under SIC 22, manmade fiber production is briefly discussed in the following paragraphs to describe the upstream processing of textiles. Manmade fibers include 1) cellulosic fibers, such as rayon and acetate, which are created by reacting chemicals with wood pulp; and 2) synthetic fibers, such as polyester and nylon, which are synthesized from organic chemicals. Since manmade fibers are synthesized from organic chemicals, yarn formation of manmade fibers does not involve the extensive cleaning and combing procedures associated with natural fibers. Manmade fibers, both synthetic and cellulosic, are manufactured using spinning processes that simulate or resemble the manufacture of silk. Spinning, in terms of manmade fiber production, is the process of forming fibers by forcing a liquid through a small opening beyond which the extruded liquid solidifies to form a continuous filament. Following spinning, the manmade fibers are drawn, or stretched, to align the polymer molecules and strengthen the filament. Manmade filaments may then be texturized or otherwise treated to simulate physical characteristics of spun natural fibers. Texturizing is often used to curl or crimp straight rod-like filament fibers to simulate the appearance, structure, and feel of natural fibers. (For more information on the synthesis of manmade fibers, refer to the EPA Industrial Sector Notebook on Plastic Resins and Manmade Fibers.)

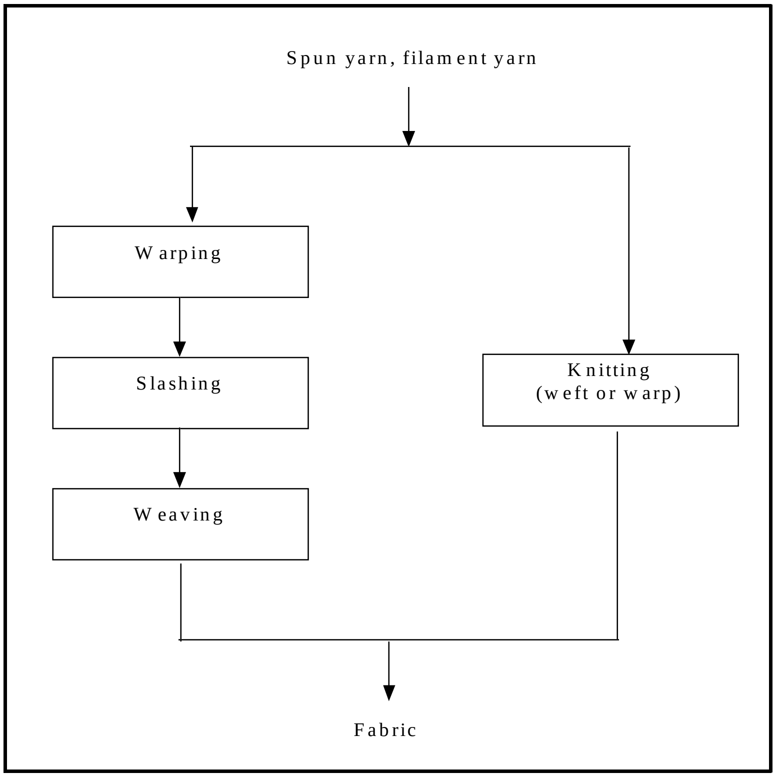
Spun yarns are created using manmade fibers that have been cut into staple-length fibers. Staple-length fibers are then used to process fibers on wool or cotton-system machinery. Methods for making spun yarn from manmade fibers are similar to those used for natural fibers. Some fibers are processed as tow, or bundles of staple fibers.

Fibers can also be produced as filament yarn, which consists of filament strands twisted together slightly. In mills, filament fibers are wound onto bobbins and placed on a twisting machine to make yarn. Filament yarns may be used directly to make fabric or further twisted to the desired consistency. Manmade filaments often require additional drawing and are processed in an integrated drawing/twisting machine. Manmade filaments are typically texturized using mechanical or chemical treatments to impart characteristics similar to those of yarns made from natural fibers.

III.A.2. Fabric Formation

The major methods for fabric manufacture are weaving and knitting. Figure 5 shows fabric formation processes for flat fabrics, such as sheets and apparel. Weaving, or interlacing yarns, is the most common process used to create fabrics. Weaving mills classified as broadwoven mills consume the largest portion of textile fiber and produce the raw textile material from which most textile products are made. Narrow wovens, nonwovens, and rope are also produced primarily for use in industrial applications. Narrow wovens include fabrics less than 12 inches in width, and nonwovens include fabrics bonded by mechanical, chemical, or other means. Knitting is the second most frequently used method of fabric construction. The popularity of knitting has increased in use due to the increased versatility of techniques, the adaptability of manmade fibers, and the growth in consumer demand for wrinkle-resistant, stretchable, snug-fitting fabrics. Manufacturers of knit fabrics also consume a sizable amount of textile fibers. Knit fabrics are generally classified as either weft knit (circular-knit goods) or warp knit (flat-knit goods). Tufting is a process used to make most carpets.

Figure 5: General Fabric Formation Processes Used for Producing Flat Fabrics

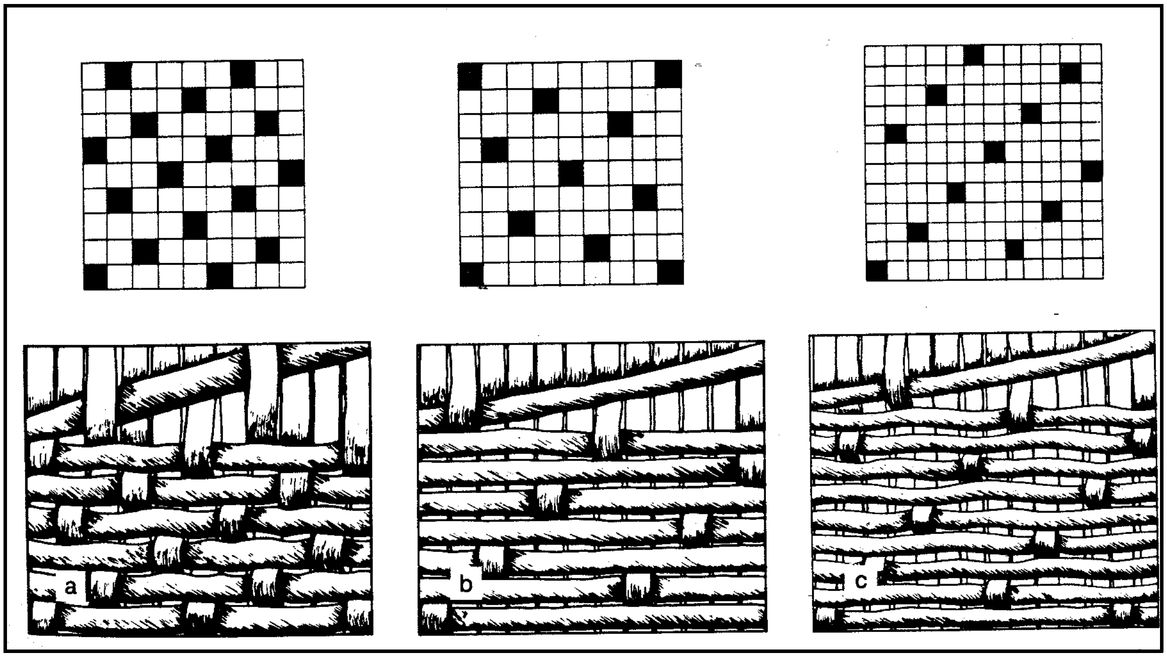


Source: ATMI, 1997.

Weaving

Weaving is performed on modern looms, which contain similar parts and perform similar operations to simple hand-operated looms. Fabrics are formed from weaving by interlacing one set of yarns with another set oriented crosswise. Figure 6 shows an example of satin weave patterns. Satin, plain, and twill weaves are the most commonly used weave patterns. In the weaving operation, the length-wise yarns that form the basic structure of the fabric are called the warp and the crosswise yarns are called the filling, also referred to as the weft. While the filling yarns undergo little strain in the weaving process, warp yarns undergo much strain during weaving and must be processed to prepare them to withstand the strain (Corbman, 1975).

Figure 6: Examples of Satin Weaving Patterns



Source: B.P. Corbman, *Textiles: Fiber to Fabric*, McGraw-Hill, Inc., 1975.

Before weaving, warp yarns are first wound on large spools, or cones, which are placed on a rack called a creel. The warp yarns are then unwound and passed through a size solution (sizing/slashing) before being wound onto a warp beam in a process known as beaming. The size solution forms a coating that protects the yarn against snagging or abrasion during weaving. Slashing, or applying size to the warp yarn, uses pad/dry techniques in a large range called a slasher. The slasher is made up of the following: a yarn creel with very precise tension controls; a yarn guidance system; and a sizing delivery system, which usually involves tank storage and piping to the size vessels. The yarn sheet is dipped one or more times in size solution and dried on hot cans or in an oven. A devise called a "lease" is then used to separate yarns from a solid sheet back into individual ends for weaving (EPA, 1996).

Starch, the most common primary size component, accounts for roughly two-thirds of all size chemicals used in the U.S. (130 million pounds per year). Starch is used primarily on natural fibers and in a blend with synthetic sizes for coating natural and synthetic yarns. Polyvinyl alcohol (PVA), the leading synthetic size, accounts for much of the remaining size consumed in the U.S. (70 million pounds per year). PVA is increasing in use since it can be recycled, unlike starch. PVA is used with polyester/cotton yarns and pure cotton yarns either in a pure form or in blends with natural and other synthetic sizes. Other synthetic sizes contain acrylic and acrylic copolymer components. Semisynthetic sizes, such as carboxymethyl cellulose (CMC) and modified starches, are also used. Oils, waxes, and other additives are often used in conjunction with sizing agents to increase the softness and pliability of the yarns. About 10 to 15 percent of the weight of goods is added as size to cotton warp yarns, compared to about 3 to 5 percent for filament synthetics.

Once size is applied, the wound beam is mounted in a loom. Shuttle looms are rapidly being replaced by shuttleless looms, which have the ability to weave at higher speeds and with less noise. Shuttleless looms are discussed in the next section. The operation of a traditional shuttle loom is discussed in this section to illustrate the weaving process.

The major components of the loom are the warp beam, heddles, harnesses, shuttle, reed, and takeup roll (see Figure 7). In the loom, yarn processing includes shedding, picking, battening, and taking up operations. These steps are discussed below.

- *Shedding.* Shedding is the raising of the warp yarns to form a shed through which the filling yarn, carried by the shuttle, can be inserted. The shed is the vertical space between the raised and unraised warp yarns. On the modern loom, simple and intricate shedding operations are performed automatically by the heddle frame, also known as a harness. This is a rectangular frame to which a series of wires, called heddles, are attached. The yarns are passed through the eye holes of the heddles, which hang vertically from the harnesses.

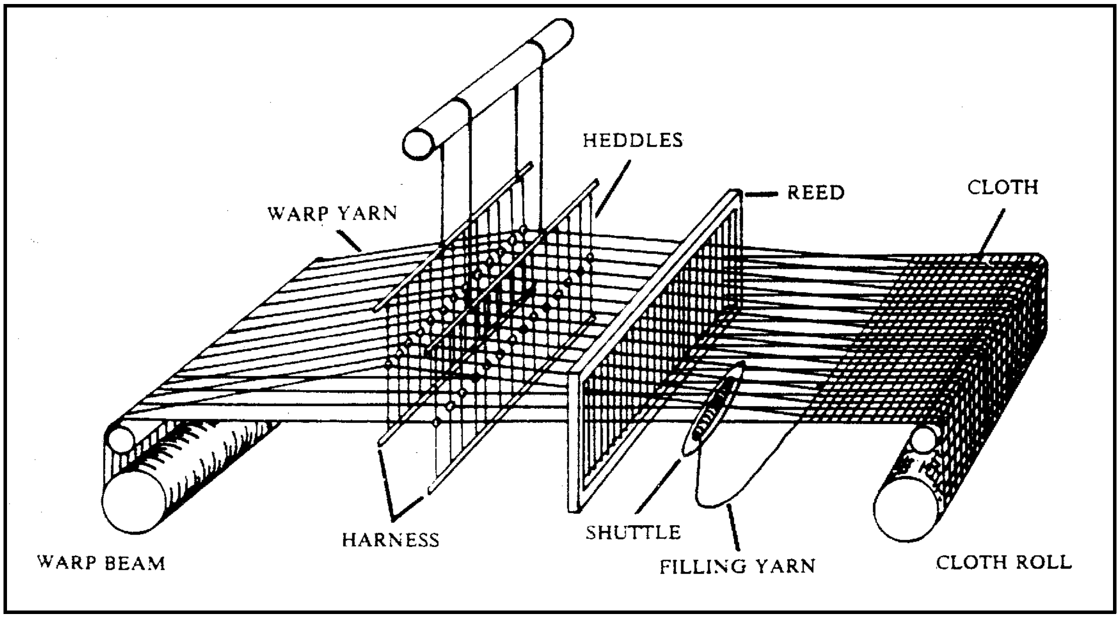
  The weave pattern determines which harness controls which warp yarns, and the number of harnesses used depends on the complexity of the weave (Corbman, 1975).

- *Picking.* As the harnesses raise the heddles, which raise the warp yarns, the shed is created. The filling yarn in inserted through the shed by a small carrier device called a shuttle. The shuttle is normally pointed at each end to allow passage through the shed. In a traditional shuttle loom, the filling yarn is wound onto a quill, which in turn is mounted in the shuttle. The filling yarn emerges through a hole in the shuttle as it moves across the loom. A single crossing of the shuttle from one side of the loom to the other is known as a pick. As the shuttle moves back and forth across the shed, it weaves an edge, or selvage, on each side of the fabric to prevent the fabric from raveling.

- *Battening.* As the shuttle moves across the loom laying down the fill yarn, it also passes through openings in another frame called a reed (which resembles a comb). With each picking operation, the reed presses or battens each filling yarn against the portion of the fabric that has already been formed. Conventional shuttle looms can operate at speeds of about 150 to 160 picks per minute.

- *Taking up and letting off.* With each weaving operation, the newly constructed fabric must be wound on a cloth beam. This process is called taking up. At the same time, the warp yarns must be let off or released from the warp beams (Corbman, 1975).

Figure 7: Typical Shuttle Loom



Source: I.B. Wingate, *Fairchild's Dictionary of Textiles,* Fairchild Publications, Inc., 1979.

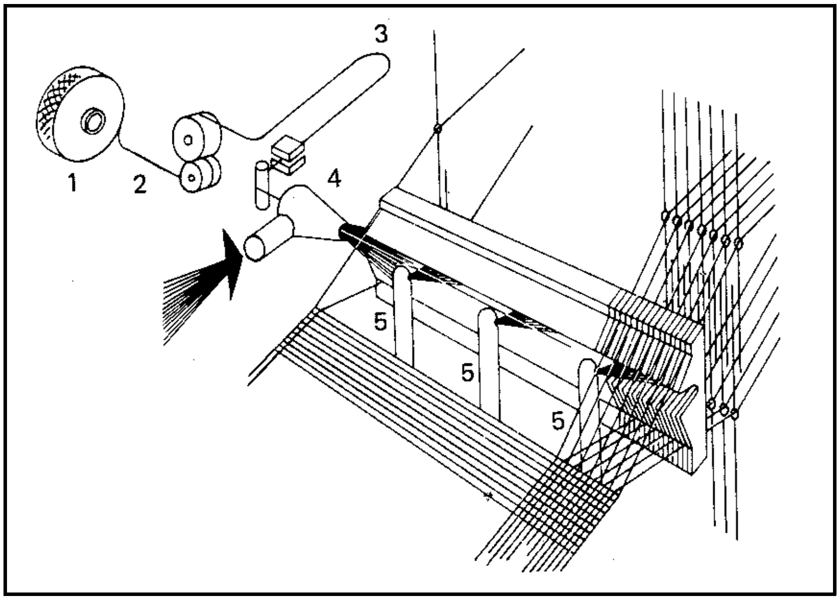
Shuttleless Looms

Because the shuttle can cause yarns to splinter and catch, several types of shuttleless looms have been developed. These operate at higher speeds and reduced noise levels. By the end of 1989, shuttleless looms represented 54 percent of all looms installed, up from 15 percent in 1980. Shuttleless looms use different techniques to transport cut pieces of fill yarn across the shed, as opposed to the continuous yarn used in shuttle looms.

Some of the common shuttleless looms include water-jet looms, air-jet looms, rapier looms, and projectile looms. Water-jet looms transport the fill yarn in a high-speed jet of water and can achieve speeds of 400 to 600 picks per minute. Water jets can handle a wide variety of fiber and yarn types and are widely used for apparel fabrics. Air-jet looms use a blast of air to move the fill yarn and can operate at speeds of 800 to 1000 picks per minute. Rapier looms use two thin wire rods to carry the fill yarn and can operate at a speed of 510 picks per minute. Rapiers are used mostly for spun yarns to make cotton and woolen/worsted fabrics. In a double rapier loom, two rods move from each side and meet in the middle. The fill yarn is carried from the rod on the fill side and handed off to the rod on the finish side of the loom. Projectile looms use a projectile to carry the fill yarn across the weave.

Shuttleless looms have been replacing the traditional fly-shuttle loom in recent years. Air looms, although limited in the types of filling yarns they can handle, are increasing in commercial use. The operation of an air jet loom is shown in Figure 8. As shown in the figure, yarn is drawn from the yarn package (1) by the measuring wheel and drive roller arrangement (2). Between the yarn package and the measuring wheel is a tube through which an air current flows in opposite direction to the yarn. This maintains a straight even feed of yarn. The yarn then forms a loop (3) which shortens as the pick penetrates further into the shed. The main jet (4) is the major projecting force for the yarn, although supplementary jets (5) are activated to prevent the pick from buckling.

Figure 8: Typical Air Jet Loom

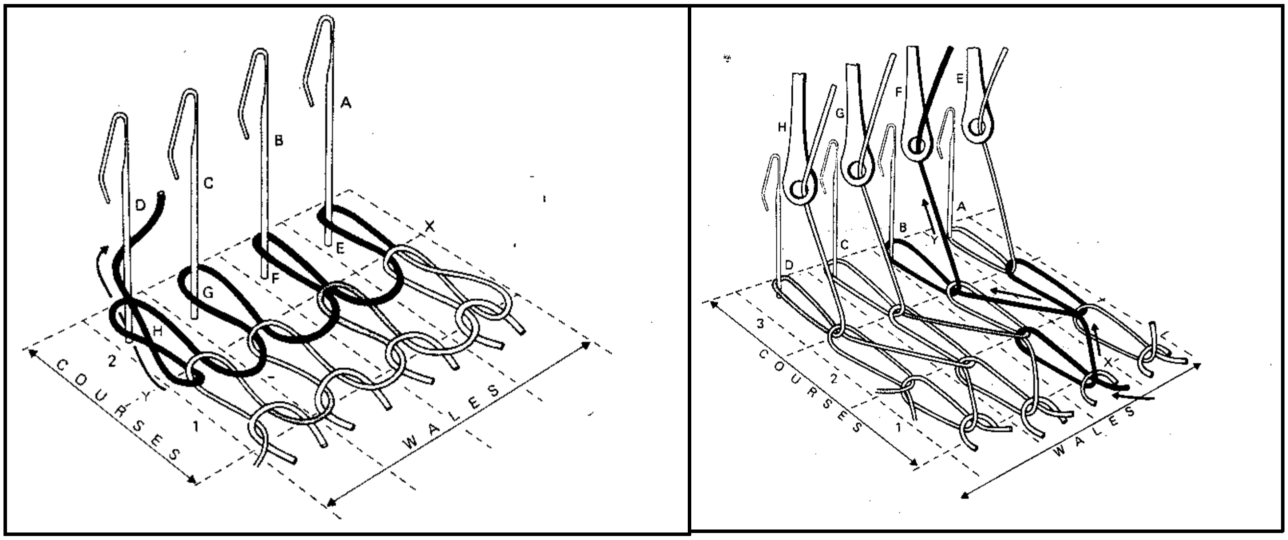


Source: A. Ormerod, *Modern Preparation and Weaving Machinery,* Butterworths, 1983.

Knitting

Knitted fabrics may be constructed by using hooked needles to interlock one or more sets of yarns through a set of loops. The loops may be either loosely or closely constructed, depending on the purpose of the fabric. Knitted fabrics can be used for hosiery, underwear, sweaters, slacks, suits, coats, rugs, and other home furnishings. Knitting is performed using either weft or warp processes, depicted in Figure 9. In weft (or filling) knitting, one yarn is carried back and forth and under needles to form a fabric. Yarns run horizontally in the fabric, and connections between loops are horizontal. In warp knitting, a warp beam is set into the knitting machine. Yarns are interlocked to form the fabric, and the yarns run vertically while the connections are on the diagonal. Several different types of machinery are used in both weft and warp knitting.

Figure 9: Comparison Between Warp and Weft Knitting Methods



(a) Weft **(b) Warp**

Source: D.J. Spencer, *Knitting Technology,* Pergamon Press, 1989.

- *Weft knitting.* Weft knitting uses one continuous yarn to form courses, or rows of loops, across a fabric. There are three fundamental stitches in weft knitting: plain-knit, purl, and rib. On a machine, the individual yarn is fed to one or more needles at a time. Weft knitting machines can produce both flat and circular fabric. Circular machines produce mainly yardage but may also produce sweater bodies, pantyhose, and socks. Flatbed machines knit full garments and operate at much slower speeds. The simplest, most common filling knit fabric is single jersey. Double knits are made on machines with two sets of needles. All hosiery is produced as a filling knit process.

- *Warp Knitting.* Warp knitting represents the fastest method of producing fabric from yarns. Warp knitting differs from weft knitting in that each needle loops its own thread. The needles produce parallel rows of loops simultaneously that are interlocked in a zigzag pattern. Fabric is produced in sheet or flat form using one or more sets of warp yarns. The yarns are fed from warp beams to a row of needles extending across the width of the machine (Figure 9b). Two common types of warp knitting machines are the Tricot and Raschel machines. Raschel machines are useful because they can process all yarn types in all forms (filament, staple, combed, carded, etc.). Warp knitting can also be used to make pile fabrics often used for upholstery.

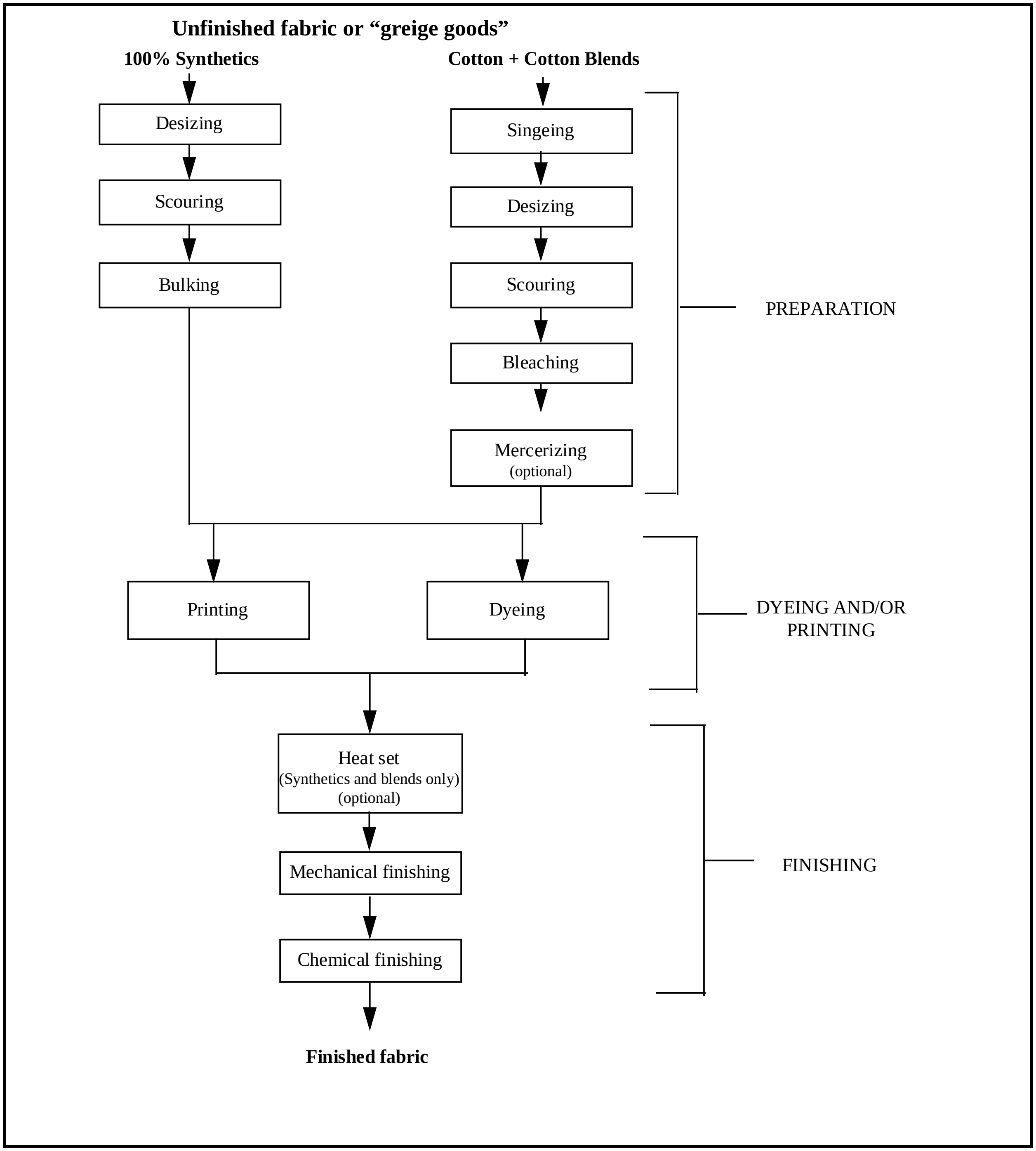
Tufting

Tufting is a process used to create carpets, blankets, and upholstery. Tufting is done by inserting additional yarns into a ground fabric of desired weight and yarn content to create a pile fabric. The substrate fabric can range from a thin backing to heavy burlap-type material and may be woven, knitted, or web. In modern tufting machines, a set of hollow needles carries the yarn from a series of spools held in a creel and inserts the yarn through the substrate cloth. As each needle penetrates the cloth, a hook on the underside forms a loop by catching and holding the yarn. The needle is withdrawn and moves forward, much like a sewing machine needle. Patterns may be formed by varying the height of the tuft loops. To make cut-loop pile, a knife is attached to the hook and the loops are cut as the needles are retracted. Well over 90 percent of broadloom carpeting is made by tufting, and modern machines can stitch at rates of over 800 stitches per minute, producing some 650 square yards of broadloom per hour.

III.A.3. Wet Processing

Woven and knit fabrics cannot be processed into apparel and other finished goods until the fabrics have passed through several water-intensive wet processing stages. Wet processing enhances the appearance, durability, and serviceability of fabrics by converting undyed and unfinished goods, known as gray or greige (*pronounced* grā[zh]) goods, into finished consumers' goods. Also collectively known as finishing, wet processing has been broken down into four stages in this section for simplification: fabric preparation, dyeing, printing, and finishing. These stages, shown in Figure 10, involve treating gray goods with chemical baths and often require additional washing, rinsing, and drying steps. Note that some of these steps may be optional depending on the style of fabric being manufactured.

Figure 10: Typical Wet Processing Steps for Fabrics



Source: ATMI, 1997.

In terms of waste generation and environmental impacts, wet processing is the most significant textile operation. Methods used vary greatly depending on end-products and applications, site-specific manufacturing practices, and fiber type. Natural fibers typically require more processing steps than manmade fibers. For most wool products and some manmade and cotton products, the yarn is dyed before weaving; thus, the pattern is woven into the fabric. Processing methods may also differ based on the final properties desired, such as tensile strength, flexibility, uniformity, and luster (Snowden-Swan, 1995).

Most manufactured textiles are shipped from textile mills to commission dyeing and finishing shops for wet processing, although some firms have integrated wet processing into their operations. A wide range of equipment is used for textile dyeing and finishing (EPA, 1996). Much of the waste generated from the industry is produced during the wet processing stages. Relatively large volumes of wastewater are generated, containing a wide range of contaminants that must be treated prior to disposal. Significant quantities of energy are spent heating and cooling chemical baths and drying fabrics and yarns (Snowden-Swan, 1995).

Fabric Preparation

Most fabric that is dyed, printed, or finished must first be prepared, with the exception of denim and certain knit styles. Preparation, also known as pretreatment, consists of a series of various treatment and rinsing steps critical to obtaining good results in subsequent textile finishing processes. . In preparation, the mill removes natural impurities or processing chemicals that interfere with dyeing, printing, and finishing. Typical preparation treatments include desizing, scouring, and bleaching. Preparation steps can also include processes, such as singeing and mercerizing, designed to chemically or physically alter the fabric. For instance, the mercerizing stage chemically treats the fabric to increase fiber strength and dye affinity, or ability to pick up dyes. This, in turn, increases the longevity of fabric finishes applied during finishing. Many of the pollutants from preparation result from the removal of previously applied processing chemicals and agricultural residues. These chemical residues can be passed on to subsequent stages with improper preparation.

Most mills can use the same preparation equipment for the entire range of products they produce. In most cases, facilities favor continuous rather than batch preparation processes for economic and pollution control reasons. A number of mills, however, prepare goods, particularly knits, batchwise on dyeing machines to simplify scheduling and handling. Sometimes, facilities operate batchwise to reduce high capital costs required for high productivity and the complexity of storing and tracking goods through continuous wet processing operations.

Because preparation is relatively uniform across most of a mill's production, preparation is usually the highest-volume process in a mill and hence an important area for pollution prevention. If fabrics contained no contamination upon arrival for wet processing, preparation processes would be unnecessary, eliminating about half the pollution outputs from wet processing and a significant amount of wastewater. The primary pollutants from preparation is wastewater containing alkalinity, BOD, COD, and relatively small amounts of other contaminants such as metals and surfactants. There are many preparation techniques, some of which are described below.

- *Singeing*. If a fabric is to have a smooth finish, singeing is essential. Singeing is a dry process used on woven goods that removes fibers protruding from yarns or fabrics. These are burned off by passing the fibers over a flame or heated copper plates. Singeing improves the surface appearance of woven goods and reduces pilling. It is especially useful for fabrics that are to be printed or where a smooth finish is desired. Pollutant outputs associated with singeing include relatively small amounts of exhaust gases from the burners.

- *Desizing*. Desizing is an important preparation step used to remove size materials applied prior to weaving. Manmade fibers are generally sized with water-soluble sizes that are easily removed by a hot-water wash or in the scouring process. Natural fibers such as cotton are most often sized with water-insoluble starches or mixtures of starch and other materials. Enzymes are used to break these starches into water-soluble sugars, which are then removed by washing before the cloth is scoured. Removing starches before scouring is necessary because they can react and cause color changes when exposed to sodium hydroxide in scouring.

- *Scouring*. Scouring is a cleaning process that removes impurities from fibers, yarns, or cloth through washing. Alkaline solutions are typically used for scouring; however, in some cases solvent solutions may also be used. Scouring uses alkali, typically sodium hydroxide, to break down natural oils and surfactants and to emulsify and suspend remaining impurities in the scouring bath. The specific scouring procedures, chemicals, temperature, and time vary with the type of fiber, yarn, and cloth construction. Impurities may include lubricants, dirt and other natural materials, water-soluble sizes, antistatic agents, and residual tints used for yarn identification. Typically, scouring wastes contribute a large portion of biological oxygen demand (BOD) loads from preparation processes (NC DEHNR, 1986). Desizing and scouring operations are often combined (ATMI, 1997).

- *Bleaching*. Bleaching is a chemical process that eliminates unwanted colored matter from fibers, yarns, or cloth. Bleaching decolorizes colored impurities that are not removed by scouring and prepares the cloth for further finishing processes such as dyeing or printing. Several different types of chemicals are used as bleaching agents, and selection depends on the type of fiber present in the yarn, cloth, or finished product and the subsequent finishing that the product will receive. The most common bleaching agents include hydrogen peroxide, sodium hypochlorite, sodium chlorite, and sulfur dioxide gas. Hydrogen peroxide is by far the most commonly used bleaching agent for cotton and cotton blends, accounting for over 90 percent of the bleach used in textile operations, and is typically used with caustic solutions. Bleaching contributes less than 5 percent of the total textile mill BOD load (NC DEHNR, 1986).

The bleaching process involves several steps: 1)The cloth is saturated with the bleaching agent, activator, stabilizer, and other necessary chemicals; 2) the temperature is raised to the recommended level for that particular fiber or blend and held for the amount of time needed to complete the bleaching action; and 3) the cloth is thoroughly washed and dried. Peroxide bleaching can be responsible for wastewater with high pH levels. Because peroxide bleaching typically produces wastewater with few contaminants, water conservation and chemical handling issues are the primary pollution concerns.

- *Mercerizing*. Mercerization is a continuous chemical process used for cotton and cotton/polyester goods to increase dyeability, luster, and appearance. This process, which is carried out at room temperature, causes the flat, twisted ribbon-like cotton fiber to swell into a round shape and to contract in length. This causes the fiber to become more lustrous than the original fiber, increase in strength by as much as 20 percent, and increase its affinity for dyes. Mercerizing typically follows singeing and may either precede or follow bleaching (Corbman, 1975).

  During mercerizing, the fabric is passed through a cold 15 to 20 percent solution of caustic soda and then stretched out on a tenter frame where hot-water sprays remove most of the caustic solution (Corbman, 1975). After treatment, the caustic is removed by several washes under tension. Remaining caustic may be neutralized with a cold acid treatment followed by several more rinses to remove the acid. Wastewater from mercerizing can contain substantial amounts of high pH alkali, accounting for about 20 percent of the weight of goods.

Dyeing

Dyeing operations are used at various stages of production to add color and intricacy to textiles and increase product value. Most dyeing is performed either by the finishing division of vertically integrated textile companies, or by specialty dyehouses. Specialty dyehouses operate either on a commission basis or purchase greige goods and finish them before selling them to apparel and other product manufacturers. Textiles are dyed using a wide range of dyestuffs, techniques, and equipment. Dyes used by the textile industry are largely synthetic, typically derived from coal tar and petroleum-based intermediates. Dyes are sold as powders, granules, pastes, and liquid dispersions, with concentrations of active ingredients ranging typically from 20 to 80 percent.

Methods of Dyeing

Dyeing can be performed using continuous or batch processes. In batch dyeing, a certain amount of textile substrate, usually 100 to 1,000 kilograms, is loaded into a dyeing machine and brought to equilibrium, or near equilibrium, with a solution containing the dye. Because the dyes have an affinity for the fibers, the dye molecules leave the dye solution and enter the fibers over a period of minutes to hours, depending on the type of dye and fabric used. Auxiliary chemicals and controlled dyebath conditions (mainly temperature) accelerate and optimize the action. The dye is fixed in the fiber using heat and/or chemicals, and the tinted textile substrate is washed to remove unfixed dyes and chemicals. Common methods of batch, or exhaust, dyeing include beam, beck, jet, and jig processing. Pad dyeing can be performed by either batch or continuous processes.

In continuous dyeing processes, textiles are fed continuously into a dye range at speeds usually between 50 and 250 meters per minute. Continuous dyeing accounts for about 60 percent of total yardage of product dyed in the industry (Snowden-Swan, 1995). To be economical, this may require the dyer to process 10,000 meters of textiles or more per color, although specialty ranges are now being designed to run as little as 2,000 meters economically. Continuous dyeing processes typically consist of dye application, dye fixation with chemicals or heat, and washing. Dye fixation is a measure of the amount of the percentage of dye in a bath that will fix to the fibers of the textile material. Dye fixation on the fiber occurs much more rapidly in continuous dying than in batch dyeing.

Each dyeing process requires different amounts of dye per unit of fabric to be dyed. This is significant since color and salts in wastewater from spent dyes are often a pollution concern for textile facilities. In addition, less dye used results in energy conservation and chemical savings. The amounts of dye used depends on the dye is exhausted from the dyebaths which determines the required dyebath ratio. The dyebath ratio is the ratio of the units of dye required per unit of fabric and typically ranges from 5 to 50 depending on the type of dye, dyeing system, and affinity of the dyes for the fibers.

Dyeing processes may take place at any of several stages of the manufacturing process (fibers, yarn, piece-dyeing). Stock dyeing is used to dye fibers. Top dyeing is used to dye combed wool sliver. Yarn dyeing and piece dyeing, done after the yarn has been constructed into fabric, are discussed in more detail below.

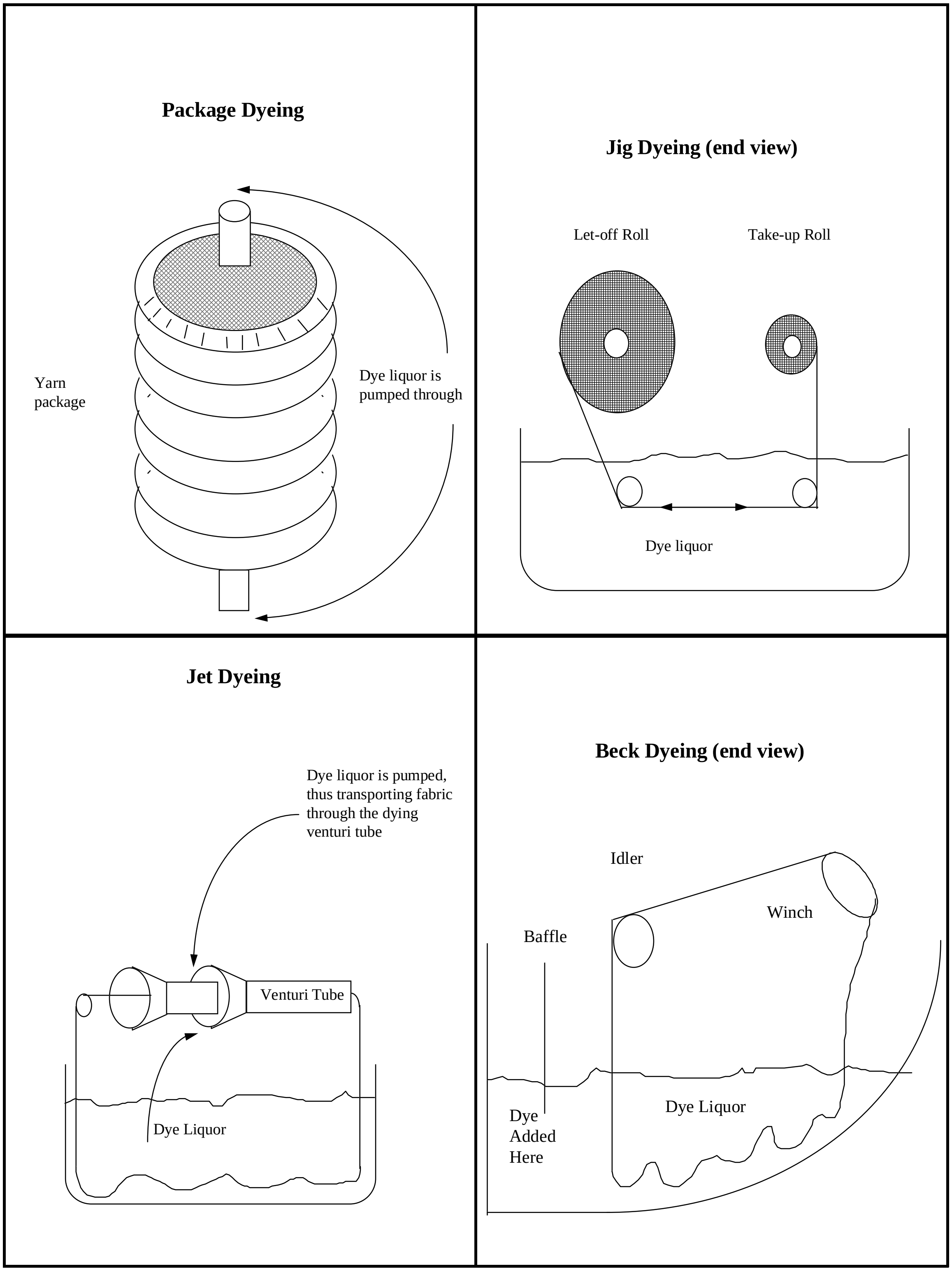
- *Yarn Dyeing.* Yarn dyeing is used to create interesting checks, stripes, and plaids with different-colored yarns in the weaving process. In yarn dyeing, dyestuff penetrates the fibers in the core of the yarn.

  Some methods of yarn dyeing are stock, package, and skein dyeing. Stock dyeing dyes fiber using perforated tubes. In package dyeing (Figure 11), spools of yarn are stacked on perforated rods in a rack and immersed in a tank where dye is then forced outward from the rods under pressure. The dye is then pressured back through the packages toward the center to fully penetrate the entire yarn. Most carded and combed cotton used for knitted outerwear is package-dyed. In skein dyeing, yarn is loosely coiled on a reel and then dyed. The coils, or skeins, are hung over a rung and immersed in a dyebath (Corbman, 1975). Skein-dyed yarn is used for bulky acrylic and wool yarns. Typical capacity for package dyeing equipment is 1,210 pounds (550 kg) and for skein dyeing equipment is 220 pounds (100 kg).

- *Piece Dyeing.* Most dyed fabric is piece-dyed since this method gives the manufacturer maximum inventory flexibility to meet color demands as fashion changes. In terms of overall volume, the largest amount of dyeing is performed using beck and jig equipment (Figure 11). Beck dyeing is a versatile, continuous process used to dye long yards of fabric. About 1,980 pounds (900 kg) of fabric can be dyed on beck equipment at a time. The fabric is passed in rope form through the dyebath. The rope moves over a rail onto a reel which immerses it into the dye and then draws the fabric up and forward to the front of the machine. This process is repeated as long as necessary to dye the material uniformly to the desired color intensity. Jig dyeing uses the same procedure of beck dyeing, however, the fabric is held on rollers at full width rather than in rope form as it is passed through the dyebath (Corbman, 1975). This reduces fabric tendency to crack or crease. Jig dyeing equipment can handle 550 pounds (250 kg) of fabric.

  Other piece dyeing methods include jet dyeing and pad dyeing. Fabric can be jet-dyed (at up to 1,100 pounds (500 kg)) by placing it in a heated tube or column where jets of dye solution are forced through it at high pressures. The dye is continually recirculated as the fabric is moved along the tube. Pad dyeing, like jig dyeing, dyes the fabric at full width. The fabric is passed through a trough containing dye and then between two heavy rollers which force the dye into the cloth and squeeze out the excess (Corbman, 1975). Figure 11 illustrates the beck, jig, and jet methods for dyeing.

Figure 11: Common Dyeing Methods



Source: *Best Management Practices for Pollution Prevention in the Textile Industry*, EPA, Office of Research and Development, 1995.

Types of Dyes

Dyes may be classified in several ways (e.g., according to chemical constitution, application class, end-use). The primary classification of dyes is based on the fibers to which they can be applied and the chemical nature of each dye. Table 6 lists the major dye classes, fixation rates, and the types of fibers for which they have an affinity. Factors that companies consider when selecting a dye include the type of fibers being dyed, desired shade, dyeing uniformity, and fastness (desired stability or resistance of stock or colorants to influences such as light, alkali, etc) (FFTA, 1991).

Most commonly in use today are the reactive and direct types for cotton dyeing, and disperse types for polyester dyeing. Reactive dyes react with fiber molecules to form chemical bonds. Direct dyes can color fabric directly with one operation and without the aid of an affixing agent. Direct dyes are the simplest dyes to apply and the cheapest in their initial and application costs although there are tradeoffs in the dyes' shade range and wetfastness (Corbman, 1975). Direct and reactive dyes have a fixation rate of 90 to 95 percent and 60 to 90 percent, respectively. A variety of auxiliary chemicals may be used during dyeing to assist in dye absorption and fixation into the fibers. Disperse dyes, with fixation rates of 80 to 90 percent, require additional factors, such as dye carriers, pressure, and heat, to penetrate synthetic fibers (Snowden-Swan, 1995; ATMI, 1997). Disperse dyes are dispersed in water where the dyes are dissolved into fibers. Vat dyes, such as indigo, are also commonly used for cotton and other cellulosic fibers.

Table 6: Typical Characteristics of Dyes Used in Textile Dyeing Operations

Dye Class	**Description**	**Method**	**Fibers Typically Applied to**	**Typical Fixation (%)**	**Typical Pollutants Associated with Various Dyes**
Acid	water-soluble anionic compounds	Exhaust/ Beck/ Continuous (carpet)	wool nylon	80-93	color; organic acids; unfixed dyes
Basic	water-soluble, applied in weakly acidic dyebaths; very bright dyes	Exhaust/ Beck	acrylic some polyesters	97-98	N/A
Direct	water-soluble, anionic compounds; can be applied directly to cellulosics without mordants (or metals like chromium and copper)	Exhaust/ Beck/ Continuous	cotton rayon other cellulosics	70-95	color; salt; unfixed dye; cationic fixing agents; surfactant; defoamer; leveling and retarding agents; finish; diluents
Disperse	not water-soluble	High temperature exhaust Continuous	polyester acetate other synthetics	80-92	color; organic acids; carriers; leveling agents; phosphates; defoamers; lubricants; dispersants; delustrants; diluents
Reactive	water-soluble, anionic compounds; largest dye class	Exhaust/ Beck Cold pad batch/ Continuous	cotton other cellulosics wool	60-90	color; salt; alkali; unfixed dye; surfactants; defoamer; diluents; finish
Sulfur	organic compounds containing sulfur or sodium sulfide	Continuous	cotton other cellulosics	60-70	color; alkali; oxidizing agent; reducing agent; unfixed dye
Vat	oldest dyes; more chemically complex; water-insoluble	Exhaust/ Package/ Continuous	cotton other cellulosics	80-95	color; alkali; oxidizing agents; reducing agents

Source: *Best Management Practices for Pollution Prevention in the Textile Industry*, EPA, Office of Research and Development, 1995; Snowden-Swan, L.J. "Pollution Prevention in the Textile Industries," in *Industrial Pollution Prevention Handbook,* Freeman, H.M. (Ed.), McGraw-Hill, Inc., New York, 1995.

Printing

Fabrics are often printed with color and patterns using a variety of techniques and machine types. Of the numerous printing techniques, the most common is rotary screen. However, other methods, such as direct, discharge, resist, flat screen (semicontinuous), and roller printing are often used commercially. Pigments are used for about 75 to 85 percent of all printing operations, do not require washing steps, and generate little waste (Snowden-Swan, 1995). Compared to dyes, pigments are typically insoluble and have no affinity for the fibers. Resin binders are typically used to attach pigments to substrates. Solvents are used as vehicles for transporting the pigment and resin mixture to the substrate. The solvents then evaporate leaving a hard opaque coating. The major types of printing are described below.

- *Rotary screen printing.* Rotary screen printing uses seamless cylindrical screens made of metal foil. The machine uses a rotary screen for each color. As the fabric is fed under uniform tension into the printer section of the machine, its back is usually coated with an adhesive which causes it to adhere to a conveyor printing blanket. Some machines use other methods for gripping the fabric. The fabric passes under the rotating screen through which the printing paste is automatically pumped from pressure tanks. A squeegee in each rotary screen forces the paste through the screen onto the fabric as it moves along (Corbman, 1975). The fabric then passes to a drying oven.

- *Direct printing.* In direct printing, a large cylindrical roller picks up the fabric, and smaller rollers containing the color are brought into contact with the cloth. The smaller rollers are etched with the design, and the number of rollers reflects the number of colors. Each smaller roller is supplied with color by a furnisher roller, which rotates in the color trough, picks up color, and deposits it on the applicator roller. Doctor blades scrape excess color off the applicator roller so that only the engraved portions carry the color to the cloth. The cloth is backed with a rubberized blanket during printing, which provides a solid surface to print against, and a layer of gray cloth is used between the cloth and the rubber blanket to absorb excess ink.

- *Discharge printing.* Discharge printing is performed on piece-dyed fabrics. The patterns are created through removal, rather than addition, of color, hence most discharge printing is done on dark backgrounds. The dyed fabric is printed using discharge pastes, which remove background color from the substrate when exposed to steam. Colors may be added to the discharge paste to create different colored discharge areas (EPA, 1996).

- *Resist printing.* Resist printing encompasses several hand and low-volume methods in which the pattern is applied by preventing color from penetrating certain areas during piece-dyeing. Examples of resist printing methods include batik, tie-dyeing, screen printing, and stencil printing.

- *Ink-Jet printing.* Ink-jet printing is a noncontact printing method in which droplets of colorant solution are propelled toward a substrate and directed to a desired spot. Ink jet is an emerging technology in the textile industry and has not yet been adopted for widespread commercial use. The dye types most amenable to ink-jet printing of textiles are fiber reactive, vat, sulfur, and naphthol dyes.

- *Heat-transfer printing.* In heat-transfer printing, the pattern is first printed onto a special paper substrate. The paper is then positioned against the fabric and subjected to heat and pressure. The dyes are transferred to the fabric via sublimation.

Finishing

Finishing encompasses chemical or mechanical treatments performed on fiber, yarn, or fabric to improve appearance, texture, or performance. Mechanical finishes can involve brushing, ironing or other physical treatments used to increase the luster and feel of textiles. Application of chemical finishes to textiles can impart a variety of properties ranging from decreasing static cling to increasing flame resistance. The most common chemical finishes are those that ease fabric care, such as the permanent-press, soil-release, and stain-resistant finishes. Chemical finishes are usually followed by drying, curing, and cooling steps. Application of chemical finishes are often done in conjunction with mechanical finishing steps (Snowden-Swan, 1995). Selected mechanical and chemical finishing techniques are described below.

Mechanical Treatments

- *Heatsetting.* Heatsetting is a dry process used to stabilize and impart textural properties to synthetic fabrics and fabrics containing high concentrations of synthetics. When manmade fibers are heatset, the cloth maintains its shape and size in subsequent finishing operations and is - stabilized in the form in which it is held during heatsetting (e.g., smooth, creased, uneven). Textural properties may include interesting and durable surface effects such as pleating, creasing, puckering, and embossing. Heatsetting can also give cloth resistance to wrinkling during wear and ease-of-care properties attributed to improvements in resiliency and in elasticity. Pollution outputs may include volatile components of spin finishes if heatsetting is performed before scouring and bleaching processes. These components are introduced to the fabrics during the manufacture of synthetic fibers, when proprietary spin finishes are applied to provide lubrication and impart special properties, such as antistatic, to the fiber.

- *Brushing and napping.* Brushing and napping decrease the luster of fabrics by roughening or raising the fiber surface and change the feel or texture of the fabric (ATMI, 1997b). These processes involve the use of wires or brushes that pull individual fibers.

- *Softening.* Calendering, or ironing, can be used to reduce surface friction between individual fibers, thereby softening the fabric structure and increasing its sheen. In calendering, the fabric passes through two or more rolls. Typically, one roll is made of chilled steel, while the other is made of a softer material like cotton fibers. The steel roll may also be heated using gas or steam. Once goods pass through the machine they are wound up at the back of the machine.

- *Optical finishing.* Luster can be added to yarns by flattening or smoothing the surfaces under pressure. This can be achieved by beating the fabric surface or passing the fabric between calendering rolls. The luster can be further increased if the rolls are scribed with closely spaced lines.

- *Shearing.* Shearing is a process that removes surface fibers by passing the fabric over a cutting blade.

- *Compacting*. Compacting, which includes the Sanforizing process, compresses the fabric structure to reduce stresses in the fabric. The Sanforizing process reduces residual shrinkage of fabrics after repeated laundering (Wingate, 1979). The fabric and backing blanket are fed between a roller and a curved braking shoe, with the blanket under tension. The tension on the blanket is released after the fabric and blanket pass the braking shoe. Compacting reduces the potential for excessive shrinkage during laundering.

Chemical Treatments

- *Optical finishes.* Optical finishes added to either brighten or deluster the textile.

- *Absorbent and soil release finishes.* These finishes that alter surface tension and other properties to increase water absorbency or improve soil release.

- *Softeners and abrasion-resistant finishes.* Softeners and abrasion-resistant finishes are added to improve feel or to increase the ability of the textile to resist abrasion and tearing.

- *Physical stabilization and crease-resistant finishes.* These finishes, which may include formaldehyde-based resin finishes, stabilize cellulosic fibers to laundering and shrinkage, imparting permanent press properties to fabrics (ATMI, 1997b).

III.A.4. Fabrication

Finished cloth is fabricated into a variety of apparel and household and industrial products. The simpler of these products, such as bags, sheets, towels, blankets, and draperies, often are produced by the textile mills themselves. Apparel and more complex housewares are usually fabricated by the cutting trades. Before cutting, fabrics must be carefully laid out. Accuracy in cutting the lay fabric is important since any defects created at this point may be carried through other operations and end up in the final product. For simple household and industrial products, sewing is relatively straightforward. The product may then be pressed to flatten the fabric and create crisp edges.

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

Much of the following section is based upon *"Best Management Practices for Pollution Prevention in the Textile Industry,"* by the U.S. EPA Office of Research and Development. Additional references are cited in the text.

Wastewater

Wastewater is, by far, the largest wastestream for the textile industry. Large volume wastes include washwater from preparation and continuous dyeing, alkaline waste from preparation, and batch dye waste containing large amounts of salt, acid, or alkali. Primary sources of biological oxygen demand (BOD) include waste chemicals or batch dumps, starch sizing agents, knitting oils, and degradable surfactants. Wet processing operations, including preparation, dyeing, and finishing, generate the majority of textile wastewater.

Types of wastewater include cleaning water, process water, noncontact cooling water, and stormwater. The amount of water used varies widely in the industry, depending on the specific processes operated at the mill, the equipment used, and the prevailing management philosophy regarding water use. Because of the wide variety of process steps, textile wastewater typically contains a complex mixture of chemicals.

Desizing, or the process of removing size chemicals from textiles, is one of the industry's largest sources of wastewater pollutants. In this process, large quantities of size used in weaving processes are typically discarded. More than 90 percent of the size used by the U.S. textile industry, or 90,000 tons, is disposed of in the effluent stream. The remaining 10 percent is recycled (EPA, 1996). Desizing processes often contribute up to 50 percent of the BOD load in wastewater from wet processing (Snowden-Swan, 1995). Table 7 shows typical BOD loads from preparation processes.

Dyeing operations generate a large portion of the industry's total wastewater. The primary source of wastewater in dyeing operations is spent dyebath and washwater. Such wastewater typically contains by-products, residual dye, and auxiliary chemicals. Additional pollutants include cleaning solvents, such as oxalic acid.

Of the 700,000 tons of dyes produced annually worldwide, about 10 to 15 percent of the dye is disposed of in effluent from dyeing operations (Snowden-Swan, 1995). However, dyes in wastewater may be chemically bound to fabric fibers (ATMI, 1997b). The average wastewater generation from a dyeing facility is estimated at between one and two million gallons per day. Dyeing and rinsing processes for disperse dyeing generate about 12 to 17 gallons of wastewater per pound of product. Similar processes for reactive and direct dyeing generate even more wastewater, about 15 to 20 gallons per pound of product (Snowden-Swan, 1995).

Table 7: Typical BOD Loads from Preparation Processes

Process	Pounds of BOD per 1,000 Pounds of Production
Singeing	0
Desizing	
starch	67
starch, mixed size	20
PVA or CMC	0
Scouring	40-50
Bleaching	
peroxide	3-4
hypochlorite	8
Mercerizing	15
Heatsetting	0

Source: *Best Management Practices for Pollution Prevention in the Textile Industry,* EPA, Office of Research and Development, 1995.
PVA = polyvinyl alcohol; CMC = carboxymethyl cellulose

Finishing processes typically generate wastewater containing natural and synthetic polymers and a range of other potentially toxic substances (Snowden-Swan, 1995). Pollution from peroxide bleaching normally is not a major concern. In most cases, scouring has removed impurities in the goods, so the only by-product of the peroxide reaction is water. The major pollution issues in the bleaching process are chemical handling, water conservation, and high pH.

Hazardous waste generated by textile manufacturers results primarily from the use of solvents in cleaning knit goods (ATMI, 1997b). Solvents may be used in some scouring or equipment cleaning operations, however, more often scouring processes are aqueous-based and cleaning materials involve mineral spirits or other chemicals (ATMI, 1997b). Spent solvents may include tetrachloroethylene and trichloroethylene (NC DEHNR, P2 Pays, 1985). A few of the more common textile industry water pollutants and their sources are discussed below. In addition, Table 8 summarizes the typical pollutant releases associated with various textile manufacturing processes.

Color

Dyes and pigments from printing and dyeing operations are the principal sources of color in textile effluent (EPA, 1996). Dyes and pigments are highly colored materials used in relatively small quantities (a few percent or less of the weight of the substrate) to impart color to textile materials for aesthetic or functional purposes. In typical dyeing and printing processes, 50 to 100 percent of the color is fixed on the fiber, as shown in Table 6. The remainder is discarded in the form of spent dyebaths or in wastewater from subsequent textile-washing operations (EPA, 1996).

*Salt*s

Several authors have identified salts in textile-dyeing wastewater as a potential problem area (US EPA, 1996). Many types of salt are either used as raw materials or produced as by-products of neutralization or other reactions in textile wet processes. Salt is used mostly to assist the exhaustion of ionic dyes, particularly anionic dyes, such as direct and fiber reactive dyes on cotton. Typical cotton batch dyeing operations use quantities of salt that range from 20 percent to 80 percent of the weight of goods dyed, and the usual salt concentration in such wastewater is 2,000 ppm to 3,000 ppm. According to one study, a moderate-sized mill that dyed about 400,000 pounds per week of cotton knit fabrics produced well over 50,000 pounds of salts and a pH of over 10 (US EPA, 1996). The wastewater from this facility contained neutralization salts from six acids and alkalis of 60 ppm. Common salt (sodium chloride) and Glaubers salt (sodium sulfate) constitute the majority of total salt use. Other salts used as raw materials or formed in textile processes include Epsom salt (magnesium chloride), potassium chloride, and others in low concentrations.

Table 8: Summary of Potential Releases Emitted During Textiles Manufacturing

Process	Air Emissions	Wastewater	Residual Wastes
Fiber preparation	little or no air emissions generated	little or no wastewater generated	fiber waste; packaging waste and hard waste
Yarn spinning	little or no air emissions generated	little or no wastewater generated	packaging wastes; sized yarn; fiber waste; cleaning and processing waste
Slashing/sizing	VOCs	BOD; COD; metals; cleaning waste, size	fiber lint; yarn waste; packaging waste; unused starch-based sizes;
Weaving	little or no air emissions generated	little or no wastewater generated	packaging waste; yarn and fabric scraps; off-spec fabric; used oil
Knitting	little or no air emissions generated	little or no wastewater generated	packaging waste; yarn and fabric scraps; off-spec fabric
Tufting	little or no air emissions generated	little or no wastewater generated	packaging waste; yarn and fabric scraps; off-spec fabric
Desizing	VOCs from glycol ethers	BOD from water-soluble sizes; synthetic size; lubricants; biocides; anti-static compounds	packaging waste; fiber lint; yarn waste; cleaning materials, such as wipes, rags, and filters; cleaning and maintenance wastes containing solvents
Scouring	VOCs from glycol ethers and scouring solvents	disinfectants and insecticide residues; NaOH; detergents, fats; oils; pectin; wax; knitting lubricants; spin finishes; spent solvents	little or no residual waste generated
Bleaching	little or no air emissions generated	hydrogen peroxide, sodium silicate or organic stabilizer; high pH	little or no residual waste generated
Singeing	small amounts of exhaust gases from the burners	little or no wastewater generated	little or no residual waste generated
Mercerizing	little or no air emissions generated	high pH; NaOH	little or no residual waste generated

Table 8: Summary of Potential Releases Emitted During Textiles Manufacturing

Process	Air Emissions	Wastewater	Residual Wastes
Heatsetting	volatilization of spin finish agents applied during synthetic fiber manufacture	little or no wastewater generated	little or no residual waste generated
Dyeing (see Table 6 for pollutants associated with particular dye classes)	VOCs	metals; salt; surfactants; toxics; organic processing assistants; cationic materials; color; BOD; COD; sulfide; acidity/ alkalinity; spent solvents	little or no residual waste generated
Printing	solvents, acetic acid from drying and curing oven emissions; combustion gases; particulate matter	suspended solids; urea; solvents; color; metals; heat; BOD; foam	little or no residual waste generated
Finishing	VOCs; contaminants in purchased chemicals; formaldehyde vapors; combustion gases; particulate matter	BOD; COD; suspended solids; toxics; spent solvents	fabric scraps and trimmings; packaging waste
Product Fabrication	little or no air emissions generated	little or no wastewater generated	fabric scraps

Source: *Best Management Practices for Pollution Prevention in the Textile Industry*, EPA, Office of Research and Development, 1995; ATMI, Comments on draft document, 1997b.

Regulatory limits imposed on textile facilities and on publicly owned treatment facilities (POTWs) that receive textile wastewater start at 250 ppm. Although the mammalian and aquatic toxicities of these salts are very low, their massive use in certain textile-dyeing processes can produce wastewater with salt levels well above the regulatory limits.

Metals

Many textile mills have few or no metals in their effluent, but whenever metals are present, they may include metals such as copper, cadmium, chromium, nickel, and zinc. Sources of metals found in textile mill effluents may include fiber, incoming water, dyes, plumbing, and chemical impurities. Dyes may contain metals such as zinc, nickel, chromium, and cobalt (ATMI, 1997b). In some dyes, these metals are functional (i.e., they form an integral part of the dye molecule); however, in most dyes, metals are simply impurities generated during dye manufacture. For example, mercury or other metals may be used as catalysts in the manufacture of certain dyes and may be present as by-products. Metals may be difficult to remove from wastewater (EPA, 1996).

Aquatic Toxicity

The aquatic toxicity of textile industry wastewater varies considerably among production facilities. Data are available that show that the wastewater of some facilities has fairly high aquatic toxicity, while others show little or no toxicity. The sources of aquatic toxicity can include salt, surfactants, ionic metals and their complexed metals therein, toxic organic chemicals, biocides, and toxic anions (EPA, 1996; ATMI, 1997b). Most textile dyes have low aquatic toxicity. On the other hand, surfactants and related compounds, such as detergents, emulsifiers, dispersants, are used in almost every textile process and can be an important contributor to effluent aquatic toxicity, BOD, and foaming (EPA, 1996).

Air Emissions

Although the textile industry is a relatively minor source of air pollutants compared with many other industries, the industry emits a wide variety of air pollutants, making sampling, analysis, treatment, and prevention more complex. Textile operations involve numerous sources of air emissions. Operations that represent the greatest concern are coating, finishing, and dyeing operations. Textile mills usually generate nitrogen and sulfur oxides from boilers and are often classified as “major sources” under the Clean Air Act (EPA, 1996).

Other significant sources of air emissions in textile operations include resin finishing and drying operations, printing, dyeing, fabric preparation, and wastewater treatment plants (ATMI, 1997b). Hydrocarbons are emitted from drying ovens and, in particular, from mineral oil from high-temperature (200 °C) drying/curing. These processes can emit formaldehyde, acids, softeners, and other volatile compounds. Residues from fiber preparation sometimes emit pollutants during heatsetting processes.

Carriers and solvents may be emitted during dyeing operations depending on the types of dyeing processes used and from wastewater treatment plant operations. Carriers used in batch dyeing of disperse dyes may lead to volatilization of aqueous chemical emulsions during heatsetting, drying, or curing stages. Acetic acid and formaldehyde are two major emissions of concern in textiles. Other potential pollutants can include solvent vapors containing toxic compounds such as acetaldehyde, chlorofluorocarbons, p-dichlorobenzene, ethyl acetate, and others. Some process chemicals, such as methyl naphthalene or chlorotoluene, may exhaust into the fibers and are later emitted from dryers as VOCs (EPA, 1996). Formaldehyde might be emitted from bulk resin storage tanks, finished fabric warehouses, driers, and curing ovens located at facilities that apply formaldehyde-containing resins to cotton and polyester/cotton blends (ATMI, 1997b). ATMI estimates that the majority of resin finishing plants emit less than one ton per year of formaldehyde from storage tanks, fabric, off-gassing.

Textile manufacturing can produce oil and acid fumes, plasticizers, and other volatile chemicals. Acetic acid emissions may arise from storage tanks, especially from vents during filling. Carbonizing processes, used in wool yarn manufacture, may emit sulfuric acid fumes and decating, a finishing process applied to wool fabrics to set the nap and develop luster, produces formic acid fumes. In addition, cleaning and scouring chemicals were estimated at 10,500 metric tons in 1988 (EPA, 1996).

Other Wastes

The primary residual wastes generated from the textile industry are nonhazardous. These include fabric and yarn scrap, off-spec yarn and fabric, and packaging waste. Cutting room waste generates a high volume of fabric scrap that can be reduced by increasing fabric utilization efficiency in cutting and sewing. Typical efficiency for using fabric averages from 72 to 94 percent. As a result, fabrication waste from carpets amounts to about 2 percent of an annual 900 million square yards of production (a value of $100 million). Denim cutting waste accounts for approximately 16 percent of denim production, or 100 million pounds annually.

Although a large portion of cutting waste goes to landfill, some innovative programs being implemented to recycle this material. Some facilities collect cotton lint for resale. Cotton trash, leaves, and stems collected during the yarn formation have been sold to farmers as animal feed.

A materials flow sheet is shown in Figure 12 and summarizes raw materials input and waste output generated during the manufacture of a cotton knit golf shirt.

Figure 12: Materials Flow for a Cotton Knit Golf Shirt

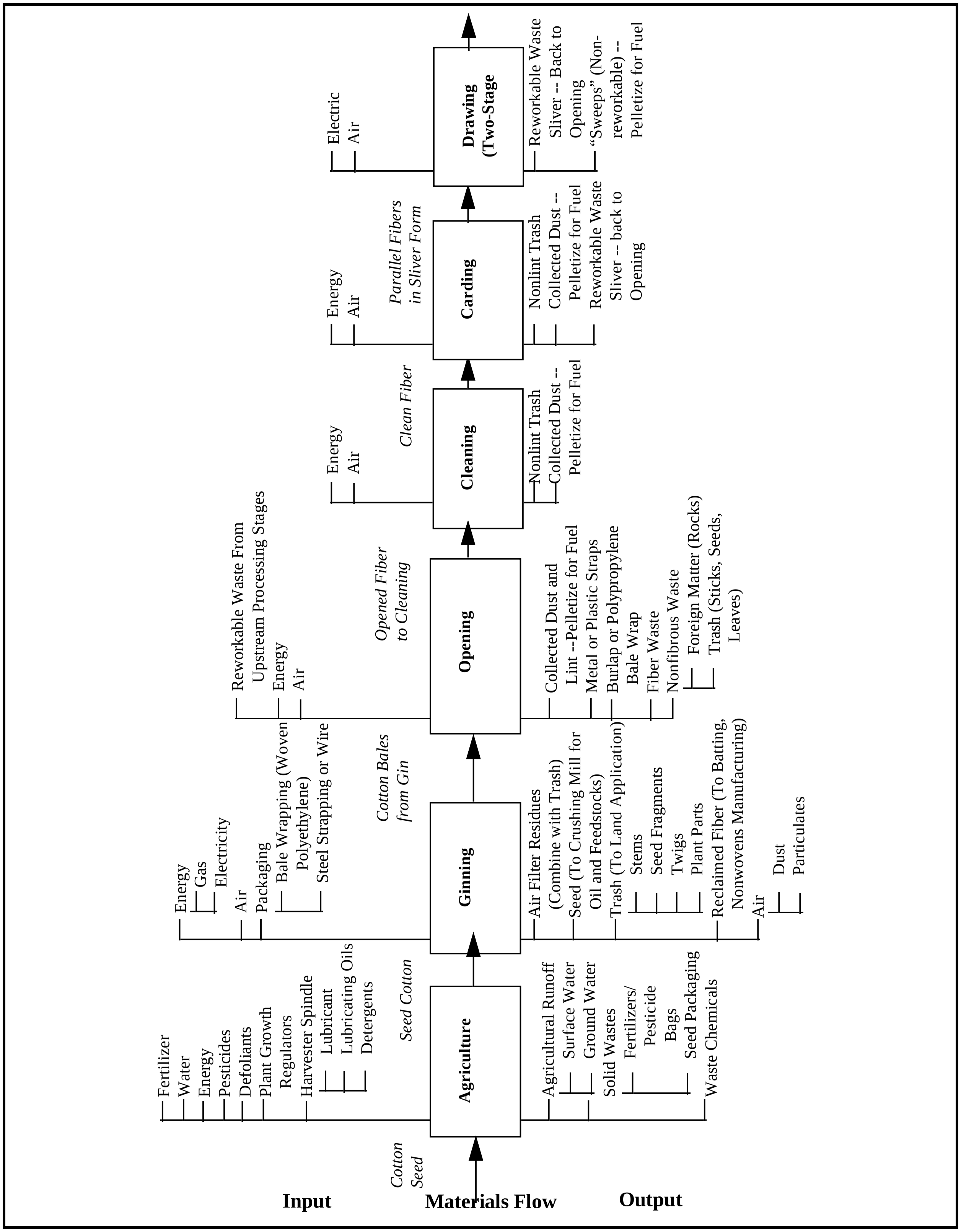


Figure 12 (cont.): Materials Flow for a Cotton Knit Golf Shirt

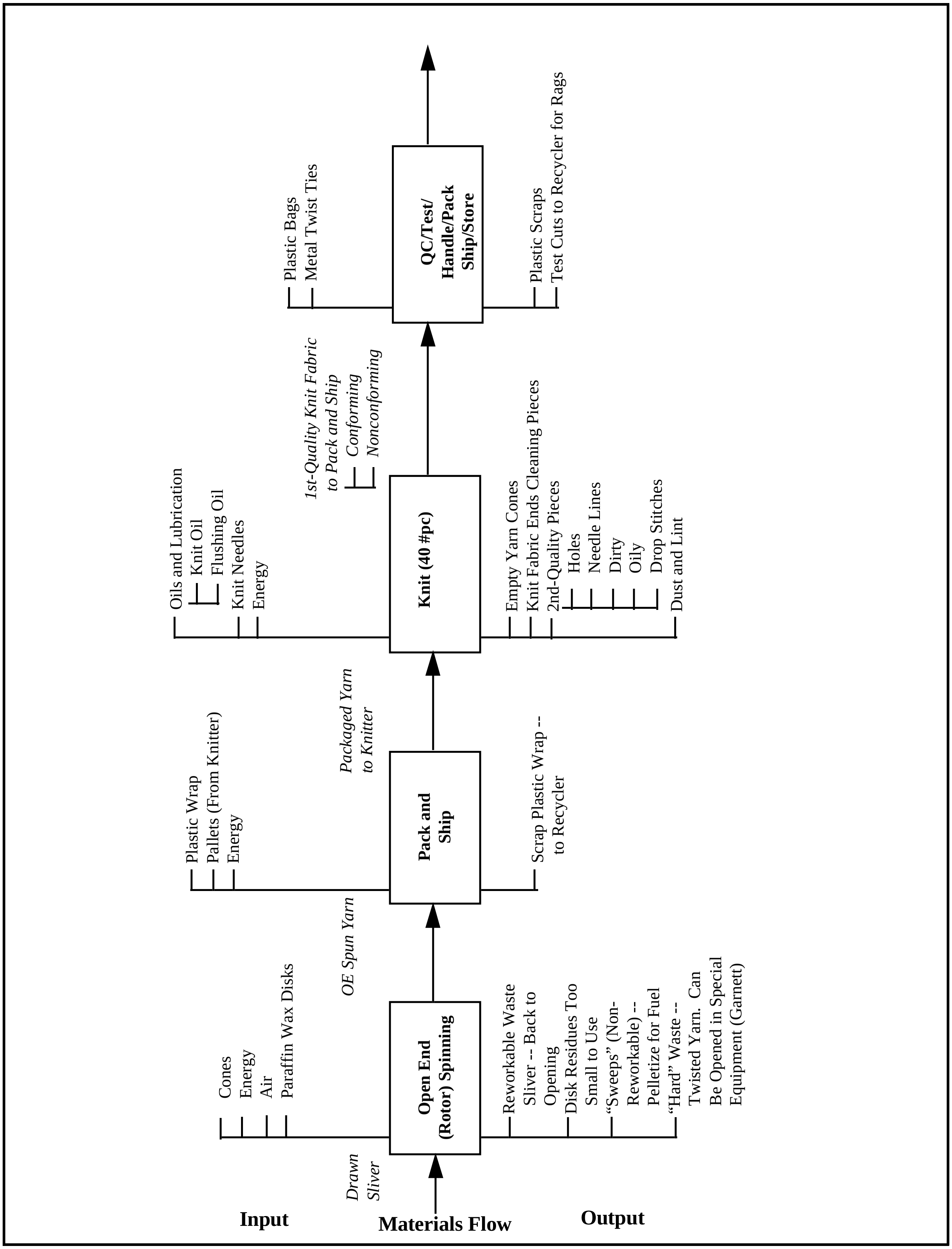


Figure 12 (cont.): Materials Flow for a Cotton Knit Golf Shirt

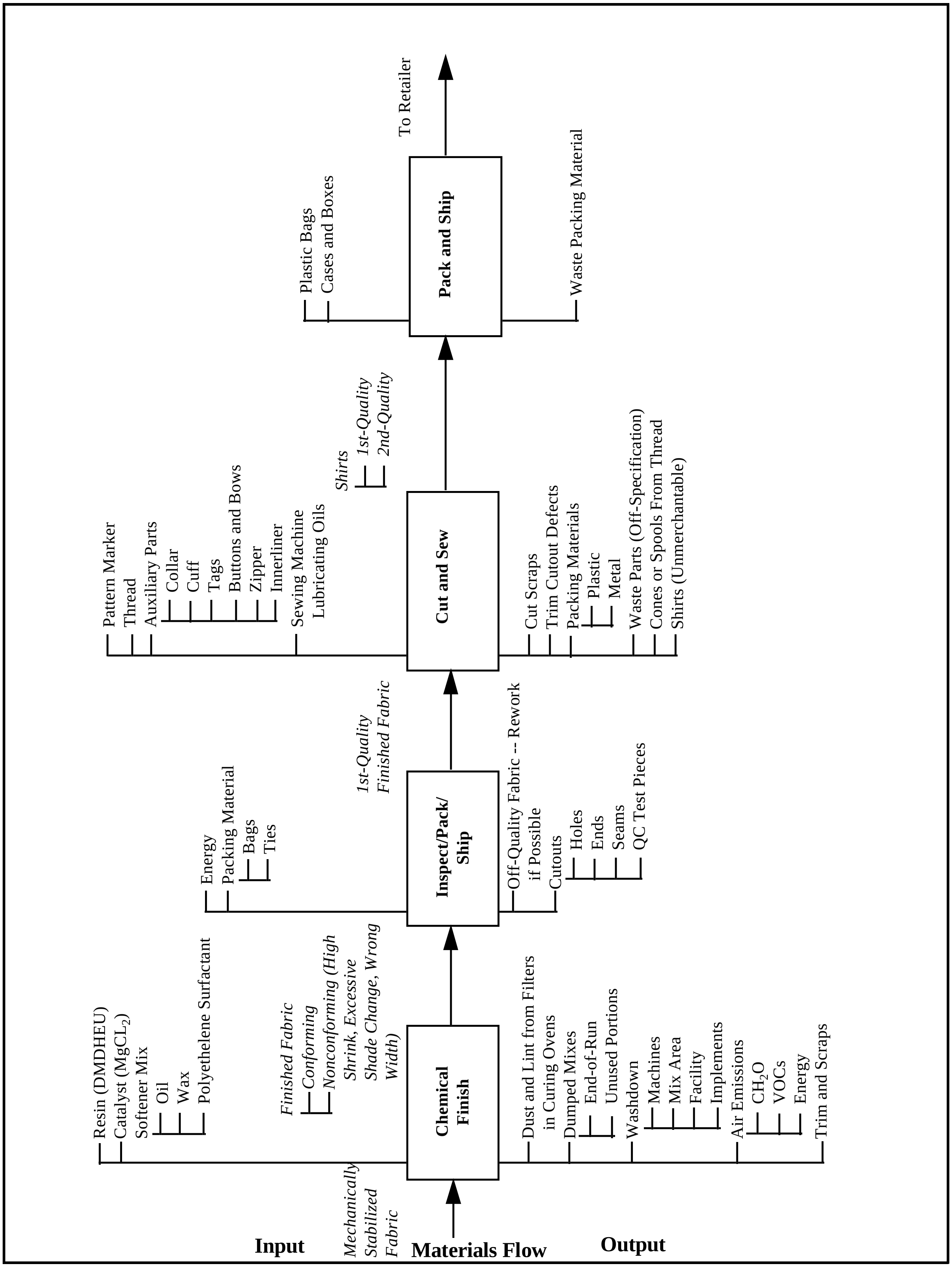
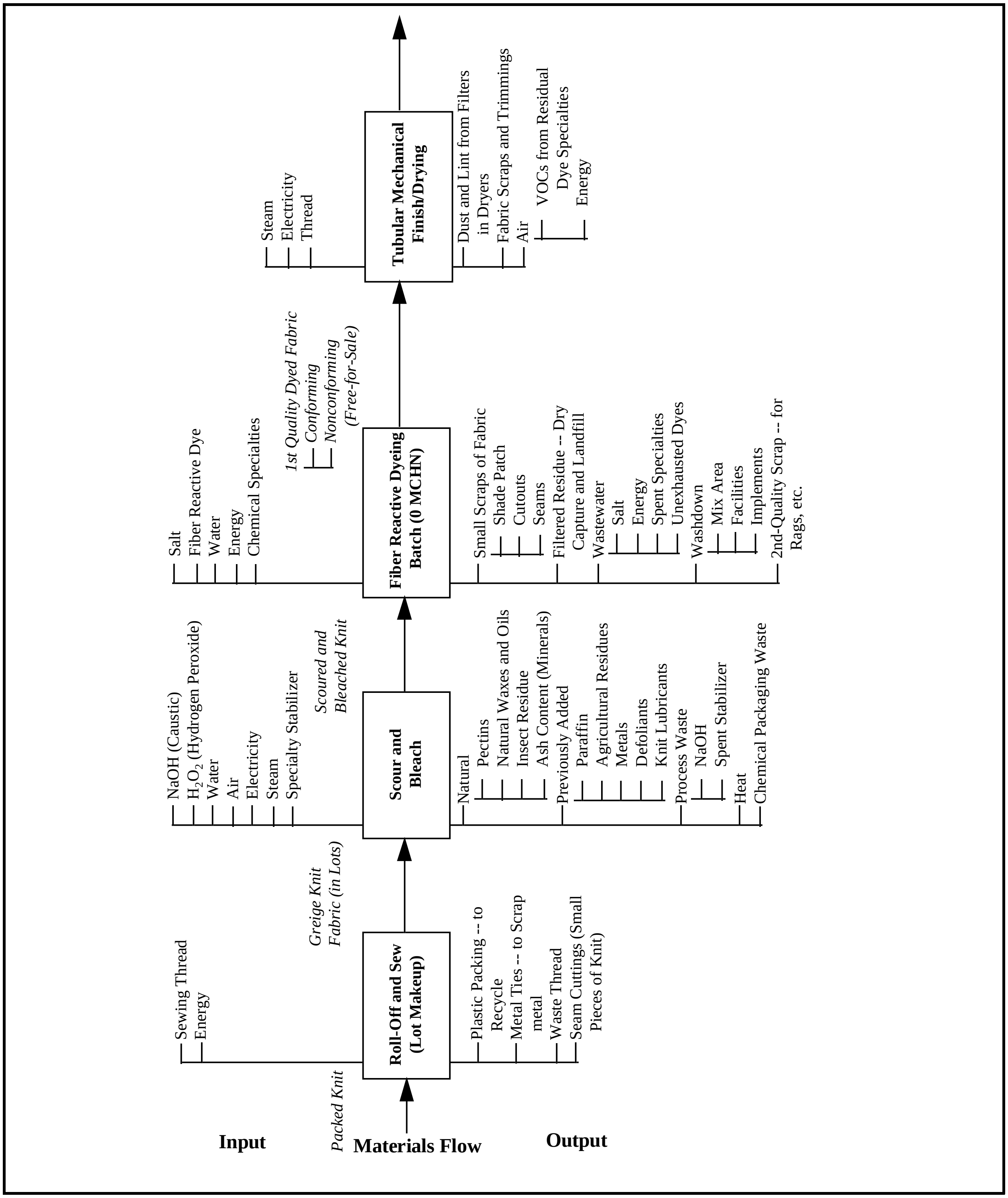


Figure 12 (cont.): Materials Flow for a Cotton Knit Golf Shirt



Source: *Best Management Practices for Pollution Prevention in the Textile Industry*, EPA, Office of Research and Development, 1995

III.C. Management of Chemicals in the Production Process

The Pollution Prevention Act of 1990 (PPA) requires facilities to report information about the management of Toxics Release Inventory (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 1994-1997 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. Background information on TRI and its limitations is presented in Section IV.

While the quantities reported for 1994 and 1995 are estimates of quantities already managed, the quantities reported for 1996 and 1997 are projections only. The PPA 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.

Table 9 shows that the TRI reporting textiles facilities managed about 57.6 million pounds of production related wastes (total quantity of TRI chemicals in the waste from routine production operations in column B) in 1995. From the yearly data in column B, it is apparent that the total quantities of production related TRI wastes increased by less than one percent between 1994 and 1995 and are projected to decrease by five percent between 1995 and 1997. Values in column C are intended to reveal the percentage of TRI chemicals that are either transferred off-site or released to the environment. Column C is calculated by dividing the total TRI transfers and releases (reported in Sections 5 and 6 of the TRI Form R) by the total quantity of production-related waste (reported in Section 8). The textile industry is expected to lower the percentage of TRI chemicals transferred off-site or released to the environment by six percent between 1995 and 1997.

The data indicate that about 57 percent of the TRI wastes were managed onsite through recycling, energy recovery, or treatment (columns D, E, and F, respectively) in 1995. About 11 percent of the wastes were managed off-site. The remaining portion of TRI chemical wastes (about 33 percent), shown in column J, were released to the environment through direct discharges to air, land, water, and underground injection, or were disposed off-site. The overall portion of wastes managed onsite (columns G, H, and I) is expected to increase by five percent between 1995 and 1996 and eight percent between 1995 and 1997. The overall portion of wastes managed off-site (columns D, E, and F) change very little from year to year.

Table 9: Source Reduction and Recycling Activity for the Textile Industry (SIC 22) as Reported within TRI

A	B	C	On-Site			Off-Site			J
			D	E	F	G	H	I	
Year	Quantity of Production-Related Waste (10^6 lbs.)[a]	% Released and Transferred[b]	% Recycled	% Energy Recovery	% Treated	% Recycled	% Energy Recovery	% Treated	% Released and Disposed Off-Site[c]
1994	57.1	7.7	23.6%	7.2%	24.0%	1.4%	3.1%	6.0%	34.9%
1995	57.6	43.0	18.6%	8.6%	30.0%	1.4%	3.6%	6.2%	33.0%
1996	55.2	N/A	21.6%	9.0%	31.2%	1.8%	2.6%	5.4%	28.3%
1997	54.5	N/A	22.3%	9.6%	30.8%	2.9%	2.3%	5.4%	26.9%

Source: *Toxics Release Inventory Database, 1995.*

[a] Within this industry sector, non-production related waste was < 1% of production related wastes for 1995.

[b] Total TRI transfers and releases as reported in Section 5 and 6 of Form R as a percentage of production related wastes.

[c] Percentage of production related waste released to the environment and transferred off-site for disposal.

IV. CHEMICAL RELEASE AND TRANSFER PROFILE

This section is designed to provide background information on the pollutant releases that are reported by this industry. The best source of comparative pollutant release information is the Toxic Release Inventory (TRI). Pursuant to the Emergency Planning and Community Right-to-Know Act, TRI includes self-reported facility release and transfer data for over 600 toxic chemicals. Facilities within SIC Codes 20 through 39 (manufacturing industries) that have more than 10 employees, and that are above weight-based reporting thresholds are required to report TRI on-site releases and off-site transfers. The information presented within the sector notebooks is derived from the most recently available (1995) TRI reporting year (which includes over 600 chemicals), and focuses primarily on the on-site releases reported by each sector. Because TRI requires consistent reporting regardless of sector, it is an excellent tool for drawing comparisons across industries. TRI data provide the type, amount and media receptor of each chemical released or transferred.

Although this sector notebook does not present historical information regarding TRI chemical releases over time, please note that in general, toxic chemical releases have been declining. In fact, according to the 1995 Toxic Release Inventory Public Data Release, reported onsite releases of toxic chemicals to the environment decreased by 5 percent (85.4 million pounds) between 1994 and 1995 (not including chemicals added and removed from the TRI chemical list during this period). Reported releases dropped by 46 percent between 1988 and 1995. Reported transfers of TRI chemicals to off-site locations increased by 0.4 percent (11.6 million pounds) between 1994 and 1995. More detailed information can be obtained from EPA's annual Toxics Release Inventory Public Data Release book (which is available through the EPCRA Hotline at 800-535-0202), or directly from the Toxic Release Inventory System database (for user support call 202-260-1531).

Wherever possible, the sector notebooks present TRI data as the primary indicator of chemical release within each industrial category. TRI data provide the type, amount and media receptor of each chemical released or transferred. When other sources of pollutant release data have been obtained, these data have been included to augment the TRI information.

TRI Data Limitations

Certain limitations exist regarding TRI data. Release and transfer reporting are limited to the approximately 600 chemicals on the TRI list. Therefore, a large portion of the emissions from industrial facilities are not captured by TRI. Within some sectors, (e.g. dry cleaning, printing and transportation equipment cleaning) the majority of facilities are not subject to TRI reporting because they are not considered manufacturing industries, or because they are below TRI reporting thresholds. For these sectors, release information from other

streams as found in stacks, vents, ducts, or pipes. Fugitive emissions include equipment leaks, evaporative losses from surface impoundments and spills, and releases from building ventilation systems.

Releases to Water (Surface Water Discharges) -- encompass any releases going directly to streams, rivers, lakes, oceans, or other bodies of water. Releases due to runoff, including storm water runoff, are also reportable to TRI.

Releases to Land -- occur within the boundaries of the reporting facility. Releases to land include disposal of toxic chemicals in landfills, land treatment/application farming, surface impoundments, and other land disposal methods (such as spills, leaks, or waste piles).

Underground Injection -- is a contained release of a fluid into a subsurface well for the purpose of waste disposal. Wastes containing TRI chemicals are injected into either Class I wells or Class V wells. Class I wells are used to inject liquid hazardous wastes or dispose of industrial and municipal wastewaters beneath the lowermost underground source of drinking water. Class V wells are generally used to inject non-hazardous fluid into or above an underground source of drinking water. TRI reporting does not currently distinguish between these two types of wells, although there are important differences in environmental impact between these two methods of injection.

TRANSFERS -- is a transfer of toxic chemicals in wastes to a facility that is geographically or physically separate from the facility reporting under TRI. Chemicals reported to TRI as transferred are sent to off-site facilities for the purpose of recycling, energy recovery, treatment, or disposal. The quantities reported represent a movement of the chemical away from the reporting facility. Except for off-site transfers for disposal, the reported quantities do not necessarily represent entry of the chemical into the environment.

Transfers to POTWs -- are wastewater transferred through pipes or sewers to a publicly owned treatments works (POTW). Treatment or removal of a chemical from the wastewater depend on the nature of the chemical, as well as the treatment methods present at the POTW. Not all TRI chemicals can be treated or removed by a POTW. Some chemicals, such as metals, may be removed, but are not destroyed and may be disposed of in landfills or discharged to receiving waters.

Transfers to Recycling -- are sent off-site for the purposes of regenerating or recovery by a variety of recycling methods, including solvent recovery, metals recovery, and acid regeneration. Once these chemicals have been recycled, they may be returned to the originating facility or sold commercially.

Transfers to Energy Recovery -- are wastes combusted off-site in industrial furnaces for energy recovery. Treatment of a chemical by incineration is not considered to be energy recovery.

Transfers to Treatment -- are wastes moved off-site to be treated through a variety of methods, including neutralization, incineration, biological destruction, or physical separation. In some cases, the chemicals are not destroyed but prepared for further waste management.

Transfers to Disposal -- are wastes taken to another facility for disposal generally as a release to land or as an injection underground.

IV.A. EPA Toxic Release Inventory for the Textile Industry

According to the 1995 Toxics Release Inventory (TRI) data, 339 textile facilities reporting SIC 22, released (to the air, water, or land) and transferred (shipped off-site or discharged to sewers) a total of 25 million pounds of toxic chemicals during calendar year 1995. This represents approximately 0.4 percent of the 5.7 billion pounds of releases and transfers from all manufacturers (SICs 20-39) reporting to TRI that year.

The releases and transfers are dominated by large volumes of solvents which are used extensively in coating textile materials with plastic and other synthetic materials. The top three chemicals released by volume are methyl ethyl ketone (MEK), toluene, and methanol. These three account for about 64 percent (11.4 million pounds) of the industry’s total releases.

Evidence of the diversity of processes at textile facilities reporting to TRI is found in the fact that the most frequently reported chemicals, methanol and ammonia, account for only 18 percent of the total number of chemicals reported by all 338 textile facilities that report to TRI. Over half of the chemicals are reported by fewer than ten facilities. The variability in facilities’ TRI chemical profiles may be attributed to the variety of processes and products in the industry.

Releases

Table 10 presents the number and volumes of chemicals released by textile manufacturing facilities reporting SIC 22, in 1995. The total volume of releases was 17.8 million pounds or 72 percent of the total volume of chemicals reported to TRI by the textile industry (i.e. releases and transfers). The top five chemicals released by this industry, in terms of volumes, include: MEK, toluene, methanol, ammonia, and xylenes (mixed isomers). The very volatile nature of these chemicals is apparent in the fact that about 98 percent

(17.5 million pounds) of the industry's releases are to the air. About 76 percent (13.6 million pounds) of all the chemicals released by the textile industry were released to air in the form of point source emissions. Another 22 percent (3.9 million pounds) were released as fugitive emissions. The remaining two percent (276,000 pounds) were released in the form of water discharges or disposals to land. Because the majority of TRI releases are in the form of air emissions, these data indicate that the large amount of wastewater discharged from textile facilities contain dilute amounts of TRI chemicals.

Transfers

Table 11 presents the number and volumes of chemicals transferred by textile manufacturing facilities reporting SIC 22, in 1995. The total volume of transfers was 7.0 million pounds or 28 percent of the total volume of chemicals reported to TRI by the textile industry (i.e. releases and transfers). Transfers to POTWs accounted for the largest amount, 40 percent, (2.8 million pounds). About 30 percent (2.1 million pounds) was transferred for either disposal, recycling, or treatment and the remaining 30 percent (2.1 million pounds) was transferred for energy recovery. Three chemicals (MEK, toluene, and ammonia) accounted for about 38 percent of the 7.0 million pounds of total transfers for this industry.

Table 10: 1995 TRI Releases for Textiles Manufacturing Facilities (SIC 22), by Number of Facilities Reporting (in pounds/year)

CHEMICAL NAME	# REPORTING CHEMICAL	FUGITIVE AIR	POINT AIR	WATER DISCHARGES	UNDERGROUND INJECTION	LAND DISPOSAL	TOTAL RELEASES	AVG. RELEASES PER FACILITY
METHANOL	64	212,358	2,717,312	1,764	0	0	2,931,434	45,804
AMMONIA	51	137,047	1,201,243	6,911	0	0	1,345,201	26,376
METHYL ETHYL KETONE	37	1,469,884	3,450,185	250	0	1	4,920,320	132,982
TOLUENE	33	588,915	2,918,775	5	0	1	3,507,696	106,294
PHOSPHORIC ACID	32	2,503	48,496	250	0	0	51,249	1,602
CHLORINE	31	13,885	20,523	11,908	0	0	46,316	1,494
ANTIMONY COMPOUNDS	30	322	1,065	1,067	0	250	2,704	90
DECABROMODIPHENYL OXIDE	26	206	1,075	1,860	0	1,754	4,895	188
ETHYLENE GLYCOL	23	5,705	131,720	9,102	0	286	146,813	6,383
CERTAIN GLYCOL ETHERS	21	20,329	166,765	18,651	0	0	205,745	9,797
CHROMIUM COMPOUNDS	20	15	18	2,712	0	1,811	4,556	228
ZINC COMPOUNDS	20	2,645	6,196	480	0	5	9,326	466
1,1,1-TRICHLOROETHANE	19	324,499	11,580	0	0	0	336,079	17,688
COPPER COMPOUNDS	18	2,199	181	10,908	0	2,789	16,077	893
FORMALDEHYDE	18	2,110	66,144	92	0	0	68,346	3,797
XYLENE (MIXED ISOMERS)	18	103,961	740,907	750	0	0	845,618	46,979
HYDROCHLORIC ACID (1995 AND AFTER "ACID AEROSOLS" ONLY)	17	4,451	171,436	250	0	5	176,142	10,361
SULFURIC ACID	15	250	250	0	0	0	500	33
DIISOCYANATES	11	1,818	1,676	0	0	0	3,494	318
N,N-DIMETHYLFORMAMIDE	11	60,816	56,263	0	0	0	117,079	10,644
BIPHENYL	11	6,935	147,813	762	0	0	155,510	14,137
N-METHYL-2-PYRROLIDONE	10	65,640	324,632	34	0	0	390,306	39,031
SODIUM NITRITE	9	19,033	18,005	0	0	0	37,038	4,115
BARIUM COMPOUNDS	8	10	10	5	0	0	25	3
TRICHLOROETHYLENE	8	40,980	241,477	0	0	0	282,457	35,307
1,2,4-TRIMETHYLBENZENE	8	6,704	44,108	3,005	0	0	53,817	6,727
NITRATE COMPOUNDS	7	0	0	187,450	0	0	187,450	26,779
FORMIC ACID	7	15,113	4,178	0	0	0	19,291	2,756
DICHLOROMETHANE	7	79,576	434,986	0	0	1	514,563	73,509
METHYL ISOBUTYL KETONE	7	84,572	331,139	0	0	0	415,711	59,387
PHENOL	6	6,189	86,482	0	0	0	92,671	15,445

Table 10 (cont.): 1995 TRI Releases for Textiles Manufacturing Facilities (SIC 22), by Number of Facilities Reporting (in pounds/year)

CHEMICAL NAME	# REPORTING CHEMICAL	FUGITIVE AIR	POINT AIR	WATER DISCHARGES	UNDERGROUND INJECTION	LAND DISPOSAL	TOTAL RELEASES	AVG. RELEASES PER FACILITY
1,2,4-TRICHLOROBENZENE	6	7,416	38,623	189	0	0	46,228	7,705
ANTIMONY	6	50	34	0	0	0	84	14
LEAD COMPOUNDS	4	5	5	5	0	0	15	4
TETRACHLOROETHYLENE	4	5,818	58,166	0	0	0	63,984	15,996
COPPER	4	0	0	0	0	0	0	0
COBALT COMPOUNDS	3	0	10	590	0	0	600	200
STYRENE	3	63,553	47,181	0	0	0	110,734	36,911
DIETHANOLAMINE	3	0	5,696	150	0	0	5,846	1,949
DI(2-ETHYLHEXYL) PHTHALATE	3	0	799	0	0	0	799	266
ARSENIC COMPOUNDS	2	0	0	0	0	0	0	0
NICKEL COMPOUNDS	2	0	0	0	0	0	0	0
ISOPROPYL ALCOHOL (MANUFACTURING, STRONG-ACID PROCESS ONLY, NO SUPPLIE	2	12,129	13,155	0	0	0	25,284	12,642
NAPHTHALENE	2	173	8,600	7,800	0	0	16,573	8,287
PROPYLENE	2	0	0	0	0	0	0	0
DIMETHYL PHTHALATE	2	0	2,708	0	0	0	2,708	1,354
LEAD	2	5	5	0	0	0	10	5
CHLORINE DIOXIDE	2	5,141	0	0	0	0	5,141	2,571
CADMIUM COMPOUNDS	1	0	0	0	0	0	0	0
THIOUREA	1	0	0	0	0	0	0	0
N-BUTYL ALCOHOL	1	0	50	1,900	0	0	1,950	1,950
HYDROGEN CYANIDE	1	250	2,566	0	0	0	2,816	2,816
VINYL CHLORIDE	1	5	5	0	0	0	10	10
ACETALDEHYDE	1	0	13,400	0	0	0	13,400	13,400
TRICHLOROFLUOROMETHANE	1	250	0	0	0	0	250	250
FREON 113	1	18,507	0	0	0	0	18,507	18,507
METHYL METHACRYLATE	1	454	1,816	0	0	0	2,270	2,270
DIBUTYL PHTHALATE	1	40	46	0	0	0	86	86
2-PHENYLPHENOL	1	0	26,240	0	0	0	26,240	26,240
ACETOPHENONE	1	0	0	0	0	0	0	0
1,4-DICHLOROBENZENE	1	14,665	0	0	0	0	14,665	14,665

Table 10 (cont.): 1995 TRI Releases for Textiles Manufacturing Facilities (SIC 22), by Number of Facilities Reporting (in pounds/year)

CHEMICAL NAME	# REPORTING CHEMICAL	FUGITIVE AIR	POINT AIR	WATER DISCHARGES	UNDERGROUND INJECTION	LAND DISPOSAL	TOTAL RELEASES	AVG. RELEASES PER FACILITY
1,2-DICHLOROETHANE	1	0	8,935	0	0	0	8,935	8,935
MALEIC ANHYDRIDE	1	0	0	0	0	0	0	0
2-METHOXYETHANOL	1	3,200	750	0	0	0	3,950	3,950
N-HEXANE	1	130,000	658	0	0	0	130,658	130,658
2-ETHOXYETHANOL	1	4,800	900	0	0	0	5,700	5,700
FOLPET	1	0	0	0	0	0	0	0
C.I. BASIC GREEN 4	1	0	0	0	0	0	0	0
TOLUENE-2,4-DIISOCYANATE	1	0	0	0	0	0	0	0
MOLYBDENUM TRIOXIDE	1	750	250	0	0	0	1,000	1,000
POLYCHLORINATED BIPHENYLS	1	0	0	0	0	0	0	0
1,1-DICHLORO-1-FLUOROETHANE	1	367,120	0	0	0	0	367,120	367,120
C.I. DISPERSE YELLOW 3	1	349	0	0	0	0	349	349
NICKEL	1	18	0	0	0	0	18	18
BARIUM	1	0	0	0	0	0	0	0
CHROMIUM	1	0	0	0	0	0	0	0
	339	3,913,368	13,575,488	268,850	0	6,903	17,764,609	52,403

Table 11: 1995 TRI Transfers for Textiles Manufacturing Facilities (SIC 22), by Number and Facilities Reporting (in pounds/year)

CHEMICAL NAME	# REPORTING CHEMICAL	POTW TRANSFERS	DISPOSAL TRANSFERS	RECYCLING TRANSFERS	TREATMENT TRANSFERS	ENERGY RECOVERY TRANSFERS	TOTAL TRANSFERS	AVG TRANSFER PER FACILITY
METHANOL	64	110,082	0	18,123	6,111	135,698	270,014	4,219
AMMONIA	51	517,662	3,849	.	1,548	2,780	525,839	10,311
METHYL ETHYL KETONE	37	4,550	27,000	280,256	324,111	775,448	1,411,365	38,145
TOLUENE	33	505	32,650	250	52,351	646,897	732,653	22,202
PHOSPHORIC ACID	32	184,990	.	.	25,329	.	210,319	6,572
CHLORINE	31	27,891	0	.	.	.	27,891	900
ANTIMONY COMPOUNDS	30	72,575	120,995	750	26,401	5,761	226,482	7,549
DECABROMODIPHENYL OXIDE	26	243,056	55,546	1,993	5,434	3,300	309,329	11,897
ETHYLENE GLYCOL	23	428,068	38,000	.	.	.	466,068	20,264
CERTAIN GLYCOL ETHERS	21	192,060	14	.	.	9,890	201,964	9,617
CHROMIUM COMPOUNDS	20	52,996	3,828	750	4,615	.	62,189	3,109
ZINC COMPOUNDS	20	60,950	91,231	6,830	7,787	1,213	168,011	8,401
1,1,1-TRICHLOROETHANE	19	0	.	614	.	3,922	4,536	239
COPPER COMPOUNDS	18	18,683	9,482	2,376	1,421	.	31,962	1,776
FORMALDEHYDE	18	5,947	251	.	5,797	121	12,116	673
XYLENE (MIXED ISOMERS)	18	58,600	.	4,800	40,755	43,330	147,485	8,194
HYDROCHLORIC ACID (1995 AND AFTER "ACID AEROSOLS" ONLY)	17	66,613	50,920	.	129,493	.	247,026	14,531
SULFURIC ACID	15	1,585	.	.	29,994	.	31,579	2,105
DIISOCYANATES	11	0	1,300	3	386	.	1,689	154
N,N-DIMETHYLFORMAMIDE	11	11,123	291	.	3,403	100,913	115,730	10,521
BIPHENYL	11	239,361	.	.	.	.	239,361	21,760
N-METHYL-2-PYRROLIDONE	10	250	1,300	72,767	13,140	94,915	182,372	18,237
SODIUM NITRITE	9	128,764	.	.	.	.	128,764	14,307
BARIUM COMPOUNDS	8	10	36,652	.	500	2,403	39,565	4,946
TRICHLOROETHYLENE	8	10	2,910	326,000	3,000	49,934	381,854	47,732
1,2,4-TRIMETHYLBENZENE	8	44,335	1,274	.	.	.	45,609	5,701
NITRATE COMPOUNDS	7	59,671	9,332	.	.	.	69,003	9,858
FORMIC ACID	7	593	.	.	.	.	593	85
DICHLOROMETHANE	7	5	.	240	5	18,849	19,099	2,728
METHYL ISOBUTYL KETONE	7	500	3,600	250	1,359	128,668	134,377	19,197
PHENOL	6	0	1,566	.	459	21,841	23,866	3,978

Table 11 (cont.): 1995 TRI Transfers for Textiles Manufacturing Facilities (SIC 22), by Number and Facilities Reporting (in pounds/year)

CHEMICAL NAME	# REPORTING CHEMICAL	POTW TRANSFERS	DISPOSAL TRANSFERS	RECYCLING TRANSFERS	TREATMENT TRANSFERS	ENERGY RECOVERY TRANSFERS	TOTAL TRANSFERS	AVG TRANSFER PER FACILITY
1,2,4-TRICHLOROBENZENE	6	80,552	31,898	.	.	.	112,450	18,742
ANTIMONY	6	20,627	18,162	1,489	1,258	230	41,766	6,961
LEAD COMPOUNDS	4	257	12,450	79,500	1,010	.	93,217	23,304
TETRACHLOROETHYLENE	4	10,928	2,340	.	45,327	.	58,595	14,649
COPPER	4	1,735	.	.	.	.	1,735	434
COBALT COMPOUNDS	3	858	907	.	.	.	1,765	588
STYRENE	3	0	.	.	177	.	177	59
DIETHANOLAMINE	3	39,979	.	.	133	.	40,112	13,371
DI(2-ETHYLHEXYL) PHTHALATE	3	4,500	.	.	.	19,200	23,700	7,900
ARSENIC COMPOUNDS	2	0	216	.	5	.	221	111
NICKEL COMPOUNDS	2	508	.	.	.	.	508	254
ISOPROPYL ALCOHOL (MANUFACTURING, STRONG-ACID PROCESS ONLY, NO SUPPLIE	2	1,916	.	.	.	.	1,916	958
NAPHTHALENE	2	0	.	.	.	.	0	0
PROPYLENE	2	0	.	.	.	.	0	0
DIMETHYL PHTHALATE	2	51,441	.	.	.	.	51,441	25,721
LEAD	2	5	2,758	.	.	458	3,221	1,611
CHLORINE DIOXIDE	2	0	.	.	.	.	0	0
CADMIUM COMPOUNDS	1	0	250	.	.	.	250	250
THIOUREA	1	0	.	.	.	.	0	0
N-BUTYL ALCOHOL	1	0	.	.	.	.	0	0
HYDROGEN CYANIDE	1	0	.	.	.	.	0	0
VINYL CHLORIDE	1	0	15,167	.	.	2,518	17,685	17,685
ACETALDEHYDE	1	30,600	.	.	.	.	30,600	30,600
TRICHLOROFLUOROMETHANE	1	0	.	.	.	.	0	0
FREON 113	1	0	.	.	.	.	0	0
METHYL METHACRYLATE	1	0	.	.	.	.	0	0
DIBUTYL PHTHALATE	1	0	1,875	.	.	3,020	4,895	4,895
2-PHENYLPHENOL	1	0	.	.	.	.	0	0
ACETOPHENONE	1	18,233	.	.	.	.	18,233	18,233
1,4-DICHLOROBENZENE	1	0	.	.	.	.	0	0

Table 11 (cont.): 1995 TRI Transfers for Textiles Manufacturing Facilities (SIC 22), by Number and Facilities Reporting (in pounds/year)

CHEMICAL NAME	# REPORTING CHEMICAL	POTW TRANSFERS	DISPOSAL TRANSFERS	RECYCLING TRANSFERS	TREATMENT TRANSFERS	ENERGY RECOVERY TRANSFERS	TOTAL TRANSFERS	AVG TRANSFER PER FACILITY
1,2-DICHLOROETHANE	1	7,659	.	.	.	.	7,659	7,659
MALEIC ANHYDRIDE	1	7,530	.	.	.	.	7,530	7,530
2-METHOXYETHANOL	1	0	.	.	.	.	0	0
N-HEXANE	1	0	.	.	.	.	0	0
2-ETHOXYETHANOL	1	0	.	.	.	.	0	0
FOLPET	1	0	1,300	.	.	.	1,300	1,300
C.I. BASIC GREEN 4	1	0	.	.	.	.	0	0
TOLUENE-2,4-DIISOCYANATE	1	0	.	.	5	.	5	5
MOLYBDENUM TRIOXIDE	1	0	2,300	.	.	.	2,300	2,300
POLYCHLORINATED BIPHENYLS	1	0	.	.	.	.	0	0
1,1-DICHLORO-1-FLUOROETHANE	1	0	.	.	.	.	0	0
C.I. DISPERSE YELLOW 3	1	5,189	.	.	.	.	5,189	5,189
NICKEL	1	0	120	.	.	.	120	120
BARIUM	1	5	.	750	10	.	765	765
CHROMIUM	1	1,602	.	.	.	.	1,602	1,602
	339	2,815,559	581,734	797,741	731,324	2,071,309	6,997,667	20,642

The TRI database contains a detailed compilation of self-reported, facility-specific chemical releases. The top reporting facilities for this sector, based on pounds released, are listed below (Table 12). Facilities that have reported only the SIC codes covered under this notebook appear on the first list. Table 13 contains additional facilities that have reported only the SIC codes covered within this report, or facilities that have reported SIC codes covered within this notebook and one or more SIC codes that are not within the scope of this notebook. Therefore, the second list includes facilities that conduct multiple operations -- some that are under the scope of this notebook, and some that may not. Currently, the facility-level data do not allow pollutant releases to be broken apart by industrial process.

Table 12: Top 10 TRI Releasing Textile Manufacturing Facilities Reporting Only SIC 22[1]

Rank	Facility	Total Releases in Pounds
1	Gencorp, Columbus, MS*	2,761,015
2	Holliston Mills Inc., Church Hill, TN	1,755,090
3	Avondale Mills, Inc., Graniteville, SC	1,260,050
4	American & Efird Inc., Mount Holly, NC	1,070,442
5	Uniroyal Engineered Products, Stoughton, WI*	758,023
6	Textileather Corporation, Toledo, OH*	520,890
7	Athol Corporation, Butner, NC*	421,229
8	Excello Fabric Finishers Inc., Coshocton, OH	414,000
9	Shaw Ind. Inc., Dalton, GA	412,873
10	Collins & Aikman Products Company, Farmville, NC	367,120
TOTAL		**9,740,732**

Source: *US Toxics Release Inventory Database, 1995.*

[1] Being included on this list does not mean that the releases are associated with non-compliance with environmental laws.

*This facility manufactures coated fabrics and is classified as SIC Code 2295, Miscellaneous Textiles, Coated Fabrics -- Not Rubberized.

Table 13: Top 10 TRI Releasing Facilities Reporting Only Textile Manufacturing SIC Codes (SIC 22) or SIC 22 and Other SIC Codes[1]

Rank	Facility	Total Releases in Pounds
1	Gencorp, Columbus, MS*	2,761,015
2	Holliston Mills Inc., Church Hill, TN*	1,755,090
3	Du Pont, Old Hickory, TN	1,737,853
4	IPC Corinth Div. Inc., Corinth, MS	1,479,471
5	Avondale Mills, Inc., Graniteville, SC	1,260,050
6	American & Efird Inc., Mount Holly, NC	1,070,442
7	E.R. Carpenter Co. Inc., Riverside, CA	896,755
8	Carpenter Co., Russellville, KY	877,660
9	Reeves Intl., Spartanburg, SC	855,355
10	Carpenter Co., Richmond, VA	799,567
TOTAL		**13,493,258**

Source: *US Toxics Release Inventory Database, 1995.*

[1] Being included on this list does not mean that the releases are associated with non-compliance with environmental laws.

*This facility manufactures coated fabrics and is classified as SIC Code 2295, Miscellaneous Textiles, Coated Fabrics -- Not Rubberized.

IV.B. Summary of Selected Chemicals Released

The following is a synopsis of current scientific toxicity and fate information for the top chemicals (by weight) that facilities within SIC 22 self-reported as released to the environment based upon 1994 TRI data. Because this section is based upon self-reported release data, it does not attempt to provide information on management practices employed by the sector to reduce the release of these chemicals.

Information regarding pollutant release reductions over time may be available from EPA's TRI and 33/50 programs, or directly from the industrial trade associations that are listed in Section IX of this document. Since these descriptions are cursory, please consult the sources referenced for a more detailed description of both the chemicals described in this section, and the chemicals that appear on the full list of TRI chemicals appearing in Section IV.C.

The brief descriptions provided below were taken from the *1994 Toxics Release Inventory Public Data Release* (EPA, 1994), the Hazardous Substances Data Bank (HSDB), and the Integrated Risk Information System (IRIS), both accessed via TOXNET.[1]

Ammonia[2] (CAS: 7664-41-7)

Sources. Ammonia is used in some printing, coating, preparation, and dyeing processes (ATMI, 1997b).

Toxicity. Anhydrous ammonia is irritating to the skin, eyes, nose, throat, and upper respiratory system.

---

[1] TOXNET is a computer system run by the National Library of Medicine that includes a number of toxicological databases managed by EPA, National Cancer Institute, and the National Institute for Occupational Safety and Health. For more information on TOXNET, contact the TOXNET help line at 800-231-3766. Databases included in TOXNET are: CCRIS (Chemical Carcinogenesis Research Information System), DART (Developmental and Reproductive Toxicity Database), DBIR (Directory of Biotechnology Information Resources), EMICBACK (Environmental Mutagen Information Center Backfile), GENE-TOX (Genetic Toxicology), HSDB (Hazardous Substances Data Bank), IRIS (Integrated Risk Information System), RTECS (Registry of Toxic Effects of Chemical Substances), and TRI (Toxic Chemical Release Inventory). HSDB contains chemical-specific information on manufacturing and use, chemical and physical properties, safety and handling, toxicity and biomedical effects, pharmacology, environmental fate and exposure potential, exposure standards and regulations, monitoring and analysis methods, and additional references.

[2] The reporting standards for ammonia were changed in 1995. Ammonium sulfate is deleted from the list and threshold and release determinations for aqueous ammonia are limited to 10 percent of the total ammonia present in solution. This change will reduce the amount of ammonia reported to TRI. Complete details of the revisions can be found in 40 CFR Part 372.

Ecologically, ammonia is a source of nitrogen (an essential element for aquatic plant growth), and may therefore contribute to eutrophication of standing or slow-moving surface water, particularly in nitrogen-limited waters such as the Chesapeake Bay. In addition, aqueous ammonia is moderately toxic to aquatic organisms.

Carcinogenicity. There is currently no evidence to suggest that this chemical is carcinogenic.

Environmental Fate. Ammonia is a corrosive and severely irritating gas with a pungent odor. Ammonia combines with sulfate ions in the atmosphere and is washed out by rainfall, resulting in rapid return of ammonia to the soil and surface waters.

Ammonia is a central compound in the environmental cycling of nitrogen. Ammonia in lakes, rivers, and streams is converted to nitrate.

Methanol (CAS: 67-56-1)

Sources. Methanol primarily arises from the use of PVA in sizing operations. It may also be emitted from finishing operations where methanol-etherated formaldehyde resins are used (ATMI, 1997b).

Toxicity. Methanol is readily absorbed from the gastrointestinal tract and the respiratory tract, and is toxic to humans in moderate to high doses. In the body, methanol is converted into formaldehyde and formic acid. Methanol is excreted as formic acid. Observed toxic effects at high dose levels generally include central nervous system damage and blindness. Long-term exposure to high levels of methanol via inhalation cause liver and blood damage in animals.

Ecologically, methanol is expected to have low toxicity to aquatic organisms. Concentrations lethal to half the organisms of a test population are expected to exceed one mg methanol per liter water. Methanol is not likely to persist in water or to bioaccumulate in aquatic organisms.

Carcinogenicity. There is currently no evidence to suggest that this chemical is carcinogenic.

Environmental Fate. Methanol is highly flammable and volatile. Liquid methanol is likely to evaporate when left exposed. Methanol reacts in air to produce formaldehyde which contributes to the formation of air pollutants. In the atmosphere it can react with other atmospheric chemicals or be washed out by rain. Methanol is readily degraded by microorganisms in soils and surface waters.

Methyl Ethyl Ketone (CAS: 78-93-3)

Sources. Methyl ethyl ketone may be used in solvent coating operations (ATMI, 1997b).

Toxicity. Breathing moderate amounts of methyl ethyl ketone (MEK) for short periods of time can cause adverse effects on the nervous system ranging from headaches, dizziness, nausea, and numbness in the fingers and toes, to unconsciousness. Its vapors are irritating to the skin, eyes, nose and throat, and can damage the eyes. Repeated exposure to moderate to high amounts may cause liver and kidney defects.

Carcinogenity. No agreement exists over the carcinogenity of MEK. One source believes MEK is a possible carcinogen to humans based on limited animal evidence. Other sources believe that there is insufficient evidence to make any statements about possible carcinogenicity.

Environmental Fate. Methyl ethyl ketone is a flammable and volatile liquid. Most of the MEK released to the environment will end up in the atmosphere. MEK can contribute to the formation of air pollutants in the lower atmosphere. It can be degraded by microorganisms living in water and soil.

Toluene (CAS: 108-88-3)

Sources. Toluene may be used in solvent coating operations (ATMI, 1997b).

Toxicity. Inhalation or ingestion of toluene can cause headaches, confusion, weakness, and memory loss. Toluene may also affect the way the kidneys and liver function.

Reactions of toluene (see environmental fate) in the atmosphere contribute to the formation of ozone in the lower atmosphere. Ozone can affect the respiratory system, especially in sensitive individuals such as asthma or allergy sufferers.

Some studies have shown that unborn animals were harmed when high levels of toluene were inhaled by their mothers, although the same effects were not seen when the mothers were fed large quantities of toluene. Note that these results may reflect similar difficulties in humans.

Carcinogenicity. There is currently no evidence to suggest that toluene is carcinogenic.

Environmental Fate. Toluene is a volatile organic chemical. A portion of releases of toluene to land and water will evaporate. Toluene may also be degraded by microorganisms. Once volatilized, toluene in the lower atmosphere will react with other atmospheric components contributing to the formation of ground-level ozone and other air pollutants.

Xylene (mixed isomers) *(CAS: 1330-20-7)*

Sources. Xylenes are used in printing operations.

Toxicity. Xylenes are rapidly absorbed into the body after inhalation, ingestion, or skin contact. Short-term exposure of humans to high levels of xylenes can cause irritation of the skin, eyes, nose, and throat, difficulty in breathing, impaired lung function, impaired memory, and possible changes in the liver and kidneys. Both short and long term exposure to high concentrations can cause effects such as headaches, dizziness, confusion, and lack of muscle coordination. Reactions of xylenes (see Environmental Fate) in the atmosphere contribute to the formation of ozone in the lower atmosphere. Ozone can effect the respiratory system, especially in sensitive individuals such as asthma or allergy sufferers.

Carcinogenity. There is currently no evidence to suggest that this chemical is carcinogenic.

Environmental Fate. Xylenes are volatile organic chemicals. As such, xylenes in the lower atmosphere will react with other atmospheric components, contributing to the formation of ground-level ozone and other air pollutants. The majority of releases to land and water will quickly evaporate, although some degradation by microorganisms will occur. Xylenes are moderately mobile in soils and may leach into groundwater, where they may persist for several years.

IV.C. Other Data Sources

The toxic chemical release data obtained from TRI captures only 7 percent of facilities in the textile industry. Reported chemicals are limited to the 316 reported chemicals. It allows, however, for a comparison across years and industry sectors. Most of the air emissions from textile facilities are not captured by TRI. The EPA Office of Air Quality Planning and Standards has compiled air pollutant emission factors for determining the total air emissions of priority pollutants (e.g., total hydrocarbons, SO_x, NO_x, CO, particulates, etc.) from many manufacturing sources.

The EPA Office of Air's database contains a wide range of information related to stationary sources of air pollution, including the emissions of a number of air pollutants which may be of concern within a particular industry. With the exception of volatile organic compounds (VOCs), there is little overlap with the TRI chemicals reported above. Table 14 summarizes annual releases of carbon monoxide (CO), nitrogen dioxide (NO_2), particulate matter of 10 microns or less (PM_{10}), total particulates (PT), sulfur dioxide (SO_2), and volatile organic compounds (VOCs).

Table 14: 1995 Criteria Air Pollutant Releases (tons/year)

Industry Sector	CO	NO_2	PM_{10}	PT	SO_2	VOC
Metal Mining	4,670	39,849	63,541	173,566	17,690	915
Nonmetal Mining	25,922	22,881	40,199	128,661	18,000	4,002
Lumber and Wood Production	122,061	38,042	20,456	64,650	9,401	55,983
Furniture and Fixtures	2,754	1,872	2,502	4,827	1,538	67,604
Pulp and Paper	566,883	358,675	35,030	111,210	493,313	127,809
Printing	8,755	3,542	405	1,198	1,684	103,018
Inorganic Chemicals	153,294	106,522	6,703	34,664	194,153	65,427
Organic Chemicals	112,410	187,400	14,596	16,053	176,115	180,350
Petroleum Refining	734,630	355,852	27,497	36,141	619,775	313,982
Rubber and Misc. Plastics	2,200	9,955	2,618	5,182	21,720	132,945
Stone, Clay and Concrete	105,059	340,639	192,962	662,233	308,534	34,337
Iron and Steel	1,386,461	153,607	83,938	87,939	232,347	83,882
Nonferrous Metals	214,243	31,136	10,403	24,654	253,538	11,058
Fabricated Metals	4,925	11,104	1,019	2,790	3,169	86,472
Electronics and Computers	356	1,501	224	385	741	4,866
Motor Vehicles, Bodies, Parts and Accessories	15,109	27,355	1,048	3,699	20,378	96,338
Dry Cleaning	102	184	3	27	155	7,441
Ground Transportation	128,625	550,551	2,569	5,489	8,417	104,824
Metal Casting	116,538	11,911	10,995	20,973	6,513	19,031
Pharmaceuticals	6,586	19,088	1,576	4,425	21,311	37,214
Plastic Resins and Manmade Fibers	16,388	41,771	2,218	7,546	67,546	74,138
Textiles	**8,177**	**34,523**	**2,028**	**9,479**	**43,050**	**27,768**
Power Generation	366,208	5,986,757	140,760	464,542	13,827,511	57,384
Ship Building and Repair	105	862	638	943	3,051	3,967

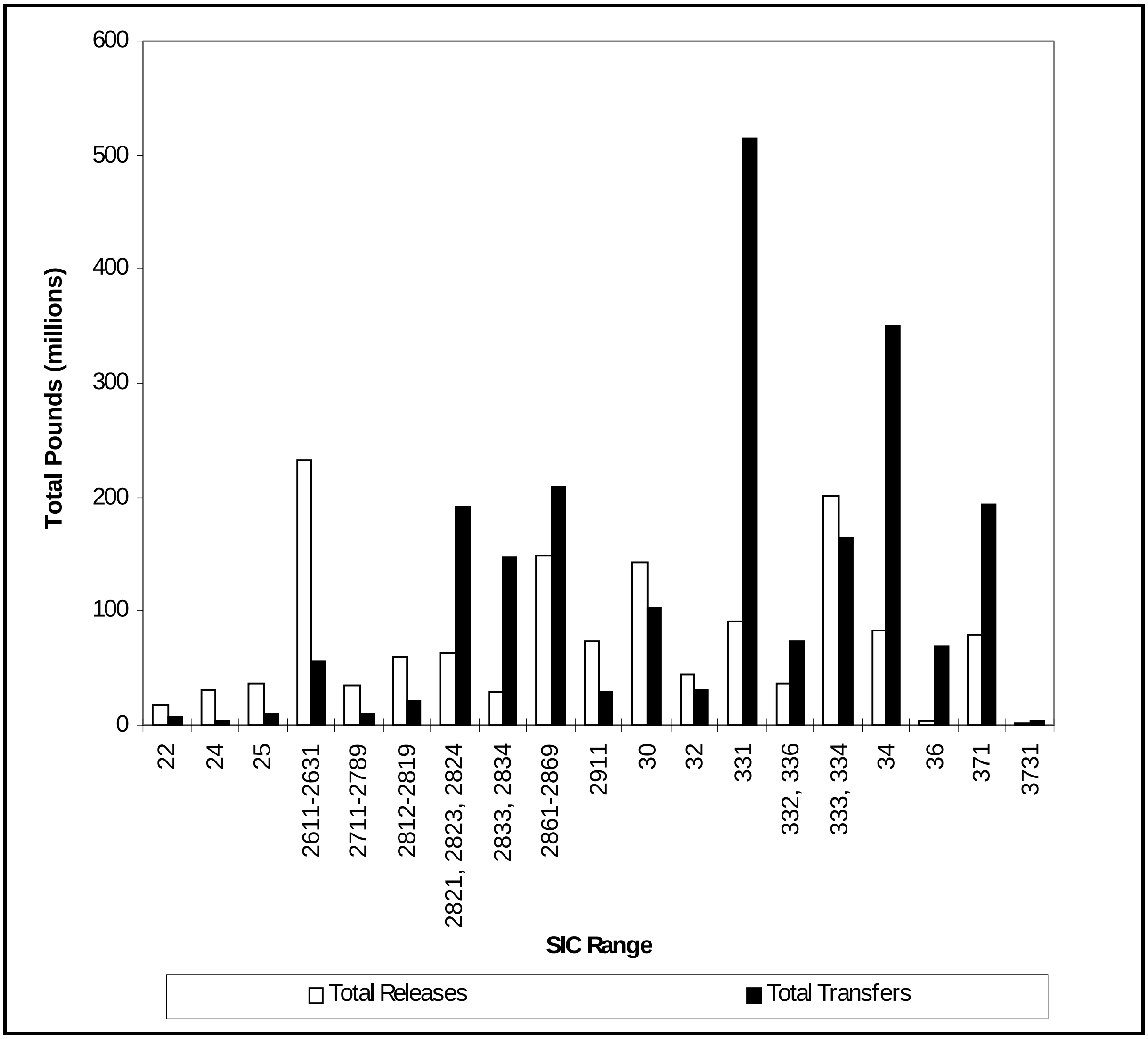
Source: U.S. EPA Office of Air and Radiation, AIRS Database, 1997.

IV.D. Comparison of Toxic Release Inventory Between Selected Industries

The following information is presented as a comparison of pollutant release and transfer data across industrial categories. It is provided to give a general sense as to the relative scale of releases and transfers within each sector profiled under this project. Please note that the following figure and table do not contain releases and transfers for industrial categories that are not included in this project, and thus cannot be used to draw conclusions regarding the total release and transfer amounts that are reported to TRI. Similar information is available within the annual TRI Public Data Release Book.

Figure 13 is a graphical representation of a summary of the 1995 TRI data for the textile industry and the other sectors profiled in separate notebooks. The bar graph presents the total TRI releases and total transfers on the vertical axis. The graph is based on the data in Table 15 and is meant to facilitate comparisons between the relative amounts of releases, transfers, and releases per facility both within and between these sectors. The reader should note, however, that differences in the proportion of facilities captured by TRI exist between industry sectors. This can be a factor of poor SIC matching and relative differences in the number of facilities reporting to TRI from the various sectors. In the case of the textile industry, the 1995 TRI data presented here covers 416 facilities. Only those facilities listing SIC Codes falling within SIC 22 were used.

Figure 13: Summary of TRI Releases and Transfers by Industry



Source: US EPA 1995 Toxics Release Inventory Database.

SIC Range	Industry Sector	SIC Range	Industry Sector	SIC Range	Industry Sector
22	**Textiles**	2833, 2834	Pharmaceuticals	333, 334	Nonferrous Metals
24	Lumber and Wood Products	2861-2869	Organic Chem. Mfg.	34	Fabricated Metals
25	Furniture and Fixtures	2911	Petroleum Refining	36	Electronic Equip. and Comp.
2611-2631	Pulp and Paper	30	Rubber and Misc. Plastics	371	Motor Vehicles, Bodies, Parts, and Accessories
2711-2789	Printing	32	Stone, Clay, and Concrete	3731	Shipbuilding
2812-2819	Inorganic Chemical Manufacturing	331	Iron and Steel		
2821, 2823, 2824	Resins and Plastics	332, 336	Metal Casting		

Table 15: Toxics Release Inventory Data for Selected Industries

Industry Sector	SIC Range	# TRI Facilities	TRI Releases		TRI Transfers		Total Releases +Transfers (million lbs.)	Average Releases + Transfers per Facility (pounds)
			Total Releases (million lbs.)	Ave. Releases per Facility (pounds)	Total Transfers (million lbs.)	Ave. Trans. per Facility (pounds)		
Textiles	**22**	**339**	**17.8**	**53,000**	**7.0**	**21,000**	**24.8**	**74,000**
Lumber and Wood Products	24	397	30.0	76,000	4.1	10,000	34.1	86,000
Furniture and Fixtures	25	336	37.6	112,000	9.9	29,000	47.5	141,000
Pulp and Paper	2611-2631	305	232.6	763,000	56.5	185,000	289.1	948,000
Printing	2711-2789	262	33.9	129,000	10.4	40,000	44.3	169,000
Inorganic Chem. Mfg.	2812-2819	413	60.7	468,000	21.7	191,000	438.5	659,000
Resins and Plastics	2821,2823, 2824	410	64.1	156,000	192.4	469,000	256.5	625,000
Pharmaceuticals	2833, 2834	200	29.9	150,000	147.2	736,000	177.1	886,000
Organic Chemical Mfg.	2861-2869	402	148.3	598,000	208.6	631,000	946.8	1,229,000
Petroleum Refining	2911	180	73.8	410,000	29.2	162,000	103.0	572,000
Rubber and Misc. Plastics	30	1,947	143.1	73,000	102.6	53,000	245.7	126,000
Stone, Clay, and Concrete	32	623	43.9	70,000	31.8	51,000	75.7	121,000
Iron and Steel	331	423	90.7	214,000	513.9	1,215,000	604.6	1,429,000
Metal Casting	332, 336	654	36.0	55,000	73.9	113,000	109.9	168,000
Nonferrous Metals	333, 334	282	201.7	715,000	164	582,000	365.7	1,297,000
Fabricated Metals	34	2,676	83.5	31,000	350.5	131,000	434.0	162,000
Electronic Equip. and Comp.	36	407	4.3	11,000	68.8	169,000	73.1	180,000
Motor Vehicles, Bodies, Parts, and Accessories	371	754	79.3	105,000	194	257,000	273.3	362,000
Shipbuilding	3731	43	2.4	56,000	4.1	95,000	6.5	151,000

Source: *US EPA Toxics Release Inventory Database, 1995.*

Page 74 intentionally left blank.

V. POLLUTION PREVENTION OPPORTUNITIES

The best way to reduce pollution is to prevent it in the first place. Some companies have creatively implemented pollution prevention techniques that improve efficiency and increase profits while at the same time minimizing environmental impacts. This can be done in many ways such as reducing material inputs, re-engineering processes to reuse by-products, improving management practices, and employing substitution of toxic chemicals. Some smaller facilities are able to actually get below regulatory thresholds just by reducing pollutant releases through aggressive pollution prevention policies.

The Pollution Prevention Act of 1990 established a national policy of managing waste through source reduction, which means preventing the generation of waste. The Pollution Prevention Act also established as national policy a hierarchy of waste management options for situations in which source reduction cannot be implemented feasibly. In the waste management hierarchy, if source reduction is not feasible the next alternative is recycling of wastes, followed by energy recovery, and waste treatment as a last alternative.

In order to encourage these approaches, this section provides both general and company-specific descriptions of some pollution prevention advances that have been implemented within the metal casting industry. While the list is not exhaustive, it does provide core information that can be used as the starting point for facilities interested in beginning their own pollution prevention projects. This section provides summary information from activities that may be, or are being implemented by this sector. When possible, information is provided that gives the context in which the technique can be used effectively. Please note that the activities described in this section do not necessarily apply to all facilities that fall within this sector. Facility-specific conditions must be carefully considered when pollution prevention options are evaluated, and the full impacts of the change must examine how each option affects air, land and water pollutant releases.

Most of the pollution prevention activities in the textile industry have focused on reducing chemical use, reusing process water, and reducing all solid waste forms - pallets, cardboard, etc (ATMI, 1997b). This section describes some of the pollution prevention opportunities for textile facilities. Much of the following section is based upon *"Best Management Practices for Pollution Prevention in the Textile Industry,"* by the U.S. EPA Office of Research and Development. Most case studies, unless noted, were taken from this document. Additional references are cited in the text.

V.A. Quality Control for Raw Materials

Raw material quality control programs can be implemented by establishing specific and appropriate purchasing, packaging, and inventory control policies to prevent the ordering and use of untested materials. Textile companies can reduce waste by working with suppliers to come up with less-polluting raw materials and by developing purchasing codes that commit companies to using less-polluting raw materials.

Benefits of such programs can include decreased production of off-quality goods, less rework, and increased product consistency. Companies can also control raw materials quality by prescreening and testing shipments as they are received. Prescreening provides facilities with opportunities to determine chemical and mechanical alternatives, proper chemical use and training, and proper disposal and treatment methods.

✔ ***Adopt environmentally responsible purchasing policies and work with suppliers to obtain less-polluting raw materials.***
Facilities can adopt purchasing policies that restrict the use of hazardous chemicals as a way to reduce waste. Facilities can also work with vendors to set acceptable guidelines for the purity and content of chemicals, like chemical specialties, which are typically of unknown composition to the textile mill.

- Mills in the United Kingdom adopted purchasing policies as a way to reduce pollution. Researchers determined that 70 percent of woolen mills in the United Kingdom emitted pentachlorophenol (PCP), a harmful agricultural residue in wool, from their finishing plants. A study determined that it originated in the incoming greige goods. By specifying in company purchasing policies that they would not accept PCP-containing greige goods, the presence of PCP in wastewater decreased by 50 percent. This was a good method of reducing this waste since there are no acceptable PCP treatment technologies (EPA, 1996).

- At its Monroe, North Carolina facility, *Bloomsburg Mills* scours, dyes, and finishes about 22 million yards of fabric per year. The facility uses dye carrier chemicals, such as tetrachloroethylene, biphenyl, and trichlorobenzene, to promote level dyeing. In an effort to reduce SARA III, Section 313 regulatory burdens (TRI reporting), *Bloomsburg Mills* discussed with vendors the elimination of these chemicals. The company substituted a dye carrier containing methyl naphthalene with non-photochemically reactive solvents. This dye carrier subsequently reduced the release of hazardous air pollutants by 91 percent from 64,713 pounds in 1988 to 5,932 pounds in 1993 (NC DEHNR, 1995).

✔ ***Perform tests on raw materials shortly after receipt.***
Prescreening raw materials can be used to determine interactions with processes, substrates, and other chemicals. This method can also be used to determine environmental effects, proper handling, and emergency procedures

for chemicals. This can enable the early detection of mislabeled drums and changes in the formulation of a chemical specialty, and reduce the occurrence of costly production mistakes stemming from untested chemicals being processed (NC DEHNR, 1986). Protocol for incoming chemical quality control may consist of the following steps: marking the date the container was opened; checking pH, viscosity, density, conductivity, and color; comparing data with previous history and vendor's standard values; entering data on a control chart for display; maintaining records; and reviewing data with the vendor. Environmental data that should be checked include whether the chemicals are listed as priority pollutants under the Clean Water Act, hazardous air pollutants under the Clean Air Act, and as 33/50 chemicals, the indoor air pollution hazard potential, and the potential for release to the environment.

- An example where raw material testing would have been useful involves a mill that used a solvent scouring chemical specialty. The manufacturer produced the chemical specialty, which consisted of emulsifier and xylene as a solvent. Without notifying its customers, the manufacturer changed the solvent composition to chlorotoluene to cut costs and minimize labeling requirements when the vendor's insurance company began to require special labeling and handling of xylene. This had a profound effect on the mill's air emissions, water toxicity, and other aspects of production. If the mill had prescreened chemical specialties, it could have detected these changes and reduced waste (NC DEHNR, 1986).

- A committee at a facility in Lumberton, North Carolina prescreened raw material (dyes and chemicals) to ensure that offensive-smelling, toxic, and other objectionable material use were minimized in the production facility. In the event that raw materials with undesirable properties had to be used due to lack of alternatives, these raw materials were identified to all workers before use. This process entailed no capital costs. Benefits, such as the ability to dispose of waste treatment sludges since they did not contain toxics or metals, were realized (NC DEHNR, 1986).

✔ ***Purchase raw materials in returnable containers.***

Facilities can work with vendors to ensure that packages can be returned without being cleaned on site. Offsite cleaning transfers chemical wastes back to the production facility, which may be better able to handle wastes. Chemical specialties should be purchased in returnable, reusable containers. Purchase of chemicals in bulk containers and intermediate bulk containers eliminates waste packing materials, and reduces spillage, handling costs, and worker exposure to chemicals. Bagged chemicals and drums tend to be more susceptible to damage and spills than bulk containers (EPA, 1996).

- At its Monroe, North Carolina facility, *Bloomsburg Mills* eliminated the disposal of 50 drums to the landfill each week by receiving and storing process chemicals in reusable totes and plastic drums (NC DEHNR, 1995).

- *Amital* began purchasing dyes and chemicals in intermediate bulk containers (IBCs) or in bulk. Drum disposal decreased by 69 per week, or about 3,500 annually. Pallet disposal decreased by 40 per week, or 2,000 annually. By making these changes, vendors were partners in the reduction of packaging waste.

V.B. Chemical Substitution

Since textile manufacturing is a chemically intensive process, a primary focus for pollution prevention should be on substituting less-polluting chemicals for textile process chemicals. Chemical substitution can eliminate chemical waste and the need for costly pollution control equipment. Opportunities for chemical substitution vary substantially among mills because of differences in environmental conditions, process conditions, product, and raw materials.

✔ ***Replace chemicals with less-polluting ones.***

By replacing solvents, facilities can reduce waste, reduce costs associated with treatment systems, and increase worker safety. This is one of the best methods to prevent pollution. Some textile chemicals that can be substituted include desizing agents, dyes, and auxiliaries. For instance, replacing enzymes with hydrogen peroxide to desize starch can be cost-effective (ATMI, 1997b). This method produces carbon dioxide and water as wastes instead of hydrolyzed starch, which increases BOD load. Copper-free dyes can be used to reduce metal loading of wastewater although this may sacrifice the range of color shades that can be achieved. Improved fixation reactives can be used to reduce unreacted and degraded dye in spent bath and improve the reuse potential of washwater. High-temperature reactives can also be used in dyeing for simultaneous application of disperse and reactive dyes. This reduces energy use and eliminates the caustic bath required after disperse dyeing. Finally, auxiliaries, such as phosphates, can be substituted with acetic acid and EDTA to reduce phosphorus load in wastewater. New washing agents can also be used to increase wash efficiency, decrease water consumption, and improve fastness of reactives (Snowden-Swan, 1995).

- *Bloomsburg Mills* substituted a solvent containing isopropanol and heptane as a suitable spot-washing alternative for 1,1,1 trichloroethane, a hazardous air pollutant. No loss of quality was noted with the substitution (NC DEHNR, 1995).
- *Guilford Mills'* has integrated plants in both North Carolina and Pennsylvania. At these plants, the company substituted a solvent-based chemical system used in the heatsetting process with a water-based chemical system. An emissions survey conducted by the company identified that heatsetting accounted for the

majority of volatile organic compound emissions. The new system uses an acrylic latex emulsion to dissolve gum which stabilizes fabric edges and prevents curling. This change accounted for most of the plants' reductions in VOC emissions, from 246.8 tons per year in 1993 to an estimated 93.7 tons per year in 1995 (NC DEHNR, 1995).

- *Cleveland Mills Company* reduced formaldehyde emission to the air by 84 percent by switching to low-shade change resins in the production process. Formaldehyde emissions at the mill dropped from 3,500 to 580 pounds per year (NC DEHNR, 1995).
- *One textile facility* investigated substitutes for sodium sulfide, which is used to convert water-insoluble dyes to the soluble form for application of sulfur dyes to textiles. The facility found that they could replace 100 parts sodium sulfide with 65 parts alkaline solution containing 50 percent reducing sugars plus 25 parts caustic soda. As a result, sulfide levels dropped substantially to below 2 ppm (Snowden-Swan, 1995).

✔ ***Replace chemical treatment with other treatment.***
Waste can be reduced by replacing chemicals in some processes with mechanical or other nonchemical treatment. Instead, some textile mills add chemicals to counteract harmful side effects of other chemicals. In many cases, offending chemicals should be adjusted, substituted, or removed from a process, rather than adding chemicals to offset undesired side effects of other chemicals.

- *JP Stevens and Company, Inc.* substituted chemical biocides, used in disinfecting air washers and cooling towers, with the use of ultraviolet light. Although this may not be viable for all facilities, during a 6-month test period, results showed improved worker safety, reduced discharge of biocides to the sanitary sewer, reduced chemical inventory and handling, improved workplace air quality, and reduced pH and foaming problems in wastewater. The facility also showed enhanced air washer performance and more consistent control of workplace air quality. The UV system operated with no required maintenance or repairs during the test. Based on chemical savings, the payback is expected to be 11 to 18 months.

V.C. Process Modification

Process changes that optimize reactions and raw materials use can be used to prevent pollution. Modifications may include improved process control systems or changes in chemical application methods.

✔ ***Use low-liquor ratio dyeing machines.***
Mills have been moving towards reduced bath ratio dyeing. Bath ratio is defined as the weight of goods (or fabric) divided by the weight of the bath. Some chemicals, such as salt and lubricants, act on the dyebath, whereas

others, such as dyes and softeners, act on the fabric. In each case, these chemicals are factored into either the weight of the bath or the weight of the fabric.

Low bath ratio dyeing can save energy and reduce chemical use, because energy and chemical use depend on bath volume. Jet dyeing and package dyeing are commonly used for low bath ratio dyeing. Typical bath ratios for exhaust dyeing methods are as follows: beck (17:1), jet (12:1), jig (5:1), and package (10:1). Pad batch methods have a 1:1 bath ratio. Ultra-low liquor bath ratios can also reduce cycle times due to quick machine drains and fills and rapid heating and cooling.

- At its Lumberton, North Carolina facility, *Alamac Knits* upgraded jet dyeing machinery to low-liquor-ratio machines with shorter cycles. This modification resulted in a decrease of between 60 and 70 percent of consumption of dye chemicals.

✔ ***Use pad batch dyeing methods.***

Use of pad batch (cold) dyeing for cotton, rayon, and blends conserves energy, water, dyes and chemicals, labor, and floor space. Pad batch dyeing methods do not require salt or chemical specialties, so this method can be a good way for facilities to reduce waste and save money. While pad batch dyeing is a cost-effective way for facilities to apply reactive dyes to cotton and rayon, this method may not achieve the desired final fabric properties for all cottons. Pad batch dyeing is also not appropriate for dyeing synthetic fabrics (ATMI, 1997b). Salt consumption can be reduced from as much as 100 percent of weight of goods to zero. Water consumption for pad batch dyeing with beam wash-off is only 10 percent of the amount used to dye fabrics using beck methods, or two gallons per pound of dyed fabric. Energy consumption can be reduced from about 9,000 BTUs per pound of dyed fabric for beck methods to under 2,000 BTUs per pound for pad batch methods with beam washing. In addition, labor costs and chemical use can be reduced up to 80 percent as compared to atmospheric beck methods (NC DEHNR, 1988).

In pad batch dyeing, prepared fabric is impregnated with liquor (water and process chemicals) containing premixed fiber reactive dyestuff and alkali. Excess liquid is squeezed out on a device known as a mangle. The fabric is then batched onto rolls or into boxes and covered with plastic film to prevent absorption of CO_2 from air or evaporation of water. The fabric is then stored for two to twelve hours. The goods can be washed with becks, beams, or other available machines. Production of between 75 and 150 yards a minute, depending on the construction and weight of goods involved, is typical. Pad batch dyeing is more flexible than continuous dyeing methods. Either wovens or knits can be dyed, and shades can be changed frequently because reactive dyes remain water soluble. The flexibility of pad batch equipment and the use of water soluble dyes minimizes cleaning operations.

- *Ti-Caro* switched to a pad-batch process for bleaching which reduced water and energy use. The bath ratio decreased on all batch processes to 10:1.

✔ ***Use countercurrent washing to reduce water use.***

Countercurrent washing decreases wastewater from preparation processes. Countercurrent washing is simple, easy to implement, and relatively inexpensive. Countercurrent washing is a technique to reuse the least contaminated water from the final wash for the next-to-last wash and so on until the water reaches the first wash stage. Washwater from the first stage is discharged (NC DEHNR, 1988). Table 16 shows typical water savings based on the number of times the water is reused. Countercurrent washing equipment can be retrofitted to any multistage continuous washing operation, whether it is installed for different fabrics or for dyeing, printing, or preparation operations. Flow optimization is usually a good pollution prevention activity to run in conjunction with countercurrent washing.

Table 16: Typical Water Savings Using Countercurrent Washing

Number of Washing Steps	Water Savings (percent)
2	50
3	67
4	75
5	80

Source: *Best Management Practices for Pollution Prevention in the Textile Industry*, EPA, Office of Research and Development, 1995.

- *Bloomsburg Mills* uses countercurrent washing to conserve water during the scouring process. The cleaner wash water enters the exit wash unit and counterflows back toward the dirtier units. This provides a more efficient cleaner wash and requires less water (NC DEHNR, 1995).

- *An international company* reduced water consumption by enacting several measures over a one-month period. Countercurrent flow was installed on all soapers, mercerizing range, and J-boxes. J-boxes are large J-shaped containers used to hold fabrics at high temperatures during bleaching. Washwater was reused in upstream processes for less critical uses, such as print blanket washing.

✔ ***Optimize process conditions.***
Mills can reduce waste and increase production efficiency by optimizing process conditions, such as temperature and time. Mills can also modify the processes themselves to increase efficiency.

- *Americal Corporation* improved dyeing exhaustion by extending the length of time fabrics were dyed by 15 minutes. Results showed about a 60 percent drop in BOD and chemical oxygen demand (COD), a 20 percent drop in fats, oils, and grease, and a 98 percent drop in ammonia-nitrogen. This resulted in a savings of $35,000 annually.

✔ ***Combine processes.***
Mills can reduce waste and increase production efficiency by combining operations. For instance, combined scouring and bleaching can save energy and water. Cold pad-batch methods can be used at room temperature for long desizing, scouring, and bleaching cycles. The single-step, cold-batch method of desizing minimizes energy and water use and maximizes productivity. Note that these methods may not help facilities achieve the desired product result in all cases (ATMI, 1997b).

V.D. Process Water Reuse and Recycle

Although they do not constitute pollution prevention as defined by the Pollution Prevention Act of 1990, recovery, recycling, and reuse can be effective tools for minimizing pollutant releases to the environment. By recovering solvents and raw materials, textile mills can reduce raw materials costs and can reduce pollution with little modification of existing processes. Water is widely used in the industry for processes ranging from dyeing to preparation and finishing. Raw materials, such as unexhausted dyestuff and additives, can also be recycled. Reuse and recycling are excellent ways for facilities to save money, reduce waste, and save energy.

✔ ***Reuse dyebaths.***
Dyebath reuse is the process of analyzing, replenishing, and reusing exhausted hot dyebaths to dye further batches of material. Although not applicable to all processes, in some processes, dyebath reuse can reduce pollution concentrations and effluent volume and generally requires a smaller capital outlay than pretreatment plant construction. It also saves on the costs of dyes, chemicals, and energy. Dyebath reuse principles can also be applied to bleach baths. Table 17 lists example costs and savings for dyebath reuse for a dye machine. Depending on the machine, types of fabrics, and range of

shades, after a couple of years, dyebath reuse could save companies about $21,000 per year for each machine.

Dye bath reuse is comprised of four basic steps. The first step is to save the exhausted dyebath. This can occur by pumping the dyebath to a holding tank, rinsing the product in the same machine in which it was dyed, and then removing the product and returning the dyebath to the dye machine. The product can also be removed from the exhausted dyebath and placed in another machine for rinsing. The dyebath can then be analyzed for residual chemicals. Unexhausted dyestuffs must be analyzed to determine the exact quantities remaining in the dyebath to ensure the proper shade in the next dyeing cycle. This analysis can be performed using a spectrophotometer and guidelines based on specific production experience. Equipment for this is available for under $10,000. After the dyebath has been analyzed, it must be reconstituted by adding water, auxiliary chemicals, and dyestuffs. If properly controlled, dyebaths can be reused for 15 or more cycles, with an average of 5 to 25 times.

Table 17: Example Costs and Savings for Dyebath Reuse

Description of Cost/Savings	**Value**
Total Costs	
Lab and support equipment	$9,000
Machine modifications, tanks, pumps, pipes	$15,000-$25,000
Annual Operating Costs	$1,000-$2,000
Total Savings (Annual)	
Dyes and chemicals	$15,000
Water	$750
Sewer	$750
Energy	$4,500

Source: *Best Management Practices for Pollution Prevention in the Textile Industry,* EPA, Office of Research and Development, 1995.

- *Adams-Millis Company* implemented dyebath reuse at its High Point, North Carolina and Franklinton, North Carolina mills. The mills reused dyebath for dyeing nylon pantyhose in rotary drum dyeing machines. Water use decreased by 35 percent with a cost savings of $0.02 per pound of production. The mill also reduced energy use by 57 percent.

- *Bigelow Carpets* reused dyebaths by equipping pairs of dyeing machines with plumbing and pumps capable of moving a processing bath back and forth from one machine to the other. This allowed immediate reuse of dyebaths for over 20 cycles. Scheduling of lots on the pair was coordinated to ensure efficient reuse. The cost savings was $60,000 per year per pair of machines. Biological oxygen demand, color, and other water pollutants were reduced.

- *Amital* saved a large amount of money by reusing dyebaths and noncontact cooling water. The facility reduced its water consumption from 320,000 gallons per day to 102,000 gallons per day and simultaneously increased production from 12 to 20 batches per day. Additionally, energy consumption for heating dyebath decreased substantially. The investment saved the company about $13,000 a month and paid for itself 30 days after implementation (Snowden-Swan, 1995).

✔ ***Reuse rinse baths.***

Wet processing consumes a large amount of water from rinsing of textiles. Preparation and finishing water can also be reused.

- *A yarn finishing company* drastically reduced wastewater pollution, soda (Na_2CO_3), and caustic consumption by implementing recycling. The new process involved reusing the rinse bath three times following mercerizing rather than dumping the bath water after each use. The spent rinsewater was then processed in an evaporator and concentrated caustic was reused in mercerizing. The facility reduced suspended solids by 80 percent, COD by 55 percent, and neutralizing soda in the wastewater by 70 percent. Corresponding reductions in hydrochloric acid used to neutralize the effluent were also made. The investment in new equipment resulted in an annual savings of $189,000, with a payback of under one year (Snowden-Swan, 1995).

- *A Kings Mountain, North Carolina facility* installed holding tanks for bleach bath reuse. The bath was reconstituted to correct strength after analysis by titration. BOD decreased over 50 percent from 842 milligrams per liter to 400 milligrams per liter. Water use also decreased. The mill also came into compliance with permits and realized economic benefits.

V.E. Equipment Modification

An additional method to reduce waste is to modify, retrofit, or replace equipment. Some facilities are switching to computer-controlled dyeing systems, which analyze the process continuously and respond more quickly and accurately than manually controlled systems. In many cases, modifying equipment can provide source reduction by reducing the ratio of water and chemicals to textile goods.

✔ ***Install automated dosing systems and dye machine controllers.***
The use of automated process control equipment has had a significant effect on the textile industry. Chemical dosing systems can be optimized to deliver the right amount of the right chemical at just the right time. These systems improve the efficiency and reliability of chemical reactions in the dyebath, ensuring more consistent and reproducible results. In addition, these systems reduce the tendency to overuse environmentally harmful chemicals, which may pass through treatment systems unreacted or may react to produce undesirable by-products. Dosing systems can also reduce handling losses and equipment cleanup. Automated dosing systems are commercially available and are being adopted throughout the textile industry.

In addition to automated dosing equipment, dye machine controllers are a good way to increase control over processes. Sales of dye machine controllers are now overtaking sales of dye machines. These devices can be retrofitted for many of the machines in mills. They contain microprocessor controllers that allow feedback control of properties such as pH, color, and temperature. Note that this method only works for acrylic because cationic dyes have high exhaust rates associated with them. This may not work for other fibers or dye classes (ATMI, 1997b).

- *Amital*, which produces acrylic yarn, implemented computer technology to automate dyebath flow and temperature in a new facility. This enabled the facility to precisely control the addition of auxiliary chemicals, such as retarders and leveling agents. As a result, *Amital* produces a clean exhausted dyebath, eliminating the need for postrinsing and reducing water and chemical consumption (Snowden-Swan, 1995).

- *Bloomsburg Mills* upgraded instrumentation and process controls for the dyeing process from manual to computer control. The controlled time of the wash after dyeing has reduced water usage by 28 percent and fuel heat consumption per yard produced by 15.9 percent (NC DEHNR, 1995).

- *Cleveland Mills Company* replaced coal-fired boilers with cleaner natural gas-fired boilers and eliminated the generation of 220,000 pounds of fly ash each year (NC DEHNR, 1995).

✔ ***Use continuous horizontal washers.***
Continuous horizontal washers can conserve energy and water. Horizontal washers work for woven fabrics in a narrow weight range (ATMI, 1997b). These washers operate by spraying clean washwater on the top (final) pass of fabric as it makes a series of horizontal traverses upward in the machine. The unprocessed fabric enters at the bottom traverse, and the water enters at the top. These vertical spray washers reduce water and energy use as well as improve quality and captured suspended solids for dry disposal. Note that vertical, double-laced washers with serpentine counterflow may be more

versatile and achieve better results than continuous horizontal washers (ATMI, 1997b).

✔ ***Use continuous knit bleaching ranges.***
Many textile companies use continuous knit bleaching ranges to reduce water consumption. These ranges consume less water, energy, and chemicals than batch preparation knitting equipment. Recent models have shown improved flexibility in terms of production capacity. Lower capacity machines are available for smaller operations. The new machines feature inherent countercurrent water use and improvements over old rope bleaching units, including better fabric transport, better chemical metering systems, and better filtering of the baths.

V.F. Good Operating Practices

Companies can improve production efficiency and maintain low operating costs by incorporating pollution prevention codes into their management procedures. These codes can include a written commitment by senior management to ongoing waste reduction at each of the company's facilities and to include pollution prevention objectives in research and new facility design. Establishing training and incentive programs and improving recordkeeping are other ways that companies can prevent pollution without changing industrial processes. These factors, along with better housekeeping practices, can help minimize wastes from maintenance and off-spec materials. Water use can be significantly reduced through minimizing leaks and spills, proper maintenance of production equipment, and identification of unnecessary washing of both fabric and equipment (NC DEHNR, 1985).

✔ ***Schedule dyeing operations to minimize machine cleaning.***
In dyeing operations, startups, stopoffs, and color changes often result in losses of substrate, potential off-quality work, and chemically intensive cleanings of machines and facilities. Scheduling dyeing operations to minimize machine cleanings can have a considerable effect on pollution prevention. Changes required by scheduling activities generate significant amounts of waste for the textile mill. Machine cleaning is a significant contributor to waste load for textile facilities, particularly for changes in polyester color sequence and oligomer build-up (ATMI, 1997b). A well-planned dyeing schedule may reduce the number of machine cleanings required and the pollution that results from startups, stopoffs, and color changes. Minimizing machine cleaning may not be possible in some cases because of the need for flexible schedules to meet changing market demands (ATMI, 1997b).

Ultimately, the need for dye machine cleaning is contingent upon the sequencing of colors in the dyeing process. The ideal sequence, requiring the least amount of machine cleaning, is to run the same color repeatedly on a particular machine. The second best way is to group colors within families (red, yellow, blue), and then run the dyes within one color family from lighter to darker values and from brighter to duller chromas.

✔ ***Optimize cleaning practices.***
Modifying equipment cleaning practices may reduce wastewater discharges and reduce solvent use. Substituting cleaning solvents with less toxic solvents can reduce hazardous waste generation and can simplify treatment of wastewater (EPA, 1996).

✔ ***Optimize housekeeping practices.***
Good inventory management can reduce waste by using all materials efficiently and reducing the likelihood of accidental releases of stored material. Although it may seem simplistic, housekeeping and work habits of chemical mixers can account for 10 to 50 percent of a mill's total effluent load in BOD, COD, metals, and organic solvents. Improvements in housekeeping generally cost little or nothing and improve employee morale, workplace safety, and product quality (NC DEHNR, 1988). Designating a materials storage area, limiting traffic through the area, and giving one person the responsibility to maintain and distribute materials can also reduce materials use and contamination and dispersal of materials.

✔ ***Adopt worker training programs.***
Companies should establish safety procedures for receiving, storing, and mixing chemicals, and implement worker training programs. These programs should inform workers of the environmental impacts of chemicals and identify those most harmful to the environment. Workers should be trained in proper procedures for handling these chemicals. Training should also include the correct procedures for pasting, dissolving, and emulsifying of chemicals. These procedures should be subject to auditing and recordkeeping. In addition, policies regarding receipt, storage, and mixing should be established.

Page 88 intentionally left blank.

VI. SUMMARY OF APPLICABLE FEDERAL STATUTES AND REGULATIONS

This section discusses the Federal regulations that may apply to this sector. The purpose of this section is to highlight and briefly describe the applicable Federal requirements, and to provide citations for more detailed information. The following sections are included:

Section VI.A contains a general overview of major statutes
Section VI.B contains a list of regulations specific to this industry
Section VI.C contains a list of pending and proposed regulations

The descriptions within Section VI are intended solely for general information. Depending upon the nature or scope of the activities at a particular facility, these summaries may or may not necessarily describe all applicable environmental requirements. Moreover, they do not constitute formal interpretations or clarifications of the statutes and regulations. For further information readers should consult the Code of Federal Regulations and other state or local regulatory agencies. EPA Hotline contacts are also provided for each major statute.

VI.A. General Description of Major Statutes

Resource Conservation and Recovery Act

The Resource Conservation And Recovery Act (RCRA) of 1976 which amended the Solid Waste Disposal Act, addresses solid (Subtitle D) and hazardous (Subtitle C) waste management activities. The Hazardous and Solid Waste Amendments (HSWA) of 1984 strengthened RCRA’s waste management provisions and added Subtitle I, which governs underground storage tanks (USTs).

Regulations promulgated pursuant to Subtitle C of RCRA (40 CFR Parts 260-299) establish a “cradle-to-grave” system governing hazardous waste from the point of generation to disposal. RCRA hazardous wastes include the specific materials listed in the regulations (commercial chemical products, designated with the code "P" or "U"; hazardous wastes from specific industries/sources, designated with the code "K"; or hazardous wastes from non-specific sources, designated with the code "F") or materials which exhibit a hazardous waste characteristic (ignitability, corrosivity, reactivity, or toxicity and designated with the code "D").

Regulated entities that generate hazardous waste are subject to waste accumulation, manifesting, and record keeping standards. Facilities must obtain a permit either from EPA or from a State agency which EPA has authorized to implement the permitting program if they store hazardous wastes for more than 90 days before treatment or disposal. Facilities may treat hazardous wastes stored in less-than-ninety-day tanks or containers without a permit. Subtitle C permits contain general facility standards such as contingency plans, emergency procedures, record keeping and reporting requirements, financial assurance mechanisms, and unit-specific standards. RCRA also contains provisions (40 CFR Part 264 Subpart S and §264.10) for conducting corrective actions which govern the cleanup of releases of hazardous waste or constituents from solid waste management units at RCRA-regulated facilities.

Although RCRA is a Federal statute, many States implement the RCRA program. Currently, EPA has delegated its authority to implement various provisions of RCRA to 47 of the 50 States and two U.S. territories. Delegation has not been given to Alaska, Hawaii, or Iowa.

Most RCRA requirements are not industry specific but apply to any company that generates, transports, treats, stores, or disposes of hazardous waste. Here are some important RCRA regulatory requirements:

- **Identification of Solid and Hazardous Wastes** (40 CFR Part 261) lays out the procedure every generator must follow to determine whether the material in question is considered a hazardous waste, solid waste, or is exempted from regulation.

- **Standards for Generators of Hazardous Waste** (40 CFR Part 262) establishes the responsibilities of hazardous waste generators including obtaining an EPA ID number, preparing a manifest, ensuring proper packaging and labeling, meeting standards for waste accumulation units, and recordkeeping and reporting requirements. Generators can accumulate hazardous waste for up to 90 days (or 180 days depending on the amount of waste generated) without obtaining a permit.

- **Land Disposal Restrictions** (LDRs) (40 CFR Part 268) are regulations prohibiting the disposal of hazardous waste on land without prior treatment. Under the LDRs program, materials must meet LDR treatment standards prior to placement in a RCRA land disposal unit (landfill, land treatment unit, waste pile, or surface impoundment). Generators of waste subject to the LDRs must provide notification of such to the designated TSD facility to ensure proper treatment prior to disposal.

- **Used Oil Management Standards** (40 CFR Part 279) impose management requirements affecting the storage, transportation, burning, processing, and re-refining of the used oil. For parties that merely generate used oil, regulations establish storage standards. For a party considered a used oil processor, re-refiner, burner, or marketer (one who generates and sells off-specification used oil), additional tracking and paperwork requirements must be satisfied.

- RCRA contains unit-specific standards for all units used to store, treat, or dispose of hazardous waste, including **Tanks and Containers**. Tanks and containers used to store hazardous waste with a high volatile organic concentration must meet emission standards under RCRA. Regulations (40 CFR Part 264-265, Subpart CC) require generators to test the waste to determine the concentration of the waste, to satisfy tank and container emissions standards, and to inspect and monitor regulated units. These regulations apply to all facilities that store such waste, including large quantity generators accumulating waste prior to shipment off-site.

- **Underground Storage Tanks** (USTs) containing petroleum and hazardous substances are regulated under Subtitle I of RCRA. Subtitle I regulations (40 CFR Part 280) contain tank design and release detection requirements, as well as financial responsibility and corrective action standards for USTs. The UST program also includes upgrade requirements for existing tanks that must be met by December 22, 1998.

- **Boilers and Industrial Furnaces** (BIFs) that use or burn fuel containing hazardous waste must comply with design and operating standards. BIF regulations (40 CFR Part 266, Subpart H) address unit design, provide performance standards, require emissions monitoring, and restrict the type of waste that may be burned.

EPA's RCRA, Superfund and EPCRA Hotline, *at (800) 424-9346, responds to questions and distributes guidance regarding all RCRA regulations. The RCRA Hotline operates weekdays from 9:00 a.m. to 6:00 p.m., ET, excluding Federal holidays.*

Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), a 1980 law known commonly as Superfund, authorizes EPA to respond to releases, or threatened releases, of hazardous substances that may endanger public health, welfare, or the environment. CERCLA also enables EPA to force parties responsible for environmental contamination to clean it up or to reimburse the Superfund for response costs incurred by EPA. The Superfund Amendments and Reauthorization Act (SARA) of 1986 revised various sections of CERCLA, extended the taxing authority for the Superfund, and created a free-standing law, SARA Title III, also known as the Emergency Planning and Community Right-to-Know Act (EPCRA).

The CERCLA hazardous substance release reporting regulations (40 CFR Part 302) direct the person in charge of a facility to report to the National Response Center (NRC) any environmental release of a hazardous substance which equals or exceeds a reportable quantity. Reportable quantities are listed in 40 CFR §302.4. A release report may trigger a response by EPA, or by one or more Federal or State emergency response authorities.

EPA implements hazardous substance responses according to procedures outlined in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) (40 CFR Part 300). The NCP includes provisions for permanent cleanups, known as remedial actions, and other cleanups referred to as removals. EPA generally takes remedial actions only at sites on the National Priorities List (NPL), which currently includes approximately 1300 sites. Both EPA and states can act at sites; however, EPA provides responsible parties the opportunity to conduct removal and remedial actions and encourages community involvement throughout the Superfund response process.

EPA's RCRA, Superfund and EPCRA Hotline, at (800) 424-9346, answers questions and references guidance pertaining to the Superfund program. The CERCLA Hotline operates weekdays from 9:00 a.m. to 6:00 p.m., ET, excluding Federal holidays.

Emergency Planning And Community Right-To-Know Act

The Superfund Amendments and Reauthorization Act (SARA) of 1986 created the Emergency Planning and Community Right-to-Know Act (EPCRA, also known as SARA Title III), a statute designed to improve community access to information about chemical hazards and to facilitate the development of chemical emergency response plans by State and local governments. EPCRA required the establishment of State emergency response commissions (SERCs), responsible for coordinating certain emergency response activities and for appointing local emergency planning committees (LEPCs).

EPCRA and the EPCRA regulations (40 CFR Parts 350-372) establish four types of reporting obligations for facilities which store or manage specified chemicals:

- **EPCRA §302** requires facilities to notify the SERC and LEPC of the presence of any extremely hazardous substance (the list of such substances is in 40 CFR Part 355, Appendices A and B) if it has such substance in excess of the substance's threshold planning quantity, and directs the facility to appoint an emergency response coordinator.

- **EPCRA §304** requires the facility to notify the SERC and the LEPC in the event of a release equaling or exceeding the reportable quantity of a CERCLA hazardous substance or an EPCRA extremely hazardous substance.

- **EPCRA §311 and §312** require a facility at which a hazardous chemical, as defined by the Occupational Safety and Health Act, is present in an amount exceeding a specified threshold to submit to the SERC, LEPC and local fire department material safety data sheets (MSDSs) or lists of MSDS's and hazardous chemical inventory forms (also known as Tier I and II forms). This information helps the local government respond in the event of a spill or release of the chemical.

- **EPCRA §313** requires manufacturing facilities included in SIC codes 20 through 39, which have ten or more employees, and which manufacture, process, or use specified chemicals in amounts greater than threshold quantities, to submit an annual toxic chemical release report. This report, known commonly as the Form R, covers releases and transfers of toxic chemicals to various facilities and environmental media, and allows EPA to compile the national Toxic Release Inventory (TRI) database.

All information submitted pursuant to EPCRA regulations is publicly accessible, unless protected by a trade secret claim.

EPA's RCRA, Superfund and EPCRA Hotline, at (800) 424-9346, answers questions and distributes guidance regarding the emergency planning and community right-to-know regulations. The EPCRA Hotline operates weekdays from 9:00 a.m. to 6:00 p.m., ET, excluding Federal holidays.

Clean Water Act

The primary objective of the Federal Water Pollution Control Act, commonly referred to as the Clean Water Act (CWA), is to restore and maintain the chemical, physical, and biological integrity of the nation's surface waters. Pollutants regulated under the CWA include "priority" pollutants, including various toxic pollutants; "conventional" pollutants, such as biochemical oxygen demand (BOD), total suspended solids (TSS), fecal coliform, oil and grease, and pH; and "non-conventional" pollutants, including any pollutant not identified as either conventional or priority.

The CWA regulates both direct and indirect discharges. The National Pollutant Discharge Elimination System (NPDES) program (CWA §502) controls direct discharges into navigable waters. Direct discharges or "point source" discharges are from sources such as pipes and sewers. NPDES permits, issued by either EPA or an authorized State (EPA has authorized 42 States to administer the NPDES program), contain industry-specific, technology-based and/or water quality-based limits, and establish pollutant monitoring requirements. A facility that intends to discharge into the nation's waters must obtain a permit prior to initiating its discharge. A permit applicant must provide quantitative analytical data identifying the types of pollutants present in the facility's effluent. The permit will then set the conditions and effluent limitations on the facility discharges.

A NPDES permit may also include discharge limits based on Federal or State water quality criteria or standards, that were designed to protect designated uses of surface waters, such as supporting aquatic life or recreation. These standards, unlike the technological standards, generally do not take into account technological feasibility or costs. Water quality criteria and standards vary from State to State, and site to site, depending on the use classification of the receiving body of water. Most States follow EPA guidelines which propose aquatic life and human health criteria for many of the 126 priority pollutants.

Storm Water Discharges

In 1987 the CWA was amended to require EPA to establish a program to address storm water discharges. In response, EPA promulgated the NPDES storm water permit application regulations. These regulations require that facilities with the following storm water discharges apply for an NPDES permit: (1) a discharge associated with industrial activity; (2) a discharge from a large or medium municipal storm sewer system; or (3) a discharge which EPA or the State determines to contribute to a violation of a water quality standard or is a significant contributor of pollutants to waters of the United States.

The term "storm water discharge associated with industrial activity" means a storm water discharge from one of 11 categories of industrial activity defined at 40 CFR 122.26. Six of the categories are defined by SIC codes while the other five are identified through narrative descriptions of the regulated industrial activity. If the primary SIC code of the facility is one of those identified in the regulations, the facility is subject to the storm water permit application requirements. If any activity at a facility is covered by one of the five narrative categories, storm water discharges from those areas where the activities occur are subject to storm water discharge permit application requirements.

Those facilities/activities that are subject to storm water discharge permit application requirements are identified below. To determine whether a particular facility falls within one of these categories, consult the regulation.

Category i: Facilities subject to storm water effluent guidelines, new source performance standards, or toxic pollutant effluent standards.

Category ii: Facilities classified as SIC 24-lumber and wood products (except wood kitchen cabinets); SIC 26-paper and allied products (except paperboard containers and products); SIC 28-chemicals and allied products (except drugs and paints); SIC 291-petroleum refining; and SIC 311-leather tanning and finishing, 32 (except 323)-stone, clay, glass, and concrete, 33-primary metals, 3441-fabricated structural metal, and 373-ship and boat building and repairing.

Category iii: Facilities classified as SIC 10-metal mining; SIC 12-coal mining; SIC 13-oil and gas extraction; and SIC 14-nonmetallic mineral mining.

Category iv: Hazardous waste treatment, storage, or disposal facilities.

Category v: Landfills, land application sites, and open dumps that receive or have received industrial wastes.

Category vi: Facilities classified as SIC 5015-used motor vehicle parts; and SIC 5093-automotive scrap and waste material recycling facilities.

Category vii: Steam electric power generating facilities.

Category viii: Facilities classified as SIC 40-railroad transportation; SIC 41-local passenger transportation; SIC 42-trucking and warehousing (except public warehousing and storage); SIC 43-U.S. Postal Service; SIC 44-water transportation; SIC 45-transportation by air; and SIC 5171-petroleum bulk storage stations and terminals.

Category ix: Sewage treatment works.

Category x: Construction activities except operations that result in the disturbance of less than five acres of total land area.

Category xi: Facilities classified as SIC 20-food and kindred products; SIC 21-tobacco products; SIC 22-textile mill products; SIC 23-apparel related products; SIC 2434-wood kitchen cabinets manufacturing; SIC 25-furniture and fixtures; SIC 265-paperboard containers and boxes; SIC 267-converted paper and paperboard products; SIC 27-printing, publishing, and allied industries; SIC 283-drugs; SIC 285-paints, varnishes, lacquer, enamels, and allied products; SIC 30-rubber and plastics; SIC 31-leather and leather products (except leather and tanning and finishing); SIC 323-glass products; SIC 34-fabricated metal products (except fabricated structural metal); SIC 35-industrial and commercial machinery and computer equipment; SIC 36-electronic and other electrical equipment and components; SIC 37-transportation equipment (except ship and boat building and repairing); SIC

38-measuring, analyzing, and controlling instruments; SIC 39-miscellaneous manufacturing industries; and SIC 4221-4225-public warehousing and storage.

Pretreatment Program

Another type of discharge that is regulated by the CWA is one that goes to a publicly-owned treatment works (POTWs). The national pretreatment program (CWA §307(b)) controls the indirect discharge of pollutants to POTWs by "industrial users." Facilities regulated under §307(b) must meet certain pretreatment standards. The goal of the pretreatment program is to protect municipal wastewater treatment plants from damage that may occur when hazardous, toxic, or other wastes are discharged into a sewer system and to protect the quality of sludge generated by these plants. Discharges to a POTW are regulated primarily by the POTW itself, rather than the State or EPA.

EPA has developed technology-based standards for industrial users of POTWs. Different standards apply to existing and new sources within each category. "Categorical" pretreatment standards applicable to an industry on a nationwide basis are developed by EPA. In addition, another kind of pretreatment standard, "local limits," are developed by the POTW in order to assist the POTW in achieving the effluent limitations in its NPDES permit.

Regardless of whether a State is authorized to implement either the NPDES or the pretreatment program, if it develops its own program, it may enforce requirements more stringent than Federal standards.

Spill Prevention, Control and Countermeasure Plans

The 1990 Oil Pollution Act requires that facilities that could reasonably be expected to discharge oil in harmful quantities prepare and implement more rigorous Spill Prevention Control and Countermeasure (SPCC) Plan required under the CWA (40 CFR §112.7). There are also criminal and civil penalties for deliberate or negligent spills of oil. Regulations covering response to oil discharges and contingency plans (40 CFR Part 300), and Facility Response Plans to oil discharges (40 CFR §112.20) and for PCB transformers and PCB-containing items were revised and finalized in 1995.

EPA's Office of Water, at (202) 260-5700, will direct callers with questions about the CWA to the appropriate EPA office. EPA also maintains a bibliographic database of Office of Water publications which can be accessed through the Ground Water and Drinking Water resource center, at (202) 260-7786.

Safe Drinking Water Act

The Safe Drinking Water Act (SDWA) mandates that EPA establish regulations to protect human health from contaminants in drinking water. The law authorizes EPA to develop national drinking water standards and to create a joint Federal-State system to ensure compliance with these standards. The SDWA also directs EPA to protect underground sources of drinking water through the control of underground injection of liquid wastes.

EPA has developed primary and secondary drinking water standards under its SDWA authority. EPA and authorized States enforce the primary drinking water standards, which are, contaminant-specific concentration limits that apply to certain public drinking water supplies. Primary drinking water standards consist of maximum contaminant level goals (MCLGs), which are non-enforceable health-based goals, and maximum contaminant levels (MCLs), which are enforceable limits set as close to MCLGs as possible, considering cost and feasibility of attainment.

The SDWA Underground Injection Control (UIC) program (40 CFR Parts 144-148) is a permit program which protects underground sources of drinking water by regulating five classes of injection wells. UIC permits include design, operating, inspection, and monitoring requirements. Wells used to inject hazardous wastes must also comply with RCRA corrective action standards in order to be granted a RCRA permit, and must meet applicable RCRA land disposal restrictions standards. The UIC permit program is primarily State-enforced, since EPA has authorized all but a few States to administer the program.

The SDWA also provides for a Federally-implemented Sole Source Aquifer program, which prohibits Federal funds from being expended on projects that may contaminate the sole or principal source of drinking water for a given area, and for a State-implemented Wellhead Protection program, designed to protect drinking water wells and drinking water recharge areas.

EPA's Safe Drinking Water Hotline, at (800) 426-4791, answers questions and distributes guidance pertaining to SDWA standards. The Hotline operates from 9:00 a.m. through 5:30 p.m., ET, excluding Federal holidays.

Toxic Substances Control Act

The Toxic Substances Control Act (TSCA) granted EPA authority to create a regulatory framework to collect data on chemicals in order to evaluate, assess, mitigate, and control risks which may be posed by their manufacture, processing, and use. TSCA provides a variety of control methods to prevent chemicals from posing unreasonable risk.

TSCA standards may apply at any point during a chemical's life cycle. Under TSCA §5, EPA has established an inventory of chemical substances. If a chemical is not already on the inventory, and has not been excluded by TSCA, a premanufacture notice (PMN) must be submitted to EPA prior to manufacture or import. The PMN must identify the chemical and provide available information on health and environmental effects. If available data are not sufficient to evaluate the chemicals effects, EPA can impose restrictions pending the development of information on its health and environmental effects. EPA can also restrict significant new uses of chemicals based upon factors such as the projected volume and use of the chemical.

Under TSCA §6, EPA can ban the manufacture or distribution in commerce, limit the use, require labeling, or place other restrictions on chemicals that pose unreasonable risks. Among the chemicals EPA regulates under §6 authority are asbestos, chlorofluorocarbons (CFCs), and polychlorinated biphenyls (PCBs).

EPA's TSCA Assistance Information Service, at (202) 554-1404, answers questions and distributes guidance pertaining to Toxic Substances Control Act standards. The Service operates from 8:30 a.m. through 4:30 p.m., ET, excluding Federal holidays.

Clean Air Act

The Clean Air Act (CAA) and its amendments, including the Clean Air Act Amendments (CAAA) of 1990, are designed to "protect and enhance the nation's air resources so as to promote the public health and welfare and the productive capacity of the population." The CAA consists of six sections, known as Titles, which direct EPA to establish national standards for ambient air quality and for EPA and the States to implement, maintain, and enforce these standards through a variety of mechanisms. Under the CAAA, many facilities will be required to obtain permits for the first time. State and local governments oversee, manage, and enforce many of the requirements of the CAAA. CAA regulations appear at 40 CFR Parts 50-99.

Pursuant to Title I of the CAA, EPA has established national ambient air quality standards (NAAQSs) to limit levels of "criteria pollutants," including carbon monoxide, lead, nitrogen dioxide, particulate matter, volatile organic compounds (VOCs), ozone, and sulfur dioxide. Geographic areas that meet NAAQSs for a given pollutant are classified as attainment areas; those that do not meet NAAQSs are classified as non-attainment areas. Under section 110 of the CAA, each State must develop a State Implementation Plan (SIP) to identify sources of air pollution and to determine what reductions are required to meet Federal air quality standards. Revised NAAQSs for particulates and ozone were proposed in 1996 and may go into effect as early as late 1997.

Title I also authorizes EPA to establish New Source Performance Standards (NSPSs), which are nationally uniform emission standards for new stationary sources falling within particular industrial categories. NSPSs are based on the pollution control technology available to that category of industrial source.

Under Title I, EPA establishes and enforces National Emission Standards for Hazardous Air Pollutants (NESHAPs), nationally uniform standards oriented towards controlling particular hazardous air pollutants (HAPs). Title I, section 112(c) of the CAA further directed EPA to develop a list of sources that emit any of 189 HAPs, and to develop regulations for these categories of sources. To date EPA has listed 174 categories and developed a schedule for the establishment of emission standards. The emission standards will be developed for both new and existing sources based on "maximum achievable control technology" (MACT). The MACT is defined as the control technology achieving the maximum degree of reduction in the emission of the HAPs, taking into account cost and other factors.

Title II of the CAA pertains to mobile sources, such as cars, trucks, buses, and planes. Reformulated gasoline, automobile pollution control devices, and vapor recovery nozzles on gas pumps are a few of the mechanisms EPA uses to regulate mobile air emission sources.

Title IV of the CAA establishes a sulfur dioxide nitrous oxide emissions program designed to reduce the formation of acid rain. Reduction of sulfur dioxide releases will be obtained by granting to certain sources limited emissions allowances, which, beginning in 1995, will be set below previous levels of sulfur dioxide releases.

Title V of the CAA of 1990 created a permit program for all "major sources" (and certain other sources) regulated under the CAA. One purpose of the operating permit is to include in a single document all air emissions requirements that apply to a given facility. States are developing the permit programs in accordance with guidance and regulations from EPA. Once a State program is approved by EPA, permits will be issued and monitored by that State.

Title VI of the CAA is intended to protect stratospheric ozone by phasing out the manufacture of ozone-depleting chemicals and restrict their use and distribution. Production of Class I substances, including 15 kinds of chlorofluorocarbons (CFCs) and chloroform, were phased out (except for essential uses) in 1996.

EPA's Clean Air Technology Center, at (919) 541-0800, provides general assistance and information on CAA standards. The Stratospheric Ozone Information Hotline, at (800) 296-1996, provides general information about regulations promulgated under Title VI of the CAA, and EPA's EPCRA

Hotline, at (800) 535-0202, answers questions about accidental release prevention under CAA §112(r). In addition, the Clean Air Technology Center's website includes recent CAA rules, EPA guidance documents, and updates of EPA activities (www.epa.gov/ttn then select Directory and then CATC).

VI.B. Industry Specific Requirements

The textile industry is affected by several major federal environmental statutes. In addition, the industry is subject to numerous laws and regulations from state and local governments designed to protect and improve the nation's health, safety, and environment. A summary of the major federal regulations affecting the textile industry follows.

Clean Water Act (CWA)

Since the textiles industry is a major water user, perhaps the most important environmental regulation affecting the textile industry is the Clean Water Act. In 1982, EPA promulgated effluent guidelines for the textile manufacturing point source category. The Textile Mills Point Source Category effluent guidelines are listed under 40 CFR Part 410. Part 410 is divided into nine subparts for each applying to a different textile manufacturing subcategory as outlined below. Each Subpart contains effluent limitations, new source performance standards (NSPS), and pretreatment standards.

Subpart	Applicability
Subpart A - Wool Scouring Subcategory	Wool scouring, topmaking, and general cleaning of raw wool.
Subpart B - Wool Finishing Subcategory	Wool finishers, including carbonizing, fulling, dyeing, bleaching, rinsing, fireproofing, and other similar processes.
Subpart C - Low Water Use Processing Subcategory	Yarn manufacturing, yarn texturizing, unfinished fabric manufacturing, fabric coating, fabric laminating, tire cord and fabric dipping, carpet tufting, and carpet backing.
Subpart D - Woven Fabric Finishing Subcategory	Woven fabric finishers which may include desizing, bleaching, mercerizing, dyeing, printing, resin treatment, water proofing, flame proofing, soil repellency application, and special finish application.
Subpart E - Knit Fabric Finishing Subcategory	Knit fabric finishers which may include bleaching, mercerizing, dyeing, printing, resin treatment, water proofing, flame proofing, soil repellency application, and special finish application.
Subpart F - Carpet Finishing Subcategory	Carpet mills which may include bleaching, scouring, carbonizing, fulling dyeing, printing, water proofing, flame proofing, soil repellency, looping, and backing with foamed and unfoamed latex and jute.

Subpart G - Stock and Yarn Finishing Subcategory	Stock or yarn dyeing or finishing which may include cleaning, scouring, bleaching, mercerizing, dyeing, and special finishing.
Subpart H - Nonwoven Manufacturing Subcategory	Applies to process wastewater discharges from manufacture of nonwoven textile products of wool, cotton, or synthetic, thermal and/or adhesive bonding procedures.
Subpart I - Felted Fabric Processing Subcategory	Applies to process wastewater discharges from manufacture of nonwoven products by employing fulling and felting operations as a means of achieving fiber bonds.

Effluent limitations representing the degree of effluent reduction attainable by using either best practicable control technologies (BPT), or best available technologies (BAT) are given for all subcategories. BPTs are used for discharges from existing point sources to control conventional and non-conventional pollutants as well as some priority pollutants. BATs are used to control priority pollutants and non-conventional pollutants when directly discharged into the nation's waters.

Best practicable control technology (BPT) limits for biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), sulfide, phenol, total chromium, and pH are set for every category (every Subpart), with the exception of Subpart C (Low Water Use Processing Subcategory). Each Subpart, with the exception again of Subpart C, also has best available technology (BAT) limits for COD, sulfide, phenols, and total chromium.

In Subpart C (Low Water Use Processing Subcategory) effluent reduction guidelines, attainable with best practicable control technologies (BPT) (40 CFR 410 Part 410.32), are set for BOD, COD, TSS, and pH only. In addition, these BPT attainable limits differ depending on which type of low water use process a facility uses. The two types of low water use processes are general processing and water jet weaving. Water jet weaving is defined as "the internal subdivision of the low water use processing subcategory for facilities primarily engaged in manufacturing woven greige goods through the water jet weaving process"(40 CFR 410 Part 410.31). General processing is any low water use processing, other that water jet processing, which facilities in this category may use. Similarly, best available technology (BAT) standards are also different depending on the process employed, but are only set for chemical oxygen demand (COD).

New source performance standards (NSPS) for BOD, COD, TSS, sulfide, phenols, total chromium, and pH are set for each subcategory. However, for the Low Water Use Processing Subcategory (Subpart C) and for the Woven

Fabric Finishing Subcategory (Subpart D), the NSPS are divided into process specific standards. For the Woven Fabric Finishing Subcategory (Subpart D) these standards are different for simple manufacturing operations, complex manufacturing operations and for desizing. In Subpart C, NSPS are for general processing and water jet weaving and are only for BOD, COD, TSS, and pH.

All existing and new sources discharging to POTWs in all subcategories in the Textile Mills Point Source Category are subject to the General Pretreatment Regulations for Existing and New Sources of Pollution set forth in 40 CFR Part 403.

The Storm Water Rule (40 CFR §122.26(b)(14) Subparts (i, ii)) requires facilities to apply for storm water discharge permits if they are subject to storm water effluent guidelines, new source performance standards, or toxic pollutant effluent standards. In addition, facilities are subject to storm water permit application requirements if their primary SIC code is one of those identified in the regulations. To determine whether a particular facility falls within one of these categories, the regulation should be consulted.

Clean Air Act (CAA)

Under Title I of the CAA, EPA has the authorization to establish New Source Performance Standards (NSPSs), which are nationally uniform emission standards for new stationary sources falling within particular industrial categories. NSPSs are based on the pollution control technology available to that category of industrial source but allow the affected industries the flexibility to devise a cost-effective means of reducing emissions. EPA has not established NSPSs for the textiles industrial category. Refer to the EPA Sector Notebook on Plastic Resins and Manmade Fibers for a discussion of the NSPS for synthetic fiber production facilities (40CFR Part 60 Subpart HHH).

Under Title V of the CAAA 1990 (40 CFR Parts 70-72) all of the applicable requirements of the Amendments are integrated into one federal renewable operating permit. Facilities defined as "major sources" under the Act must apply for permits within one year from when EPA approves the state permit programs. Since most state programs were not approved until after November 1994, Title V permit applications will, for the most part, began to be due in late 1995. Due dates for filing complete applications vary significantly from state to state, based on the status of review and approval of the state's Title V program by EPA.

A facility is designated as a major source under Title V if it includes sources subject to the NSPS acid rain provisions or NESHAPS, or if it releases a certain amount of any one of the CAAA regulated pollutants (SO_x, NO_x, CO, VOC, PM_{10}, hazardous air pollutants, extremely hazardous substances, ozone depleting substances, and pollutants covered by NSPSs) depending on the region's air quality category. Title V permits may set limits on the amounts of pollutant emissions; require emissions monitoring, and record keeping and reporting.

Depending on their location and operational factors, some of the larger textiles manufacturing facilities may be considered major sources and therefore would apply for a Title V permit.

Resource Conservation and Recovery Act (RCRA)

The Resource Conservation and Recovery Act (RCRA) was enacted in 1976 to address problems related to hazardous and solid waste management. RCRA gives EPA the authority to establish a list of solid and hazardous wastes and to establish standards and regulations for the treatment, storage, and disposal of these wastes. Regulations in Subtitle C of RCRA address the identification, generation, transportation, treatment, storage, and disposal of hazardous wastes. These regulations are found in 40 CFR Part 124 and CFR Parts 260-279. Under RCRA, persons who generate waste must determine whether the waste is defined as solid waste or hazardous waste. Solid wastes are considered hazardous wastes if they are listed by EPA as hazardous or if they exhibit characteristics of a hazardous waste: toxicity, ignitability, corrosivity, or reactivity.

Products, intermediates, and off-specification products potentially generated at textiles facilities that are considered hazardous wastes are listed in 40 CFR Part 261.33(f). Some of the handling and treatment requirements for RCRA hazardous waste generators are covered under 40 CFR Part 262 and include the following: determining what constitutes a RCRA hazardous waste (Subpart A); manifesting (Subpart B); packaging, labeling, and accumulation time limits (Subpart C); and record keeping and reporting (Subpart D).

Some textiles facilities may store some hazardous wastes at the facility for more than 90 days and may be considered a storage facility under RCRA. Storage facilities are required to have a RCRA treatment, storage, and disposal facility (TSDF) permit (40 CFR Part 262.34). In addition, some textiles facilities considered TSDF facilities are subject to the following regulations covered under 40 CFR Part 264: contingency plans and emergency procedures (40 CFR Part 264 Subpart D); manifesting, record keeping, and reporting (40 CFR Part 264 Subpart E); use and management of containers (40 CFR Part 264 Subpart I); tank systems (40 CFR Part 264 Subpart J); surface impoundments (40 CFR Part 264 Subpart K); land treatment (40 CFR Part 264 Subpart M); corrective action of hazardous waste releases (40 CFR Part 264 Subpart S); air emissions standards for process vents of processes that process or generate hazardous wastes (40

CFR Part 264 Subpart AA); emissions standards for leaks in hazardous waste handling equipment (40 CFR Part 264 Subpart BB); and emissions standards for containers, tanks, and surface impoundments that contain hazardous wastes (40 CFR Part 264 Subpart CC).

Many textiles manufacturing facilities are also subject to the underground storage tank (UST) program (40 CFR Part 280). The UST regulations apply to facilities that store either petroleum products or hazardous substances (except hazardous waste) identified under the Comprehensive Environmental Response, Compensation, and Liability Act. UST regulations address design standards, leak detection, operating practices, response to releases, financial responsibility for releases, and closure standards.

VI.C. Pending and Proposed Regulatory Requirements

A NESHAP for Fabric Coating, Printing and Dying is under development and is scheduled to be proposed in November 1999 and promulgated in November 2000. (Contact Paul Almodovar, US EPA Office of Air and Radiation, at 919-541-0283.)

Page 106 intentionally left blank.

VII. COMPLIANCE AND ENFORCEMENT PROFILE

Background

Until recently, EPA has focused much of its attention on measuring compliance with specific environmental statutes. This approach allows the Agency to track compliance with the Clean Air Act, the Resource Conservation and Recovery Act, the Clean Water Act, and other environmental statutes. Within the last several years, the Agency has begun to supplement single-media compliance indicators with facility-specific, multimedia indicators of compliance. In doing so, EPA is in a better position to track compliance with all statutes at the facility level, and within specific industrial sectors.

A major step in building the capacity to compile multimedia data for industrial sectors was the creation of EPA's Integrated Data for Enforcement Analysis (IDEA) system. IDEA has the capacity to "read into" the Agency's single-media databases, extract compliance records, and match the records to individual facilities. The IDEA system can match Air, Water, Waste, Toxics/Pesticides/EPCRA, TRI, and Enforcement Docket records for a given facility, and generate a list of historical permit, inspection, and enforcement activity. IDEA also has the capability to analyze data by geographic area and corporate holder. As the capacity to generate multimedia compliance data improves, EPA will make available more in-depth compliance and enforcement information. Additionally, sector-specific measures of success for compliance assistance efforts are under development.

Compliance and Enforcement Profile Description

Using inspection, violation and enforcement data from the IDEA system, this section provides information regarding the historical compliance and enforcement activity of this sector. In order to mirror the facility universe reported in the Toxic Chemical Profile, the data reported within this section consists of records only from the TRI reporting universe. With this decision, the selection criteria are consistent across sectors with certain exceptions. For the sectors that do not normally report to the TRI program, data have been provided from EPA's Facility Indexing System (FINDS) which tracks facilities in all media databases. Please note, in this section, EPA does not attempt to define the actual number of facilities that fall within each sector. Instead, the section portrays the records of a subset of facilities within the sector that are well defined within EPA databases.

As a check on the relative size of the full sector universe, most notebooks contain an estimated number of facilities within the sector according to the Bureau of Census (See Section II). With sectors dominated by small businesses, such as metal finishers and printers, the reporting universe within the EPA databases may be small in comparison to Census data. However, the group selected for inclusion in this data analysis section should be consistent with this sector's general make-up.

Following this introduction is a list defining each data column presented within this section. These values represent a retrospective summary of inspections and enforcement actions, and reflect solely EPA, State, and local compliance assurance activities that have been entered into EPA databases. To identify any changes in trends, the EPA ran two data queries, one for the past five calendar years (April 1, 1992 to March 31, 1997) and the other for the most recent twelve-month period (April 1, 1996 to March 31, 1997). The five-year analysis gives an average level of activity for that period for comparison to the more recent activity.

Because most inspections focus on single-media requirements, the data queries presented in this section are taken from single media databases. These databases do not provide data on whether inspections are state/local or EPA-led. However, the table breaking down the universe of violations does give the reader a crude measurement of the EPA's and states' efforts within each media program. The presented data illustrate the variations across EPA Regions for certain sectors.[3] This variation may be attributable to state/local data entry variations, specific geographic concentrations, proximity to population centers, sensitive ecosystems, highly toxic chemicals used in production, or historical noncompliance. Hence, the exhibited data do not rank regional performance or necessarily reflect which regions may have the most compliance problems.

Compliance and Enforcement Data Definitions

General Definitions

Facility Indexing System (FINDS) -- this system assigns a common facility number to EPA single-media permit records. The FINDS identification number allows EPA to compile and review all permit, compliance, enforcement and pollutant release data for any given regulated facility.

Integrated Data for Enforcement Analysis (IDEA) -- is a data integration system that can retrieve information from the major EPA program office databases. IDEA uses the FINDS identification number to link separate data records from EPA's databases. This allows retrieval of records from across

---

[3] EPA Regions include the following states: I (CT, MA, ME, RI, NH, VT); II (NJ, NY, PR, VI); III (DC, DE, MD, PA, VA, WV); IV (AL, FL, GA, KY, MS, NC, SC, TN); V (IL, IN, MI, MN, OH, WI); VI (AR, LA, NM, OK, TX); VII (IA, KS, MO, NE); VIII (CO, MT, ND, SD, UT, WY); IX (AZ, CA, HI, NV, Pacific Trust Territories); X (AK, ID, OR, WA).

media or statutes for any given facility, thus creating a "master list" of records for that facility. Some of the data systems accessible through IDEA are: AIRS (Air Facility Indexing and Retrieval System, Office of Air and Radiation), PCS (Permit Compliance System, Office of Water), RCRIS (Resource Conservation and Recovery Information System, Office of Solid Waste), NCDB (National Compliance Data Base, Office of Prevention, Pesticides, and Toxic Substances), CERCLIS (Comprehensive Environmental and Liability Information System, Superfund), and TRIS (Toxic Release Inventory System). IDEA also contains information from outside sources such as Dun and Bradstreet and the Occupational Safety and Health Administration (OSHA). Most data queries displayed in notebook sections IV and VII were conducted using IDEA.

Data Table Column Heading Definitions

Facilities in Search -- are based on the universe of TRI reporters within the listed SIC code range. For industries not covered under TRI reporting requirements (metal mining, nonmetallic mineral mining, electric power generation, ground transportation, water transportation, and dry cleaning), or industries in which only a very small fraction of facilities report to TRI (e.g., printing), the notebook uses the FINDS universe for executing data queries. The SIC code range selected for each search is defined by each notebook's selected SIC code coverage described in Section II.

Facilities Inspected --- indicates the level of EPA and state agency inspections for the facilities in this data search. These values show what percentage of the facility universe is inspected in a one-year or five-year period.

Number of Inspections -- measures the total number of inspections conducted in this sector. An inspection event is counted each time it is entered into a single media database.

Average Time Between Inspections -- provides an average length of time, expressed in months, between compliance inspections at a facility within the defined universe.

Facilities with One or More Enforcement Actions -- expresses the number of facilities that were the subject of at least one enforcement action within the defined time period. This category is broken down further into federal and state actions. Data are obtained for administrative, civil/judicial, and criminal enforcement actions. Administrative actions include Notices of Violation (NOVs). A facility with multiple enforcement actions is only counted once in this column, e.g., a facility with 3 enforcement actions counts as 1 facility.

Total Enforcement Actions -- describes the total number of enforcement actions identified for an industrial sector across all environmental statutes. A facility with multiple enforcement actions is counted multiple times, e.g., a facility with 3 enforcement actions counts as 3.

State Lead Actions -- shows what percentage of the total enforcement actions are taken by state and local environmental agencies. Varying levels of use by states of EPA data systems may limit the volume of actions recorded as state enforcement activity. Some states extensively report enforcement activities into EPA data systems, while other states may use their own data systems.

Federal Lead Actions -- shows what percentage of the total enforcement actions are taken by the United States Environmental Protection Agency. This value includes referrals from state agencies. Many of these actions result from coordinated or joint state/federal efforts.

Enforcement to Inspection Rate -- is a ratio of enforcement actions to inspections, and is presented for comparative purposes only. This ratio is a rough indicator of the relationship between inspections and enforcement. It relates the number of enforcement actions and the number of inspections that occurred within the one-year or five-year period. This ratio includes the inspections and enforcement actions reported under the Clean Water Act (CWA), the Clean Air Act (CAA) and the Resource Conservation and Recovery Act (RCRA). Inspections and actions from the TSCA/FIFRA/ EPCRA database are not factored into this ratio because most of the actions taken under these programs are not the result of facility inspections. Also, this ratio does not account for enforcement actions arising from non-inspection compliance monitoring activities (e.g., self-reported water discharges) that can result in enforcement action within the CAA, CWA, and RCRA.

Facilities with One or More Violations Identified -- indicates the percentage of inspected facilities having a violation identified in one of the following data categories: In Violation or Significant Violation Status (CAA); Reportable Noncompliance, Current Year Noncompliance, Significant Noncompliance (CWA); Noncompliance and Significant Noncompliance (FIFRA, TSCA, and EPCRA); Unresolved Violation and Unresolved High Priority Violation (RCRA). The values presented for this column reflect the extent of noncompliance within the measured time frame, but do not distinguish between the severity of the noncompliance. Violation status may be a precursor to an enforcement action, but does not necessarily indicate that an enforcement action will occur.

Media Breakdown of Enforcement Actions and Inspections -- four columns identify the proportion of total inspections and enforcement actions within EPA Air, Water, Waste, and TSCA/FIFRA/EPCRA databases. Each column is a percentage of either the "Total Inspections," or the "Total Actions" column.

VII.A. Textile Industry Compliance History

Table 18 provides an overview of the reported compliance and enforcement data for the textiles industry over the past five years (April 1992 to April 1997). These data are broken out by EPA Region[4] thereby permitting geographical comparisons. A few points evident from the data are listed below.

- Over 60 percent of textile sector inspections and enforcement actions were in Region IV where most of the industry's facilities (61 percent) are located.
- Region II, with only 24 facilities, carried out relatively few inspections in relation to the number of facilities (19 months between inspections on average) but had the highest enforcement to inspection rate (0.15).
- Region III had the shortest average time between inspections (11 months) but one of the lowest enforcement to inspection rates (0.04).

---

[4] EPA Regions include the following states: I (CT, MA, ME, RI, NH, VT); II (NJ, NY, PR, VI); III (DC, DE, MD, PA, VA, WV); IV (AL, FL, GA, KY, MS, NC, SC, TN); V (IL, IN, MI, MN, OH, WI); VI (AR, LA, NM, OK, TX); VII (IA, KS, MO, NE); VIII (CO, MT, ND, SD, UT, WY); IX (AZ, CA, HI, NV, Pacific Trust Territories); X (AK, ID, OR, WA).

Table 18: Five-Year Enforcement and Compliance Summary for the Textile Industry

A	B	C	D	E	F	G	H	I	J
Region	**Facilities in Search**	**Facilities Inspected**	**Number of Inspections**	**Average Months Between Inspections**	**Facilities with 1 or More Enforcement Actions**	**Total Enforcement Actions**	**Percent State Lead Actions**	**Percent Federal Lead Actions**	**Enforcement to Inspection Rate**
I	43	40	143	18	11	14	79%	21%	0.10
II	24	15	74	19	6	11	82%	18%	0.15
III	31	24	168	11	6	6	100%	0%	0.04
IV	217	160	976	13	25	46	98%	2%	0.05
V	20	15	49	24	3	4	100%	0%	0.08
VI	7	4	22	19	1	1	0%	100%	0.05
VII	1	1	4	15	0	0	0%	0%	0.00
VIII	0	0	0	--	0	0	0%	0%	--
IX	9	6	17	32	0	0	0%	0%	0.00
X	3	2	12	15	1	1	0%	100%	0.08
TOTAL	355	267	1,465	15	53	83	90%	10%	0.06

VII.B. Comparison of Enforcement Activity Between Selected Industries

Tables 19 and 20 allow the compliance history of the textiles sector to be compared to the other industries covered by the industry sector notebooks. Comparisons between Tables 19 and 20 permit the identification of trends in compliance and enforcement records of the industry by comparing data covering the last five years (April 1992 to April 1997) to that of the past year (April 1996 to April 1997). Some points evident from the data are listed below.

- Of the sectors listed, facilities in the textile sector had one of the highest proportions of state lead enforcement actions (90 percent) over the past five years. In addition, the industry had a relatively low enforcement to inspection rate (0.06) during this period.
- Over the past year, the enforcement to inspection rate for the industry decreased further to a rate lower than many of the other sectors listed (0.04).
- The textile sector had a low percentage of facilities inspected with violations (56 percent) and enforcement actions (6 percent) in the past year compared to most of the sectors listed.

Tables 21 and 22 provide a more in-depth comparison between the textiles industry and other sectors by breaking out the compliance and enforcement data by environmental statute. As in the previous tables (Tables 19 and 20), the data cover the last five years (Table 21) and the last one year (Table 22) to facilitate the identification of recent trends. A few points evident from the data are listed below.

- The percentage of inspections carried out under each environmental statute has changed slightly between the average of the past five years and that of the past year. Inspections under CAA increased from 58 percent to 66 percent while inspections under CWA decreased from 22 percent to 17 percent.
- The percentage of enforcement actions carried out under RCRA, CWA, and FIFRA/TSCA/EPCRA/Other decreased significantly between the average of the past five years and that of the past year, while enforcement actions under CAA increased from 54 percent to 75 percent.

Table 19: Five-Year Enforcement and Compliance Summary for Selected Industries

A	B	C	D	E	F	G	H	I	J
Industry Sector	**Facilities in Search**	**Facilities Inspected**	**Number of Inspections**	**Average Months Between Inspections**	**Facilities with 1 or More Enforcement Actions**	**Total Enforcement Actions**	**Percent State Lead Actions**	**Percent Federal Lead Actions**	**Enforcement to Inspection Rate**
Metal Mining	1,232	378	1,600	46	63	111	53%	47%	0.07
Coal Mining	3,256	741	3,748	52	88	132	89%	11%	0.04
Oil and Gas Extraction	4,676	1,902	6,071	46	149	309	79%	21%	0.05
Non-Metallic Mineral Mining	5,256	2,803	12,826	25	385	622	77%	23%	0.05
Textiles	**355**	**267**	**1,465**	**15**	**53**	**83**	**90%**	**10%**	**0.06**
Lumber and Wood	712	473	2,767	15	134	265	70%	30%	0.10
Furniture	499	386	2,379	13	65	91	81%	19%	0.04
Pulp and Paper	484	430	4,630	6	150	478	80%	20%	0.10
Printing	5,862	2,092	7,691	46	238	428	88%	12%	0.06
Inorganic Chemicals	441	286	3,087	9	89	235	74%	26%	0.08
Resins and Manmade Fibers	329	263	2,430	8	93	219	76%	24%	0.09
Pharmaceuticals	164	129	1,201	8	35	122	80%	20%	0.10
Organic Chemicals	425	355	4,294	6	153	468	65%	35%	0.11
Agricultural Chemicals	263	164	1,293	12	47	102	74%	26%	0.08
Petroleum Refining	156	148	3,081	3	124	763	68%	32%	0.25
Rubber and Plastic	1,818	981	4,383	25	178	276	82%	18%	0.06
Stone, Clay, Glass and Concrete	615	388	3,474	11	97	277	75%	25%	0.08
Iron and Steel	349	275	4,476	5	121	305	71%	29%	0.07
Metal Castings	669	424	2,535	16	113	191	71%	29%	0.08
Nonferrous Metals	203	161	1,640	7	68	174	78%	22%	0.11
Fabricated Metal Products	2,906	1,858	7,914	22	365	600	75%	25%	0.08
Electronics	1,250	863	4,500	17	150	251	80%	20%	0.06
Automobile Assembly	1,260	927	5,912	13	253	413	82%	18%	0.07
Shipbuilding and Repair	44	37	243	9	20	32	84%	16%	0.13
Ground Transportation	7,786	3,263	12,904	36	375	774	84%	16%	0.06
Water Transportation	514	192	816	38	36	70	61%	39%	0.09
Air Transportation	444	231	973	27	48	97	88%	12%	0.10
Fossil Fuel Electric Power	3,270	2,166	14,210	14	403	789	76%	24%	0.06
Dry Cleaning	6,063	2,360	3,813	95	55	66	95%	5%	0.02

Table 20: One-Year Enforcement and Compliance Summary for Selected Industries

A	B	C	D	E		F		G	H
Industry Sector	Facilities in Search	Facilities Inspected	Number of Inspections	Facilities with 1 or More Violations		Facilities with 1 or more Enforcement Actions		Total Enforcement Actions	Enforcement to Inspection Rate
				Number	Percent*	Number	Percent*		
Metal Mining	1,232	142	211	102	72%	9	6%	10	0.05
Coal Mining	3,256	362	765	90	25%	20	6%	22	0.03
Oil and Gas Extraction	4,676	874	1,173	127	15%	26	3%	34	0.03
Non-Metallic Mineral Mining	5,256	1,481	2,451	384	26%	73	5%	91	0.04
Textiles	**355**	**172**	**295**	**96**	**56%**	**10**	**6%**	**12**	**0.04**
Lumber and Wood	712	279	507	192	69%	44	16%	52	0.10
Furniture	499	254	459	136	54%	9	4%	11	0.02
Pulp and Paper	484	317	788	248	78%	43	14%	74	0.09
Printing	5,862	892	1,363	577	65%	28	3%	53	0.04
Inorganic Chemicals	441	200	548	155	78%	19	10%	31	0.06
Resins and Madmade Fibers	329	173	419	152	88%	26	15%	36	0.09
Pharmaceuticals	164	80	209	84	105%	8	10%	14	0.07
Organic Chemicals	425	259	837	243	94%	42	16%	56	0.07
Agricultural Chemicals	263	105	206	102	97%	5	5%	11	0.05
Petroleum Refining	156	132	565	129	98%	58	44%	132	0.23
Rubber and Plastic	1,818	466	791	389	83%	33	7%	41	0.05
Stone, Clay, Glass and Concrete	615	255	678	151	59%	19	7%	27	0.04
Iron and Steel	349	197	866	174	88%	22	11%	34	0.04
Metal Castings	669	234	433	240	103%	24	10%	26	0.06
Nonferrous Metals	203	108	310	98	91%	17	16%	28	0.09
Fabricated Metal	2,906	849	1,377	796	94%	63	7%	83	0.06
Electronics	1,250	420	780	402	96%	27	6%	43	0.06
Automobile Assembly	1,260	507	1,058	431	85%	35	7%	47	0.04
Shipbuilding and Repair	44	22	51	19	86%	3	14%	4	0.08
Ground Transportation	7,786	1,585	2,499	681	43%	85	5%	103	0.04
Water Transportation	514	84	141	53	63%	10	12%	11	0.08
Air Transportation	444	96	151	69	72%	8	8%	12	0.08
Fossil Fuel Electric Power	3,270	1,318	2,430	804	61%	100	8%	135	0.06
Dry Cleaning	6,063	1,234	1,436	314	25%	12	1%	16	0.01

**Percentages in Columns E and F are based on the number of facilities inspected (Column C). Percentages can exceed 100% because violations and actions can occur without a facility inspection.*

Table 21: Five-Year Inspection and Enforcement Summary by Statute for Selected Industries

Industry Sector	Facilities Inspected	Total Inspections	Total Enforcement Actions	Clean Air Act		Clean Water Act		RCRA		FIFRA/TSCA/ EPCRA/Other	
				% of Total Inspections	% of Total Actions	% of Total Inspections	% of Total Actions	% of Total Inspections	% of Total Actions	% of Total Inspections	% of Total Actions
Metal Mining	378	1,600	111	39%	19%	52%	52%	8%	12%	1%	17%
Coal Mining	741	3,748	132	57%	64%	38%	28%	4%	8%	1%	1%
Oil and Gas Extraction	1,902	6,071	309	75%	65%	16%	14%	8%	18%	0%	3%
Non-Metallic Mineral Mining	2,803	12,826	622	83%	81%	14%	13%	3%	4%	0%	3%
Textiles	**267**	**1,465**	**83**	**58%**	**54%**	**22%**	**25%**	**18%**	**14%**	**2%**	**6%**
Lumber and Wood	473	2,767	265	49%	47%	6%	6%	44%	31%	1%	16%
Furniture	386	2,379	91	62%	42%	3%	0%	34%	43%	1%	14%
Pulp and Paper	430	4,630	478	51%	59%	32%	28%	15%	10%	2%	4%
Printing	2,092	7,691	428	60%	64%	5%	3%	35%	29%	1%	4%
Inorganic Chemicals	286	3,087	235	38%	44%	27%	21%	34%	30%	1%	5%
Resins and Manmade Fibers	263	2,430	219	35%	43%	23%	28%	38%	23%	4%	6%
Pharmaceuticals	129	1,201	122	35%	49%	15%	25%	45%	20%	5%	5%
Organic Chemicals	355	4,294	468	37%	42%	16%	25%	44%	28%	4%	6%
Agricultural Chemicals	164	1,293	102	43%	39%	24%	20%	28%	30%	5%	11%
Petroleum Refining	148	3,081	763	42%	59%	20%	13%	36%	21%	2%	7%
Rubber and Plastic	981	4,383	276	51%	44%	12%	11%	35%	34%	2%	11%
Stone, Clay, Glass and Concrete	388	3,474	277	56%	57%	13%	9%	31%	30%	1%	4%
Iron and Steel	275	4,476	305	45%	35%	26%	26%	28%	31%	1%	8%
Metal Castings	424	2,535	191	55%	44%	11%	10%	32%	31%	2%	14%
Nonferrous Metals	161	1,640	174	48%	43%	18%	17%	33%	31%	1%	10%
Fabricated Metal	1,858	7,914	600	40%	33%	12%	11%	45%	43%	2%	13%
Electronics	863	4,500	251	38%	32%	13%	11%	47%	50%	2%	7%
Automobile Assembly	927	5,912	413	47%	39%	8%	9%	43%	43%	2%	9%
Shipbuilding and Repair	37	243	32	39%	25%	14%	25%	42%	47%	5%	3%
Ground Transportation	3,263	12,904	774	59%	41%	12%	11%	29%	45%	1%	3%
Water Transportation	192	816	70	39%	29%	23%	34%	37%	33%	1%	4%
Air Transportation	231	973	97	25%	32%	27%	20%	48%	48%	0%	0%
Fossil Fuel Electric Power	2,166	14,210	789	57%	59%	32%	26%	11%	10%	1%	5%
Dry Cleaning	2,360	3,813	66	56%	23%	3%	6%	41%	71%	0%	0%

Table 22: One-Year Inspection and Enforcement Summary by Statute for Selected Industries

Industry Sector	Facilities Inspected	Total Inspections	Total Enforcement Actions	Clean Air Act		Clean Water Act		RCRA		FIFRA/TSCA/ EPCRA/Other	
				% of Total Inspections	% of Total Actions	% of Total Inspections	% of Total Actions	% of Total Inspections	% of Total Actions	% of Total Inspections	% of Total Actions
Metal Mining	142	211	10	52%	0%	40%	40%	8%	30%	0%	30%
Coal Mining	362	765	22	56%	82%	40%	14%	4%	5%	0%	0%
Oil and Gas Extraction	874	1,173	34	82%	68%	10%	9%	9%	24%	0%	0%
Non-Metallic Mineral Mining	1,481	2,451	91	87%	89%	10%	9%	3%	2%	0%	0%
Textiles	**172**	**295**	**12**	**66%**	**75%**	**17%**	**17%**	**17%**	**8%**	**0%**	**0%**
Lumber and Wood	279	507	52	51%	30%	6%	5%	44%	25%	0%	40%
Furniture	254	459	11	66%	45%	2%	0%	32%	45%	0%	9%
Pulp and Paper	317	788	74	54%	73%	32%	19%	14%	7%	0%	1%
Printing	892	1,363	53	63%	77%	4%	0%	33%	23%	0%	0%
Inorganic Chemicals	200	548	31	35%	59%	26%	9%	39%	25%	0%	6%
Resins and Manmade Fibers	173	419	36	38%	51%	24%	38%	38%	5%	0%	5%
Pharmaceuticals	80	209	14	43%	71%	11%	14%	45%	14%	0%	0%
Organic Chemicals	259	837	56	40%	54%	13%	13%	47%	34%	0%	0%
Agricultural Chemicals	105	206	11	48%	55%	22%	0%	30%	36%	0%	9%
Petroleum Refining	132	565	132	49%	67%	17%	8%	34%	15%	0%	10%
Rubber and Plastic	466	791	41	55%	64%	10%	13%	35%	23%	0%	0%
Stone, Clay, Glass and Concrete	255	678	27	62%	63%	10%	7%	28%	30%	0%	0%
Iron and Steel	197	866	34	52%	47%	23%	29%	26%	24%	0%	0%
Metal Castings	234	433	26	60%	58%	10%	8%	30%	35%	0%	0%
Nonferrous Metals	108	310	28	44%	43%	15%	20%	41%	30%	0%	7%
Fabricated Metal	849	1,377	83	46%	41%	11%	2%	43%	57%	0%	0%
Electronics	420	780	43	44%	37%	14%	5%	43%	53%	0%	5%
Automobile Assembly	507	1,058	47	53%	47%	7%	6%	41%	47%	0%	0%
Shipbuilding and Repair	22	51	4	54%	0%	11%	50%	35%	50%	0%	0%
Ground Transportation	1,585	2,499	103	64%	46%	11%	10%	26%	44%	0%	1%
Water Transportation	84	141	11	38%	9%	24%	36%	38%	45%	0%	9%
Air Transportation	96	151	12	28%	33%	15%	42%	57%	25%	0%	0%
Fossil Fuel Electric Power	1,318	2,430	135	59%	73%	32%	21%	9%	5%	0%	0%
Dry Cleaning	1,234	1,436	16	69%	56%	1%	6%	30%	38%	0%	0%

VII.C. Review of Major Legal Actions

Major Cases/Supplemental Environmental Projects

This section provides summary information about major cases that have affected this sector, and a list of Supplemental Environmental Projects (SEPs).

VII.C.1. Review of Major Cases

As indicated in EPA's *Enforcement Accomplishments Report, FY1995 and FY1996* publications, one significant enforcement actions was resolved between 1995 and 1996 for the textiles industry.

J-Street Site (Erwin, Harnett County, NC): On August 9, 1995, EPA issued unilateral administrative order (UAOs) to Swift Textiles, Inc., and Burlington Industries, Inc. The UAOs require the Respondents to conduct an engineering evaluation/cost analysis, expanded site investigation and a removal action for the J-Street Site, located in Erwin, Harnett County, North Carolina. Swift Textiles, Inc. is the present owner/operator of the site and Burlington Industries, Inc., was an owner/operator of the facility at the time of disposal of hazardous substances. Both Burlington and Swift have been very cooperative and are complying fully with the terms of the UAO.

VII.C.2. Supplementary Environmental Projects (SEPs)

Supplemental environmental projects (SEPs) are environmental projects that require the non-compliant facility to complete specific projects. Information on SEP cases can be accessed via the Internet at EPA's Enviroene website: http://es.inel.gov/sep.

VIII. COMPLIANCE ACTIVITIES AND INITIATIVES

This section highlights the activities undertaken by this industry sector and public agencies to voluntarily improve the sector's environmental performance. These activities include those independently initiated by industrial trade associations. In this section, the notebook also contains a listing and description of national and regional trade associations.

VIII.A. EPA Voluntary Programs

33/50 Program

The 33/50 Program is a groundbreaking program that has focused on reducing pollution from seventeen high-priority chemicals through voluntary partnerships with industry. The program's name stems from its goals: a 33% reduction in toxic releases by 1992, and a 50% reduction by 1995, against a baseline of 1.5 billion pounds of releases and transfers in 1988. The results have been impressive: 1,300 companies have joined the 33/50 Program (representing over 6,000 facilities) and have reached the national targets a year ahead of schedule. The 33% goal was reached in 1991, and the 50% goal -- a reduction of 745 million pounds of toxic wastes -- was reached in 1994. The 33/50 Program can provide case studies on many of the corporate accomplishments in reducing waste (Contact 33/50 Program Director David Sarokin -- 260-6396).

Table 23 lists those companies participating in the 33/50 program that reported four-digit SIC codes within SIC 22 to TRI. In addition, the number of facilities within each company that are participating in the 33/50 program and that report four-digit SIC codes within SIC 22 to TRI is shown. Finally, where available and quantifiable against 1988 releases and transfers, each company’s 33/50 goals for 1995 and the actual total releases, transfers and percent reduction between 1988 and 1994 are presented.

The textile manufacturing industry as a whole used, generated, or processed twelve of the seventeen target TRI chemicals in 1994. Of the 33/50 target chemicals, methyl ethyl ketone, toluene, xylenes, and methyl isobutyl ketone are *released* the most by volume (pounds). Methyl ethyl ketone is released in the greatest quantity overall. It is released at a rate almost twice that of toluene, the next largest chemical released. Together methyl ethyl ketone and toluene account for about 71 percent of 33/50 chemicals released by textile facilities and approximately 41 percent of the industry’s total TRI releases in 1994.

Of the target chemicals, methyl ethyl ketone, trichloroethylene, toluene, and xylenes (mixed isomers) are *transferred* the most by volume (pounds). Methyl ethyl ketone is transferred in the greatest quantity. The volume of it is transferred at a rate almost two and a half times greater than trichloroethylene, the next largest volume of chemical transferred. Together methyl ethyl ketone and trichloroethylene account for about 61 percent of 33/50 chemicals transferred by textile facilities and approximately 17 percent of the industry's total TRI transfers in 1994.

Table 23 shows that 47 textile companies listed under SIC 22 are participating in the 33/50 program. Within these 47 companies, 114 facilities reporting four-digit SIC codes within SIC 22 are participating in the 33/50 program. This comprises 27 percent of the textile manufacturing facilities reporting to TRI. Not every facility owned by the companies shown may be participating in the 33/50 program. The 33/50 goals shown for companies with multiple textile facilities are company-wide, potentially aggregating either more than one facility or facilities not carrying out textile manufacturing operations. In addition to company-wide goals, individual facilities may have their own 33/50 goals or may be listed specifically as not participating in the program. The actual percent reductions shown in the last column apply only to companies' textile facilities. Therefore, direct comparisons to those company goals incorporating non-textile manufacturing facilities or excluding certain facilities may not be possible. For information on specific facilities participating in 33/50, contact David Sarokin at 202-260-6907 at the 33/50 Program Office.

Table 23: Textile Industry Participation in the 33/50 Program

Parent Company (Headquarters Location)	Company-Owned Facilities Reporting 33/50 Chemicals	Company-Wide % Reduction Goal[1] (1988 to 1995)	1988 TRI Releases and Transfers of 33/50 Chemicals (pounds)	1994 TRI Releases and Transfers of 33/50 Chemicals (pounds)	Actual % Reduction for Facilities (1988-1994)
A T R Wire & Cable Co. Danville, KY	1	100	79,174	0	100
Albany International Corp. Albany, NY	1	*	0	0	0
Allied-Signal Inc. Morristown, NJ	1	50	160,600	0	100
American Home Products Corp. Madison, NJ	1	50	76,750	0	100
Amoco Corp. Chicago, IL	3	50	14,490	259	98
Barnhardt Manufacturing, Co. Charlotte, NC	4	25	57,693	76,090	-32
BGF Industries, Inc. Greensboro, NC	1	***	12,700	0	100
Borden Inc. New York, NY	1	*	73,900	0	100
BP America Inc. Cleveland, OH	1	24	217,882	0	100
Bridport-Grundy Inc. Moodus, CT	1	12	124,475	76,781	38
Burke Mills, Inc. Valdese, NC	1	35	42,863	0	100
Coating Technologies International Inc. Columbia, SC	3	59	7,778,051	5,169,485	34
Coats Viyella North America Charlotte, NC	8	38	175,277	101,859	42
Collins & Aikman Holdings II, Charlotte, NC	16	***	1,435,072	17,894	99
Continental General Tire Inc. Akron, OH	1	***	12,320	0	100
Crystal Springs Print Works Chickamauga, GA	1	50	40,850	0	100
Dundee Mills Inc. Griffin, GA	1	50	250	0	100
Exxon Corporation Irving, TX	1	50	7	5	29
Farley Inc. Chicago, IL	5	2	68,410	3,545	95
Ferro Corporation Cleveland, OH	1	50	36,650	0	100

Parent Company (Headquarters Location)	Company-Owned Facilities Reporting 33/50 Chemicals	Company-Wide % Reduction Goal[1] (1988 to 1995)	1988 TRI Releases and Transfers of 33/50 Chemicals (pounds)	1994 TRI Releases and Transfers of 33/50 Chemicals (pounds)	Actual % Reduction for Facilities (1988-1994)
GencorpInc. Akron, OH	2	33	5,427,191	2,957,175	46
Glen Raven Mills Inc. Burlington, NC	4	50	54,724	116,042	-112
Grafil Inc. Sacramento, CA	1	***	0	21,192	0
Hood Coatings, Inc. Georgetown, MA	1	76	39,249	2,994	92
Joan Fabrics Corp Tyngsboro, MA	2	**	0	0	0
Magee Industrial Enterprises Bloomsburg, PA	1	*	342,615	0	100
Manning Fabrics Inc. Pinehurst, NC	1	*	27,429	0	100
Mascotech, Taylor, MI	1	35	295,229	0	100
Masland Industries Carlisle, PA	2	***	283,626	0	100
Middlesex Research Mfg. Co. Hudson, MA	1	100	39,000	0	100
Milliken and Company Spartanburg, SC	18	50	681,599	40,805	94
Odyssey Partners LP New York, NY	2	***	897,200	3,912	100
Parker Hannifin Corp. Cleveland, OH	1	50	34,171	0	100
Paulsen Wire Rope Corp. Sunbury, PA	1	80	15,000	0	100
Penn Columbia Corp. New York, NY	1	50	64,750	0	100
Precision Fabrics Group Inc. Greensboro, NC	1	100	1,387	1,390	0
Ruddick Corp. Charlotte, NC	2	***	160,000	315,242	-97
Russell Corp Alexander City, AL	2	90	346,015	137,699	60
Santee Print Works Sumter, SC	1	33	106,650	68,762	36
Sara Lee Corp. Chicago, IL	2	1	0	86	0
Scapa Group Inc. Raleigh, NC	3	**	0	37,800	0
Schneller Inc. Kent, OH	1	*	250	47,870	-19048

Parent Company (Headquarters Location)	Company-Owned Facilities Reporting 33/50 Chemicals	Company-Wide % Reduction Goal[1] (1988 to 1995)	1988 TRI Releases and Transfers of 33/50 Chemicals (pounds)	1994 TRI Releases and Transfers of 33/50 Chemicals (pounds)	Actual % Reduction for Facilities (1988-1994)
Springs Industries Inc. Fort Mill, SC	5	80	185,528	8,987	95
Textile, Rubber and Chemical Corp. Dalton, GA	1	*	0	702	0
Trefilarbed Arkansas Inc. Pine Bluff, AR	1	*	0	83,315	0
United Silk Mills, USA Ltd. New York, NY	1	60	77,650	0	100
Zeneca Holdings Inc. Wilmington, DE	2	*	0	0	0
TOTAL	**114**		**19,486,677**	**9,289,891**	**52**

Source: *US EPA 33/50 Program Office, 1996.*

[1] Company-wide Reduction Goals aggregate all company-owned facilities which may include facilities not producing textiles.

* = Reduction goal not quantifiable against 1988 TRI data.

** = Use reduction goal only.

*** = No numeric reduction goal.

Note: Some of the facilities listed in this table manufacture coated fabrics and are classified as SIC Code 2295, Miscellaneous Textiles, Coated Fabrics -- Not Rubberized.

Environmental Leadership Program

The Environmental Leadership Program (ELP) is a national initiative developed by EPA that focuses on improving environmental performance, encouraging voluntary compliance, and building working relationships with stakeholders. EPA initiated a one year pilot program in 1995 by selecting 12 projects at industrial facilities and federal installations which would demonstrate the principles of the ELP program. These principles include: environmental management systems, multimedia compliance assurance, third-party verification of compliance, public measures of accountability, pollution prevention, community involvement, and mentor programs. In return for participating, pilot participants received public recognition and were given a period of time to correct any violations discovered during these experimental projects.

EPA is making plans to launch its full-scale Environmental Leadership Program in 1997. The full-scale program will be facility-based with a 6-year participation cycle. Facilities that meet certain requirements will be eligible to participate, such as having a community outreach/employee involvement programs and an environmental management system (EMS) in place for 2 years. (Contact: http://es.inel.gov/elp or Debby Thomas, ELP Deputy Director, at 202-564-5041)

Project XL

Project XL was initiated in March 1995 as a part of President Clinton's *Reinventing Environmental Regulation* initiative. The projects seek to achieve cost effective environmental benefits by providing participants regulatory flexibility on the condition that they produce greater environmental benefits. EPA and program participants will negotiate and sign a Final Project Agreement, detailing specific environmental objectives that the regulated entity shall satisfy. EPA will provide regulatory flexibility as an incentive for the participants' superior environmental performance. Participants are encouraged to seek stakeholder support from local governments, businesses, and environmental groups. EPA hopes to implement fifty pilot projects in four categories, including industrial facilities, communities, and government facilities regulated by EPA. Applications will be accepted on a rolling basis. For additional information regarding XL projects, including application procedures and criteria, see the May 23, 1995 Federal Register Notice. (Contact: Fax-on-Demand Hotline 202-260-8590, Web: http://www.epa.gov/ProjectXL, or Christopher Knopes at EPA's Office of Policy, Planning and Evaluation 202-260-9298)

Climate Wise Program

Climate Wise is helping US industries turn energy efficiency and pollution prevention into a corporate asset. Supported by the technical assistance, financing information and public recognition that Climate Wise offers, participating companies are developing and launching comprehensive industrial energy efficiency and pollution prevention action plans that save money and protect the environment. The nearly 300 Climate Wise companies expect to save more than $300 million and reduce greenhouse gas emissions by 18 million metric tons of carbon dioxide equivalent by the year 2000. Some of the actions companies are undertaking to achieve these results include: process improvements, boiler and steam system optimization, air compressor system improvements, fuel switching, and waste heat recovery measures including cogeneration. Created as part of the President's Climate Change Action Plan, Climate Wise is jointly operated by the Department of Energy and EPA. Under the Plan many other programs were also launched or upgraded including Green Lights, WasteWi$e and DoE's Motor Challenge Program. Climate Wise provides an umbrella for these programs which encourage company participation by providing information on the range of partnership opportunities available. (Contact: Pamela Herman, EPA, 202-260-4407 or Jan Vernet, DoE, 202-586-4755)

Energy Star Buildings Program

EPA's ENERGY STAR Buildings Program is a voluntary, profit-based program designed to improve the energy-efficiency in commercial and industrial buildings. Expanding the successful Green Lights Program, ENERGY STAR Buildings was launched in 1995. This program relies on a 5-stage strategy designed to maximize energy savings thereby lowering energy bills, improving occupant comfort, and preventing pollution -- all at the same time. If implemented in every commercial and industrial building in the United States, ENERGY STAR Buildings could cut the nation's energy bill by up to $25 billion and prevent up to 35% of carbon dioxide emissions. (This is equivalent to taking 60 million cars of the road). ENERGY STAR Buildings participants include corporations; small and medium sized businesses; local, federal and state governments; non-profit groups; schools; universities; and health care facilities. EPA provides technical and non-technical support including software, workshops, manuals, communication tools, and an information hotline. EPA's Office of Air and Radiation manages the operation of the ENERGY STAR Buildings Program. (Contact: Green Light/Energy Star Hotline at 1-888-STAR-YES or Maria Tikoff Vargas, EPA Program Director at 202-233-9178 or visit the ENERGY STAR Buildings Program website at http://www.epa.gov/appdstar/buildings/)

Green Lights Program

EPA's Green Lights program was initiated in 1991 and has the goal of preventing pollution by encouraging U.S. institutions to use energy-efficient lighting technologies. The program saves money for businesses and organizations and creates a cleaner environment by reducing pollutants released into the atmosphere. The program has over 2,345 participants which include major corporations, small and medium sized businesses, federal, state and local governments, non-profit groups, schools, universities, and health care facilities. Each participant is required to survey their facilities and upgrade lighting wherever it is profitable. As of March 1997, participants had lowered their electric bills by $289 million annually. EPA provides technical assistance to the participants through a decision support software package, workshops and manuals, and an information hotline. EPA's Office of Air and Radiation is responsible for operating the Green Lights Program. (Contact: Green Light/Energy Star Hotline at 1-888-STARYES or Maria Tikoff Vargar, EPA Program Director, at 202-233-9178 the)

WasteWi$e Program

The WasteWi$e Program was started in 1994 by EPA's Office of Solid Waste and Emergency Response. The program is aimed at reducing municipal solid wastes by promoting waste prevention, recycling collection and the manufacturing and purchase of recycled products. As of 1997, the program had about 500 companies as members, one third of whom are Fortune 1000 corporations. Members agree to identify and implement actions to reduce their solid wastes setting waste reduction goals and providing EPA with yearly progress reports. To member companies, EPA, in turn, provides technical assistance, publications, networking opportunities, and national and regional recognition. (Contact: WasteWi$e Hotline at 1-800-372-9473 or Joanne Oxley, EPA Program Manager, 703-308-0199)

NICE^3

The U.S. Department of Energy is administering a grant program called The National Industrial Competitiveness through Energy, Environment, and Economics (NICE^3). By providing grants of up to 45 percent of the total project cost, the program encourages industry to reduce industrial waste at its source and become more energy-efficient and cost-competitive through waste minimization efforts. Grants are used by industry to design, test, and demonstrate new processes and/or equipment with the potential to reduce pollution and increase energy efficiency. The program is open to all industries; however, priority is given to proposals from participants in the forest products, chemicals, petroleum refining, steel, aluminum, metal casting and glass manufacturing sectors. (Contact: http//www.oit.doe.gov/access/nice3, Chris Sifri, DOE, 303-275-4723 or Eric Hass, DOE, 303-275-4728)

Design for the Environment (DfE)

DfE is working with several industries to identify cost-effective pollution prevention strategies that reduce risks to workers and the environment. DfE helps businesses compare and evaluate the performance, cost, pollution prevention benefits, and human health and environmental risks associated with existing and alternative technologies. The goal of these projects is to encourage businesses to consider and use cleaner products, processes, and technologies. For more information about the DfE Program, call (202) 260-1678. To obtain copies of DfE materials or for general information about DfE, contact EPA's Pollution Prevention Information Clearinghouse at (202) 260-1023 or visit the DfE Website at http://es.inel.gov/dfe.

VIII.B. Trade Association/Industry Sponsored Activity

VIII.B.1 Environmental Programs

Encouraging Environmental Excellence (E3)

The Encouraging Environmental Excellence (E3) program is a voluntary environmental initiative, created in 1992, by the American Textile Manufacturers Institute (ATMI). The program aims to strengthen textile companies' commitment to addressing environmental issues. E3 encourages member companies to focus their environmental efforts in the areas of recycling and waste reduction, pollution prevention, and water and energy conservation. Companies may join the E3 program provided they are in compliance with all federal and state environmental laws, and follow a 10-point set of guidelines set forth by ATMI. Some of these guidelines include: providing ATMI with a company environmental policy; submitting a copy of environmental audits showing that the company is in compliance with federal and states laws; listing a set of environmental goals and target achievement dates; and describing how the company has been able to offer assistance to citizens, interest groups, other companies, and government agencies. In 1995, 52 textile companies were members of the E3 program. For more information on ATMI's E3 program, please contact, ATMI at 202-862-0500.

American Textile Partnership (AMTEX)

The American Textile Partnership (AMTEX) is a collaborative research program between the United States Integrated Textile Complex (U.S. ITC), the United States Department of Energy (U.S. DOE), national research laboratories, and research universities. The U.S. ITC includes manufacturers of fibers, fabrics, apparel, sewn products, and retailers. The goal of AMTEX is to strengthen the national and international competitiveness of the U.S. ITC through research and development. AMTEX runs several projects, some of which directly or indirectly address environmental issues facing the textile industry. Projects that specifically address environmental issues are highlighted below.

Textile Resource Conservation (TRec)

The Textile Resource Conservation (TRec) is one of many projects under the American Textile Partnership (AMTEX). The goal of the TRec project is to develop resource-efficient textile manufacturing processes which use less energy and natural resources, with no net waste to the environment. The project aims to:

- Recover and reuse 100,000 tons of knit fabric waste valued at $474 million per year.

- Reduce water use by 133 billion gallons per year, including 50 billion gallons sent to waste treatment at a combined cost of $146 million.

- Recover valuable raw materials. For example, raw materials in reactive dyes alone were valued at over $66 million/year.

So far the program's achievements include:

- Developing a method for recovering dyes and colorants.
- Developing a process for recovering and reusing polyester and cotton from scrap fabric and apparel.
- Demonstrating a method by which the amount of chemical, water, and energy needed to scour, wash, and finish fabrics is greatly reduced.
- Developing a water-based method for removing oil and grease from fabric instead of using volatile solvents.

For more information, contact Don Alexander, Project Manager, at the Institute of Textile Technology at 864-595-0035.

Demand Activated Manufacturing Architecture (DAMA)

The Demand Activated Manufacturing Architecture (DAMA) is a project under AMTEX, that aims to develop a computer-based information system by the end of the decade. This system will link all aspects of the U.S. Integrated Textile Complex (ITC) in an electronic marketplace, thereby streamlining the entire industry. (The ITC includes manufacturers of fibers, fabrics, apparel, sewn products, and retailers.) Through this electronic marketplace, companies will be able to identify, compare, buy and sell resources, products, and services offered.

Through DAMA, all sectors of the ITC will be linked with each other through electronic mail (E-mail), the World Wide Web, and other Internet interfaces. DAMA hopes that this will allow companies to be more responsive to changes and shifts in customer demands, thereby enabling the ITC to streamline the entire textile and apparel production process. As a result, shipment and handling costs should be reduced and overproduction curbed. Additionally, it is projected that $25 billion per year can be saved by better inventory management through DAMA (Textile/Clothing Technology Corp., 1996) For more information on the DAMA project, contact James Lovejoy at the Textile/Clothing Technology Corp. (TC^2) at 919-380-2184.

VIII.B.2. Summary of Trade Associations

American Textile Manufacturers
Institute (ATMI)
1130 Connecticut Ave., NW, Suite 1200
Washington, DC 20036-3954
Phone: (202) 862-0500
Fax: (202) 862-0570
http://www.atmi.org

Members: 150 companies
Staff: 36
Budget: $2,000,000-$5,000,000

The American Textile Manufacturers Institute (ATMI) is the one of the largest trade associations for the textile industry. Members companies of ATMI, are located in more than 30 different states and process approximately 80 percent of textile fibers consumed by plants in the United States (ATMI, 1997). ATMI serves as the main liaison between the various sectors of the textile industry, and government agencies and the media. It also provides its members with information on international trade, government relations, and economic conditions facing the industry. Additionally, ATMI also provides product, communication, and administrative services for its members. ATMI also puts out several publications including *Textile Hi-Lights, Textile Trends* and *Global View.*

Northern Textile Association (NTA)
230 Congress Street,
Boston, MA 02110
Phone: (617) 542-8220
Fax: (617) 542-2199

Members: 280 mills
Staff: 6-10
Budget: $250,000-$500,000

The Northern Textile Association (NTA) is the oldest trade association for the textile industry. Its members are located in 23 states in the U.S. as well as in Canada and overseas. However, the majority of its members are still primarily located in New England. Although a large proportion of its members manufacture cotton and synthetic yarns, NTA also represents manufacturers of wool, flock, felt, elastic, and luxury fiber products. NTA also acts as a liaison between the industry and federal, state, national and international agencies.

American Association for Textile Technology
P.O. Box 99
Gastonia, NC 28053
Phone: (704) 824-3522
Fax: (704) 824-0630

Members: 400 individuals
Staff: 2
Budget: $10,000-$25,000

This association is composed of individuals involved in fiber, yarn, and fabric formation technology. Organized in 1934 and incorporated in 1945, this group encourages the growth and dissemination of knowledge in the field of textile technology and marketing.

American Association of Textile Chemists and Colorists
P.O. Box 12215
Research Triangle Park, NC 27709-2215
Phone: (919) 549-8141
Fax: (919) 549-8933

Members: 8,000 individuals and 300 organizations
Staff: 20-25
Budget: $2,000,000-$5,000,000

This group was founded in Boston in 1921 with 270 charter members and incorporated in Massachusetts. The American Association of Textile Chemists and Colorists promotes the increase in knowledge of the application of dyes and chemicals in the textile industry and the use of textile wet processing machinery. Publications include the *AATCC Technical Manual* (annual) and *Textile Chemist & Colorist* (monthly).

American Yarn Spinners Association
P.O. Box 99
Gastonia, NC 28053
Phone: (704) 824-3522
Fax: (704) 824-0630

Members: 120 companies
Staff: 7
Budget: $100,000-$250,000

This group was formed, in 1967, from the merger of the Carded Yarn Association and the Combed Yarn Spinners. This group is affiliated with the Craft Yarn Council of America. This group absorbed the Long Staple Yarn Association in 1974, the Yarn Dyers Association in 1976, the Carpet Yarn Association in 1981, and the Association of Synthetic Yarn Manufacturers in 1988.

Carpet and Rug Institute
310 S. Holiday Ave.
P.O. Box 2048
Dalton, GA 30722-2048
Phone: (706) 278-3176
Fax: (706) 278-8835

Members: 225 companies
Staff: 15
Budget: $1,000,000-$2,000,000

This group was formed, in 1928, from the merger of the American Carpet Institute and the Tufted Textile Manufacturers Association. The group publishes a membership directory and holds annual meetings in the fall.

INDA, Association of the Nonwoven Fabrics Industry	
1001 Winstead Drive, Suite 460	
Cary, NC 27513	Members: 135 companies
Phone: (919) 677-0060	Staff: 13
Fax: (919) 677-0211	Budget: $1,000,000-$2,000,000

This group includes suppliers of fibers, adhesives, chemicals, fluff pulp, plastic film and related materials, roll goods producers, machinery and equipment suppliers, finishers and converters, and marketers of finished products. INDA publishes the *INDA Journal of Nonwoven Research* (quarterly), the *Nonwoven Handbook*, and a variety of conference papers.

International Society of Industrial Fabric Manufacturers	
1337 Garden Circle Drive	Members: 350 individuals
Newberry, SC 29108	Staff: 1
Phone: (803) 939-8513	Budget: under $10,000

Members of this group include engineers, executives, technicians and salespersons in the industrial fabrics and textile industry. Formerly called the International Society of Industrial Yarn Manufacturers, this association holds two semi-annual meetings in the spring and fall.

International Textile and Apparel Association	
P.O. Box 1360	Members: 1,000 individuals
Monument, CO 80132-1360	Staff: 1
Phone: (719) 488-3716	Budget: $100,000-$250,000

Formerly known as the Association of College Professors of Textiles and Clothing, this association started up as an outgrowth of regional conferences of textile and clothing professors. Active members are people engage in college or university instruction, research, and/or administration in textiles, clothing, or a related area. Publications include *The Clothing and Textiles Research Journal* (quarterly) and the *ITAA Proceedings.*

Knitted Textile Association	
386 Park Avenue South, 9th Floor	
New York, NY 10016	Members: 165 companies
Phone: (212) 689-3807	Staff: 2-5
Fax: (212) 889-6160	Budget: $250,000-$500,000

This group was first established as the Knitted Fabric Group. Members include makers of knitted fabrics of all types and their suppliers. This trade association holds an annual meeting in March.

Page 132 intentionally left blank.

IX. CONTACTS AND REFERENCES

For further information on selected topics within the textile industry a list of publications and contacts are provided below.

Contacts[5]

Name	Organization	Telephone	Subject
Belinda Breidenbach	EPA, Office of Compliance	202-564-7022	Compliance assistance and regulatory requirements
Paul Almodovar	EPA, Office of Air Quality Planning and Standards	919-541-0283	Regulatory development
Doug Williams	EPA, Office of Research and Development	513-569-7361	Industrial processes and pollution prevention
Brent Smith	NC State	919-515-6548	Manmade fibers processes and pollution prevention methods
Jane Henriques	American Textile Manufacturers Institute	202-862-0500	Industrial processes and pollution prevention methods
Karen Addis	American Textile Manufacturers Institute	202-862-0500	Industrial processes
David Trumbull	Northeast Textile Association (NTA)	617-542-8220	Environmental initiatives and programs and regulatory issues

CAA: Clean Air Act
CWA: Clean Water Act
OECA: Office of Enforcement and Compliance Assurance
NEIC: National Enforcement Investigations Center
RCRA: Resource Conservation and Recovery Act

---

[5] Many of the contacts listed above have provided valuable background information and comments during development of this document. EPA appreciates this support and acknowledges that the individuals listed do not necessarily endorse all statements made within this notebook.

References

Section II - Introduction, Background, and Scope

1) American Textiles Manufacturers Institute (ATMI). *Textiles: America's First Industry*, Washington, DC, 1997a.

2) American Textiles Manufacturers Institute (ATMI). Comments on draft of this document, 1997b.

3) American Textiles Manufacturers Institute (ATMI). *The U.S. Textile Industry, Scope and Importance*, Office of the Chief Economist, Washington, DC, 1996.

4) Benjamin, R.(Ed.) *Fairchild's Textile & Apparel Financial Directory 1996*, Fairchild Publications, New York, NY, 1996.

5) Gale Research Inc. *Ward's Business Directory of U.S. Private and Public Companies,* 1995.

6) Neefus, J.D. "Textile Industrial Processes," in *Industrial Hygiene Aspects of Plant Operations, Volume 1, Process Flows,* Cralley, L.V. and Cralley, L.J. (eds.)., MacMillan Publishing Co., Inc., New York, NY, 1982.

7) Office of Management and Budget. *Standard Industrial Classification Manual*, Washington, DC, 1987.

8) United States Department of Commerce. *1992 Census of Manufactures, Industry Series, Weaving and Floor Covering Mills, Industries 2211, 2221, 2231, 2241, and 2273*, Bureau of the Census, Washington, DC, 1995.

9) United States Department of Commerce. *1992 Census of Manufactures, Industry Series, Knitting Mills, Industries 2251, 2252, 2253, 2254, 2257, 2258, and 2259,* Bureau of the Census, Washington, DC, 1995.

10) United States Department of Commerce. *1992 Census of Manufactures, Industry Series, Dyeing and Finishing Textiles, Except Wool Fabrics and Knit Goods, Industries 2261, 2262, and 2269*, Bureau of the Census, Washington, DC, 1995.

11) United States Department of Commerce. *1992 Census of Manufactures, Industry Series, Yarn and Thread Mills, Industries 2281, 2282, and 2284,* Bureau of the Census, Washington, DC, 1995.

12) United States Department of Commerce. *1992 Census of Manufactures, Industry Series, Miscellaneous Textile Goods, Industries 2295, 2296, 2297, 2298, and 2299,* Bureau of the Census, Washington, DC, 1995.

13) United States Environmental Protection Agency. *Best Management Practices for Pollution Prevention in the Textile Industry,* EPA, Office of Research and Development, 1996.

14) Wilson, K. *A History of Textiles*, Westview Press, Boulder, CO, 1979.

Section III - Industrial Process Description

1) American Textiles Manufacturers Institute (ATMI). Comments on draft of this document, 1997b.

2) Calfa, L., Holbrook, J., Keenan, C., and T. Reilly. *A Guide to Pollution Prevention in Woolen Mills.* Prepared for Northern Textile Association, Boston, 1993.

3) Corbman, B.P. *Textiles: Fiber to Fabric,* 5th edition, McGraw-Hill, Inc., New York, 1975.

4) Foundation of Flexographic Technical Association (FFTA). *Flexography: Principles and Practices,* 4th edition, Ronkonkoma, NY, 1991.

5) Ormerod, A. *Modern Preparation and Weaving Machinery,* Butterworth and Co. Ltd, London, 1983.

6) Oxtoby, E. *Spun Yarn Technology,* Butterworth and Co. Ltd, London, 1987.

7) Press, J.J. *Man-made Textile Encyclopedia,* Textile Book Publishers, Inc., New York, 1959.

8) Snowden-Swan, L.J. "Pollution Prevention in the Textile Industries," in *Industrial Pollution Prevention Handbook,* Freeman, H.M. (Ed.), McGraw-Hill, Inc., New York, 1995.

9) Spencer, D.J. *Knitting Technology,* 2nd edition, Pergamon Press, Oxford, 1983.

10) United States Environmental Protection Agency. *Best Management Practices for Pollution Prevention in the Textile Industry,* EPA, Office of Research and Development, 1996.

11) Wingate, Dr. Isabel B. *Fairchild's Dictionary of Textiles,* 6th edition, Fairchild Publications, New York, 1979.

Section V - Pollution Prevention Opportunities

1) Calfa, L., Holbrook, J., Keenan, C., and T. Reilly. *A Guide to Pollution Prevention in Woolen Mills.* Prepared for Northern Textile Association, Boston, 1993.

2) NCDEHNR. *Case Studies: A Compilation of Successful Waste Reduction Projects Implemented by North Carolina Businesses and Industries.* North Carolina Department of Environment, Health, and Natural Resources, Office of Waste Reduction, Raleigh, North Carolina, 1995.

3) NCDEHNR. *Identification and Reduction of Pollution Sources in Textile Wet Processing.* North Carolina Department of Environment, Health, and Natural Resources, Office of Waste Reduction, Raleigh, North Carolina, 1991.

4) NCDEHNR. *A Workbook for Pollution Prevention by Source Reduction in Textile Wet Processing.* North Carolina Department of Environment, Health, and Natural Resources, Office of Waste Reduction, Raleigh, North Carolina, 1988.

5) Snowden-Swan, L.J. "Pollution Prevention in the Textile Industries," in *Industrial Pollution Prevention Handbook,* Freeman, H.M. (Ed.), McGraw-Hill, Inc., New York, 1995.

6) United States Environmental Protection Agency. *Best Management Practices for Pollution Prevention in the Textile Industry,* EPA, Office of Research and Development, 1995.

Section VII - Federal Statutes and Regulations

1) Internet Site: http://cbmnt1.energylan.sandia.gov/amtexwww/conservation.html

2) Textile/Clothing Technology Corp. (TC^2), *The Textile Revolution: DAMA The Demand Activated Manufacturing Architecture Project*, Cary, NC, 1996.