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INDUSTRIAL RECOVERED-MATERIALS-UTILIZATION TARGETS FOR THE TEXTILE-MILL-PRODUCTS INDUSTRY

Work Performed Under Contract No. EM-78-C-03-1694

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U. S. DEPARTMENT OF ENERGY

Division of Industrial Energy Conservation

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INDUSTRIAL RECOVERED-MATERIALS-UTILIZATION TARGETS FOR THE TEXTILE-MILL-PRODUCTS INDUSTRY

Prepared for:
U. S. Department of Energy
Assistant Secretary for Conservation and Solar Energy
Office of Industrial Programs

√ 950 1216

Under Contract No. EC-77-C-03-1694

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This document was prepared by Booz-Allen & Hamilton Inc., under direction by the Office of Industrial Programs, Office of the Assistant Secretary for Conservation and Solar Energy, U.S. Department of Energy. The analysis and determinations indicated in this document have been used as a basis for recovered materials utilization targets for the textile mill products industry. These targets are required to be established by Section 374A of the Energy Policy and Conservation Act as amended by the National Energy Conservation Policy Act.

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EXECUTIVE SUMMARY

The Congress, in the National Energy Conservation and Policy Act of 1978 (NECPA), directed the Department of Energy to establish materials recovery targets for four basic industrial sectors. Included were the metals and metal products, paper and allied products, rubber, and textile mill products industries. The targets were developed to provide incentives for using energy saving recovered materials and to provide a yardstick for measuring progress and improvement in this endeavor. Within DOE, responsibility for establishing the targets was assigned to the Office of Industrial Programs, Assistant Secretary for Conservation and Solar Applications.

The NECPA indicates that the targets should represent the maximum technically and economically feasible increase in the use of energy-saving recovered materials that each industry can achieve progressively by January 1, 1987. Materials affected by recovered materials targets include and are limited to aluminum, copper, lead, zinc, iron, steel, paper and associated products, textile mill, products and rubber. The use of these constituents for purposes other than the manufacture of the typical products was not considered in determining or satisfying the targets for each industry. This excluded the burning of waste material to produce heat or steam and the use of recovered chemicals and other by-products common to the four industries.

Using information gathered from the textile mill products industry and from other textile-related sources, DOE has developed recovered materials targets for that industry. This report presents those targets and their basis and justification.

1. THE TEXTILE MILL PRODUCTS INDUSTRY

The textile mill products industry is primarily a fabricated products industry. It processes natural fibers, man-made fibers, and continuous man-made filament into yarn and fabric. The Department of Commerce (DOC), in its Standard Industrial Code (SIC) classification, indicates that this diverse industry (SIC 22) is made up of 30 four-digit sublevels performing the following manufacturing operations:

- Preparing fiber and subsequently manufacturing yarn, thread, braids, twine, and cordage
- Manufacturing broad woven fabric, narrow woven fabric, knit fabric, and carpets and rugs from yarn
- Dyeing and finishing fiber, yarn, knit apparel, and fabric
- Coating, water proofing, or otherwise treating fabric
- Integrated manufacturing of knit apparel and other finished articles from yarn
- Manufacturing felt goods, lace goods, non-woven fabrics, and miscellaneous textiles.

Typical operations of the textile industry include inspection and testing fibers, blending natural and man-made fibers, spinning into yarn, and weaving into fabric. This fabric is then inspected, dyed and finished to the specifications of the customer in one or more of many finishing processes. Some integrated mills produce finished products such as:

- Sheeting
- Toweling
- Carpets and rugs
- Knitted underwear and outerwear
- Thread
- Lace goods
- Tire cord and fabric.

Many of the approximately 7000 plants in the U.S. textile industry generate products that are used solely by other textile manufacturing operations:

- Apparel fabric is finished in the broad woven state and shipped to apparel manufacturers for cutting and sewing
- Finishing mills prepare greige goods for use in other operations
- Texturizing mills prepare continuous filament yarn for use in weaving and knitting operations.

Many times, because of the economics of scale, several greige mills will supply greige goods to one finishing plant for final processing.

Operational economics are extremely critical for the firms in the textile industry. The industry is mature and the largest firm commands about 7 percent of the market. There are over 5000 firms in the United States with only about 80 of them publicly held. In fact, the second largest firm is a privately-held company. To be able to operate in such a competitive market, continuous production at minimum cost is imperative. However, it is essential to maintain the quality demanded by intermediate and final consumers such as the apparel industry, retail chains, and individual customers.

The textile mill products industry is also under pressure from foreign textile imports. The textile market is growing at about 3 percent per year and imports are growing at 6 percent. Cheaper foreign imports exert a pressure on the industry to reduce its labor intensiveness by installing more modern equipment. Progress has and will continue to be slow because of a lack of investment capital. The industry's current profit is about 2 percent of sales and there is little capital available from the equity or debt markets.

There is also a large demand for capital created by several government regulations, primarily the OSHA cotton dust and noise standards, and environmental standards. The industry has little availability of non-discretionary capital and this is not anticipated to change between now and 1987.

2. RECOVERED MATERIALS IN THE TEXTILE MILL PRODUCTS INDUSTRY

Waste material generated in the textile mill products industry is consumed in secondary processes within the industry to improve production economics. Over 12 billion pounds of virgin fiber was purchased by the textile mill products industry in 1977. As shown in Figure ES-1, about 93.2 percent of this was consumed in producing first-tier products (those fashion and style conscious items that must adhere to strict quality specifications).

The remaining virgin fibers, which constitute about 6.8 percent of the total, are those that are too short to make an acceptable product (comber and wool noils) and those that are process operating waste (card strips, sweep waste, thread waste, mill or process ends). Those wastes become input material to the second tier segments of the industry which use them in felting, furniture padding, non-woven materials and the like (see Figure ES-2). In this tier, utility is the primary criteria as most of the products are not seen by the final customer.

This waste generated by the textile mill products industry plus the small amount purchased from waste dealers is almost totally utilized in the second tier products. The remaining, which is about 0.7 percent of the total purchased virgin fiber, is generally discarded to landfills although some small portion is burned for boiler fuel. The total fiber dumped is about 100 million pounds per year and is considered to be unusable by the waste reprocessors.

There is a waste processing subsector within the textile mill products industry. This was created by the need for the collection, classification, separation, and preprocessing of available waste from those firms with no second tier processes for delivery to the second tier firms. The waste processors tend to be small, privately-owned companies that operate within a local area. These companies also operate on very low margins and cannot afford expensive preprocessing equipment or labor intensive manual sorting. As it is, many such firms are threatened by the capital requirements of the OSHA cotton dust and noise standards. It is not likely they could install new separating and preprocessing equipment even if it were available.

FIGURE ES-1
Typical Waste Flow in the Textile Mill Products Industry

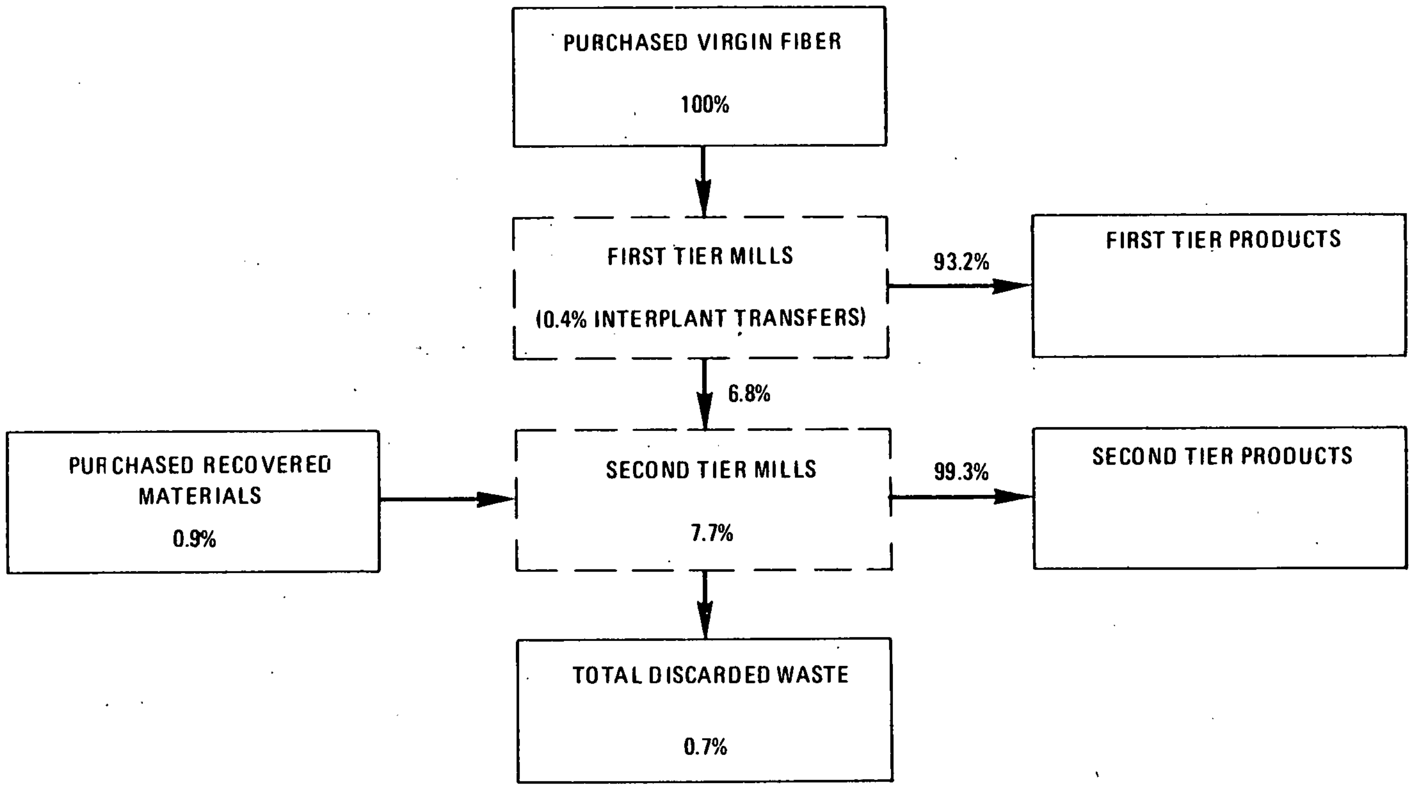
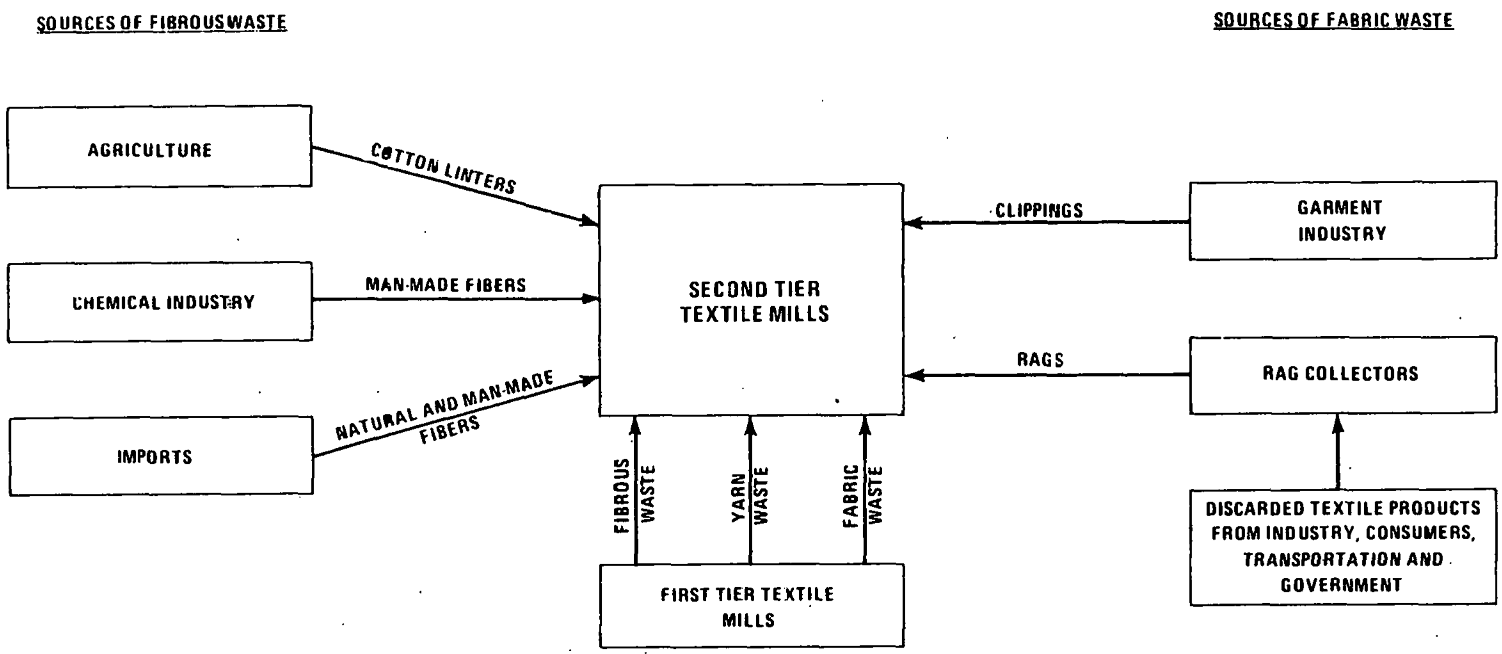


FIGURE ES-2
Sources of Waste for the Second Tier of the Textile Mill Products Industy



3. RECOVERED MATERIALS TARGETS

Materials recovery targets were developed for each four digit SIC sector for the textile mill products industry. This was accomplished by determining from available data the amount of material currently being reused and projecting that use to 1987. The targets established are the percentage of fiber used by each sector that is to be satisfied by recovered materials. Qualitative judgments were made about the effect of various factors, such as:

- Anticipated new technologies that could affect the use of recovered materials by 1987
- Anticipated changes in the intermediate and final markets that could affect the use of recovered materials.

Taking into account the effects of such factors, the targets for 1987 were established.

Activities and policies that may be undertaken by the industry and by state, federal, and local governments to increase the use of recovered materials were also addressed.

Shown in Figure ES-3 are the targets for the textile mill products industry. As indicated, all but two of the four-digit codes in the first tier of the textile mill products industry have a target of zero percent. The only exceptions are wool processing, SICs 2231 and 2283. The following subsectors, then, all have targets of zero percent:

- SIC 221 through 2284, except for SIC 2231 and 2283 (broad woven fabric and yarn mills, wool)
- SIC 2292 (lace goods)
- SIC 2295 (coated fabrics, not rubberized).

FIGURE ES-3
Recovered Materials Targets
for the Textile Mill Products Industry

SIC	INDUSTRY SUBDIVISION	PROCESSED MATERIAL		1978 LEVEL OF RECOVERED MATERIALS USE	1987 RECOVERED MATERIALS TARGET
		MILLION POUNDS	PERCENT OF TOTAL	PERCENT OF TOTAL FIBER & YARN PROCESSED	PERCENT OF TOTAL FIBER & YARN PROCESSED
2211	BROAD WOVEN FABRIC MILLS, COTTON	2,587.8	16.6	0	0
2221	BROAD WOVEN FABRIC MILLS, MAN-MADE FIBER & SILK	2,717.5	17.5	0	0
2231	BROAD WOVEN FABRIC MILLS, WOOL	178.9	1.1	13	13
2241	NARROW FABRICS, COTTON, WOOL, SILK & MAN-MADE	194.3	1.2	0	0
2251	WOMEN'S FULL LENGTH & KNEE LENGTH HOSIERY	89.8	0.6	0	0
2252	OTHER HOSIERY	120.4	0.8	0	0
2253	KNIT OUTERWEAR MILLS	315.7	2.0	0	0
2254	KNIT UNDERWEAR MILLS	147.5	0.9	0	0
2257	CIRCULAR KNIT FABRIC MILLS	1,094.5	7.0	0	0
2258	WARP KNIT FABRIC MILLS	496.9	3.2	0	0
2259	KNITTING MILLS, N.E.C.	7.7	0.0	0	0
2261	BROAD WOVEN FABRIC FINISHERS, COTTON	N/A	N/A	0	0
2262	BROAD WOVEN FABRIC FINISHERS, SILK & MAN-MADE	N/A	N/A	0	0
2269	TEXTILE FINISHERS, N.E.C.	N/A	N/A	0	0
2271	WOVEN CARPETS & RUGS	83.1	0.5	0	0
2272	TUFTED CARPETS & RUGS	1,306.7	8.4	0	0
2279	CARPETS & RUGS, N.E.C.	41.6	0.3	0	0
2281	YARN SPINNING MILLS, COTTON, SILK, MAN-MADE FIBERS	2,706.1	17.3	0	0
2282	YARN TEXTURIZING, COTTON, SILK, MAN-MADE FIBER	891.6	5.7	0	0
2283	YARN MILLS, WOOL	123.9	0.8	13	13
2284	THREAD MILLS	139.2	0.9	0	0
2291	FELT GOODS, EXCEPT WOVEN FELTS & HATS	58.5	0.4	59	80
2292	LACE GOODS	5.0	0.0	0	0
2293	PADDING & UPHOLSTERY FILLING	330.0	2.1	93	93
2295	COATED FABRICS, NOT RUBBERIZED	136.2	0.9	0	0
2296	TIRE CORD & FABRIC	741.4	4.8	0	0
2297	NON-WOVEN FABRICS	641.0	4.1	17	15
2298	CORDAGE & TWINE	95.2	0.6	22	22
2299	TEXTILE GOODS, N.E.C.	–	–	–	–

These sectors do not currently use recovered primary or secondary waste and are not likely to begin doing so by 1987. The technology will not be available for using recovered materials to make products that will be acceptable to the customers of these subsectors.

In the second tier of the industry, SIC 2296 also is assigned a zero target. This subsector includes the tire cord and fabric industry, whose products are directly related to auto safety, making strength a primary characteristic. The requirements for production of tire cord and fabric are very strict and rigidly controlled by the Department of Transportation.

Several subsectors of the industry currently use primary waste and small amounts of secondary waste for their final products. Except for wool yarn spinning and weaving, these subsectors are in the second tier of the industry. The following materials recovery targets are designated for them:

- SIC 2231 Broad Woven Fabric Mills, Wool: 13 percent
- SIC 2283 Yarn Mills, Wool: 13 percent
- SIC 2291 Felt Goods, Except Woven Felt and Hats: 80 percent
- SIC 2293 Padding and Upholstery Filling: 93 percent
- SIC 2297 Nonwoven Fabrics: 15 percent
- SIC 2298 Cordage and Twine: 22 percent

The waste reprocessing subsector does not to have the capability of substituting recovered materials since it does not use any virgin fibers; therefore, no target was established for SIC 2294.

It should be noted that most of the companies involved in these subsectors are relatively small firms, consuming much less than 1 trillion Btu's per year. Therefore, they will not be required to report their recovered materials and energy use to DOE.

1. INTRODUCTION

In the National Energy Conservation and Policy Act (NECPA) of 1978, the Congress directed the U.S. Department of Energy (DOE) to establish recovered materials targets in the following four industrial sectors:

- Metals and metal products
- Paper and allied products
- Rubber
- Textile mill products.

The stimulation for this project came at least partially from the success of various aluminum can recycling programs instituted by a major aluminum firm. The concept of using solid waste recovered materials is based on the premise that the reuse of these materials will conserve scarce raw materials and energy in both the process and feedstock forms. The use of such materials should also reduce environmental pollution by diminishing the amount of solid waste disposed of in landfills. This report describes targets for the textile mill products industry and shows how those targets were determined.

1.1 MATERIALS RECOVERY TARGETS ARE REQUIRED BY LAW FOR THE TEXTILE MILL PRODUCTS INDUSTRY

The National Energy Conservation and Policy Act of 1978* directs DOE to set voluntary targets for the increased use of energy-saving recovered materials. The targets to be established are for each of the following industries:

- Metal and metal products
- Paper and allied products
- Textile mill products
- Rubber.

Materials affected include aluminum, copper, lead, zinc, iron, steel, paper and allied paper products, textile mill products, and rubber.

* Public Law 95-619 (Title IV, Part 4), passed by the 95th Congress.

As stated in the law, the purpose of these targets is to conserve energy, conserve scarce natural resources, and protect the environment. This purpose is to be accomplished by:

- Establishing targets for the increased industrial utilization of recovered materials

- Creating procedures whereby the subject industries may cooperate with the federal government in the establishment and achievement of such targets

- Providing incentives (and as stated in the legislative history, a yardstick for measuring progress) for increased industrial utilization of energy-saving recovered materials in the subject industries.

Legislative history preceeding passage of the NECPA indicated that Congress intended with this action to provide incentives for the four industries to increase their use of energy-saving recovered materials on a voluntary basis. As a result, the DOE was directed to consult with the major industries affected by the targets.

The NECPA states that the targets are to be established by DOE. (See Appendix A for relevant sections of the law.) This responsibility was assigned to the Office of Industrial Programs in the Office of Conservation and Solar Applications.

The NECPA indicates that the targets should represent the maximum technically and economically feasible increase in the use of energy-saving recovered materials that each industry can achieve progressively by January 1, 1987.

Using information gathered from the textile mill products industry and from many other textile-related sources, DOE has developed materials recovery targets for the industry. This report presents those targets and their basis and justification.

1.2 THE TEXTILE MILL PRODUCTS INDUSTRY CONSISTS OF DIVERSE SUBSECTORS THAT PRODUCE A WIDE VARIETY OF TEXTILE PRODUCTS

The textile mill products industry is primarily a fabricated products industry. It processes natural fibers, man-made fibers, and continuous, man-made filament, fabricating them into finished yarn and fabric. The Department of Commerce, in its Standard Industrial Code (SIC) definitions, states that the textile mill products industry (SIC 22) includes establishments performing any of the following manufacturing operations:

- Preparing fiber and subsequently manufacturing yarn, thread, braids, twine, and cordage
- Manufacturing broad woven fabric, narrow woven fabric, knit fabric, and carpets and rugs from yarn
- Dyeing and finishing fiber, yarn, knit apparel, and fabric
- Coating, waterproofing, or otherwise treating fabric
- Integrated manufacturing of knit apparel and other finished articles from yarn
- Manufacturing felt goods, lace goods, non-woven fabrics, and miscellaneous textiles.

The 4-digit Standard Industrial Code numbers for SIC 22 are defined in Table 1-1. Appendix B gives a representative listing of products in each 4-digit subsector of the textile mill products industry.

As indicated in Appendix B, textile mill products are quite diverse, ranging from knitted under- and outerwear to broad woven fabric used in the apparel industry. Several of the 4-digit operations are completely integrated, in that the basic fiber is processed into a finished item within one facility. Representative types of integrated mills include the following:

- Sheeting
- Toweling
- Carpets and rugs
- Knitted underwear and outerwear

TABLE 1-1
Subsectors of the Textile Mill Products Industry
Standard Industrial Code (SIC) Classification

SIC 2211	BROAD WOVEN FABRIC MILLS, COTTON
SIC 2221	BROAD WOVEN FABRIC MILLS, MAN-MADE FIBER AND SILK
SIC 2231	BROAD WOVEN FABRIC MILLS, WOOL (INCLUDING DYEING AND FINISHING)
SIC 2241	NARROW FABRICS AND OTHER SMALLWARES MILLS, COTTON, WOOL, SILK AND MAN-MADE FIBER
SIC 2251	WOMEN'S FULL LENGTH AND KNEE LENGTH HOSIERY MILLS
SIC 2252	HOSIERY MILLS, EXCEPT WOMEN'S FULL LENGTH AND KNEE LENGTH HOSIERY
SIC 2253	KNIT OUTERWEAR MILLS
SIC 2254	KNIT UNDERWEAR MILLS
SIC 2257	CIRCULAR KNIT FABRIC MILLS
SIC 2258	WARP KNIT FABRIC MILLS
SIC 2259	KNITTING MILLS, NOT ELSEWHERE CLASSIFIED
SIC 2261	DYEING AND FINISHING TEXTILES, EXCEPT WOOL FABRIC AND KNIT GOODS
SIC 2262	FINISHERS OF BROAD WOVEN FABRICS OF MAN-MADE FIBER AND SILK
SIC 2269	FINISHERS OF TEXTILES, NOT ELSEWHERE CLASSIFIED
SIC 2271	WOVEN CARPET AND RUG MILLS
SIC 2272	TUFTED CARPET AND RUG MILLS
SIC 2279	CARPET AND RUG MILLS, NOT ELSEWHERE CLASSIFIED
SIC 2281	YARN SPINNING MILLS, COTTON, MAN-MADE FIBERS AND SILK
SIC 2282	YARN TEXTURIZING, THROWING, TWISTING AND WINDING MILLS, COTTON, MAN-MADE FIBERS AND SILK
SIC 2283	YARN MILLS, WOOL, INCLUDING CARPET AND RUG YARN
SIC 2284	THREAD MILLS
SIC 2291	FELT GOODS, EXCEPT WOVEN FELTS AND HATS
SIC 2292	LACE GOODS
SIC 2293	PADDINGS AND UPHOLSTERY FILLINGS
SIC 2294	PROCESSED WASTE AND RECOVERED FIBERS AND FLOCK
SIC 2295	COATED FABRICS, NOT RUBBERIZED
SIC 2296	TIRE CORD AND FABRIC
SIC 2297	NONWOVEN FABRICS
SIC 2298	CORDAGE AND TWINE
SIC 2299	TEXTILE GOODS, NOT ELSEWHERE CLASSIFIED

- Thread
- Lace goods
- Tire cord and fabric.

Many of the approximately 7,000 plants in the U.S. textile industry generate products that are used solely by other textile manufacturing operations. Examples of these are as follows:

- Apparel fabric is processed only to the finished broad woven state in the textile mill products industry. It is then shipped to apparel manufacturers where it is cut and sewn into final consumer products. Therefore, the customer for this apparel fabric is the apparel manufacturer (SIC 23), not the final consumer.

- Textured yarn mills process continuous filament yarn extruded by the chemical industry to make it usable by the broad woven mills in weaving fabric.

- Many finishing mills only clean, desize, dye, print, and heat-set fabric produced in a weaving mill (greige goods) for use in an apparel factory or other end uses. The finishing mills are generally contract operations that have the fabric shipped into their facility, finished, and shipped back to the customer.

Process and economic balances within individual integrated companies dictate that one economic process, such as a finishing operation, be supplied greige goods (woven, but unfinished) by several knitting or weaving operations. As the industry is currently constituted, several dispersed spinning or weaving mills provide greige goods to a central mill that finishes its own greige goods in addition to those supplied by the other mills. This interdependency exists throughout the textile industry, with each succeeding operation imposing quality criteria and product characteristics on the output of each preceding process. For example, the weaving operations served by a relatively small yarn texturing mill require that the mill produce yarns with more than 300 different characteristics from one input material, such as polyester continuous filament yarn.

There are two general tiers of products in the textile mill products industry. The first tier (composed of many sublevels) contains 85 percent of all materials processed. It includes SICs 2211 through 2284 and SICs 2292 and 2295. In this first tier, a great deal of emphasis is placed on the style and fashion of the finished consumer product (apparel, sheets, towels, etc.). Changes in the quality, appearance, and feel of the products in this tier are dictated by consumer choice, not by the textile manufacturers. For example, one apparel firm cuts all of one apparel item from lengths of fabric no greater than 10 yards to help ensure color consistency in the various parts of the item that are to be fitted together.

In the first tier, quality control of the required fiber, yarn, and fabric characteristics is very strenuous. In many greige goods operations, each yard of fiber is inspected for defects and imperfections before being finished. A product that is not totally free of imperfections is downgraded to seconds or used in second tier products. In texturizing man-made continuous filament yarn, each package (doff or bobbin) of yarn is woven into a small sample, dyed with a sensitive color, and graded relative to a master. From 20 to 30 percent of all inspected packages are downgraded as a result of this inspection. The inspection guarantees the dyeability of the texturized yarn, a guarantee required by the weaving and finishing mills.

The second tier of products in the textile mill products industry include products where stress is on utility rather than style or fashion. Products in the second tier are covered by SICs 2291, 2293, 2294, 2296, 2297, and 2298 and consist of cordage and rope, tire cords, furniture padding and stuffing, bandages, nonwoven products, apparel padding, felting, pocket linings, apparel linings, etc. Quality is maintained in this second tier of the industry, but emphasis is placed on strength, absorbency, and feel. Therefore, the textile manufacturers have more freedom in producing these items than they do with items in the first tier, and production economics are given more consideration. This sector of the industry represents less than 15 percent of the total fiber usage in the industry.

The textile mill products industry uses very small naturally-occurring fibers (wool, silk, cotton), man-made fibers (polyester, nylon, acrylic, etc.) and man-made continuous filament yarn. Fabrication involves spinning a yarn from the small fibers or continuous filament and then weaving or knitting the yarn into a fabric. Unlike the textile industry in much of the rest of the world, the U.S. textile industry is subject to extremely exacting standards of color consistency, fabric feel, and appearance. These standards are imposed by intermediate consumers. Only very small quantities of undesirable fibers or foreign particles are allowed in the fabricating operation, so that drastic changes in raw material or operating procedures are unusual once a successful operation has been established. Therefore, recovered materials targets will have a great impact on the operation of the industry.

1.3 RECOVERED MATERIALS TARGETS ARE COMPUTED AS PERCENTAGES; RECOVERED MATERIALS ARE TO BE SPECIFIED PERCENTAGES OF RAW MATERIALS USED

In response to NECPA provisions, DOE has determined that targets would be set for the use of recovered materials. Recovered materials were to be acquired from waste generated in the aluminum, copper, lead, zinc, iron, steel, paper and allied paper products, textile mill products, and rubber industries. The targets were also to apply only to the basic elements in the industry's products. In the textile mill products industry, this included natural staple fibers, man-made staple fibers, continuous man-made filament, and yarn made from these fibers. Thus, the target excludes chemicals, dyestuffs, backings, cleaners, and all other ancillary items used in the manufacture of textile products.

The textile mill products industry very carefully weighs the fibers used in spinning, and it purchases continuous filament and yarn by weight. Therefore, targets for the industry are defined according to weight. Specifically, the recovered materials target for fiber and yarn input consumed in a given textile mill products operation is the percentage of total fiber and yarn by weight supplied by recovered materials.

Fibers and yarn used in the textile mill products industry are all produced by that industry. Copper has sometimes been used as a yarn in carpets to reduce hazards from static electricity, and some steel parachutes have been woven from thin steel yarn, but neither of these items is produced in significant quantities by the industry.

The apparel industry (SIC 23) is a large current and potential source of fabric waste. For purposes of establishing the targets, it is considered as a source of waste material, even though it is not technically a part of the textile mill products industry,(as defined by the Standard Industrial Code).

In determining the recovered materials target for the textile mill products industry, it was necessary to define the types of waste to be included. DOE considered the following three types of solid waste:

- Reworkable Waste (Home Scrap). Reworkable waste, also known as home scrap, is a waste-product created during the normal manufacturing operation of the textile mill products industry and is returned directly to the process. Because of the quality requirements imposed by customers of the industry, reworkable waste is limited to staple fibers that are still in the soft, untwisted form. These consist of the mill-ends of the soft, untwisted rope generated during the spinning process (silver, roving, pneumafil, drawing waste) and the noils combed from cotton (comber noils) which can be reintroduced into the total fiber consumed. It was decided that this waste would not be used in establishing or achieving the targets.

- Primary Waste (Scrap). Primary waste is the waste generated in the manufacture of the basic textile mill products and used at another location. It includes the following waste products:

    - Mill-ends (fiber, yarn, and fabric)
    - Yarn waste from various spinning and weaving operations
    - Picking room waste (fly, motes)
    - Sweep wastes from various sections of the mill
    - Card strips
    - Selvage trim
    - Cutting room waste from sheeting, toweling, and knitting operations.

    Primary waste also includes the cutting room waste generated by the apparel industry (SIC 23).

The SIC 22 waste product items can consist of from 1 to 20 percent of the fiber from which they are generated, depending on the raw material and the quality characteristics required in the final product. Currently, these waste products, almost entirely consumed by the second tier of the industry, are used to make the nonstyle- and nonfashion-oriented products. Primary waste will be included in establishing and achieving the materials recovery targets.

- Secondary Waste (Scrap). Secondary waste, also termed post-consumer waste, consists of textile-based products (apparel, carpets, sheeting, toweling, etc.) that have been used and discarded by the final consumer. Most of this waste finds its way to the landfill, although it is sometimes collected and dispersed by charitable organizations. Secondary waste will be included in establishing and achieving the materials recovery targets.

In establishing targets for the textile mill products industry (SIC 22), it was decided to derive targets for each 4-digit SIC subsector, because the products, product characteristics, and quality requirements vary between subsectors. To take an extreme example, the furniture padding industry differs markedly from the broad woven cotton industry in operation and quality of final product. A target set for one would be entirely meaningless for the other.

Procedures discussed in the following section were used to establish realistic targets to be achieved by the textile mill products industry.

1.4 MATERIALS RECOVERY TARGETS WERE ESTABLISHED BY DETERMINING HOW MUCH RECOVERED MATERIAL IS CURRENTLY USED IN EACH INDUSTRY SUBSECTOR AND PROJECTING MAXIMUM POSSIBLE USE TO 1987

As required by the NECPA, the various subsectors of the textile mill products industry were consulted in setting the materials recovery targets. Industry associations consulted are as follows:

- American Apparel Manufacturers Association
- American Association for Textile Technology

- American Cotton Linters Association
- American Textile Machinery Association
- American Textile Manufacturers Institute (ATMI)
- Boston Wool Trade Association
- Carpet and Rug Institute (CRI)
- Cordage Institute
- Felt Manufacturers Association
- International Non-wovens and Disposables Association (INDA)
- Institute of Textile Technology
- Lace and Embroidery Association
- Man-made Fibers Association
- National Association of Recycling Industries (NARI)
- Textile Dealers Association of America, Inc.
- Textile Fiber and By-Products Association
- Textile Quality Control Association
- Wool Bureau, Inc.

DOE and Booz, Allen representatives visited major operations within the industry as part of the target-setting effort. Operations at most of the major companies in the industry were visited. In addition, several major waste dealers were visited to discuss their operations and the waste processing segment of the industry. All visits were made with several objects in mind:

- Gaining the required understanding of the major textile-making operations

- Determining how much recovered material is currently used in each subsector of the textile mill products industry

- Developing an understanding of the material flow in each subsector of the industry

- Learning what characteristics the users of textile products require in those products

- Understanding the sensitivity of these characteristics to the use of recovered materials

- Determining any other factors that could influence the use of recovered materials in the industry.

During the DOE/Booz, Allen visits, personnel at all the firms willingly provided information and answered questions. Cooperation was complete and the material provided was quite useful.

A determination of material flow in the textile mill products industry was made. It was based on the information provided by private companies and by various trade associations, as well as being drawn from published data (primarily the Department of Commerce Census of Manufacturers). Using the data obtained, it was possible to ascertain how waste material is currently handled and how much is used in the manufacture of textile products. For those subsectors where the use of recovered materials was feasible, projections were made as to how much could be used in 1987. This was done in the following steps:

- Examining current and potential technologies for processing and using textile wastes
- Evaluating industry economic and financial conditions that will affect the use of recovered materials between now and 1987
- Estimating the effect of various regulations on the use of recovered materials
- Projecting the total use of fiber raw material in 1987.

The projections thus obtained were established as targets for the various industry subsectors. Subsectors with zero targets were also evaluated, but no projections to 1987 were made. After the targets were established, actions for enhancing the use of recovered materials were evaluated. This included steps that could be taken by the textile mill products industry or by various levels of government. The activities considered included marketing and production changes by the industry. Government activities included items such as the following:

- Changes in labeling regulations
- Changes in procurement procedures
- Tax incentives
- Loan guarantees
- Changes in transportation regulations
- Government-sponsored research and development.

Each of these actions was evaluated to determine what effect it would have on the use of recovered materials.

* * * * *

This chapter has discussed the origin and purpose of recovered materials targets for the textile industry. The following chapters present information needed for the target-setting process and show how the targets were developed.

2. OVERVIEW OF THE U.S. TEXTILE INDUSTRY

The textile industry is one of the major segments of the manufacturing industry. Its two primary segments, textile mill products and apparel, produce a variety of intermediate and finished products (see Figure 2-1). In general, the textile mill products industry (SIC 22) processes natural fibers, man-made fibers, and man-made continuous filament into fabric, yarn and some finished products that require little additional processing. The apparel industry makes finished garments and accessories from the textile fabrics provided by SIC 22.

This chapter presents an overview of the textile industry, providing some background on the following:

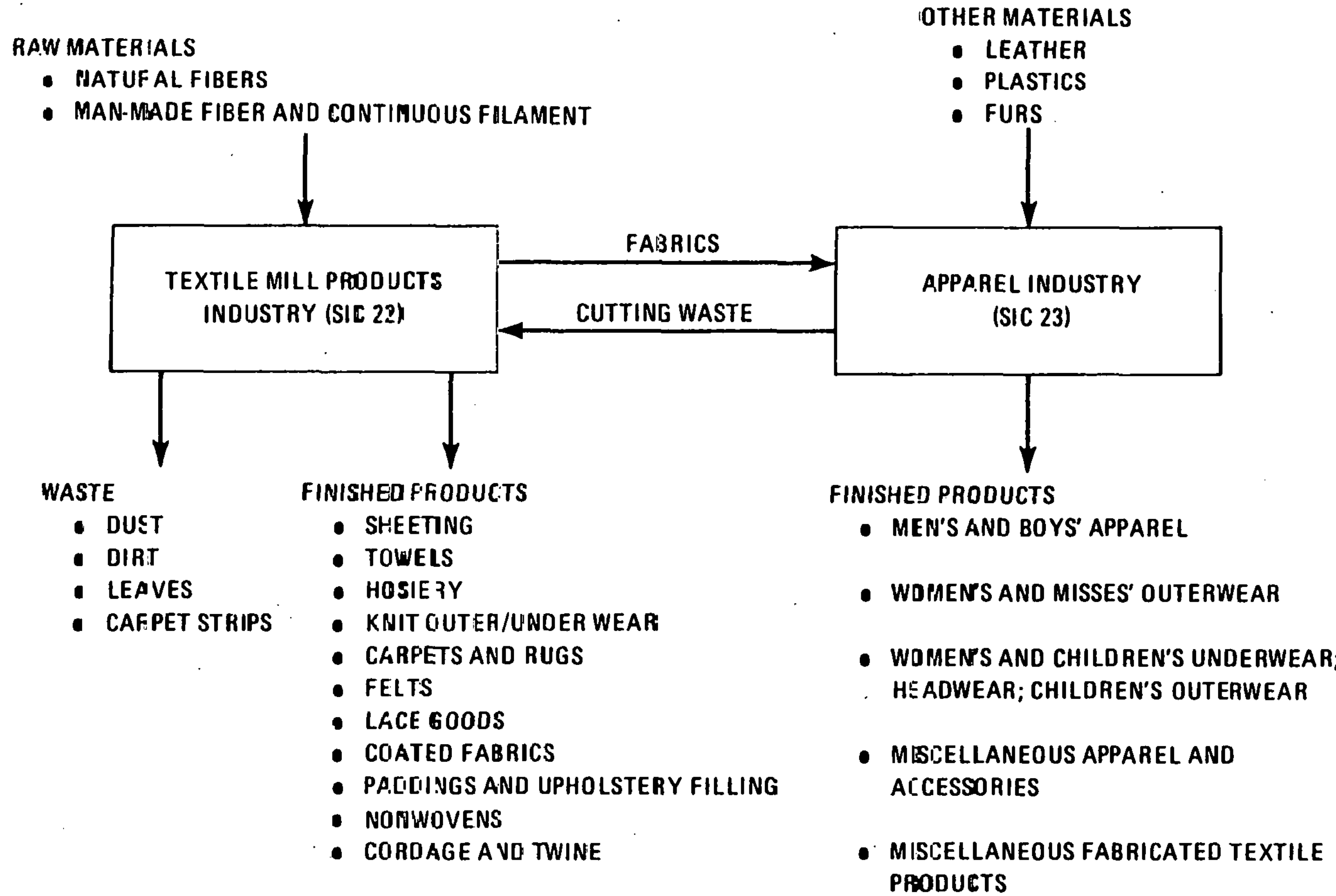
- Textile mill products industry
- Apparel industry
- Consumer tastes and requirements and how they affect the textile mill products manufacturers, the apparel industry, and retailers.

2.1 THE TEXTILE MILL PRODUCTS INDUSTRY CONSISTS OF DIVERSE SUBSECTORS THAT PRODUCE A WIDE VARIETY OF TEXTILE PRODUCTS

The U.S. textile mill products industry consumed over 12.5 billion pounds of material in 1978, transforming it into a variety of goods worth nearly $40 billion. These goods, produced in a variety of shapes, sizes, colors, and textures, were sold in various sectors for direct use or further processing.

The industry is primarily located in the southeastern and northeastern regions of the United States. Of the more than 7,000 establishments (employing approximately 900,000 workers) processing textile mill products in 1972, over 90 percent are in these two regions, western regions. Though the northeastern and southeastern regions have nearly the same number of establishments, the shipments from the southeast are nearly three times those from the northeast because plants in the southeast are much larger.

FIGURE 2-1
Primary Structure of the U.S. Textile Industry



2.1.1 The Textile Industry Can Be Separated Into Two Tiers

The industry can be separated into two tiers. The first tier produces a high quality, fashion-oriented, outerwear, while the second emphasizes the production of nonfashion, utility-oriented items. These second tier products are often made from reworked by-products or waste from the first tier. The 2-tier structure of the industry is shown in Figure 2-2. The following paragraphs contain several points about this structure.

2.1.1.1 First Tier of the Textile Mill Products Industry

The first tier of the textile mill products industry consists of firms that manufacture goods affected by consumer taste for high quality, fashion-oriented items. This tier processes raw cotton and other natural fibers and first quality, man-made fibers and continuous filament, producing items such as the following:

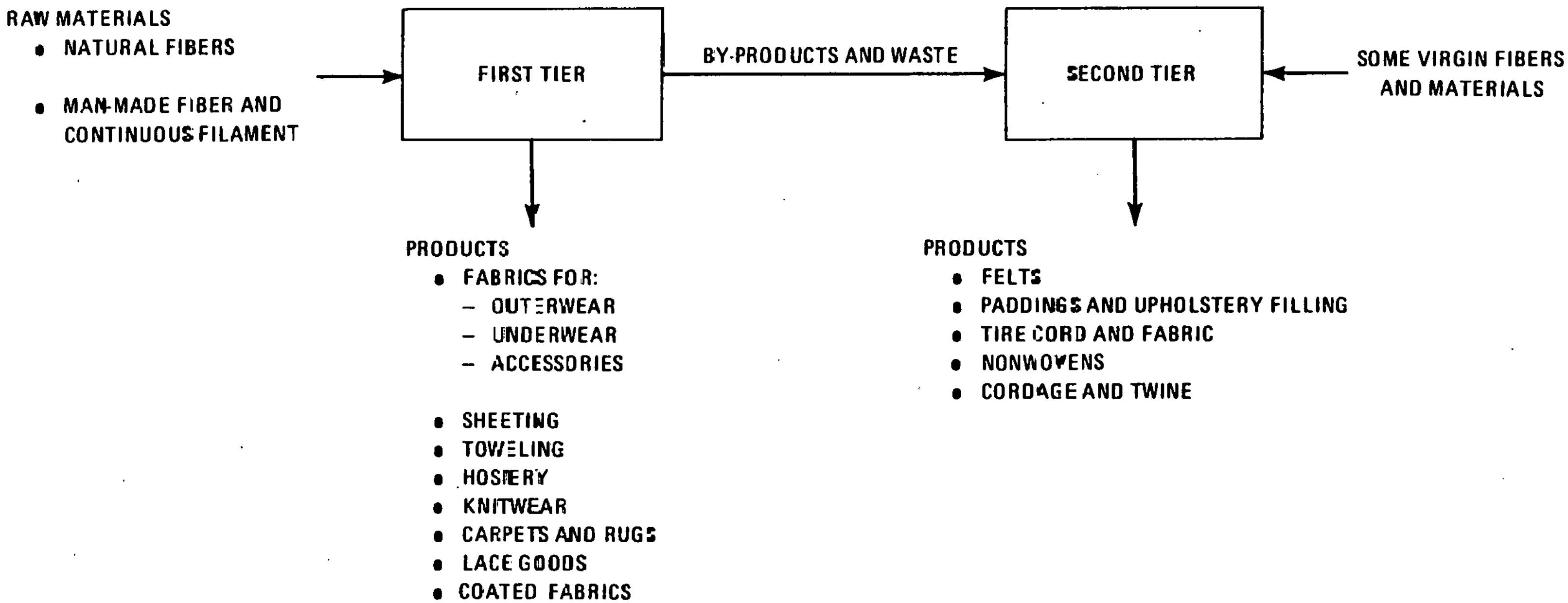
- Fabrics for outerwear/underwear/accessories
- Sheeting
- Toweling
- Hosiery
- Knitwear
- Carpets and rugs
- Lace goods
- Coated fabrics.

These items are all used in areas where visual qualities and texture are important. For example, the look and feel of fabric for shirts strongly influence consumer selection. For this reason, the requirements for consistency in color, texture, and fiber content are very high. Products cannot have random holes, lumps, inconsistent colors, or other variations and still earn consumer acceptance.

Quality control at this level of the industry is very strenuous. In many cases, each yard of fabric is inspected for defects and imperfections before being finished. A product that is not totally free of imperfections is downgraded to seconds or used in second tier products.

These strict requirements have caused many producers to limit the sources and types of raw material they will use. All first tier manufacturers use first quality, virgin

FIGURE 2-2
The Two Tier Structure of the Textile Mill Products Industry



materials, assuring themselves of a more uniform product. Furthermore, first tier manufacturers usually select and retain specific suppliers of raw materials to further guarantee consistency for the consumer. The manufacturers must do this because of the variability of natural fibers, such as cotton, from field to field and the differences in chemical processes used to prepare man-made fibers and continuous filament.

2.1.1.2 Second Tier of the Textile Mill Products Industry

Second tier firms supply products that are subject to other, nonfashion requirements. These products are more utility-oriented, function being much more important than style or color. These products include the following:

- Felts
- Paddings and upholstery filling
- Tire cord and fabric
- Nonwovens
- Cordage and twine.

Specifications for these materials concern such matters as strength, durability, resiliency, fluffiness, density, and absorbency. Specifications for some of these products, mostly tire cord and some cordage, dictate the use of virgin fibers with high consistency so that a specific tensile strength or durability index can be achieved. In the manufacture of certain nonwovens, virgin materials may be needed because of the nature of the extruding process. However, a majority of the second tier items can be produced using by-products and waste from the first tier.

Most second tier products are hidden from view while in use (e.g., carpet pads, stuffing, and automotive insulation). The exacting color and texture requirements of the first tier are therefore not necessary. This makes the use of wastes and by-products acceptable, and it helps to reduce manufacturing costs.

2.1.2 Operations in the Textile Mill Products Industry

The Department of Commerce, in its Standard Industrial Code (SIC) definitions, indicates that the textile mill products industry (SIC 22) includes establishments engaged in performing any of the following operations:

- Preparing fiber and subsequently manufacturing yarn, thread, braids, twine and cordage

- Manufacturing broad woven fabric, narrow woven fabric, knit fabric, and carpets and rugs from yarn

- Dyeing and finishing fiber, yarn, knit apparel, and fabric

- Coating, watorproofing, or otherwise treating fabric

- Integrated manufacturing of knit apparel and other finished articles from yarn

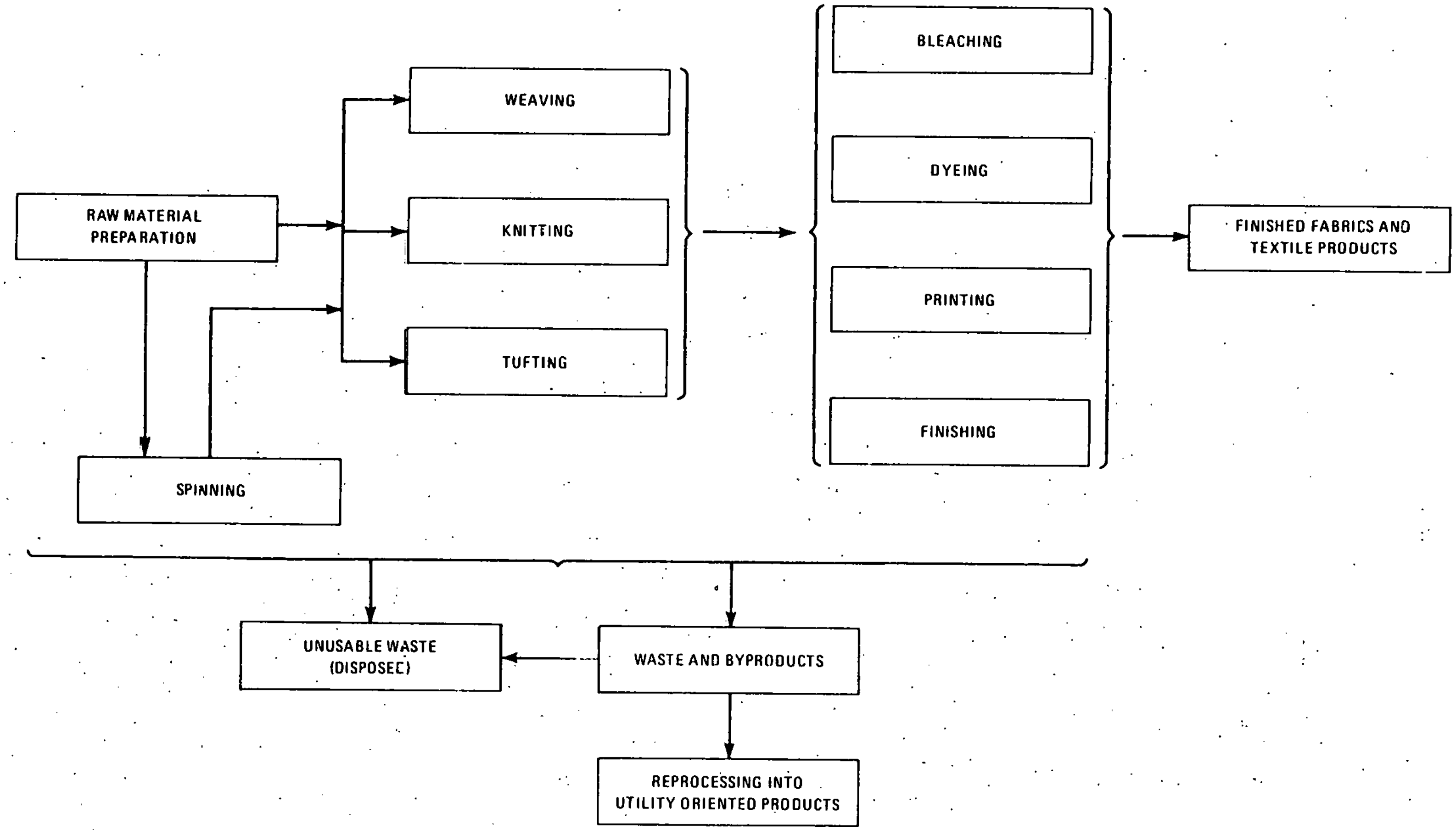
- Manufacturing felt goods, lace goods, nonwoven fabrics, and miscellaneous textiles.

Operations in the textile mill products industry mechanically and chemically alter the characteristics of natural and man-made raw materials to form fabricated products. The raw materials are separated, stretched, twisted, and interlocked in various mechanical processes. The chemical processes used to process the fibers and cloth include cleaning, dyeing, coating, and chemically treating the materials to alter feel, color, and durability. Figure 2-3 shows the primary process flows in the textile mill products industry.

Textile mill products, as can be seen in Appendix B, are quite diverse, ranging from knitted under- and outer-wear to broad woven fabric for the apparel industry. While several of the 4-digit operations are completely integrated in that the basic fiber is processed into a finished consumer item within one facility, most firms perform single operations, such as weaving, dyeing, or coating or are only integrated through a few operations. Representative types of integrated mills include the following:

- Sheeting
- Toweling
- Carpets and rugs
- Knitted underwear and outerwear
- Thread
- Lace goods
- Tire cord and fabric.

FIGURE 2-3
Primary Process Flows in the Textile Mill Products Industry



The four largest firms in the industry are integrated, and each has over $1 billion in sales. Nevertheless, these four firms comprise only about 15 percent of the total sales in this highly fragmented industry. Integration has occurred to provide two principal benefits:

- The economics of the textile industry reward the integrated producers. With captive fiber and cloth production, mills can be balanced and unit costs reduced. The need for many separate marketing and distribution functions is also eliminated.

- Product quality and consistency can be ensured, because the processes at each step are the same from run to run. This allow the standardization of process steps, settings, and standards and improves the consistency of the product.

Industry trends are toward increased vertical integration, diversification, and consolidation, the reasons being the same as those just stated. However, the resulting reduction in process and market flexibility has caused many firms to become very reluctant to change any product characteristics, lest the changes have a negative effect on product economics, process variables, or market acceptance.

Most mills are either partially integrated or specialized by process and depend on one another for economic success and process balance. As the industry is currently constituted, several dispersed spinning or weaving mills provide greige goods (woven but unfinished) to a central mill that finishes its own greige goods in addition to those supplied by the other mills. Such interdependency exists because of the minimum economic size required for the various processes and because of the relative economics of central batch processing of materials. In addition, most chemical processes require skills and knowledge different from those required for mechanical processing. Smaller mills often cannot afford the development of a chemical processing section, because of the high capital investment required. Interdependency also makes one group more aware of another group's quality criteria and product characteristics. This tends to further limit the flexibility of the smaller processors; for instance, they cannot introduce new blends or dyes that are not acceptable to another group's market.

Because of the favorable economics resulting from integration and process balancing, the U.S. textile mill products industry has been able to reduce the penetration rate of low-cost foreign imports. However, even with additional process modifications to reduce labor costs, the textile trade deficit for 1977 was nearly $3.4 billion. This competition from imports has forced the textile mill products industry to focus on two areas:

- Increased automation to offset rising labor costs
- Increased emphasis on product quality and consistency, to retain consumer demand for the higher priced U.S. goods.

The emphasis on quality and consistency extends to the apparel industry, the market most affected by imports.

2.2 THE APPAREL INDUSTRY IS THE MAJOR USER OF INTERMEDIATE TEXTILE MILL PRODUCTS

The apparel industry (SIC 23) uses over 40 percent of all products fabricated in the textile mill products industry (SIC 22), producing a variety of garments and accessories. In 1978, the 16,000 plants in the industry produced goods valued at over $60 billion retail. Table 2-1 gives examples of the items produced by this industry.

2.2.1 Structure of the Apparel Industry

Establishments in the apparel industry are generally much smaller than those in the textile mill products industry. In 1972, there were three times as many apparel industry plants, but they produced only about 15 percent more value added. The smaller apparel firms tend to be located near major wholesale and retail trade centers and normally produce higher style garments. Well over 50 percent of the plants are located in three states—New York, New Jersey, and Pennsylvania. The few large apparel plants are located generally in the Southeast and tend to produce low style items such as work clothes.

The apparel industry has three major types of operation:

- The manufacturer purchases fabric, employs production workers in his own plant to cut

TABLE 2-1
Apparel Industry Products

FOR WOMEN AND GIRLS	FOR MEN AND BOYS	FOR INFANTS
DRESSES	TAILORED CLOTHING	DAYWEAR
SUITS	DRESS PANTS	SLEEPWEAR
SLACKS	CASUAL PANTS	HOSIERY
BLOUSES/SHIRTS	WORK PANTS	HEADWEAR
OUTERWEAR/RAINWEAR	JEANS	
FOUNDATION GARMENTS	OVERALLS/COVERALLS	
INTIMATE APPAREL	OUTERWEAR/RAINWEAR	
UNIFORMS	DRESS SHIRTS	
HEADWEAR	SPORT SHIRTS	
PAJAMAS/ROBES	WORK SHIRTS	
HOSIERY	UNDERWEAR	
SCARVES/KERCHIEFS	UNIFORMS	
CAREER APPAREL	HEADWEAR	
	PAJAMAS/ROBES	
	HOSIERY	
	TIES/SCARVES	
	CAREER APPAREL	

and sew garments, and sells the finished products. He thus does all the work normally associated with manufacturing operations.

- The jobber has primarily entrepreneurial functions, such as buying new materials, designing and preparing samples, arranging with outside factories (contractors) for the manufacture of his garments from his own materials, and marketing the finished products. However, a number of jobbers also maintain cutting operations within their own establishments, relying on outside factories for other processing (sewing, finishing, etc.).

- The contractor employs production workers in his own establishment to process materials owned by others, makes products to specifications, and is not involved in the sale of the finished garment.

Garments produced in the apparel industry are sold to customers through sales outlets and stores. The apparel industry is thus a link between the fabric producers and the garment sellers. Members of this latter group are perhaps most sensitive to consumer demands.

The apparel industry is much more fragmented than the textile mill products industry, although there are signs of gradual concentration and integration. Vertical integration is accomplished through the formation of textile/apparel or apparel/retail combination. Examples of textile/apparel combinations include companies that have combined both knitting and cut-and-sew operations (e.g., Munsingwear and Hanes). Apparel/retail combinations include companies like Hart, Schaffner, and Marx or Walton Clothing, Inc. Horizontal integration is achieved through product diversification. An example would be an apparel company that manufactures ladies' blouses and men's jackets or men's swimwear and ladies' robes. Both forms of integration can provide favorable economies of scale in production and distribution as well as ensuring more consistent markets and products.

2.2.2 Product Quality is Carefully Controlled in the Apparel Industry

Product consistency is important for the typical apparel item. Many apparel manufacturers purchase by specification for just this reason. The properties of the material affect not only the quality of the final product but also its handling characteristics during production. Thus, to maintain continuity in production and product quality from lot to lot and style to style, little or no changes can take place in raw material properties. This means that a rigid set of practical specifications must be established for those raw material properties which will cause major modifications in production methods or product quality. The specifications fall into two categories governing fabric performance and garment performance. Fabric performance during garment manufacture includes properties that will affect any of the following:

- Handling on the cutting table and the cutting itself
- Sewing and handling during sewing
- Garment finishing.

Garment performance during use includes properties that affect any of the following:

- Normal wear
- Garment renovation (repair)
- Garment alteration.

If clear and carefully documented specifications are communicated to the textile mills, the fabrics can be manufactured to meet the needs of the apparel producers. The specifications used for fabric quality typically include some or all of the following:

- Physical characteristics—weight, fiber content, count, type of finish, finished width
- Performance characteristics—colorfastness, shrinkage, durable press features, strength, care characteristics, flame retardant features
- Visual defects—grading system and acceptable level

- Shade tolerance variation—shade range between and within shipments, bales, or pieces

- Put up—package type and size, piece lengths or diameters, tube type, ticket information

- Test methods or procedures—used to ensure compliance with state requirements.

Apparel manufacturers trying to produce quality items at reasonable costs give their fabric requirements to the supplier and request assistance in selecting raw materials of acceptable quality. Figure 2-4 gives an example of a fabric specifications data sheet used to communicate specifications to the supplier. These written specifications do not constitute a complete list of all product characteristics; they only indicate primary specifications that are of special concern to the purchaser. The mills must still provide fabric that meets all recognized performance requirements, whether or not the requirements are enumerated in the written contract. This strong emphasis on fabric quality and consistency can be better appreciated if one understands the relationship between the textile mill products industry, the apparel industry, and retailers. This relationship is discussed in the following section.

2.3 CONSUMERS REQUIRE HIGH QUALITY CONSISTENCY IN THE TEXTILE PRODUCTS THEY BUY

Many consumers use texture, color, consistency of fabric, and construction as their primary criteria in selecting textile products. This is true for the buying of outerwear, sheeting, carpet, and most products that are visible in normal use. Consumers of the second tier textile products (felts, paddings, tire cord, etc.) emphasize instead the utility of the products. This section discusses only the first group, the consumers of fashion and style oriented products.

Consumer taste has a great influence on most of the apparel and fabric production in the United States. Consumer preferences create the demand for products. These preferences are of course influenced by advertising and merchandizing as well as by the ideas and preferences of apparel designers. (The designers, who exhibit their products at shows during the year, influence the ordering

FIGURE 2-4
Example of a Fabric Specification Data Sheet

SUGGESTED FABRIC SPECIFICATION DATA SHEET

To be prepared by fabric supplier and given to buyer at the time of sample submission.

Fabric Manufacturer: ______________________ **Contract No.:**_____ **Date:** __________
Fabric Brand Name: ______________________ **Construction Name:** __________
Fiber Content: ____________________ **Special Finish:** ____________________

YARNS:
Generic Title: ____________ Size of Yarn(s): Warp/ Wales: __________ Fill/ Course: __________

No. of turns per inch: Warp/Wales: ________ Course/Fill: ____________________
Texture Type: Warp/Wales: __________ Course/Fill: ____________________

Construction Description:
Warp/Wales: ______________ Course/Fill: ________ Finished Width _____ ± _____
Weight: Per sq. yd. ________ oz. ± ______ Per linear yd. ________ oz. ± __________
End use of the fabric: ______________________________

Property	Performance Level		Test Method
	Average	Minimum	
STRENGTH: Tensile (W/F) Tear (W/F) Bursting			ASTM-D 1682-64 ASTM-D 1424-63 ASTM-D 231-62
STRETCH: (W/F) %			ASTM-D 2594-72
SHRINKAGE: 1. Hothead Pressing (W/F) 2. Home Laundry & Tumble Dry (W/F)			1. As agreed between buyer and seller 2. AATCC-124-75
ABRASION: Describe Method: 1. __________ 2. __________ 3. __________			ASTM-D 1175-71

FIGURE 2-4 (Continued)

Property	Performance Level		Test Method
PILLING: Describe Method: 1. ____________ 2. ____________			ASTM-D 1375-72 (For laboratory use only. Not recommended for commercial acceptance.)
SNAGGING: Describe Method: 1. ____________ 2. ____________			AATCC-65-76 (For women's nylon hosiery only)
STIFFNESS: Before Washing After Washing			ASTM-D 1388-64
SMOOTHNESS			AATCC 124-75
SEAM SLIPPAGE			ASTM-D 434-75
CREASE RETENTION			AATCC-88C-75
WATER REPELLENCY: Impact Spray			AATCC-42-77 AATCC-22-77

Colorfastness	Minimum Rating	Test Method
Laundering (C/S)		AATCC-61-72—AATCC-124-75
Crocking (W/D)		AATCC-8-77
Light		AATCC-16A-77
Perspiration		AATCC-15-76
Atmospheric gases		AATCC-23-75
Clorine Retention		AATCC-3-75

Visual Defects	Performance Level	Lot Maximum	Roll Reject
Points Per 100 Square Yards			

FIGURE 2-4 (Concluded)

COMPLIANCE WITH SPECIAL REQUIREMENTS ON PRODUCT

Mandatory Government Requirements:

(A.) F.T.C. Permanent Care Labeling: ____________________

(B.) F.T.C. Fiber Identification: ____________________

(C.) Country of Origin (where applicable) ____________________

(D.) Other: ____________________

Package and Packing Requirements:

Rolls __________ Flat Fold __________ Yds/each, Min. __________ Max. __________

Max. no. of pieces/put up __________ Length of shortest piece __________

Wrapper: ____________________

Data on tag: __________

Mfg. Name __________

Style No. __________

Color __________

Gr. Wt. __________

Brand Name __________

Piece No. __________

Gr. Yds. __________ Net Yds. __________

New Wt. __________

Shipping Case: One shade per case __________

Label on outside of case to describe content: ____________________

Date of shipment __________ Other __________

____

____

____

Special Instructions: ____________________

____

____

Date __________ ____________________ Buyer

Date __________ ____________________ Salesman

Date __________ ____________________ Other and subsequent production of goods.) Nevertheless, the key to success in the apparel trade is the ability to anticipate and satisfy the desires of consumers.

As previously mentioned, apparel producers are a link between the consumer and the textile mill products industry. In this position, they must try to balance some strong forces. The economics of the textile mill products industry dictate long runs and few changes in product mix, but the retail trade, influenced by consumer taste, must respond rapidly to changes in style. This causes apparel manufacturers to have a strong tendency toward offering the same types of fiber and fabric construction from season to season and year to year while altering the garment style. Under normal conditions, an apparel manufacturer offers fewer than 10 percent changes in fiber or fabric construction annually. Exceptions to this trend occur when innovations are made in fabric performance or styling. Recent examples of this include durable press, soil release, double knits, and denim.

It is clear, then, that garment producers are very interested in maintaining consistent product quality from run to run and year to year. Variations in fabric characteristics are not acceptable to most consumers of these products; consequently, such variations are also not acceptable to the producers. For this reason, the specifications for consistency of fabric and construction are very strict.

Partly because of this emphasis on quality and consistency in fabric and garment construction, the U.S. apparel industry has an international reputation for very fine products. This has allowed producers of U.S. textile goods to charge the higher prices demanded by their more expensive cost structures. As foreign industries become more automated and their product quality increases, U.S. retailers and the apparel industry may set more stringent specifications in order to retain their margin in quality over foreign competitors, a margin that would continue to generate consumer demand.

* * * * *

This chapter has presented an overview of the U.S. textile industry. The remainder of this report will focus on the sector to which the recovered materials targets apply, the textile mill products industry. The following chapter presents a discussion of the technology currently being used in the production of textile mill products.

3. TEXTILE MILL PRODUCTS INDUSTRY OPERATIONS

The textile mill products industry (SIC 22) is made up of a large number of facilities designed for the conversion of natural and man-made fibers into fabrics and other textile-related products. This conversion occurs in a series of very complicated operations in which the fibers are processed, fabricated into yarn and fabric, and finished to a form acceptable to consumers. The industry must closely control the characteristics of its products in response to the strict specifications of its customers (e.g., the apparel industry and retail chains). These market-oriented specifications require the textile mill products industry to maintain tight controls in three basic areas:

- Raw material (fiber) inputs
- Manufacturing operations
- Chemical and mechanical treatments of fiber, yarn, and fabric.

Processes in each of these areas are extremely complicated and the quality characteristics of the production output are highly sensitive to change. Therefore, the textile mill products industry devotes considerable time and resources to them. The current and projected technologies available to the industry for its production processes are discussed in the sections that follow.

3.1 TEXTILE PRODUCTION PROCESSES AFFECT THE RESULTING PRODUCT'S CHARACTERISTICS

The primary purpose of the textile mill products industry is to process fibers and continuous filament into fabric for use in various textile products. Through careful control and combination of processes, desirable textile characteristics can be developed from various fiber types and fiber blends. This section examines the various fibers and common textile processing techniques indicating their influence on the quality and characteristics of the resulting fabric. The discussion will center on the system for processing cotton because the processing of man-made fibers is similar though somewhat less complicated due to the uniformity of the fibers.

3.1.1 The Primary Raw Material in the Textile Industry is Fiber

The primary raw material in the textile industry is the fiber. Prior to the twentieth century, the only available fibers were those derived from either animals or plants. These fibers, primarily cotton and wool, were the dominant fibers in the textile industry until the advent of man-made fibers. Now there are hundreds of fiber types available; each type having its own special characteristics. When different fiber types are combined or blended, the properties of the individual fibers are also combined.

Fibers available to the textile industry are divided into two categories—natural fibers and man-made fibers. Man-made fibers are obtained from cellulosic or synthetic materials, whereas natural fibers are derived from animals or plants. Table 3-1 lists major fibers and gives their source or composition.

Fibers are transformed into final yarn and fabric products through various manufacturing processes. Customer orders specify the fiber or combination of fibers that is desired. Table 3-2 lists some of the most important characteristics possessed by the various fibers.

3.1.2 Yarn Formation Is a Series of Mechanical Operations

Yarns are formed through several mechanical operations. In these operations, the fibers are cleaned and prepared for spinning into the desired yarn. In order to determine the exact operations and amount of processing necessary for the production of a particular yarn, the type and quality of the fiber and the end-use of the yarn must be known. Figures 3-1 and 3-2 give operations generally used in the production of cotton yarn. These operations are described in the following paragraphs.

3.1.2.1 Opening, Blending, and Picking Processes

The opening, blending, and picking processes are interconnected preparatory operations. Opening eliminates dirt, leaves, seeds, and other foreign matter from the mixed

TABLE 3-1
Classification of Fibers

TYPE	NAME OF FIBER	SOURCE OR COMPOSITION
NATURAL FIBERS:		
VEGETABLE	COTTON	COTTON BOLL (CELLULOSE)
	LINEN	FLAX STALK (CELLULOSE)
	JUTE	JUTE STALK (CELLULOSE)
	HEMP	HEMP OR ABACA STALK (CELLULOSE)
	SISAL	AGAVE LEAF (CELLULOSE)
	KAPOK	KAPOK TREE (CELLULOSE)
	RAMIE	RHEA OR CHINA GRASS (CELLULOSE)
	COIR	COCONUT HUSK (CELLULOSE)
	PINA	PINEAPPLE LEAF (CELLULOSE)
ANIMAL	WOOL	SHEEP (PROTEIN)
	SILK	SILKWORM (PROTEIN)
	HAIR	HAIR-BEARING ANIMALS (PROTEIN)
MAN-MADE FIBERS:		
CELLULOSIC	RAYON	COTTON LINTERS OR WOOD
	ACETATE	COTTON LINTERS OR WOOD
	TRIACETATE	COTTON LINTERS OR WOOD
SYNTHETIC LONG-CHAIN POLYMERS	NYLON	POLYAMIDE
	POLYESTER	DIHYDRIC ALCOHOL AND TEREPHTHALIC ACID
	ACRYLIC	ACRYLONITRILE (AT LEAST 85%)
	MODACRYLIC	ACRYLONITRILE (35%–84%)
	SPANDEX	POLYURETHANE (AT LEAST 85%)
	OLEFIN	ETHYLENE OR PROPYLENE (AT LEAST 85%)
	SARAN	VINYLIDENE CHLORIDE (AT LEAST 80%)
	VINYON	VINYL CHLORIDE (AT LEAST 85%)
MINERAL	GLASS	SILICA SAND, LIMESTONE, AND OTHER MINERALS
	CERAMIC	MINERALS
METALLIC	METAL	ALUMINUM, SILVER, GOLD, STAINLESS STEEL
RUBBER	RUBBER	NATURAL OR SYNTHETIC RUBBER

TABLE 3-2
Fiber Characteristics

		1 LENGTH	2 LUSTER	3 STRENGTH	4 ELASTICITY	5 RESILIENCE	6 HEAT CONDUCTIVITY	7 DRAPABILITY	8 ABSORBENCY	9 CLEANLINESS AND WORKABILITY	10 REACTION TO BLEACHES	11 SHRINKAGE	12 DAMAGING EFFECT OF HEAT AT DEGREE F	13 EFFECT OF MILDEW	14 EFFECT OF SUNLIGHT	15 RESISTANCE TO ALKALIES	16 RESISTANCE TO ACIDS	17 AFFINITY FOR DYES
MOST COMMONLY USED NATURAL FIBERS	COTTON	½ TO 2½ INCHES	LITTLE	GOOD	LOW	VERY LOW	VERY GOOD	VERY LOW	GOOD	GOOD	VERY GOOD	HIGH	LOW 300 F	LOW	HIGH	EXCELLENT	NONE	FAIR TO GOOD
	WOOL	1-8 INCHES	MINIMAL		VERY HIGH	VERY GOOD	NON-CONDUCTOR	EXCELLENT	EXCELLENT	POOR	MODERATE TO POOR	VERY HIGH	LOW 266 F	GOOD	MODERATE	SOME	SOME	HIGH
	SILK	1,200 TO 4,000 FEET	GENERALLY HIGH	STRONGEST OF NAT. FIBERS	VERY HIGH	VERY GOOD	NON-CONDUCTOR	EXCELLENT	VERY GOOD	VERY GOOD	MODERATE TO POOR	MODERATE	MODERATE 330 F.	GOOD	HIGH	GOOD	SOME	EXCELLENT
	LINEN	12 TO 20 INCHES	HIGH	2ND STRONGEST	LEAST	LEAST	BEST	LOW	VERY GOOD	VERY GOOD	VERY GOOD	HIGH	LOW 300 F	LOW	GOOD	GOOD	NONE	POOR
MOST COMMONLY USED MAN-MADE FIBERS	RAYON	VARIABLE	CONTROLLED	VERY STRONG	LOW	VERY LOW	VERY GOOD	LOW	VERY GOOD	MODERATE	VARIES	HIGH	300-350 F.	HIGH	VARIES	HIGH	NONE	GOOD
	ACETATE	VARIABLE	CONTROLLED	LOW	GOOD	GOOD	LOW	FAIR	MODERATE	GOOD	POOR	MODERATE	350 F.	MODERATE	LOW	MODERATE	NONE	VARIES
	TRIACETATE	VARIABLE	CONTROLLED BRIGHT	LIKE WOOL WEAKER WHEN WET	GOOD	VERY GOOD	LOW	FAIR	MODERATE	GOOD	POOR	LOW	480 F.	RESISTANT	LOW	MODERATE	NONE	GOOD
	NYLON	VARIABLE	CONTROLLED BRIGHT	RELATIVELY STRONG	VERY HIGH	VERY GOOD	VARIES	EXCELLENT	LOW	GOOD	FAIR	LOW	300 F.	RESISTANT	MODERATE	HIGH	FAIR	FAIR
	POLYESTER	VARIABLE	CONTROLLED BRIGHT	RELATIVELY STRONG	VERY LOW	VERY GOOD	FAIR	FAIR	VERY LOW	GOOD	FAIR	LOW	450 F.+	RESISTANT	MODERATE	HIGH	GOOD	GOOD
	ACRYLIC	VARIABLE	CONTROLLED BRIGHT	VARIES – MODER. STRONG	LITTLE	VERY GOOD	LOW	VARIES FAIR	LOW	GOOD TO VERY GOOD	FAIR	LOW	400-490 F.	RESISTANT	VERY LOW	FAIR TO GOOD	GOOD	VARIES WITH TYPE
	MODACRYLIC	VARIABLE	CONTROLLED BRIGHT	GOOD	LITTLE	VERY GOOD	LOW	VARIES FAIR	LOW VARIES	GOOD TO VERY GOOD	VARIES	LOW	260 F.	RESISTANT	LOW	GOOD	GOOD	MODERATE
	SPANDEX	VARIABLE	DULL	LOW	MOST ELASTIC	VERY HIGH	GOOD	VERY GOOD	VERY LOW	VERY GOOD	VARIES	LOW	160 F.	RESISTANT	MODERATE	POOR TO GOOD	POOR TO GOOD	GOOD
	SARAN	VARIABLE	SEMIDULL	VERY STRONG	VERY HIGH	VERY GOOD	LOW	LOW	NON-ABSORBENT	GOOD	FAIR	LOW	210 F.	RESISTANT	LOW	GOOD	FAIR TO GOOD	UNCHANGEABLE
	GLASS FIBER	VARIABLE	CONTROLLED BRIGHT	STRONGEST	NONE	RELATIVELY HIGH	VARIES FROM HIGH TO LOW	GOOD VARIES	NON-ABSORBENT	EXCELLENT	FAIR	LOW	600 F.+	RESISTANT	NONE	MODERATE	GOOD	COMPLICATED

FIGURE 3-1
Process for Cleaning and Preparing Fibers

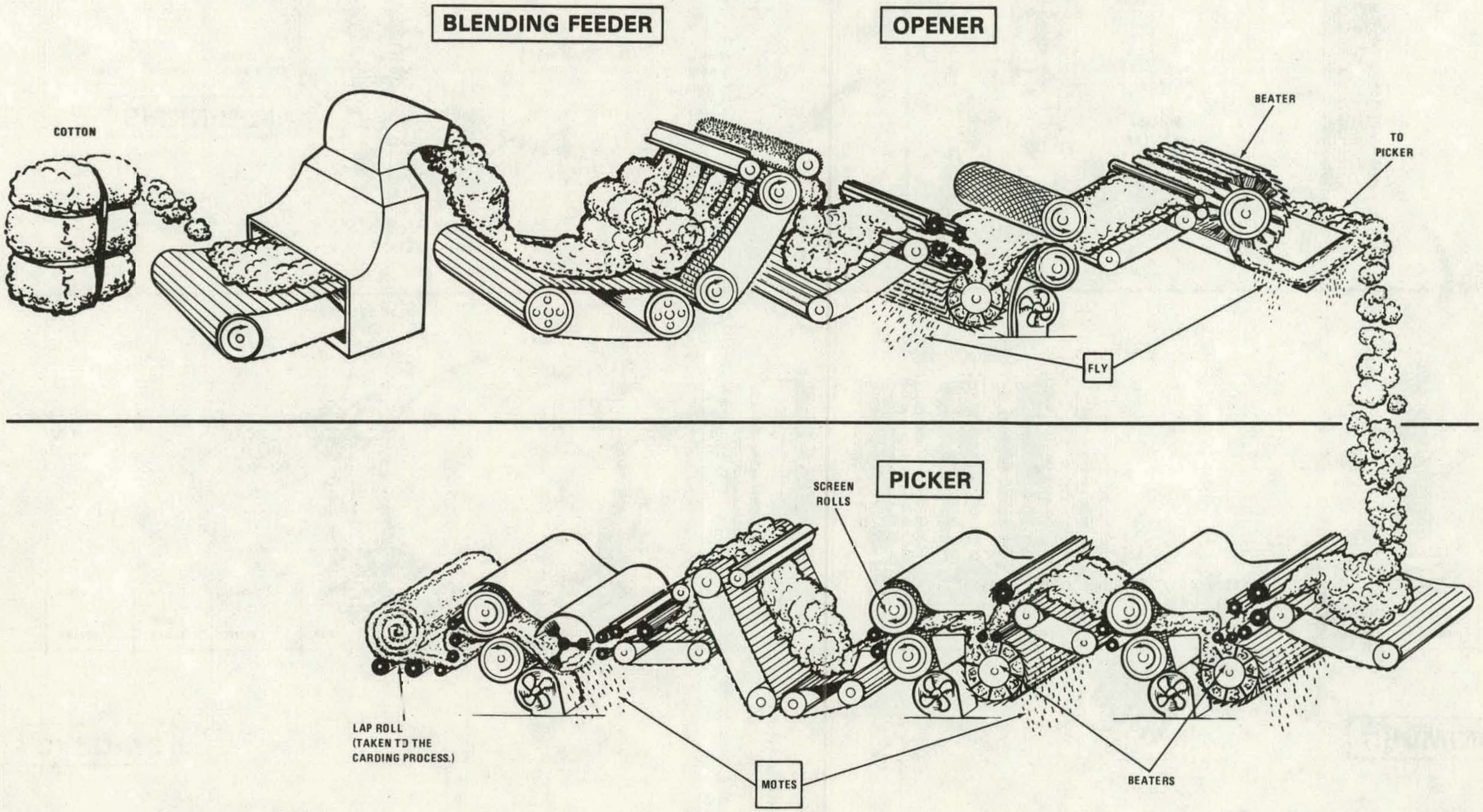
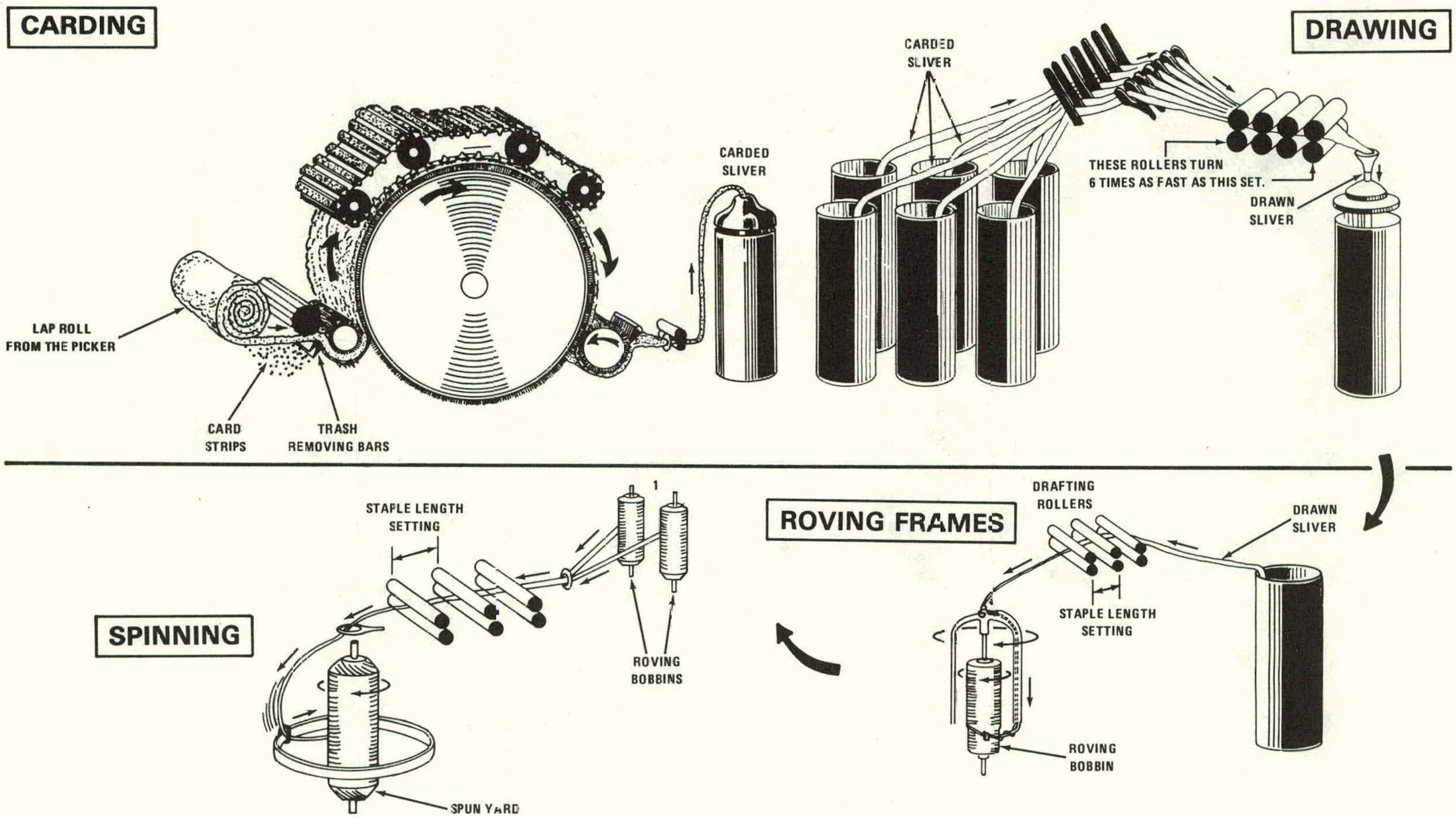


FIGURE 3-2
The Yarn Forming Process



cotton through a number of different beating and air suction operations. This process also loosens, limps, and fluffs-up the fibers. In blending, contents of many bales are mixed to attain a degree of uniformity. Most companies blend several (4 to 42) bales simultaneously to obtain a well-balanced blend and to achieve desired fiber characteristics in fiber maturity and fiber length—micronaire. The picking process further opens and blends the fibers. Fibers in the pickers pass through several beaters and screen rolls into a lap roll. (A lap roll of cotton is about 40 inches wide and 10 inches in diameter; it contains layers of 1-inch thick cotton laps.) The opening, blending, and picking processes were shown in Figure 3-1. The waste generated by these processes are referred to as motes and fly.

3.1.2.2 Carding Process

In the process called carding, fibers are cleaned and arranged in parallel order. Cleaning removes large amounts of waste, tangled fibers, and short fibers. Short fibers are removed to make subsequent operations (drawing, roving, and spinning) go more smoothly. Removing the shorter fibers also produces or improves such yarn characteristics as high tensile strength, smoothness, and resilience. The resulting clean and parallel cotton fibers are drawn out of the card in sliver form into a sliver can, as shown in Figure 3-2.

3.1.2.3 Drawing Process

In the drawing process, six, eight, or more slivers are combined into one in order to obtain higher uniformity of fibers, more parallel fibers, and uniform blending of different fibers such as polyester. A drawing frame is used to combine and pull slivers; generally, the resulting sliver is as thick as the original, but proportionally longer. For example, six slivers are combined, the resulting drawn product is six times longer. The process is illustrated in Figure 3-2.

3.1.2.4 Lapping and Combing Process

Lapping and combing are two additional steps used in producing higher quality yarns. The lapping processes flatten the sliver into an approximately 8-inch wide strip, while the combing process involves the removal of short fibers. The combing waste is known as comber noils. The combed cotton possesses greater strength and a higher luster than its non-combed counterpart making possible the production of finer cotton yarns.

3.1.2.5 Roving Process

The roving process reduces the diameter of the drawn sliver, strengthens and tightens the sliver, and imparts the first twisting action. This process involves the use of consecutively-positioned drafting rolls, each set turning faster than the preceding pair. The spacing of the rolls are designed to be a fraction of an inch longer than the longest average fibers used. If longer fibers penetrate the process, they may be torn by the rollers; whereas shorter fibers can cause ends-down (stopping the yarn-forming process) or lumping between the rolls. Ends-down have an adverse effect on the economics of textile production, while lumping causes unevenness or damage in yarns. The roving process is illustrated in Figure 3-2.

3.1.2.6 Spinning Process

Spinning is a combination of drawing and the simultaneous application of a twist to the drawn roving. The drawing process is similar to that of roving although designed to produce a finer and stronger product. The twisting is applied to create a permanent hold of the fibers and to supply strength. In general, the spinning process can influence such yarn characteristics as appearance, durability, softness, strength, and serviceability.

3.1.3 Production of Woolen Yarns

Woolen yarns are more complicated to produce than cotton yarns. This is because of the variety of grades of wool in the bale and the high level of contaminants in the fleece, requiring careful grading and wet preparatory treatment. Some of the steps in wool yarn production are described in the following paragraphs.

3.1.3.1 Grading and Separation of Wool

When the wool reaches the mill, it contains the fleece of several sheep. Each fleece contains different grades of wool requiring careful manual grading and separating of groups of fibers according to length, diameter, and quality. The grading and separating process is performed by skilled workers, expert in wool identification.

3.1.3.2 Cleansing and Treating of Wool

The production of wool yarn is further complicated by various cleansing and treating operations. Some of the preparatory operations are wet processes designed to cleanse the wool from suint oils and other foreign particles. The most commonly used preparatory processes are shown in Figure 3-3.

3.1.4 Yarn Formation From Man-Made Fibers

Forming yarn from man-made fibers is much simpler than forming it from either wool or cotton. This is primarily due to the purity and uniformity of man-made fibers, characteristics that permit the elimination of the various cleaning processes. In other aspects, yarn from man-made fibers is similar to forming it from cotton. However, because of the great variations within man-made fibers, some steps in yarn formation are still peculiar to these materials.

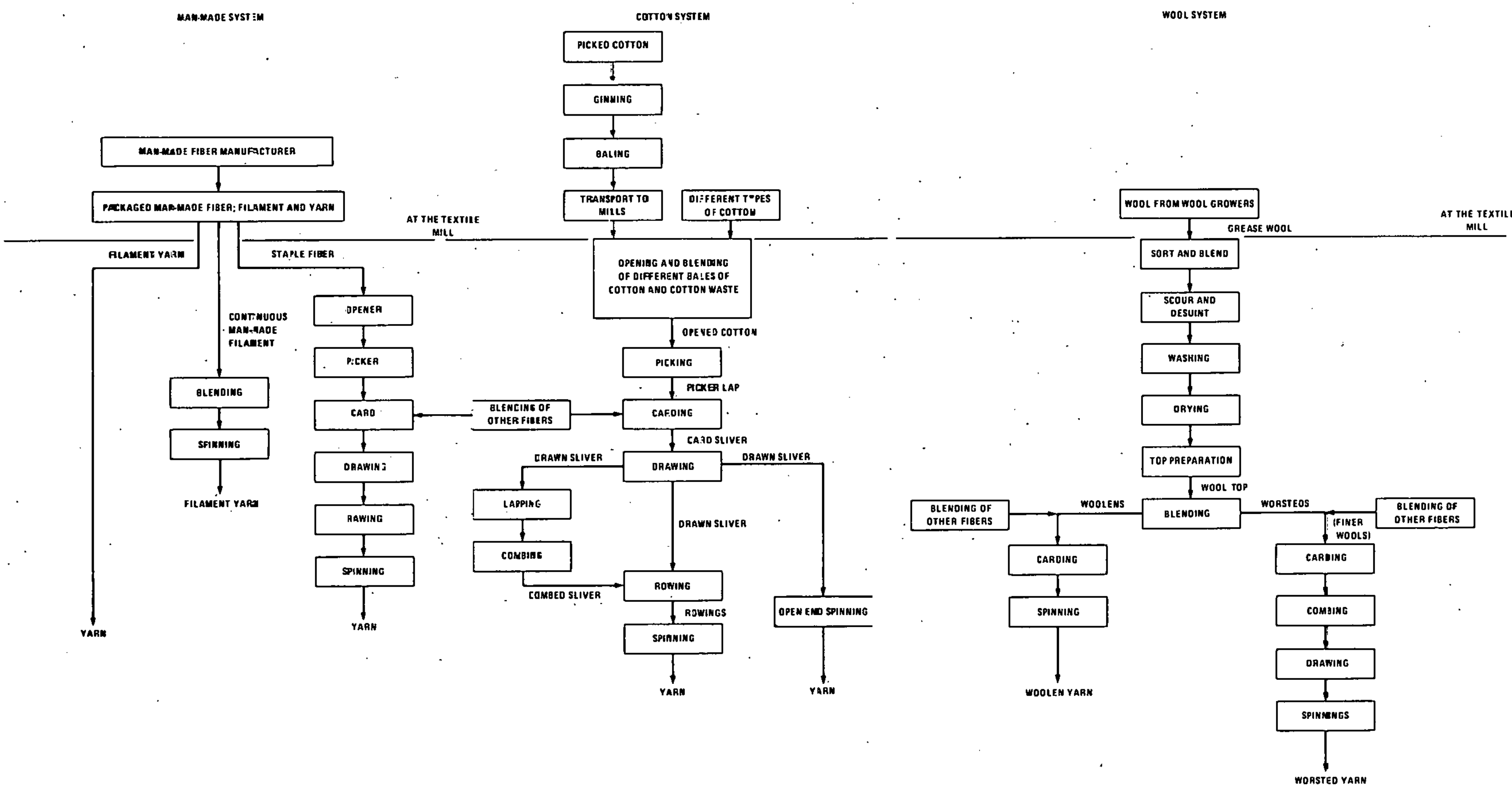
3.1.4.1 Continuous Filament Fibers

In the case of continuous filament fibers, the yarns can be formed by twisting several filaments (the number of filaments varies, but 32 and 64 are common). Often, continuous filament yarn is produced by chemical industries manufacturing the filament. A flow diagram of the process for producing man-made fiber yarn is shown in Figure 3-3.

3.1.4.2 Treatments for Man-Made Fibers

Many man-made fibers are often treated to create new surface, shape, and texture characteristics; these steps

FIGURE 3-3
Major Operations in Man-Made Cotton and
Woolen Yarn Forming Processes



are taken to provide consumers with desired yarn or fabric properties. The fiber treatments are known as texturizing. Some common fiber characteristics that can be obtained through texturizing are elasticity or stretch, high bulk, and loop bulk. Textured man-made fibers are produced through mechanical heat-setting operations on the thermoplastic filament fibers. In the case of continuous filament yarns such as rayon, nylon, or polyester, texturizing processes are applied to simulate the appearance and feel of natural fibers.

3.1.5 Textile Fabric Formation

Fabric is formed by connecting yarn made of fibers into flexible sheets of textile materials. There are three major fabric-forming processes—weaving, knitting, and nonwoven processing. The general characteristics of these processes are discussed in the following paragraphs.

3.1.5.1 The Weaving Process

Weaving consists of the interlacing of warp yarn with crosswise fill yarns. The warp yarns must undergo treatments (sizing), which do not improve the quality of the yarn, but prepare the yarn for the strain of weaving. After treatment, the warp yarns are set into the loom (weaving machine) in an arrangement determined according to the desired designs and fabric characteristics. Characteristics, advantages, and limitations of the basic weaves are given in Table 3-3.

3.1.5.2 The Knitting Process

Knitting is a process of fabric construction achieved by the interlooping of yarns into a series of connected loops. Knitting machines can form hundreds of loops at a time and have the capacity to create different knitting designs. The outstanding characteristic of knitted fabrics is their exceptional stretchability which can be achieved even from nonstretchable yarn. Knitted goods are also known to have good insulating qualities, high levels of absorbency, high weight, and wrinkle resistance.

TABLE 3-3
Characteristics, Advantages, and Limitations of Basic Weaves

WEAVE	CHARACTERISTICS	ADVANTAGES	LIMITATIONS
PLAIN	NO DISTINCT DESIGN UNLESS YARNS HAVE CONTRASTING COLORS	MAXIMUM YARDAGE; EASILY PRODUCED; INEXPENSIVE; STRONG; ADAPTABLE FOR DIRECT PRINTING AND OTHER FINISHING PROCESSES	SLEAZY FABRIC IF THREAD COUNT IS LOW
BASKET	BASKET PATTERN	ATTRACTIVE; INEXPENSIVE; DRAPABLE; ABSORBENT	NOT DURABLE FOR APPAREL; SOILS EASILY
RIBBED	CORDED EFFECTS	ORNAMENTAL	NOT SERVICEABLE IF OF INFERIOR CONSTRUCTION
TWILL	DISTINCT DIAGONAL DESIGN	STRONG, FIRM TEXTURE; INCREASED DRAPABILITY; INTERESTING DESIGNS	REQUIRES CARE TO KEEP CLEAN; DEVELOPS SHINE
SATIN	LUSTER; INTERRUPTED DIAGONAL DESIGN DISCERNIBLE WITH MAGNIFYING GLASS	BEAUTY CONTRIBUTED BY LUSTER; SMOOTH; MAXIMUM DRAPABILITY	EXCESSIVELY LONG FLOATS MAY SNAG AND ROUGHEN FABRIC

3.1.5.3 The Nonwoven Process

The nonwoven method of production refers to the creation of a textile product directly from fibers without the use of yarn. Instead chemical bonding agents and/or physical means of bonding are used. The nonwoven manufacturing system is based on four basic processes, each of which can be done in different ways. The four basic processes and the various methods of performing each are as follows:

- Fiber preparation can be achieved through opening, conditioning, blending, and chip preparation

- Web forming is done through card or garnett laying, air laying, or web laying.

- Web bonding is the actual fabric forming process, performed through such operations as point bonding, print bonding, needle punching, or jet entanglement.

- Some post-treatment operations include drying, curing, finishing, printing, and dyeing.

A particularly attractive characteristic of the nonwoven approach is its simple fabric-forming operation. Such time consuming processes as drawing, roving, spinning, weaving, and knitting can be omitted and various other mechanical and chemical operations are also not needed. Nonwoven textile items are low in cost, in great part because they can be produced simply and quickly. However, certain desirable fabric characteristics cannot as yet be obtained. The product has little tensile strength and little or no elasticity or drapability. However, certain non-wovens have high thermal insulating properties. Because of their lack of desirable characteristics, nonwovens are used primarily in non-outerwear and second tier textile goods.

Tufting is the process of punching extra loops of yarn into a woven fabric. The tufts are generally created perpendicular to the primary backing, which adds a desired third dimension to such fabrics as carpets, chenille bedspreads, and bathroom mats. The yarn most often used in tufting is made from continuous filament to ensure smooth operation and maximum strength. In carpets, where there is much abrasion, the backing is coated with latex to hold the tufts. (The latex backing forms a permanent and irreversible bond which makes the reprocessing of carpet waste impossible at this time.)

3.1.6 Textile Finishing Processes

In the textile industry, finishing is an important and complicated process. It has many forms and they must be adapted to the kind of fiber and yarn used in the fabric. More important, the finishing must be adapted to the fabric's intended purpose. In order to obtain predictable and desirable qualities through finishing, the type of fiber or fibers in the fabric must be identified. (The implication of this requirement for the use of recovered materials is critical and will be discussed further.) There are many important textile finishing processes and the predominant effect of each on various textile mill products has been ascertained, but new finishing processes are being developed each year. Some of the more prevalent finishing processes currently used are discussed below.

3.1.6.1 Singeing

Singing or gassing is the removal of lint, fuzz, thread, and fiber ends by burning with a gas flame to obtain a smooth, clean finish. This finishing technique is often used for fine-quality yarns.

3.1.6.2 Bleaching

Bleaching is the removal of color, stains, or discolorations from the fabric or yarn prior to dyeing, pringing, or other finishing. Bleaching ensures a consistent uptake of dye by the fabric. The fiber content of the product must be known because a bleach reacts differently to different types of fibers.

3.1.6.3 Mercerization

Mercerization is the passing of a fabric through a cold 15 to 20 percent solution of caustic soda. The soda solution is later removed from the fabric. Mercerization is used only for cotton and it increases the luster, strength, and body of the fibers and yarn. It also increases the product's affinity for certain dyes.

3.1.6.4 Slack Mercerization

Slack mercerization is the process of soaking and stretching the fabric in the caustic soda solution for approximately 1 minute. This process, which is used only for cotton, adds 15 to 20 percent stretch to the fabric. It also increases the abrasion resistance of the fabric by approximately a multiple of four. In this process, the fabric's strength is reduced by 30 to 50 percent.

3.1.6.5 Shrinking

Shrinking is using water, steam, or chemicals to reduce the size of the fabric. It counteracts the extra, unnatural length gained through the continuous application of tension during fabric production. Shrinking methods vary with fiber type and fabric construction.

3.1.6.6 Tentering

Tentering is a process for drying the fabric, evening its weight, and aligning the filling yarn perpendicular to the warp yarn.

3.1.6.7 Temporary Stiffening

Temporary stiffening is the immersing of fabrics in a solution of starch to add stiffness, weight, strength, and a preservative. Other temporary additives are oils, flour, glue, etc.

3.1.6.8 Permanent Stiffening

Permanent stiffening can be obtained by chemical processes that change the cellular structure of the fiber. This is done to achieve stiffness, smoothness, permanency, and soil resistance.

3.1.6.9 Calendering

Calendering is essentially an ironing process designed to add sheen to the fabric. The effect is achieved by passing the fabric between large, heated rollers. When calendering is performed on a fabric treated with temporary stiffening agents, a stiff polished, or glazed surface is obtained.

3.1.6.10 Napping

Napping produces a fuzzy finish through combing. The process is used to obtain a desired feel, warmth, and serviceability. The yarn intended for napping is loosely spun to make napping easier. A shearing process is used to even yarn irregularities.

3.1.6.11 Shape-Retentive Finishes

Shape-retentive finishes prevent deformation of the fabric from unintentional wrinkling. These finishes are all obtained through the use of resins or reactants that combine chemically with the fiber. Side effects of some shape-retentive finishes are a considerable loss in strength, absorption, and comfort.

3.1.6.12 Other Finishes

Many other finishes can be applied to textile fabric, for physical or chemical finishing. However, the remaining finishing processes, dyeing and printing, are applied to most textile mill products.

Dyeing is a complex process designed to enhance the appearance of the fabric. Its complexity arises from the nonhomogeneous nature of the fibers, the effect of finishing operations, and the high sensitivity of dyeing to changes in dye mix. Selecting the proper dye is extremely important, but it is also quite difficult. This is because new dyes have been introduced and there are also new fibers, new fiber blends, new finishing processes, and a demand for new color tones.

Some classes of dyes, their uses, and characteristics are listed in Table 3-4.

Printing is an alternative way to decorate fabrics. There are different methods of printing, a few of which are as follows:

- Block printing employes blocks designed to print small areas at a time. This form of printing is in limited use.

  Roller printing is a continuous multicolor process.

TABLE 3-4
Selected Dye Classes, Their Uses, and Characteristics

DYE CLASS	GENERAL DESCRIPTION	USES	FASTNESS								
			LIGHT	WASHING	STAINING (BLEEDING)	DRY CLEANING	HOT PRESSING	CROCKING	GAS FADING	SEAWATER	PERSPIRATION
BASIC	ORGANIC BASE DISSOLVED IN INORGANIC ACID .... LIMITED USE	COTTON (WITH MORDANT), WOOL, SILK, NYLON, POLYESTERS, ACRYLICS, MODACRYLICS	POOR, EXCELLENT ON ACRYLICS	POOR ON NATURAL FIBERS, GOOD ON OTHERS	BLEEDS EASILY ON WOOL, SILK	MOSTLY POOR, GOOD ON ACRYLICS	NOT AFFECTED	GOOD RESISTANCE ON ACRYLICS	NOT SUSCEPTIBLE	VERY POOR, GOOD ON ACRYLICS	GENERALLY POOR
OXIDATION BASES	ONE OF EARLIEST SYNTHETICS	PRIMARILY FOR DYEING COTTON, ALSO WOOL, SILK, ACETATE	EXCELLENT	VERY GOOD	VERY GOOD	VERY GOOD	NOT AFFECTED	VERY GOOD	NOT SUSCEPTIBLE	NOT AFFECTED	GOOD
ACID	COMPLETE COLOR RANGE	PRIMARILY FOR WOOL AND SILK ... ALSO ACETATE, NYLONS, ACRYLICS, MODACRYLICS, SPANDEX	GENERALLY VERY GOOD	POOR	BLEED EASILY, STAIN ADJACENT FIBERS	GOOD	NOT AFFECTED	EXCELLENT	NOT SUSCEPTIBLE	FAIR	FAIR
ACID-MILLING	COMPLETE COLOR RANGE, DULLER THAN ACID DYES	SAME AS ACID	GENERALLY VERY GOOD	GOOD	GOOD RESISTANCE	GOOD	NOT AFFECTED	EXCELLENT	NOT SUSCEPTIBLE	GOOD	FAIR TO GOOD
ACID-PREMETALIZED	REQUIRE STRONG ACID BATH	SUITABLE FOR CARPETING, DECORATIVE FABRICS	GOOD TO EXCELLENT	FAIR TO GOOD	GENERALLY GOOD RESISTANCE	GOOD	NOT AFFECTED	GOOD TO EXCELLENT	NOT SUSCEPTIBLE	FAIR TO GOOD	GOOD
NEUTRAL-PREMETALIZED	SHADES FAIRLY BRIGHT BUT LESS SO THAN ACID COLORS	WOOL, SILK, NYLONS, ACRYLICS, MODACRYLICS, VINYLIDENE-DERIVED FIBERS	VERY GOOD TO EXCELLENT	FAIR TO GOOD	GENERALLY GOOD RESISTANCE	GOOD	NOT AFFECTED	GOOD TO EXCELLENT	NOT AFFECTED	GOOD TO EXCELLENT	GOOD
MORDANT (CHROME)	FAIRLY COMPLETE COLOR RANGE BUT DULLER THAN ACID DYES	CARPETING, DECORATIVE FABRICS, SILK, NYLONS, CELLULOSIC FIBERS	GOOD TO EXCELLENT	GOOD	CONSIDERABLE STAINING OF ADJACENT FIBERS	FAIR TO GOOD	NOT AFFECTED	FAIR TO GOOD	NOT AFFECTED	GOOD	GENERALLY GOOD
SUBSTANTIVE DIRECT	COMPLETE SHADE RANGE, COLORS DULLER THAN BASIC OR ACID DYES	PRIMARILY FOR CELLULOSIC FABRICS	GOOD TO EXCELLENT	POOR	GOOD RESISTANCE	GOOD	GOOD	VERY GOOD IN MOST SHADES ON COTTON, RAYONS	NOT AFFECTED	POOR TO GOOD	GOOD
DEVELOPED	COMPLETE SHADE RANGE, COLORS DULLER THAN BASIC OR ACID DYES	SAME AS SUBSTANTIVE DYES	GOOD TO EXCELLENT	FAIR	GOOD RESISTANCE	GOOD	GOOD	VERY GOOD IN MOST SHADES ON COTTON, RAYONS	NOT AFFECTED	POOR TO GOOD	GOOD
AZOIC	HELPS TO REDUCE TEMPERATURE OF BATH TO FACILITATE DYEING; COMPLETE SHADE RANGE	COTTON GOODS, ACETATE, NYLONS	GOOD TO EXCELLENT	GOOD, SOME SENSITIVE TO CHLORINE BLEACH	FAIR, SOMETIMES STAINS ADJACENT WHITES.	GOOD	GOOD	DEPENDS ON DYEING TECHNIQUE AND AFTER TREATMENT	NOT AFFECTED	GOOD	GENERALLY GOOD
DISPERSE	INSOLUBLE IN WATER, GOOD SHADE RANGE	PRIMARILY FOR ACETATE; ALSO TRIACETATE, NYLONS, POLYESTERS, ACRYLICS, MODACRYLICS, OLEFINS, AS WELL AS CELLULOSIC FIBERS	FAIR TO EXCELLENT, DEPENDING ON FIBER	FAIR TO GOOD	STAINS WOOL BADLY	GOOD	SOME COLOR CHANGE POSSIBLE	GOOD	POOR TO GOOD RESISTANCE, DEPENDING ON FIBER	GOOD	GOOD
SULFUR	GENERALLY INSOLUBLE IN WATER, COMPLETE SHADE RANGE	APPLICABLE TO STOCK, YARN, PIECE GOODS	POOR TO FAIR FOR YELLOWS AND BROWNS	SENSITIVE TO CHLORINE BLEACH	DEPENDING ON SHADE, DEPTH, AFTER TREATMENT	GOOD	GOOD	POOR TO GOOD	NOT AFFECTED	GOOD	GOOD
VAT	INSOLUBLE IN WATER, INCOMPLETE BUT ADEQUATE SHADE RANGE	PRIMARILY FOR COTTON, ALSO WOOL	GENERALLY EXCELLENT	GOOD	GOOD RESISTANCE	GOOD	GENERALLY GOOD	FAIR TO GOOD	GENERALLY NOT AFFECTED	GOOD	GOOD
REACTIVE	FORM CHEMICAL COMBINATION WITH FIBER, DISTINGUISHING CLASS FROM OTHERS	PRIMARILY FOR COTTON APPAREL, DECORATIVE FABRICS FOR BRIGHT COLORS	GOOD TO VERY GOOD	GOOD, SENSITIVE TO CHLORINE BLEACH	GOOD RESISTANCE	GOOD	NOT AFFECTED	GOOD	NOT SUSCEPTIBLE	GOOD, SOME FAIR	GOOD
PIGMENT	ALL INSOLUBLE IN WATER WITH NO AFFINITY FOR FIBER, FIXED ON FIBER WITH RESINOUS BINDERS AND CURED AT HIGH TEMPERATURES	PRIMARILY FOR PRINTING COTTON OF ALL WEIGHTS; ALSO RAYON, ACETATE, NYLONS, POLYESTERS, OLEFINS	VERY GOOD TO EXCELLENT	GOOD	GOOD	GOOD	GOOD	GOOD FOR LIGHT TO MEDIUM SHADES	MAJORITY NOT SUSCEPTIBLE	GOOD	GOOD
OPTICAL BRIGHTNERS	ALSO CALLED FLUORESCENT WHITENERS, BRIGHTNESS CAUSED BY ABSORPTION OF OF ULTRAVIOLET LIGHT AND REFLECTION OF VISIBLE BLUE LIGHT	MUCH USED ON COTTON; ALSO WOOL, ACETATE, NYLONS, ACRYLICS	FAIR	VARIES	NOT AFFECTED	NOT KNOWN TO BE AFFECTED	NOT KNOWN TO BE AFFECTED	NOT KNOWN TO BE AFFECTED	NOT KNOWN TO BE AFFECTED	NOT KNOWN TO BE AFFECTED	NOT KNOWN TO BE AFFECTED

DATA BASED UPON DYE CHART–1963, TEXTILE WORLD

- Duplex printing simultaneously prints both sides of the fabric.

- Discharge printing displaces the dye on a dyed fabric to obtain such effects as polka dots.

As indicated by this overview, textile operations are a complicated series of technical processes that are highly dependent on the quality in input fibers. The characteristics of the final output are influenced by each of the operations and the acceptability of final products is determined by the control exercised over these operations.

3.2 NO TECHNOLOGIES ARE NOW AVAILABLE TO PREPARE TEXTILE WASTE FOR USE IN MAKING FIRST TIER YARN AND FABRIC

Less than 1 percent of the fibers consumed by the textile mill products industry are not used in some way. This means that only about 100 million pounds go unused, in spite of the fact that individual processes may generate unused fibers at rates up to 25 percent of total input. Raw material control in the textile mill products industry is pervasive because the industry is operating on a low profit margin and raw material constitutes 40 to 60 percent of total product cost. As previously indicated, operating personnel make great efforts to reprocess waste by cycling such by-products as comber noils and motes back into the system. Waste that cannot be used by the upper tier mills are generally sold either to textile waste reprocessors or to mills that produce second tier textile products. The by-products are reprocessed in various ways, but they cannot be upgraded for use by the first tier textile mills.

3.2.1 Fibrous Waste Reprocessing

Reprocessing fibrous material involves identification, grading, cleaning, carding, blending, and baling it. If the waste product is not clearly identified by the supplier, the reprocessors usually examine the waste visually to determine its quality. Some larger reprocessors may use more scientific methods such as burning tests, microscopic analysis, and chemical tests. When the waste is identified and graded, it is stored until shipment to a user in the second tier of the textile industry. Before shipment, the waste is moved into the reprocessing area for preparation according to the buyer's specifications.

Heavily-contaminated waste such as sweep waste is emptied onto a conveyor belt where it is manually examined and cleaned. Magnets are sometimes used to remove metallic impurities. After the waste is sufficiently cleaned of major impurities, it enters a hopper feeder where heavy impurities are removed. At this stage the waste is still contaminated with dust and smaller particles of waste.

To further purify the product, reprocessors beat and mix it in a step cleaner, thus loosening the impurities. The loosened product is ready to be processed through conventional cleaning machines, resembling the opener, picker, and card used in first tier textile mills. This purifying and cleaning process is known as willowing. (Willowing creates much cotton and fiber dust, a problem treated in the OSHA Cotton Dust Standards.) The willowing process is often accompanied or followed by a blending process similar to the blending operations at first tier textile mills. This process is used to obtain a desired fiber mix.

3.2.2 Yarn Waste Reprocessing

Yarn waste reprocessing operations include sorting, chopping, and shredding. The various yarns are handled as follows:

- The longest cords are sold to cordage manufacturers.
- Second longest cords are sold to string mop manufacturers.
- Cords too short for use as yarn are chopped into small lengths, shredded, and picked into a fiber form (with some stray yarn), termed "shoddy," and sold for use in the production of some coarse yarns. The coarse yarns are formed into such items as industrial mats and floor mops.

Many buyers of reprocessed yarn specify the fiber content of the product. Certain buyers also request that the product not contain chemical contaminants. In order to meet these specifications, the reprocessors pay considerable attention to identifying and sorting the yarn into various quality and fiber groupings. The sorting process is performed manually on conveyors or sorting tables. The selected yarns are cut into shorter lengths by guillotine cutters or rotary cutters. The cut yarn, usually between 1/3 and 3 inches long, is conveyed to a shredder that is designed to delump, tear, and open yarn and fabric waste. Shredding is accomplished in one or more main cylinders, equipped with special shredding pins. The speed of the cylinders and the size and density of the pins determine the extent to which the yarn can be opened, fluffed, and delumped.

Products such as wool or rayon that are intended for respinning can be further refined through a process known as garnetting. Garnetting makes shredded materials sufficiently fibrous that they are not detrimental to the carding operation. The garnett operates like a shredder, except that its cylinder is lined with garnetting wires instead of pins. The wires resemble the teeth of a saw.

3.2.3 Fabric Waste Reprocessing

Fabric waste is reprocessed for use in the second tier of the industry through mechanical processes very similar to those used in reprocessing yarn waste. The identification and sorting operations are time-consuming manual processes, but they ensure a certain degree of fiber and quality control.

The sorted fabric is cut by mechanical or hand cutters into pieces small enough to feed into the rag picker. Rag picking is a tearing and shredding process employing heavy rotating cylinders equipped with forged teeth. The various forged teeth available for the rag picker are designed to tear, cut, and shred the fabric.

The picked (torn) fabric is conveyed on air blowers to a separator for elimination of heavy particles such as zippers and buttons. The reclaiming processes that follow separation are identical to the processes employed in yarn waste recovery.

These types of textile waste are currently being processed in the waste products subsector of the industry (SIC 2294) and they are used throughout the second tier of the textile mill products industry and in other industrial applications. However, there are no processes currently available to upgrade this waste for use in the making of products in the first tier of the industry.

3.3 NO TECHNICAL DEVELOPMENTS FOR IMPROVING THE USE OF REPROCESSED TEXTILE WASTE ARE ANTICIPATED BEFORE 1987

Several important technological developments are expected to influence the generation of waste in the textile mill products industry. These developments are as follows:

- Automatic waste collection systems designed to control dust and waste at the textile mills
- Open-end spinning systems which use more short fibers in the production of yarn
- Growth of the nonwoven method of fabric formation which can use waste fibers in some applications.

3.3.1 Automatic Waste Collection

Waste generated during the yarn production process will be handled by automatic collection devices designed to pneumatically collect, transport, grade, and bale all waste generated during the yarn preparation process. One such system is being produced and installed by the Pneumafil Corporation. Systems such as those developed and installed by Pneumafil have been designed for the elimination of cotton dust from the air. The value of the system in waste collection is its ability to collect and sort all the waste generated at the spinning plant. Some systems can be equipped with waste-grading equipment designed to sort waste into three categories—reworkable waste, salable waste, and disposable waste.

Since pneumatic systems require closed yarn preparatory operations, all floor-sweep fibrous waste will be eliminated. This system is expected to reduce slightly the amount of generated cotton wastes and to reduce the quality of the salable cotton waste.

The technical feasibility of this process has been established in several installations in Europe and the United States. The number of operations of such air quality and waste control systems should increase substantially over the next few years due to the requirements of the OSHA cotton dust standards.

3.3.2 Open-End Spinning

Open-end spinning is another established technology that will influence the generation of waste in the textile mill products industry. Open-end spinning systems spin yarn directly from sliver (see Figure 3-2). The removal of short fibers during carding and picking is partially designed to reduce the "ends-down" during the conventional spinning process (e.g., drawing and roving). However, open-end spinning systems are destined to spin yarn directly, skipping the drawing and roving process. Consequently, compared with ring spinning, open-end spinning systems can use more of the short fibers. Open-end spinning systems have additional advantages, such as the following:

- Require one-half to one-third of the normal floor space per pound of output
- Consume up to 30 percent less energy per output, depending on product type
- Minimize pollution in the working environment because of the system of yarn preparation
- Have higher speeds of production
- Result in more economic production for low-count yarns.

Some of these advantages are offset by the following:

- High cost of the system
- Different physical characteristics of the yarn, such as low tensile strength
- Increased number of ends-down during weaving
- Higher level of pollution during subsequent operations due to the higher number of short fibers in the yarn.

Open-end spinning was developed in Europe during the early 1960's and became available in the United States in the mid-1960's. By 1976, there were 168,792 open-end spinning frames in the U.S. textile mills, representing approximately 2 percent of the total U.S. spinning capacity. An estimated 350,000 open-end spindles will be operating in the U.S. by the end of 1979, based on the Treasury Department's growth rate of 60,000 units per year.

There are no composite forecasts available on the 1987 open-end spinning capacity. Textile industry experts believe that 20 to 25 percent of all U.S. spinning may be done on open-end spinning machines by that time. Assuming a 20 percent capacity penetration of the open-end spinning process, its effect on waste is estimated to be as follows:

- Reduction in quantity and quality of reworkable waste
- Reduction in quantity and quality of salable waste
- No effect on disposable waste
- Increase in quantity of yarn waste due to weaving problems (looms-down)
- Increase in the amount of post-consumer waste, due to poor wear characteristics.

Open-end spinning is expected to reduce the overall quality and quantity of waste generated by the first tier textile mills. However, this reduction in fibrous waste may be offset by the increase in secondary (post-consumer) waste.

3.3.3 Nonwoven Fabric Production

Recent developments in the production of nonwoven textile products and in the development of man-made fibers are responsible for the phenomenal growth of nonwovens. In the 2 years between 1975 and 1977, nonwoven consumption has grown from 508 million pounds to 641 million pounds (a 26 percent increase). Forecasts by the trade association of the nonwoven fabric industry—the International Non-Wovens and Disposables Association (INDA)—indicate further growth from 641 million pounds in 1977 to 815 million pounds in 1981 (a 27 percent increast). Sales of these fabrics are expected to grow 8 to 20 percent per year, depending on the process and markets.

The nonwoven production system generally includes four basic steps—fiber preparation, web formation, web bonding, and post-treatment. Technically, the process is capable of using most types of fibers including fibers with short staple lengths. However, the properties of the individual fibers are transmitted into the properties of the fabric. As in the production of standard textile products, desired fabric characteristics are attainable only through effective fiber control. Investigations indicate that expanded use of nonwovens will cause more short length fibers and more irregular fibers to be used. This will result in competition between producers of nonwoven goods and other users of waste fibers for the limited and shrinking supply of waste fibers. However, since approximately 40 percent of nonwovens are disposable goods, secondary waste will increase.

3.3.4 Overall Effects of Anticipated Technological Changes

Discussions with textile waste dealers and nonwoven manufacturers indicate that technological change is expected to have two overall effects:

- Moderate reduction in the amount of salable, textile-mill-generated waste
- Marked reduction in the quality of salable, textile-mill-generated waste.

Because of the anticipated decrease in the supply of salable waste, the second tier textile mills will seek alternate sources of cheap materials. These sources include imports of textile mill waste and increased use of garment industry waste and nonfiber wastes.

Investigations did not uncover any waste reprocessing technology that would influence or alter the present mode or level of textile waste utilization by 1987. Faster and more automated waste recovery systems have been developed in Europe and their functions and methods of operation are identical to those machines developed at the turn of the century.

In the early 1970's, various European institutions, such as the Shirley Institute and Leeds University in England tried to develop fiber-separating equipment. Such equipment would make it possible to use certain blends by separating and sorting the individual fibers. Two methods of fiber separation were examined:

- Solvent extraction is a method of chemically separating loose fibers from a blend. Solvents would react with and dissolve one of the fiber types in the blend. Because of the complicated chemical parameters created by the various treatments and blends of man-made fibers, solvent extraction did not develop into a marketable process.

- Electrostatic fiber separation is based on the fact that different electrical charges are generated by various fibers. In experimental operations, a 98 percent fiber separation was achieved. However, the process was plagued with numerous problems, both mechanical and economic; and the development of the system was suspended.

These technologies are not expected to have any impact on the waste recovery process prior to 1987 unless extensive research programs and agressive development programs are implemented. Presently there is no evidence that such programs will be forthcoming.

* * * * *

Technical processes currently used or anticipated were discussed in this chapter. The following chapter will examine the economic environment in which the textile mill products industry operates.

CHAPTER 3 SOURCES

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2. Conversations and correspondence with representatives of the following associations:

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   - American Association for Textile Technology, Inc.
   - American Cotton Linter Association
   - American Cotton Waste Exchange
   - American Textile Machinery Association
   - American Textile Manufacturers Association
   - American Yarn Spinners Association
   - Boston Wool Trade Association
   - Institute of Textile Technology
   - Man-made Fiber Producers Association
   - National Association of Recycling Industries, Inc.
   - Textile Dealers Association of America, Inc.
   - Textile Fibers and By-products Association
   - Textile Quality Control Association.

3. Conversations with representatives of the following government agencies:

   - Department of Agriculture
   - Office of Textiles (U.S. Department of Commerce)
   - Patent Office (U.S. Department of Commerce).

4. Conversations with textile experts from the following institutions:

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   - Georgia Institute of Technology
   - Philadelphia College of Textiles and Science
   - Textile Research Center, Texas Tech University
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4. ECONOMIC ANALYSIS OF THE TEXTILE MILL PRODUCTS INDUSTRY

The U.S. textile mill products industry is a mature industry, having been a leader in the industrial revolution more than 200 years ago. Textile mills were once small, family-owned businesses; and even today the industry is highly competitive, with a large number of small, single-plant firms. However, economic conditions have forced a movement toward larger, more fully integrated textile mill operations.

The industry has experienced a slow rate of technological change, and it has therefore, remained quite labor intensive relative to other manufacturing industries. Faced with rising labor costs and increasing competition from less expensive foreign imports, textile mills have been forced to adopt more automated processes to improve production efficiency and reduce costs. But profits were low in the past, and this has limited the ability of the industry to make the necessary investments to improve its competitive position.

Although the industry is more than 200 years old in the United States, it is still changing. The purpose of this chapter is to examine the evolving nature, structure, and performance of the textile mill products industry and to assess its ability to finance capital investments over the next decade.

4.1 THE TEXTILE MILL PRODUCTS INDUSTRY IS CHANGING BUT IT IS STILL HIGHLY COMPETITIVE

The textile mill products industry is composed of more than 5,000 firms and over 7,000 individual plants employing 913,800 in 1977. Most are small, weakly capitalized firms, and many are single-plant firms. In fact, in the 1972 Census of Manufactures, 2,700 plants were reported to employ less than 20 workers each. Textile mills are also small relative to other industrial companies. Of the top 500 industrial companies listed in Fortune 500, the largest textile mill firm ranked only 102nd on the basis of sales in 1977, down from 98th in 1976.

The textile mill products industry began with family-owned operations. One of the largest firms in the industry is still a closely-held family business. In 1975, only 80 firms were openly held; the rest were closed corporations.

As previously noted, the textile mill products industry is highly competitive. In 1977, the largest firm had only a 7 percent market share on the basis of sales. Like other competitive industries, it is characterized by a low level of seller concentration. Table 4-1 shows the share of the domestic market held by the largest four, eight, twenty, and fifty firms. An industry with a market share above 50 for the largest four or above 70 for the largest eight is considered concentrated. Most segments of the textile mill products industry are very unconcentrated.* In fact, yarn mills are one of the least concentrated and, therefore, most competitive segments of the industry. Furthermore, the table shows that between 1967 and 1972, the concentration ratios for 10 of the 30 segments of the industry actually declined.

Some restructuring of industry has been taking place, however, due to economic pressures. Vertical and horizontal mergers have been effected as firms try to become more fully integrated and thus gain control of costs and improve market positions. Consequently, the size and the market share of many individual firms have increased over time. Concentration in industry as a whole, however, remains relatively low.

During the early 1960's, the larger textile mills improved their market share significantly through acquisition. This posed a threat to the future of small, nonintegrated textile mills, and the Federal Trade Commission (FTC) took action against a major textile mill in 1968. The firm finally agreed to a consent order stating that no further mergers or acquisitions would be made for 10 years except with prior FTC approval. The FTC subsequently issued merger guidelines for the textile industry. The key elements of the FTC policy statement are quoted in Table 4-3.

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* The major customer of the textile mill products industry—the apparel industry—is also unconcentrated (See Table 4-2).

TABLE 4-1
Market Shares in the Textile Mill Products Industry
(SIC 22)

INDUSTRY SEGMENT	YEAR	FIRMS	4 LARGEST FIRMS	8 LARGEST FIRMS	20 LARGEST FIRMS	50 LARGEST FIRMS
WEAVING MILLS, COTTON	1972	190	31	48	72	93
	1967	218	30	48	68	88
WEAVING MILLS, MAN-MADE FIBER & SILK	1972	256	39	54	72	88
	1967	272	46	54	68	86
WEAVING AND FINISHING MILLS, WOOL	1972	178	38	49	70	90
	1967	282	55	62	76	88
NARROW FABRIC MILLS	1972	324	20	31	49	71
	1967	345	19	31	40	70
WOMEN'S HOSIERY, EXCEPT SOCKS	1972	256	35	49	69	87
	1967	302	32	44	64	82
HOSIERY, N.E.C.	1972	376	19	29	46	66
	1967	423	25	32	46	65
KNIT OUTERWEAR MILLS	1972	882	16	26	44	59
	1967	1156	15	22	33	47
KNIT UNDERWEAR MILLS	1972	74	46	61	85	98
	1967	99	36	54	77	95
CIRCULAR KNIT FABRIC MILLS	1972	630	23	31	49	69
WARP KNIT FABRIC MILLS	1972	174	27	46	72	91
KNITTING MILLS, N.E.C.	1972	72	52	67	83	98
	1967	61	54	71	89	99
FINISHING PLANTS, COTTON	1972	182	27	41	67	89
	1967	202	42	59	64	87
FINISHING PLANTS MAN-MADE FIBER & SILK	1972	219	56	64	77	89
	1967	212	37	49	63	81
FINISHING PLANTS, N.E.C.	1972	189	24	36	58	86
	1967	187	29	44	64	86
WOVEN CARPETS AND RUGS	1972	64	78	91	98	99+
	1967	55	76	93	99	99+

TABLE 4-1
Concluded

INDUSTRY SEGMENT	YEAR	FIRMS	MARKET SHARE 4 LARGEST FIRMS	MARKET SHARE 8 LARGEST FIRMS	MARKET SHARE 20 LARGEST FIRMS	MARKET SHARE 50 LARGEST FIRMS
TUFTED CARPETS AND RUGS	1972	333	20	33	56	78
	1967	210	26	41	67	87
CARPETS AND RUGS, N.E.C.	1972	80	78	88	94	99
	1967	78	78	84	99	99
YARN MILLS, EXCEPT WOOL	1972	263	21	31	50	74
	1967	256	21	31	51	73
THROWING AND WINDING MILLS	1972	177	35	51	74	92
	1967	159	50	62	79	93
WOOL YARN MILLS	1972	91	45	59	83	97
	1967	127	26	42	68	91
THREAD MILLS	1972	61	62	77	92	99+
	1967	63	62	81	95	99+
FELT GOODS, EXCEPT WOVEN FELTS & HATS	1972	38	51	75	96	100
	1967	33	61	80	98	100
LACE GOODS	1972	99	34	51	75	94
	1967	134	31	52	74	92
PADDINGS AND UPHOLSTERY FILLING	1972	119	28	40	62	87
	1967	133	34	50	60	88
PROCESSED TEXTILE WASTE	1972	102	54	68	86	97
	1967	132	36	60	70	89
COATED FABRICS, NOT RUBBERIZED	1972	185	35	52	73	88
	1967	157	31	48	70	88
TIRE CORD AND FABRIC	1972	9	84	98		
	1967	12	83	96	100	
NONWOVEN FABRICS	1972	68	43	62	84	99
CORDAGE AND TWINE	1972	134	36	56	76	91
	1967	147	34	52	77	94
TEXTILE GOODS, N.E.C.	1972	338	25	36	54	72

TABLE 4-2
Market Shares for the Apparel Industry

INDUSTRY SEGMENT	4 LARGEST	8 LARGEST	20 LARGEST	50 LARGEST
MEN'S AND BOYS' SUITS AND COATS	19	31	48	65
MEN'S AND BOYS' DRESS SHIRTS AND NIGHTWEAR	22	31	50	69
MEN'S AND BOYS' UNDERWEAR	49	71	91	99+
MEN'S AND BOYS' SEPARATE TROUSERS	29	41	60	76
MEN'S AND BOYS' WORK CLOTHING	38	53	70	84
MEN'S AND BOYS' CLOTHING, N.E.C.	20	27	41	63
WOMEN'S AND MISSES' BLOUSES & WAISTS	18	26	38	55
WOMEN'S AND MISSES' DRESSES	9	13	18	28
WOMEN'S AND MISSES' SUITS & COATS	13	18	26	40
WOMEN'S AND MISSES' OUTERWEAR, N.E.C.	18	25	37	52
WOMEN'S AND CHILDREN'S UNDERWEAR	15	23	41	63
BRASSIERES AND ALLIED GARMENTS	31	45	67	86
MILLINERY	17	26	44	68
HATS & CAPS, EXCEPT MILLINERY	26	39	57	77
CHILDREN'S DRESSES AND BLOUSES	17	26	42	63
CHILDREN'S COATS AND SUITS	18	31	55	83
CHILDREN'S OUTERWEAR, N.E.C.	22	32	48	69
FUR GOODS	7	12	23	39
FABRIC DRESS AND WORK GLOVES	41	59	80	95
ROBES AND DRESSING GOWNS	24	39	59	83
WATERPROOF OUTERGARMENTS	31	40	56	79
LEATHER AND SHEEP LINED CLOTHING	19	32	57	82
APPAREL BELTS	21	32	51	72
APPAREL AND ACCESSORIES, N.E.C.	24	37	57	77
CURTAINS AND DRAPERIES	35	43	52	64
HOUSEFURNISHINGS, N.E.C.	23	30	43	60
TEXTILE BAGS	27	43	61	84
CANVAS AND RELATED PRODUCTS	23	29	40	55
PLEATING AND STITCHING	22	31	45	61
AUTOMOTIVE AND APPAREL TRIMMINGS	67	74	80	85
SCHIFFLI MACHINE EMBROIDERIES	19	28	42	58
FABRICATED TEXTILE PRODUCTS, N.E.C.	23	34	51	69

SOURCE: U.S. DEPARTMENT OF COMMERCE, 1972 CENSUS OF MANUFACTURES.

TABLE 4-3

Merger Guidelines for the Textile Mill Products Industry

THE FOLLOWING ACTIVITIES WERE SEEN AS SUBJECT TO FTC EXAMINATION:

1. "ANY MERGER BETWEEN TEXTILE MILL PRODUCT FIRMS WHERE THE COMBINED SALES OR ASSETS OF THE FIRMS EXCEED $300 MILLION AND THE SALES OR ASSETS OF THE SMALLER FIRM IN THE MERGER EXCEED $10 MILLION.

2. ANY HORIZONTAL MERGER IN A TEXTILE MILL PRODUCT SUBMARKET WHERE (A) THE COMBINED FIRMS RANK AMONG THE TOP FOUR OR (B) HAVE A COMBINED MARKET SHARE OF 5 PERCENT OR MORE OF ANY SUBMARKET IN WHICH THE FOUR LARGEST FIRMS ACCOUNT FOR 35 PERCENT OR MORE OF THE MARKET.

3. ANY VERTICAL MERGER, EITHER "BACKWARD" INTO THE SUPPLYING MARKET OR "FORWARD" INTO A PURCHASING MARKET, WHERE A PARTICULAR ACQUISITION OR SERIES OF ACQUISITIONS MAY INVOLVE MARKET SHARES OF 10 PERCENT OR MORE OF THE RELEVANT MARKET OR WHERE THE ACQUISITION OR SERIES OF ACQUISITONS MAY TEND SIGNIFICANTLY TO RAISE BARRIERS TO ENTRY IN EITHER MARKET OR TO DISADVANTAGE EXISTING NON-INTEGRATED OR PARTIALLY INTEGRATED FIRMS IN EITHER MARKET BY DENYING THEM FAIR ACCESS TO SOURCES OF SUPPLY OR MARKETS.

4. ANY ACQUISITION OF A TEXTILE MILL PRODUCT FIRM WITH SALES OR ASSETS OF $100 MILLION OR MORE AND RANKING AMONG THE FOUR LARGEST PRODUCERS OF A TEXTILE MILL PRODUCT BY A NON-TEXTILE MILL PRODUCT FIRM WITH SALES OR ASSETS IN EXCESS OF $250 MILLION AND WITH A SUBSTANTIAL MARKET POSITION IN ANOTHER INDUSTRY. A SUBSTANTIAL MARKET POSITION IS DEFINED AS BEING ONE OF THE TOP FOUR SELLERS OF A PRODUCT OR SERVICE IN WHICH THE FOUR LARGEST COMPANIES ACCOUNT FOR 40 PERCENT OR MORE OF THE MARKET."[1]

SOURCE: FEDERAL TRADE COMMISSION, <u>ENFORCEMENT POLICY WITH RESPECT TO MERGERS IN THE TEXTILE MILL PRODUCTS INDUSTRY</u>, NOVEMBER 22, 1968.

More recently, the 1968 guidelines have been rescinded due to the adoption of the Hart-Scott-Rodino amendment to Section 7 of the Clayton Act. Basically, the amendment states that the following mergers or acquisitions will be subject to FTC examination:

- If a firm with $100 million or more in sales or assets merges with a firm with $10 million or more in sales or assets
- If the purchase price of an acquisition is $15 million or more; or if the acquisition amounts to 15 percent of the voting securities or assets of the company.

The amendment has the effect of making more mergers and acquisitions subject to FTC scrutiny, e.g., the size of the larger firm in the merger was reduced from $300 to $100 million.

The nature of the textile mill products industry contributes to the competitive market structure. The industry produces greige and finished fabric (intermediate goods which are made into finished products by the apparel, home finishings, or other industries). In addition, some final consumer items are produced within the industry, generally items requiring very little additional processing after fabrication. Some of these items are as follows:

- Women's and men's hosiery
  Knit outerwear
- Knit underwear
- Blankets
- Sheets and pillow cases
- Woven and tufted carpets and rugs
- Towels and washcloths.

The degree of product differentiation varies between intermediate and final goods. Greige broadwoven goods, for example, tend to be homogeneous. They usually have standard widths, thread counts, and weights. Consequently, cotton and man-made greige goods are essentially commodity fabrics. Even 65/35 polyester/cotton blends have become commodity fabrics. Market prices for cotton, man-mades, and blends are quoted daily—not unlike agricultural commodities, including cotton and wool. For homogeneous products like greige goods, product differentiation and the corresponding barrier to competition is quite low.

Finished fabric is less homogeneous. Finishes with special characteristics are often indentified by brand name. The man-made fiber producers have also contributed to fabric differentiation by developing and marketing a wide variety of fibers with special and often unique characteristics, the fibers usually being identified by brand name. Final products too are often characterized by a higher degree of product differentiation. For example, there is some brand identification for knit underwear, towels, sheets, and carpets.

For the industry as a whole, product differentiation is fairly low. Because the industry is so competitive, near or perfect substitutes for homogeneous and even branded products are plentiful. Consequently, textile mill producers must remain price competitive. Continued restructuring of the textile mill products industry is expected over the next 10 years. The Hart-Scott-Rodino amendment, however, should be an even more effective constraint on merger and acquisition activity than the 1968 guidelines. In addition, the low level of product differentiation and the comparatively small size of textile mill operations should keep the industry competitive through 1987.

4.2 THE DEMAND FOR TEXTILE MILL PRODUCTS HAS GROWN SLOWLY AND CAN FLUCTUATE SIGNIFICANTLY FOR A FIRM OR FOR THE INDUSTRY

The textile mill products industry is a high volume, slow growth business. When demand slackens, production falls rapidly because accumulating inventories is risky.* Consequently, total fiber consumption falls when the demand for textile mill products falls. In 1978, total fiber consumption by U.S. textile mills was more than 12.5 billion

* Inventories are risky in the textile mill products industry, even through they can serve as a hedge against increasing labor and material costs. The demand for textile mill products is far too volatile and uncertain to permit the accumulation of inventories during periods of slack demand. In many industries where demand is seasonal or otherwise unevenly distributed throughout the year, operating efficiency is achieved by maintaining fairly consistent production levels during the year even when demand is low, and selling out of inventory when demand picks up. However, in the textile mill products industry, production rises and falls with demand to avoid inventory risk except for the most staple items, where demand is more predictable.

pounds, yet the growth of fiber consumption has averaged only 3 percent annually over the past 10 years.

The growth in demand for man-made fibers has been far more dramatic. Total fiber consumption includes cotton, wool, and man-made fibers. Between 1969 and 1978, cotton consumption declined 23 percent and wool consumption fell 63 percent, but man-made fiber consumption increased more than 69 percent. Consequently, in 1978 total U.S. mill consumption by fiber was distributed as follows:

.	Cotton	24.3 percent
.	Man-made fiber	74.8 percent
.	Wool	0.9 percent

The consumption of fibers by U.S. textile mills since 1962 is shown in Table 4-4.

Most of the estimates for total fiber consumption growth through the next decade and beyond range between 2 and 3 percent per year. If the 3 percent historic growth rate continues, total fiber consumption by U.S. textile mills could reach 16.4 billion pounds by 1987. With a 2 percent growth rate, consumption would be 15 billion pounds.

Although cotton and wool consumption have fallen steadily since the early 1960's, the decline appears to be slowing and even stablizing at current levels. Since the total growth of fiber consumption has been only 3 percent annually, the continued growth of man-made fibers at the historic rate of 7.7 percent appears unlikely. Given the projected stabilization of cotton and wool consumption, man-made fiber consumption is projected to grow at 3 percent annually. At that rate, man-made fiber consumption by 1987 will be 12.2 billion pounds. If cotton consumption remains at 3.1 billion pounds/year, and wool at 120 million pounds/year, the distribution of fibers in 1987 will be as follows:

.	Cotton	20.1 percent
.	Man-made fiber	79.1 percent
.	Wool	0.7 percent

The demand for textile mill products is cyclical and tends to follow the trend of the general economy. Fiber consumption, for example, peaked at over 12.4 billion pounds in 1973. During the 1974-75 recession, consumption fell sharply—nearly 2 billion pounds—, and not until 1978 did it reach the level previously achieved in 1973. Textile

TABLE 4-4
Total Fiber Consumption By
U.S. Textile Mills
(Millions of Pounds)

PERIOD	TOTAL MILL CONSUMPTION	COTTON	MAN-MADE FIBER	WOOL
1962	7,070.9	4,229.8	2,412.8	428.3
1963	7,267.2	4,080.6	2,775.0	411.6
1964	7,805.7	4,286.9	3,162.2	356.6
1965	8,523.3	4,522.2	3,614.1	387.1
1966	9,037.1	4,676.8	3,990.1	370.2
1967	9,028.0	4,470.2	4,245.3	312.5
1968	9,823.1	4,188.0	5,305.5	329.6
1969	9,837.3	3,972.4	5,552.1	312.8
1970	9,595.0	3,853.8	5,500.9	240.3
1971	10,706.5	3,985.8	6,529.2	191.5
1972	11,648.3	3,864.0	7,565.7	218.6
1973	12,473.1	3,657.6	8,664.2	151.3
1974	11,100.5	3,309.0	7,698.0	93.5
1975	10,553.3	3,026.7	7,416.6	110.0
1976	11,588.6	3,413.9	8,053.0	121.7
1977	12,190.9	3,182.6	8,900.2	108.1
1978	12,557.9	3,049.4	9,391.4	117.1

SOURCE: U.S. DEPARTMENT OF AGRICULTURE, COMMODITY ECONOMICS DIVISION. ECONOMIC RESEARCH SERVICE.
NOTE: GROUP TOTALS MAY NOT ADD TO GRAND TOTAL DUE TO ROUNDING.

mill activity generally responds rapidly to economic downturns but much more slowly to economic upswings.

Since most textile mill items are intermediate products, their demand should be examined on an end-use basis. There are three major end-use categories for textile mill products—apparel, home furnishings, and industrial and consumer products. Demand in each category is closely tied to the level of consumer income and other factors. The demand for apparel, for example, is influenced by the following:

- Size and growth of the population
- Demographic characteristics of the population
- Level of consumer income.

Home furnishings demand depends on the following:

- New family formations
- Changes in residences
- Level of consumer income.

The demand for apparel has slowed just as population growth has slowed in the United States. Both apparel and home furnishings are products consumers tend to postpone buying during recessions, and demand tends to rebound much more slowly than it declined. Every new home sold leads to about four additional household moves, which stimulates the demand for home furnishings. However, new housing starts are quite sensitive to general economic activity. Table 4-5 gives a substantial decline in housing starts during the 1974-75 recession.

Finally, industrial markets for textile mill products also tend to follow the business cycle. As employment and industrial production decline, the demand for industrial textiles also declines.

The cyclical nature of demand is a macroeconomic effect. The demand for textile mill products is further influenced on a microeconomic level. Consumer tastes, preferences, and spending patterns are major influences on consumption. Consumer demand consists of a base, staple demand and a fashion demand. The former includes products bought fairly consistently from year to year; the latter is far more erratic. Shifts in consumer preferences in the short run can lead to excess production capacity for certain products and insufficient production capacity for others.

TABLE 4-5
New Housing Units Started
1960 to 1977
(Thousands)

YEAR	TOTAL	% CHANGE
1960	1296	-16.6
1961	1365	5.3
1962	1492	9.3
1963	1635	9.6
1964	1561	-4.5
1965	1510	-3.3
1966	1196	-20.8
1967	1322	10.5
1968	1545	16.9
1969	1500	-2.9
1970	1469	-2.1
1971	2085	41.9
1972	2379	14.1
1973	2057	-13.5
1974	1352	-34.3
1975	1171	-13.4
1976	1548	32.2
1977	1990	28.6

SOURCE: U.S. DEPARTMENT OF COMMERCE, STATISTICAL ABSTRACT OF THE UNITED STATES, TABLE NO. 1366.

Since 1967 the prices of textile mill and apparel products have increased much more slowly than have the prices for other industrial commodities. Table 4-6 compares the following wholesale price indexes:

- Total textile products and apparel
- Apparel
- Textile home furnishings
- Broadwoven goods
- Industrial commodities.

Apparel prices have increased more moderately than have the prices for other textile products. All textile and apparel prices have increased more slowly than have other industrial commodity prices. The intense competition in the textile and apparel industries and the increasing competition from foreign imports are partly responsible for these relatively low rates of price increase.

4.3 PRODUCTION COSTS FOR TEXTILE MILL PRODUCTS ARE HIGH AND HAVE BEEN INCREASING

The textile mill products industry is highly labor and material intensive. Production costs represent a substantial portion of product value. In 1976, for example, salaries and wages were 20.2 percent of the value of shipments and material costs were 61 percent. Consequently, inflationary pressures can seriously influence the operations of textile mills. There are four major cost components in industrial production processes that must be examined for the textile mill products industry—labor, materials, energy, and capital.

4.3.1 The Labor Cost Component

The textile mill products industry is one of the largest employers in the United States. Further, of the 913,800 textile workers in 1977, more than 80 percent are classified as unskilled or semi-skilled, compared to 60 percent for all manufacturing. In October 1978, average hourly earnings for textile workers were $4.42, compared to $6.33 for all manufacturing; the textile workers thus earned 69.8 percent of the average manufacturing wage. While textile workers' earnings have increased 88.9 percent since 1969, earnings in all manufacturing rose 98.4 percent. The southward movement of employment in the industry over the past three decades is partially responsible for the relative decline in textile

TABLE 4-6
Wholesale Price Indexes: Textile Mills, Apparel, and Industrial Products
(1967-1977)

YEAR	TOTAL TEXTILE PRODUCTS AND APPAREL	APPAREL	TEXTILE HOUSE-FURNISHINGS	BROADWOVEN GOODS	INDUSTRIAL COMMODITIES
1967	100.0	100.0	–	100.3	100.0
1968	103.7	103.6	–	103.5	102.5
1969	106.0	107.4	–	103.9	106.0
1970	107.1	110.8	–	106.1	110.0
1971	109.0	113.6	–	110.9	114.1
1972	113.6	114.8	109.2	122.3	117.9
1973	123.8	119.0	113.3	144.3	125.9
1974	139.1	129.5	143.1	177.8	153.8
1975	137.9	133.4	151.9	175.4	171.5
1976	148.2	139.9	159.3	–	182.4
1977	154.0	147.3	171.3	–	195.1

SOURCE: DEPARTMENT OF LABOR.

worker earnings. As wages increased in the North, textile mills moved South where wages traditionally have been lower. Table 4-7 shows the changing geographical distribution of textile mills.

Employment has declined in the textile mill products industry from over 1 million in 1969 to 914,000 in 1977. Foreign competition and the decline in demand for labor in textile mills have been contributing factors. The Trade Adjustment Assistance Act states that workers who can show their jobs were lost due to import competition are eligible for assistance, and between April 1975 and March 1978, 6,600 workers in the textile mill products industry were recipients of these benefits. By comparison, 45,916 workers in the apparel industry received assistance during that period, indicating a far greater foreign trade impact in the apparel industry.

While employment declined 6.7 percent from 1972 to 1976, salaries and wages measured as a percentage of the value of shipments declined proportionally (at 6.5 percent). As foreign imports have gained an increasing market share, textile mills have adopted less labor intensive practices, thereby reducing the demand for labor. However, the substitution of capital for labor has been insufficient to compensate for increasing import penetration.

Increased unionization and the recent influx of high wage industries into the South have provided additional upward pressure on textile mill wages. If this trend continues without a continued shift toward less labor intensive practices, salaries and wages could begin to take an increasing share of the value of textile shipments.

4.3.2 The Material Cost Component

The cost of materials (including energy) was 61 percent of the value of textile mill products industry shipments in 1976. Fibers represent a substantial portion of these material costs. The total consumption of fibers by U.S. textile mills in 1978 was more than 12.5 billion pounds, including cotton, wool, and man-made fibers. Cotton accounted for 24.3 percent, while wool contributed less than 1 percent. Man-made fibers amounted to 9.4 billion pounds, 74.8 percent of total consumption. The two major natural fibers—cotton and wool—are agricultural commodities, so their prices tend to fluctuate. Cotton and wool prices depend on the following factors:

TABLE 4-7
Geographic Distribution of Textile Mill Employment
(1950-1970)

	EMPLOYMENT	PERCENT OF INDUSTRY EMPLOYMENT	EMPLOYMENT	PERCENT OF INDUSTRY EMPLOYMENT
NORTH	506,000	40.5	211,000	21.7
SOUTH	603,000	48.2	669,000	68.8

SOURCE: U.S. DEPARTMENT OF LABOR, BUREAU OF LABOR STATISTICS, EMPLOYMENT AND EARNINGS, STATES AND AREAS 1939 - 1975.

- Annual crop production
- Carryover stock
- Government support levels
- Cotton and wool imports
- Demand for natural fibers.

Annual cotton production in the United States since 1962 has varied between 7 and 14 million bales. (One bale is approximately equivalent to 480 pounds.) Supply fell to 7.4 million bales in 1967, rose to 13.7 million bales in 1972, and fell again to 8.3 million bales in 1975.

Man-made fiber prices are more stable. In fact, although 1.5-denier polyester staple dropped sharply from 98 cents per pound in 1964 to 61 cents per pound in 1968, it remained constant at 61 cents through April of 1975.

Wool prices also vary significantly from year to year. Wool is a much more expensive fiber than either cotton or polyester. Table 4-8 gives prices for all three fibers for the period 1964 to 1975.

While cotton prices have risen since 1964, polyester staple prices have fallen. At the same time, polyester has replaced cotton in many end-uses, and cotton-polyester blends have risen in popularity. Blends have increased from 50 percent to 65 percent polyester in commodity fabrics. Increases to 75 percent or more are anticipated.

Price is only one factor leading to the increased use of polyester and other man-made fibers. Textile mills, for example, tend to prefer man-made over natural fibers for a variety of reasons, including the following:

- Prices tend to be more stable; a reliable supply at stable, predictable prices makes production and investment decisions less risky.

- More and more man-made fibers with specific properties are being developed to satisfy both the textile mill and the textile mill customer.

- Man-made fibers are more uniform, increasing production efficiency and the uniformity of the textile mill fabric or other products.

- Man-made fibers yield more yarn per pound than either cotton or wool; therefore, less waste is generated.

TABLE 4-8
Prices for Natural and Man-Made Fibers
1964 to 1976
(Dollars per Pound)

YEAR	COTTON[1]	POLYESTER[2]	WOOL[3]
1964	0.296	0.98	1.397
1965	0.280	0.85	1.249
1966	0.206	0.80	1.349
1967	0.254	0.66	1.215
1968	0.220	0.61	1.207
1969	0.209	0.61	1.221
1970	0.219	0.61	1.024
1971	0.281	0.61	0.664
1972	0.272	0.62	1.157
1973	0.444	0.61	2.500
1974	0.427	0.61	1.760
1975	0.511	0.59	1.502
1976	0.638	–	–

[1] AMERICAN UPLAND (EXCLUDING LINTERS); FARM PRICE
[2] 1.5 DENIER STAPLE; F.O.B. PRODUCING PLANT
[3] RAW, CLEAN, BASIS; GRADED TERRITORY FINE

SOURCE: SURVEY OF CURRENT BUSINESS.

The continued demand for man-made fibers could result in an increased percentage of man-made fibers in blended fabrics. One key to changing blend ratios is consumer taste; without the unqualified assurance of market acceptance, changes in blend ratios or any other changes that affect product quality are slow to materialize. Textile mills are slow to make changes that could affect their market share.

Man-made fiber producers are far less competitive than natural fiber producers. In fact, the federal government has recently begun to investigate possible anticompetitive activities leading to the shared monopolization of the chemical industry (the producers of man-made fibers). Shared monopolies are those industries where the top three to six companies control at least 75 percent of the market. In 1972 the four largest cellulosic fiber producers had a 97 percent market share. Man-made fiber producers are even beginning to move into the textile mill industry through nonwovens. DuPont, a major chemical company, is one of the largest nonwoven fabric producers in the United States.

Most noncellulosic fiber is made from petrochemicals. Approximately 1 percent of U.S. petroleum consumption goes to the production of synthetic fibers. If the price of crude oil rises significantly over the next 10 years, the cost of man-made fibers may also increase. Less competitive industries find it much easier to pass along increased costs. This makes it likely that the more competitive textile mill products industry would bear the burden of the shift toward man-made fibers.

If cotton could be processed to give it some of the characteristics of man-made fibers or if it could achieve greater price stability, it could conceivably regain a larger share of the total fiber market. Research and development in man-made fibers has far exceeded that in natural fibers. DuPont alone spent $28.5 million on fiber research in 1973. On the other hand, the funds available to the natural fiber producer industry for R&D are limited. The Consumer Protection Act of 1973 authorizes the Secretary of Agriculture to make available $10 million annually for research. Furthermore, under the Cotton Research and Promotion Act of 1966, upland cotton producers are assessed for the funds earmarked for research and promotion. In 1973, upland cotton production was 12.9 billion bales; consequently a total of $22.9 million from both sources was available for research. This was less than DuPont alone spent during that year. In the future, increased R&D for natural fibers could improve the competitive position of both cotton and wool. However, since funds for R&D are more available to man-made fiber producers, any major shift from current trends seems unlikely. Actually, R&D spending by the textile mill products industry has lagged behind that for all other manufacturing, as shown in Table 4-9.

4.3.3 The Energy Cost Component

Energy consumption and fuel costs for the textile mill products industry are low relative to those same items for other industries. The industry is the tenth ranked energy-consuming industrial sector. Figure 4-1 shows that the steel, aluminum, and paper industries use far more energy as a percent of sales than the textile industry. Energy costs as compiled by the Bureau of the Census amount to less than 3 percent of the value of shipments. However, given the continued shift toward man-made fibers--especially petro-chemical, non-cellulosic fibers--the energy share of total costs would rise if serious or prolonged energy shortages or rapidly rising energy prices prevail.

In 1972, the U.S. textile industry consumed about 0.4 quads of process energy. This is equal to 2 percent of U.S. industrial energy consumption and 0.6 percent of total U.S. energy consumption. Natural gas and electricity are the principal forms of energy, as shown in the following breakdown of consumption:

Natural gas	29 percent
Electricity	24 percent
Oil	19 percent
Coal	9 percent
Other (propane, etc)	19 percent.

4.3.3.1 Dry Processing

Spinning and weaving of textiles (dry processing) consume about 0.16 quad per year, or about 40 percent of the industry's energy. Energy is consumed primarily in the form of electricity for equipment drives, lighting, and environmental conditioning. Other sources of energy are used for space heating.

Energy consumption for environmental conditioning (the control of humidity, temperature, and static electricity) is particularly important to the spinning and weaving processes. Such controls lessen fire and explosion hazards and allow for rapid, uninterrupted movement of thread, yarn, and cloth.

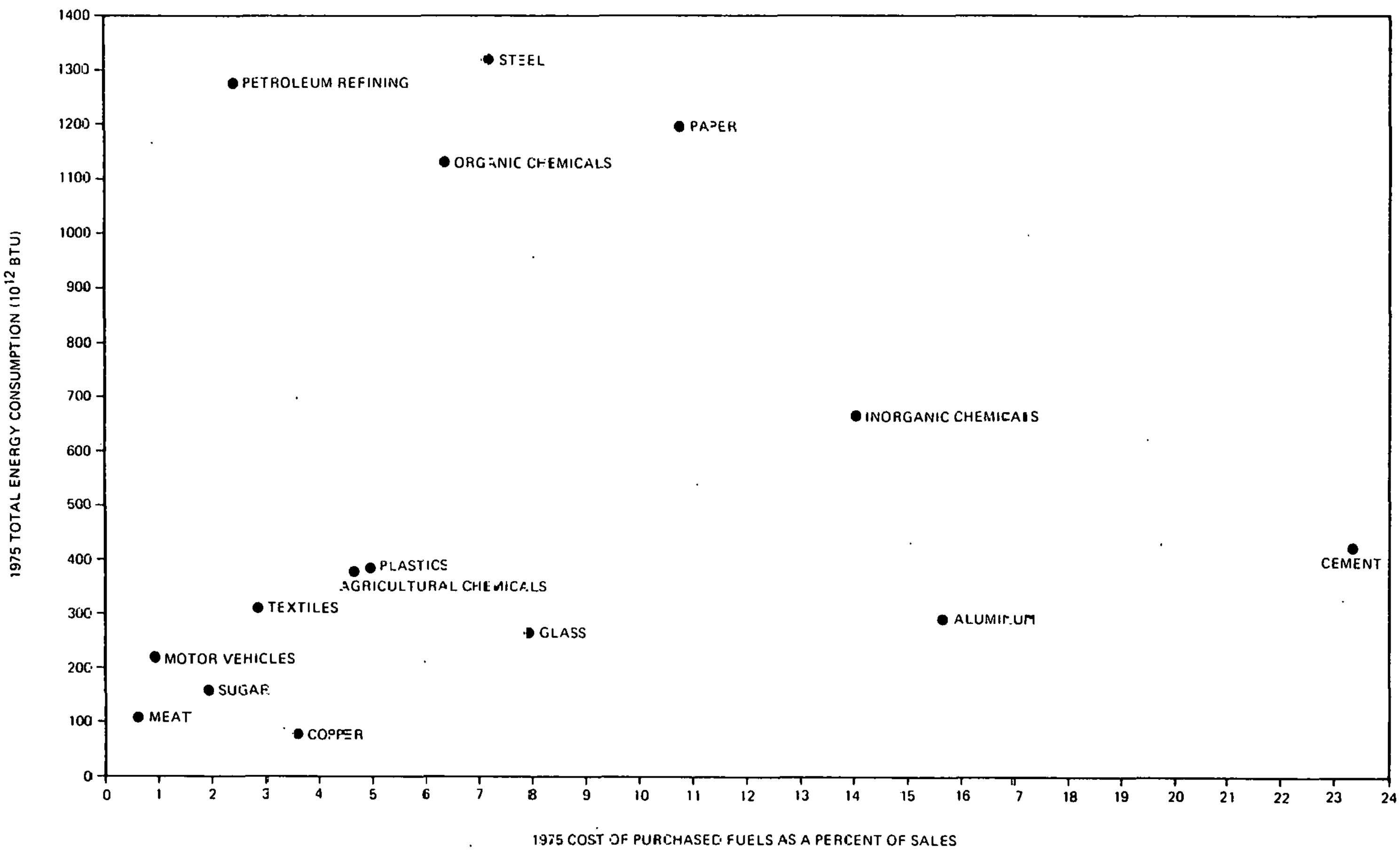
TABLE 4-9
R&D Spending in the Textile Mill
Products Industry vs R&D Spending in All Industries
(Millions)

YEAR	TEXTILES	ALL INDUSTRIES
1973	$64	$20,900
1974	72	23,100
1975	70	22,573
1976	60	27,566
1977e	68	30,623
1978f	74	39,707
% CHANGE (73-78)	16	90

e = ESTIMATE
f = FORECAST

SOURCES: NATIONAL SCIENCE FOUNDATION
McGRAW HILL – DEPARTMENT OF ECONOMICS.

FIGURE 4-1
Total Energy Consumption and the Cost of Purchased Fuels



SOURCE: ANNUAL SURVEY OF MANUFACTURERS 1975
BUREAU OF THE CENSUS
DEPARTMENT OF COMMERCE

4.3.3.2 Wet Processing

Dyeing and finishing, the processes of converting greige goods into marketable goods (wet processing), account for about 60 percent of the energy consumed in the textile industry. This is about 0.24 quads per year, the energy being supplied as natural gas, oil, and coal for driving steam boilers. Natural gas is also used to fire dyers for heat-setting, finishing, and moisture removal. Energy consumption in the major stages of wet processes is as follows:

. Preparation	17 percent
. Batch process dyeing	33 percent
. Continuous dyeing	13 percent
. Drying	25 percent
. Finishing	12 percent
. Total dyeing and finishing	100 percent

Preparation operations are continuous and are conducted to prepare greige goods for dyeing. Energy is supplied to preparation stages to heat water and chemicals which remove foreign matter and to develop steam for bleaching. These steps help ensure a consistent dye color throughout the material batch. Preparation operations include three stages: desizing, scouring and bleaching.

Dyeing is accomplished by several variations of batch and continuous processes. Batch processes include six variations; the six, with the percent of dyeing energy used by each, are as follows:

. Atmospheric beck	40 percent
. Jig	3 percent
. Pressure beck	4 percent
. Jet	4 percent
. Package/beam	17 percent
. Stock	4 percent

In addition, there are three variations of the continuous dyeing process in use today:

. Fabric dye range	13 percent
. Carpet dye range	4 percent
. Printer	11 percent
. Total energy for dyeing	100 percent

Approximately one-half of the dyeing is accomplished in a dye beck or kettle. This process is energy inefficient. Approximately 98 percent of the supplied energy is discarded in the dye liquor after the dyeing operation is complete, and the remaining 2 percent is lost by radiation.

Drying and finishing are generally continuous operations. Equipment is typically one of four types: infrared radiation, mechanical (roller process), steam cans, or hot air. Like color dyeing, the drying processes in use today are inefficient when compared with what is theoretically possible.

4.3.4 The Capital Cost Component

Capital expenditures in the textile mill products industry have shown a mild upward trend during the past 10 years, in spite of the fact that profit levels are lower than they are in other manufacturing industries. (See Table 4-10 for data on textile mill products industry capital expenditures.) Expenditures on new plants and equipment rose from $630 million in 1969 to nearly $1.1 billion in 1978, or about 7.5 percent annually. McGraw-Hill estimates that expenditures on new plants and equipment will grow 9.8 percent annually through 1991. At this rate, capital expenditures could reach $2.4 billion by 1987. Much of the growth in capital expenditures over the next ten years will be due to the increasing costs of equipment replacement; the need to improve production efficiency through automation; and the increased demands by government agencies that standards be met regarding cotton dust, noise, etc. The 9.8 percent growth rate seems reasonable in the face of these increasing costs and regulations.

Capital investment in the textile mill products industry has averaged about 2.6 percent of sales annually since 1970. Some of the larger firms in the industry spend a significantly greater percentage of sales on capital investment. In a recent analysis of seven major textile mill product companies by Merrill Lynch, the larger firms spent between 4 and 6 percent of sales, mostly to improve existing facilities and to increase efficiency, rather than to expand capacity.

There is a disparity between the growth projection made by the American Textile Manufacturers Institute (ATMI) and that based on Bureau of the Census data. While the ATMI data indicate a growth of 7.5 percent annually for new plant and equipment expenditures, the Census shows a fairly steady $1 billion annual expenditure. ATMI data

TABLE 4-10
Capital Expenditures in the Textile Mill Products Industry

YEAR	NEW PLANT AND EQUIPMENT EXPENDITURES (MILLIONS)	SALES* (MILLIONS)	CAPITAL EXPENDITURES AS PERCENT OF SALES
1970	560	21,599	2.6
1971	610	22,938	2.7
1972	730	25,616	2.8
1973	770	29,113	2.6
1974	840	31,220	2.7
1975	660	28,116	2.3
1976	810	33,932	2.4
1977	920	34,317	2.7

* SALES ARE NET OF RETURNS, ALLOWANCES, EXCISE AND SALES TAXES

SOURCE: ATMI, FEDERAL TRADE COMMISSION, U.S. DEPARTMENT OF COMMERCE.

were considered more appropriate for this report, because the Census data include textile operations owned by firms whose major activity is outside the textile industry, whereas ATMI data do not. Operations outside SIC 22 are not relevant to this analysis.

According to the 1972 Census of Manufactures, capital expenditures varied from a low of $16,000 per plant (for lace goods) to a high of $536,000 per plant (for yarn throwing and winding). As shown in Table 4-11, only six segments of the industry had capital expenditures per plant over $200,000.

4.4 INCREASING COMPETITION FROM FOREIGN IMPORTS HAS PROMPTED CHANGES IN THE INDUSTRY

During the 1960's, imports of textile and apparel products nearly tripled. The pace has continued through the 1970's. In 1977, more than $5.9 billion worth of textile and apparel products were imported. Since the rise in exports has been much slower, the textile trade deficit has steadily increased. The last trade surplus was in 1957. In 1977, the deficit had reached nearly $3.4 billion (see Table 4-12).

The import penetration of U.S. markets has seriously threatened the domestic textile mill products industry. Domestic apparel markets have been affected the most. Apparel is the major consumer of textile mill products, consuming 42 percent of all fibers. The increase in imports has shrunk domestic apparel markets for U.S. textile mill products. Table 4-13 illustrates the growth of imports relative to the domestic market. Cotton textile and apparel products showed the greatest penetration since 1967. Kurt Salmon Associates, Inc., a New York textile and apparel consulting firm, predicts that, under present trade policies, total imports could increase to 35 percent of the domestic market by 1990.

In 1977, the General Agreement on Tariffs and Trade (GATT) Multifiber Arrangement was renewed for 4 years. Under this agreement, a 6 percent quota growth for combined textile and apparel imports is permitted. Since total fiber consumption grows at only 3 percent annually, the textile trade deficit will continue to rise under this arrangement. However, recent agreements between the textile industry and administration representatives may reduce this continuing growth somewhat.

TABLE 4-11
Capital Expenditures Per Plant for
Six Industry Segments*

TEXTILE MILL SEGMENT	CAPITAL EXPENDITURE PER PLANT
YARN THROWING AND WINDING	$536,000
TIRE CORD AND FABRIC	489,000
CIRCULAR KNIT FABRIC	337,000
WEAVING MILLS, MAN-MADE	331,000
WEAVING MILLS, COTTON	237,000
WARP KNIT FABRIC	237,000
YARN MILLS, EXCEPT WOOL	226,000

* THE SEGMENTS INCLUDED IN THIS EXHIBIT HAD CAPITAL EXPENDITURES PER PLANT IN EXCESS OF $200,000 IN 1972.

SOURCE: DEPARTMENT OF COMMERCE, 1972 CENSUS OF MANUFACTURERS.

TABLE 4-12
U.S. Textile Trade
F.A.S. Values
(Millions of Pounds)

PERIOD	IMPORTS[1]	EXPORTS[1]	BALANCE OF TEXTILE TRADE[2]
1957	549	563	+ 14
1958	562	526	− 36
1959	744	542	− 202
1960	866	618	− 248
1961	773	578	− 195
1962	1,013	580	− 433
1963	1,074	583	− 491
1964	1,132	681	− 451
1965	1,342	640	− 702
1966	1,516	679	− 837
1967	1,460	695	− 765
1968	1,818	694	−1,124
1969	2,125	753	−1,372
1970	2,402	776	−1,626
1971	2,913	837	−2,076
1972	3,411	993	−2,418
1973	3,722	1,497	−2,225
1974	3,952	2,165	−1,787
1975	3,780	2,027	−1,753
1976	5,269	2,480	−2,789
1977	5,926	2,567	−3,359
1978:			
1ST Q	1,711	603	−1,108
2ND Q	1,968	722	−1,246
3RD Q	2,274	711	−1,563

[1]IMPORT AND EXPORT DATA INCLUDE TEXTILE MANUFACTURES, AND CLOTHING (EXCEPT DONATED FOR CHARITY) OF ALL FIBERS COMPILED ON THE BASIS OF THE STANDARD INTERNATIONAL TRADE CLASSIFICATION (DIVISION 65 FOR TEXTILES AND 84 FOR CLOTHING) OF THE FT-990. [2]TEXTILE BALANCE OF TRADE REPRESENTS EXPORTS MINUS IMPORTS. MINUS SIGN INDICATES AN EXCESS OF IMPORTS OVER EXPORTS.

SOURCE: ATMI

TABLE 4-13
Ratio of U.S. Imports for Consumption to Apparent Domestic Market for Textile Mill and Apparel Products*

YEAR	TEXTILE AND APPAREL PRODUCT RATIO		
	COTTON	WOOL	MAN-MADE
1967	9.5	21.6	3.9
1968	10.7	25.4	4.6
1969	11.7	25.4	5.3
1970	11.2	28.0	8.2
1971	11.6	28.0	10.5
1972	14.6	25.1	9.4
1973	14.5	26.3	7.3
1974	14.7	22.6	6.3
1975	15.7	19.6	6.4
1976	19.1	23.4	7.1

* APPARENT DOMESTIC CONSUMPTION IS DEFINED AS DOMESTIC PRODUCTION PLUS IMPORTS MINUS EXPORTS.

SOURCE: DEPARTMENT OF COMMERCE, U.S. PRODUCTION, IMPORTS, AND IMPORT/PRODUCTION RATIOS FOR COTTON, WOOL, AND MAN-MADE FIBER TEXTILES AND APPAREL, JANUARY 1978.

Increasing labor costs in the United States and, consequently, an inefficient labor intensity in U.S. textile mills have improved the competitive position of foreign imports. Labor costs are much lower abroad. Although the domestic textile mill products industry is somewhat less labor intensive than its foreign competitors, even greater automation is needed in order to accomplish the following:

- Improve the efficiency of U.S. textile mill production
- Increase the rate of production in U.S. textile mills
- Reduce the unit costs of U.S. textile mill products.

The increasing concentration in the textile mill products industry has been necessary to maintain a competitive position in the face of rising labor costs and shrinking domestic markets. However, textile mill operations have not expanded overseas because of the high capital costs of plant and equipment, even though labor costs are much lower abroad. Apparel operations that are more labor intensive are better suited to "foreign flight." In the textile mill products industry, the movement toward more fully integrated, less labor intensive operations has been the key to maintaining a competitive position.

4.5 THE TEXTILE MILL PRODUCTS INDUSTRY HAS BEEN ECONOMICALLY LESS SUCCESSFUL THAN OTHER INDUSTRIES

The value of textile shipments in 1977 was $40.8 billion. Estimates for 1978 range between $43.7 and $45 billion. The value of shipments has grown 10 percent annually from 1969 to 1978. At that rate, textile shipments could top $1 trillion by 1987. However, because of the segmented nature of the textile mill products industry, a substantial part of these figures comes from intra-industry transactions. The value of shipments in the industry in 1976 was $36.4 billion according to the 1976 Annual Survey of Manufactures. The cost of materials was nearly $22.2 billion; value added was only $14.2 billion. Consequently, the profit margin for textile mills is quite low.

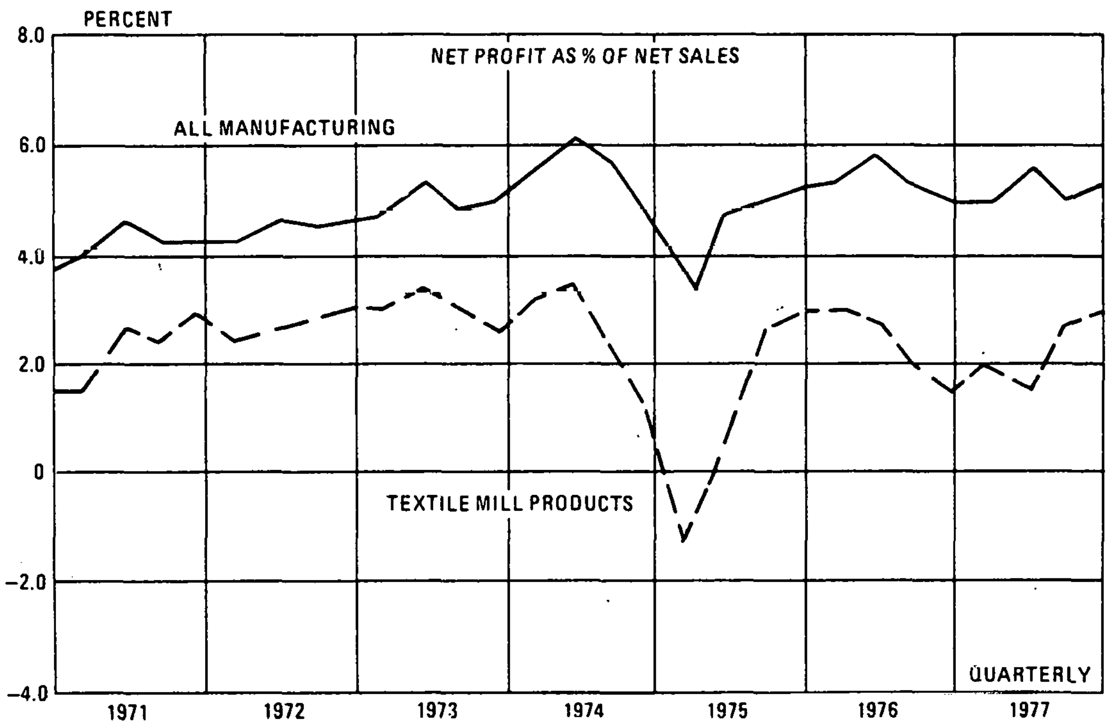
In a competitive industry like the textile mill products industry, low profits are to be expected. In fact, profits in the industry have been historically lower than the average for all manufacturing industries. In 1977, profit per dollar of sales was 2.4 percent. By comparison, all manufacturing industries achieved 5.3 percent. Profit on stockholder's equity was 8.7 percent for the textile mill products industry in 1977 compared to 14.2 percent for all manufacturing (see Figure 4-2). In an industry experiencing rapid growth, competition is less intensive and larger returns are possible. In a slow growth business like the textile industry, competition is keen, and this depresses profit margins. To make matters worse, privately held companies have been willing in the past to accept smaller returns than their openly held competitors. As a result, the industry has remained competitive despite the trend toward larger, more fully integrated operations.

Profits for the industry appear to respond to general economic conditions. In 1975, profits fell to only 1.5 percent; in 1973, prior to the recession, they were at 2.9 percent. Despite the movement toward integration in the industry, a movement that will improve value added and increase profits, industry profits have shown little improvement since 1970. Although profits fluctuate with the economy, their general trend has not been upward.

In a high volume business like the textile mill products industry, profit is sensitive to mill operating rates (or capacity utilization). When mill operating rates are below optimum levels, price competition is keen. Increasing mill operating rates can improve financial performance. But general economic conditions and market demand dictate production levels. When sales decline, mills must produce less. The textile mill products industry is market oriented, and reducing the lead time between production and delivery is essential; yet inventories are risky to the textile mill producer. So the primary adjustment mechanism when demand rises or falls is the rate of production. Operating rates for the past three years are shown in Table 4-14. As the economy rose out of the 1974-75 recession, capacity utilization rose from 54.7 percent in the first quarter of 1975 to 86.2 percent in the fourth. For the textile mill products industry, then, production is highly responsive to general economic conditions. In fact, production is more responsive in this industry than it is in all manufacturing industries. The Federal Reserve Board (FRB) Index of Industrial Production shows far greater swings for textile mills than for all manufacturing industries (Figure 4-3).

FIGURE 4-2

Profit in the Textile Mill Products Industry



	1970	1971	1972	1973	1974	1975	1976	1977
SALES:[1]								
ALL MANUFACTURING INDUSTRIES	708,810	751,061	849,523	978,594	1,060,215	1,065,215	1,203,233	1,328,063
TEXTILE MILL PRODUCTS	21,599	22,938	25,616	29,113	31,220	28,116	33,932	34,317
NET PROFITS:[2]								
ALL MANUFACTURING INDUSTRIES	28,572	31,038	36,467	48,134	58,747	49,135	64,519	70,366
TEXTILE MILL PRODUCTS	413	558	659	831	780	409	809	828
PROFIT PER DOLLAR OF SALES:[3]								
ALL MANUFACTURING INDUSTRIES	4.0	4.2	4.3	5.0	5.5	4.6	5.4	5.3
TEXTILE MILL PRODUCTS	1.9	2.4	2.6	2.9	2.5	1.5	2.4	2.4
PROFIT ON TOTAL ASSETS:[4]								
ALL MANUFACTURING INDUSTRIES	5.1	5.2	5.5	6.7	8.0	6.2	7.5	7.0
TEXTILE MILL PRODUCTS	2.8	3.7	4.0	4.7	3.8	2.2	4.2	4.4
PROFIT ON STOCKHOLDERS' EQUITY:[4]								
ALL MANUFACTURING INDUSTRIES	9.3	9.7	10.6	13.1	14.9	11.6	14.0	14.2
TEXTILE MILL PRODUCTS	5.1	6.6	7.5	9.6	8.0	4.4	8.0	8.7

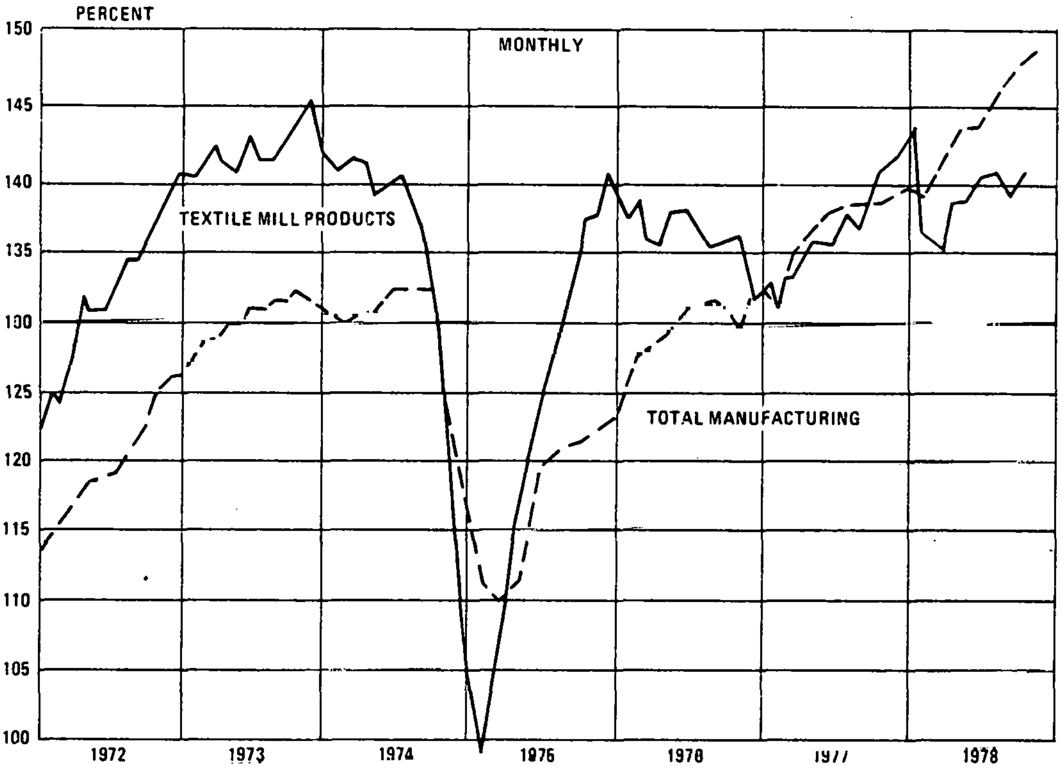
[1]SALES ARE NET OF RETURNS, ALLOWANCES, EXCISE AND SALES TAXES, IN MILLIONS OF DOLLARS. [2]AFTER FEDERAL AND OTHER INCOME TAXES, IN MILLIONS OF DOLLARS. [3]PERCENT OR CENTS. [4]ANNUAL DATA ARE QUARTERLY AVERAGES. QUARTERLY DATA AT ANNUAL RATES. NOTE: PROFIT DATA INCLUDE CERTAIN FOREIGN INCOME. SOURCE: FEDERAL TRADE COMMISSION, ATMI.

TABLE 4-14
Output, Capacity, and Operating Rates for the Textile Mill Products Industry

YEAR	QUARTER	OUTPUT	CAPACITY	PERCENT UTILIZATION
1975	1st	93.3	131.0	54.7
	2nd	94.9	132.9	71.4
	3rd	110.7	133.9	82.7
	4th	118.2	137.2	86.2
1976	1st	116.5	138.2	84.2
	2nd	115.5	139.0	83.1
	3rd	114.4	139.8	81.8
	4th	111.7	140.6	79.4
1977	1st	111.3	141.4	78.7
	2nd	110.9	141.9	78.1
	3rd	112.3	142.5	78.8
	4th	117.9	143.0	82.4

SOURCE: STANDARD & POOR'S INDUSTRY SURVEY: TEXTILES JULY 13. 1978.

FIGURE 4-3
Index of Industrial Production
(1967=100)



INDUSTRY GROUPING*	ANNUAL AVERAGES 1971	1972	1973	1974	1975	1976	1977	1978
TOTAL INDEX	109.6	119.7	129.8	129.3	117.8	129.8	137.1	144.0
ALL MANUFACTURING	108.2	118.9	129.8	129.4	116.3	129.5	137.1	144.5
TEXTILE MILL PRODUCTS	116.5	132.7	142.9	132.8	122.3	136.4	137.1	136.8
COTTON FABRICS	90.8	88.7	83.5	76.6	70.7	80.8	76.5	73.0
MAN-MADE FABRICS	118.9	138.9	162.8	158.4	141.0	170.0	163.2	168.2
WOOL FABRICS	47.6	43.3	56.0	44.8	44.8	54.7	49.9	57.6
KNIT GOODS	135.3	173.6	194.0	183.5	175.0	189.8	194.3	192.3
FABRIC FINISHING	110.0	123.6	135.4	130.5	119.5	130.9	146.0	155.5
CARPETING	149.1	180.5	194.3	179.9	157.7	166.4	180.5	181.9
YARN & MISC. TEXTILES	130.0	140.2	145.4	129.1	116.8	130.5	127.0	132.5
APPAREL PRODUCTS	104.7	109.4	117.3	114.3	107.6	122.2	124.2	124.2

NOTE: MOST RECENT DATA ARE PRELIMINARY. *SEASONALLY ADJUSTED MONTHLY DATA.
SOURCE: U.S. FEDERAL RESERVE SYSTEM, ATMI.

For the industry, demand, production, and profitability are cyclical. For any given textile firm, an additional level of uncertainty can affect performance. In the U.S. textile mill products industry, the typical mill offers a fairly limited product line. Horizontal integration through diversification has improved product mix, but if the major product line suffers from reduced demand, firms do poorly.

The textile mill products corporations listed in the top 1,000 industrials in Fortune for the past 4 years show considerable variability in performance from year to year. The variability is caused in part by changing demand conditions. Furthermore, it is clear that size does not guarantee larger returns. Variability from firm to firm is also large and independent of size. Cyclical and consumer demand fluctuations are a far greater influence than the size of the company. In fact, a small, nonintegrated textile mill can reap huge profits in any given year if it hits on the right product or product mix. The move toward more fully integrated operations does not seem to have had a great effect on performance in the industry as a whole. This is shown in Tables 4-15 and 4-16.

4.6 SIGNIFICANT RETURNS ARE REQUIRED TO ENCOURAGE NEW INVESTMENTS, BECAUSE TEXTILE MILLS OPERATE ON THIN MARGINS

In assessing the ability of the textile mill products industry to finance capital investments, the foregoing analysis centered on the significance of the economic environment in which the industry operates. The following factors were shown to affect economic performance:

- Competitive structure of the industry
- Slow industry growth
- Sensitivity to cycles in general business activity
- Sensitivity to variable consumer tastes and preferences
- High production costs for textile mill products
- Increasing penetration of imports into domestic textile markets.

TABLE 4-15

Profit on Sales by Company and Year

INDUSTRIAL CORP. RANK					NET INCOME AS % OF SALES			
1974	1975	1976	1977	TEXTILE COMPANY*	1974	1975	1976	1977
80	104	98	102	BURLINGTON INDUSTRIES	4.3	2.1	4.5	3.8
157	181	160	163	J.P. STEVENS	3.1	1.8	2.9	2.3
212	208	207	255	UNITED MERCHANTS & MFGS.	3.2	(–)	1.3	(–)
293	317	311	316	SPRINGS MILLS	2.3	1.2	2.4	2.4
297	329	287	281	WEST POINT-PEPPERELL	4.3	3.8	3.8	3.3
289	331	355		INDIAN HEAD		0.8	4.5	
307	338	351	369	M. LOWENSTEIN & SONS	1.4	(–)	1.5	(–)
378	409	372	390	DAN RIVER	1.6	(–)	1.8	2.2
384	367	326	317	CONE MILLS	3.5	5.2	5.7	6.3
410	415	393	393	CANNON MILLS	3.9	4.7	3.5	1.9
439	441	440	416	COLLINS & AIKMAN	4.0	0.7	4.9	4.2
481	493	480	443	FIELDCREST MILLS	0.5	3.3	3.6	4.1
496	482	455	446	HANES	(–)	3.4	4.9	5.0
532	577	524	513	RIEGEL TEXTILE	3.4	3.5	5.2	4.2
583	619	533	542	GRANITEVILLE	5.2	4.4	4.3	3.9
574	642	627	621	LUDLOW	2.6	(–)	1.5	0.3
642	656	603	579	REEVES BROTHERS	4.6	1.6	4.1	3.8
599	662	670	727	TEXFI INDUSTRIES	(–)	(–)	(–)	(–)
610	687	779	897	E.T. BARWICK IND.	(–)	(–)	(–)	(–)
623	691	597	611	AVONDALE MILLS	(–)	2.3	2.1	2.4
582	699	677	720	CHELSEA INDUSTRIES	(–)	0.8	0.2	1.1
777	777	931		BATES MFG.	7.9	5.5	(–)	(–)
731	778	745	714	BIBB MFG.	1.5	4.9	(–)	1.5
800	857	727	708	TEXTILES	4.1	3.7	6.7	6.9
851	858	780	737	DIXIE YARNS	2.3	1.7	2.2	3.8
908	952	897	951	GUILFORD MILLS	(–)	0.3	3.0	3.2

SOURCE: FORTUNE, 1975, 1976, 1977, 1978.

*DEERING MILLIKEN CORPORATION IS A PRIVATE CORPORATION SO NO FIGURES ARE AVAILABLE. IT IS ESTIMATED TO BE THE THIRD LARGEST COMPANY IN THE TEXTILE INDUSTRY, CLOSE TO J.P. STEVENS.

TABLE 4-16
Profit on Stockholders' Equity
by Company and Year

TEXTILE COMPANY	NET INCOME AS A PERCENT OF STOCKHOLDERS EQUITY		
	1975	1976	1977
BURLINGTON INDUSTRIES	4.4	10.8	8.9
J.P. STEVENS	4.8	9.3	7.6
UNITED MERCHANTS & MFGS.	(–)	(–)	(–)
SPRINGS MILLS	2.4	5.3	5.4
WEST POINT-PEPPERELL	8.4	10.7	10.0
INDIAN HEAD	2.6	11.6	(–)
M. LOWENSTEIN & SONS	(–)	5.8	(–)
CONE MILLS	13.7	16.2	18.4
DAN RIVER	(–)	6.2	7.0
CANNON MILLS	7.0	6.1	6.6
COLLINS & AIKMAN	2.0	14.1	12.7
HANES	10.9	16.3	15.9
FIELDCREST MILLS	10.4	12.1	15.2
RIEGEL TEXTILE	9.9	16.8	13.7
GRANITEVILLE	11.5	14.2	12.1
LUDLOW	(–)	5.9	1.3
REEVES BROTHERS	4.2	12.1	11.6
TEXFI INDUSTRIES	(–)	(–)	(–)
E.T. BARWICK INDUSTRIES	(–)	(–)	(–)
AVONDALE MILL	5.4	6.8	7.4
CHELSEA INDUSTRIES	3.6	1.0	5.4
BIBB MANUFACTURING	11.8		4.6
TEXTILES	3.7	18.7	18.4
DIXIE YARNS	5.6	8.7	15.6
BATES MANUFACTURING	17.4	(–)	(–)
GUILFORD MILLS	1.4	15.6	14.2

SOURCE: FORTUNE, 1976, 1977, 1978.

Further analysis of the narrow operating margin faced by various segments of the textile mill products industry is necessary at the level of the production process. This analysis can provide some insight into textile mill process economics and can therefore, give a better understanding of the industry.

As indicated earlier, the demand for textile mill products can shift abruptly. If a textile mill could shift production quickly in response to an unexpected change in demand, performance could be improved. But in a textile mill, shifts in production are difficult. Existing equipment may not have enough flexibility for a shift from production of one fabric to production of another. Furthermore, it is both time and labor intensive to alter the production process. In the fabric weaving process, for example, warp yarns are still tied in by hand in most cases. Dudley (1974) gives an excellent example of the problem faced by textile mills.

> At the mill level, it is difficult and time consuming to change from production of 100 percent man-made fiber to production of 100 percent cotton fiber, or vice-versa. Major difficulties may even be encountered in shifting from production of man-made fiber-cotton blends to production of 100 percent cotton fabric. All of one fiber must be run out of the machines which are changing fiber and the machines must be thoroughly cleaned. This is a major undertaking and naturally quite time-consuming. During the change, neither labor nor machines operate at peak efficiency. So once a mill shifts from cotton to man-made fiber in response to an anticipated price or supply movement, it is unlikely that the change will be reversed unless planners at the individual mill level feel they must do so to avert a severe profit squeeze or in response to strong consumer demand. This explains in part the apparent difficulty cotton experiences when attempting to recover markets in a specific end-use once it has been displaced. That is, the change is in response to anticipated longrun factors, and profit maximization drives would tend to counter the shutdown necessary to move back to cotton. This would also explain any lack of direct competitive shortrun responses by cotton and man-made fibers to seasonal price fluctuations.

Production shifts, then, are made in response to long-run but not short-run factors.

In Tables 4-17 through 4-19, price indexes for the principal products and major cost components of three major textile mill products industry segments are summarized for 1975 through 1977. These segments are:

- Yarn spinning mills: cotton, man-made fibers, and silk (SIC 2281)
- Broadwoven fabric mills: cotton (SIC 2211)
- Broadwoven fabric mills: man-made fiber and silk (SIC 2221).

The tables show the relationship between prices and costs for these major industry segments and how they have changed over time.

A 1976 study of the textile mill products industry by SCS Engineers showed that, based on FTC data for 1974-75, the industry achieved an overall payback period of 5.6 years. This corresponded to a return on capital of 4 percent.* By comparison, investments with a 3-year payback period required earning 7.5 percent on capital, and a 2-year payback required earning 11.2 percent on capital.

An interesting study of the textile and apparel industries by the Council on Wage and Price Stability in 1978 included an analysis of the current profitability of a textile mill producing woven greige cloth. The study indicated that a 12 to 15 percent rate of return on investment (ROI) is required by textile mills. Using this conclusion and adding a construction cost of $25 million and a 6 percent annual operating cost increase, the Council determined that greige broadwoven fabric prices would have to increase at 6.4 percent and 7.5 percent, respectively, to achieve the 12 and 15 percent ROI. However, the price of greige cotton broadwoven fabric increased only 1.7 percent from 1976 to 1977, and synthetic broadwoven gray fabric decreased by 1 percent during the period. This indicates that the economics of constructing a new greige broadwoven facility or making major capital improvements in such a facility are unfavorable.

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* Return on capital is defined as net income after taxes as a percent of total capital (stockholders' equity plus long term debt).

TABLE 4-17
Price Indexes of Principal Products and Major Cost Components in Yarn Mills (SIC 2281) 1975-1977

PRINCIPAL PRODUCTS (GRAY)	1972 % TOTAL SHIPMENTS	PRICE INDEXES (1972 = 100)		
		1975	1976	1977
CARDED COTTON YARNS	21.8	125.5	162.9	164.9
COMBED COTTON YARNS	12.5	121.6	157.5	162.2
RAYON AND ACETATE SPUN YARN	8.7	112.0	168.3	160.4
ALL OTHER NONCELLULOSIC SPUN YARN	5.3	119.9	145.7	147.9
MAJOR COST COMPONENTS:				
MATERIALS:				
COTTON	14.9	187.0	228.6	163.7
RAYON FIBER	4.3	145.9	156.5	163.4
POLYESTER FIBER	6.4	95.2	98.6	110.3
POLYESTER YARN	4.2	98.3	61.9	75.1
FUEL AND ELECTRICITY	1.7	225.0	245.0	284.0
PAYROLLS	23.0	126.1	135.6	146.6
CAPITAL CHARGE	7.8	. . .	. . .	. . .

SOURCE: DEPARTMENT OF COMMERCE.

TABLE 4-18
Price Indexes of Principal Products and Major Cost Components in Cotton Broadwoven Fabric (SIC 2211) 1975-1977

PRINCIPAL PRODUCTS	1972 % TOTAL SHIPMENTS	PRICE INDEXES (1972 = 100) 1975	1976	1977
COTTON SHEETING	20.0	112.3	137.8	139.6
CARDED COLORED YARN	6.4	158.2	186.7	209.8
DYED AND FINISHED FABRIC	16.7	143.2	194.0	215.4
TOWELS AND WASHCLOTHS	12.0	134.6	193.0	205.6
MAJOR COST COMPONENTS:				
MATERIALS:				
COTTON	25.0	187.0	228.6	163.7
POLYESTER FIBER	3.9	95.2	98.6	110.3
SYNTHETIC YARN	4.6	122.2	137.9	144.4
PURCHASED FABRIC	6.0	97.3	102.3	105.9
FUELS AND ELECTRICITY	2.2	225.0	245.0	284.0
PAYROLLS	28.0	128.7	140.4	152.8
CAPITAL CHARGE	8.5	. . .	. . .	. . .

SOURCE: DEPARTMENT OF COMMERCE.

TABLE 4-19

Price Indexes of Principal Products and Major Cost Components in Man-made and Silk Broadwoven Fabrics (SIC 2221) 1975-1977

PRINCIPAL PRODUCTS	1972 % TOTAL SHIPMENTS	PRICE INDEXES (1972 = 100)		
		1975	1976	1977
100% FILAMENT FABRICS	13.3	124.0	146.8	142.7
100% SPUNPOLYESTER WITH COTTON	26.0	140.0	104.7	103.2
FINISHED BROADWOVEN	15.4	111.6	126.4	123.6
MAJOR COST COMPONENTS:				
MATERIALS:				
COTTON	6.4	187.0	228.6	163.7
POLYESTER FIBER	5.4	95.2	98.6	110.3
RAYON YARN	3.8	126.8	139.6	130.4
POLYESTER YARN	3.8	98.3	61.9	75.1
SPUN YARN	8.7	122.2	137.9	144.4
PURCHASED FABRIC	3.8	97.3	102.3	105.9
FUELS AND ELECTRICITY	1.7	225.0	245.0	284.0
PAYROLLS	25.4	128.5	139.4	151.9
CAPITAL CHARGE	7.2	...	...	...

SOURCE: DEPARTMENT OF COMMERCE.

4.7 MATERIALS RECOVERY IS MARGINAL ECONOMICALLY IN BOTH THE FIRST AND SECOND TIERS OF THE TEXTILE MILL PRODUCTS INDUSTRY

Textile waste can be used in two basic ways:

- Making fabric for the first tier of the industry
- Reprocessed into products for use in the second tier of the industry.

4.7.1 First Tier Waste Material Recovery

The use of recycled material or fiber in new fabric lowers fabric quality, increases production costs, and reduces production efficiency. Information taken from a report by a private company and shown to investigators indicated that the reintroduction of damaged or short fibers into the various production processes could result in additional costs and operating problems. For example, besides the capital and operating costs of the equipment to process additional waste materials, the following problems could occur, resulting in increased costs:

- Increased cotton dust problems and the additional capital expenditures to meet OSHA standards
- Possible equipment damage and increased maintenance costs
- Increased waste, reducing production efficiency
- Reduced yarn quality (increased yarn breakage), increasing process down time and reducing labor and equipment efficiency in winding, warping, slashing, and weaving operations.

Another private company report shown to the investigators indicated that merely changing the mix of cotton seriously affected production economics. The proposed change called for deleting California cotton from the U.S. cotton mix. Prior to the proposed change, the mix was 25 percent California cotton, 50 percent Arizona cotton and 25 percent Memphis cotton. The new ratio in the absence of California cotton was to be 50 percent each. The analysis concluded that a 1 percent increase in waste, a 2 percent decrease in spinning efficiency, and a reduction in yarn strength (causing increased breakage and poorer fabric yield) due to this proposed change could result in additional costs of more than $0.5 million. The increased waste generated using waste fibers would be even more expensive due to the shorter fiber length. Furthermore, since product quality would be affected, the profit margin would ultimately be affected from the revenue side as well.

Since cotton and polyester fibers sell for 60 cents or more per pound and the waste by-product sells for only a fraction of that price, it would seem advisable, in a low margin industry, to use this waste in the production of new fabric. By mixing 60-cent cotton with less expensive cotton waste, a less expensive mix could be achieved.

In fact, major textile mills do use reworkable waste in the production process. However, primary and secondary waste is not used in the first tier industry because it is not technically feasible to produce an acceptable product with these wastes. Given the low margin incentive toward improved waste utilization, if it were technically feasible, it would be done.

Because of the low margin in the textile mill products industry, increased use of waste to reduce costs is expected. More efficient equipment that generates less waste will be developed. Less waste will then be available, and waste prices will increase, reducing the margin between virgin and recycled material. This will further reduce the incentive to use recycled fiber. The quality of the waste will also be lower, due to the more efficient primary usage. Consequently, even fewer economic uses will exist for textile mill waste by 1987.

4.7.2 Second Tier Waste Material Recovery

The generation of waste in the textile mill products and apparel industries has resulted in the development of the textile waste processing segment of the textile mill products industry. This segment is small relative to the industry as a whole. In 1976 it accounted for less than 0.5 percent of the total value of textile mill products shipments ($166.2 million). Material costs for reprocessors are significantly higher than the industry average (71.4 percent compared to 61 percent for the whole industry). Furthermore, costs increased considerably over time from 62.5 percent in 1972 to 71.4 percent in 1976. By comparison, material costs for the entire industry were 58.8 percent of the value of shipments in 1972, rising to only 61 percent by 1976. This reflects a 42 percent increase in materials costs for the reprocessors, compared with a 34.5 percent increase for the whole industry.

Recycled textiles are high volume, low margin items. The increasing use of synthetics and synthetic blends has reduced the available quantity of pure cotton and wool wastes, which yield much higher returns. Waste prices vary tremendously depending on waste content. (Prices for waste textiles by fabric type are shown in Table 4-20.) For example pure cotton or wool materials have prices higher than that for mixed rags. The market for wiping cloths is probably the largest single market for old and new rags. Wiping cloth manufacturing is the most profitable segment of the rag collection industry.

In 1972 reprocessors paid salaries and wages amounting to 16.7 percent of the value of shipments. By 1976 the figure had increased to 18.4 percent. For the textile mill industry as a whole, this percentage actually declined 6.4 percent.

4.7.2.1 Waste Reprocessor Capital Expenditures

Capital expenditures by textile waste reprocessors are low relative to those for the rest of the industry. In 1976, the ratio of capital expenditures to the value of shipments for the textile waste processors was 2.2 percent. For the industry as a whole, the ratio was 3.0. However, the cost of reprocessing equipment represents a significant expenditure in such a low margin industry. For example, a major textile machinery manufacturer indicated the installed costs of textile reprocessing equipment and machines are as follows:

- Olympic pulling machine, 3 cylinder, Laroche model, total horsepower 183: Estimated installed cost is $138,000.

- CR 500 rotary cutter with metal detector, total horsepower 14: Estimated installed cost is $38,848.

- Cyclomatic, total housepower 58: Estimated installed cost is $68,250.

TABLE 4-20
Textile Waste Price Changes
(January 1978 to January 1979)

TYPE	JANUARY 9 1978	JANUARY 10 1979	PERCENT CHANGE
WIPING MATERIALS [1]			
INSTITUTION NO. 1 WHITE	22-24	37-39	65%
INSTITUTE MEDIUM WHITE	18-20	28-30	58%
NO. 1 MIXED LIGHT-WEIGHT COLORED	12-14	21-23	69%
INSTITUTION NO. 1 MEDIUM-WEIGHT COLORED	8-10	14-16	67%
INSTITUTION NO. 1 GANAZIES	33-35	45-47	35%
WOOL STOCK [2]			
MIXED KNITS	26-27	42-43	60%
MIXED MERINOS	8½-9½	17-18	94%
ROUGH WORSTEDS	2-2½	8-9	278%
WOOL BODIES	6-7	14-15	123%
ROOFING RAGS [3]			
NO. 1 ROOFING (CHICAGO)	(NOMINAL)	(NOMINAL)	–
NO. 1 ROOFING (N.Y.)	(NOMINAL)	(NOMINAL)	–
MIXED RAGS [4]			
BALTIMORE	2-2½	6-8	211%
CHICAGO	2-2½	6-8	211%
NEW YORK	2-2½	6-8	211%
NEW COTTON CUTTINGS [5]			
CANTON FLANNELS, UNBLEACHED	7-8	15-16	107%
CANTON FLANNELS, BLEACHED	5-6	13-14	146%
SOFT UNBLEACHED MUSLINS	9-10	17-18	84%
OSNABURG CUTTINGS	7-8	15-16	107%
SUNTAN KHAKI CUTTINGS	4-5	12-13	178%
NO. 1 WHITE SHIRT CUTTINGS	10-11	19-20	86%
UNDERWEAR CUTS, BLEACHED	N/A	12-13	–
UNDERWEAR CUTS, UNBLEACHED	N/A	16-17	–

1 WIPING CLOTH MANUFACTURERS BUYING PRICES, CENTS PER POUND, IN SIZEABLE QUANTITIES, DEPENDING UPON QUALITY, ALL PRICES NOMINAL

2 REPRESENTATIVE GRADER'S BUYING PRICES, IN LARGE QUANTITIES, CENTS PER POUND, ALL PRICES NOMINAL

3 PRICES PAID BY DEALERS AND BROKERS, CENTS PER HUNDRED POUNDS

4 GRADERS BUYING PRICES FOR INSTITUTION MIXED RAGS F.O.B. CITIES NAMED

5 BROKERS' AND LARGE DEALERS AVERAGE BUYING PRICES FOR SIZEABLE LOTS

SOURCE: FIBER MARKET NEWS

An additional 10 percent investment tax credit over the existing 10 percent credit (for a total of 20 percent) is in effect for expenditures associated with preparing material for recycling or actually recycling it. All sorting, processing, and other preparation equipment are covered whether they are involved in the recycling of primary waste or secondary waste.

4.7.2.2 Waste Reprocessor Profit Margins

As previously noted, the margins achieved by waste reprocessors are quite low. One producer's margin was no more than 7 to 10 percent, which he indicated was a minimum for survival. As waste prices have increased, the profit margins have been squeezed. Also, as synthetics and blended fabrics have increased in popularity, the percentage of high quality, high value waste has declined. Furthermore, transportation and handling costs, which are major elements of cost to the waste reprocessor, can seriously cut into profit margins.

Several examples of narrow margin on waste reprocessing were obtained from interviews with manufacturers of padding and upholstery stuffing. For example, black or grey polyester fiber sells for 9 to 12 cents per pound. Since the raw material costs less than 2 cents per pound, transportation costs 3 to 5 cents per pound,* and processing costs 5 to 7 cents per pound, there is clearly a very slim margin for profit.

Another manufacturer of shredded material and fiber stated that high quality material sells for 20 cents per pound. Since freight plus handling costs 2 cents per pound, this higher quality material is the only type that seems to justify an investment. Textured polyester is sold

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* To transport these materials from Massachusetts to Baltimore or Philadelphia costs 3 to 3-1/2 cents per pound. From Massachusetts to the South, the cost is 4 to 4-1/2 cents per pound.

by one processor for 6 cents per pound. Given costs for transportation (2 cents per pound), handling (1 cent), and baling (2 cent), only a penny margin is possible.

One processor noted that scraps and remnants from the apparel industry are purchased at 30 to 50 cents per pound. After cutting, sorting, and grading, they are sold as wiping cloths for 80 to 90 cents per pound.

4.7.2.3 Summary

In summary, then, waste reprocessing is a low margin business with transportation costs representing a large part of total costs. The quality of waste has deteriorated and will continue to do so and the industry will find it more and more difficult to obtain a sufficient return. Waste reprocessing, then, may experience some decline over the next 10 years, especially as incentives increase to use more waste in the primary sector. (The OSHA cotton dust standard may have an extremely detrimental effect on the waste reprocessing industry, especially since margins and capital availability are both already low.)

4.8 CAPITAL INVESTMENT IS NEEDED IN THE TEXTILE MILL PRODUCTS INDUSTRY, BUT ACCESS TO CAPITAL IS LIMITED

The textile mill products industry is in a very difficult situation with respect to capital investment. The industry is labor intensive, and labor costs have risen in the United States, while competition from abroad has intensified. Therefore, there is a growing need for technological change and modernization to improve productivity. The rising labor costs have forced manufacturers to adopt labor-saving technological improvements, which increase labor and equipment efficiency. Low profits have slowed the rate of capital investment and federal regulations have tended to consume whatever capital funds were available. Some investment for modernization does take place, and the domestic industry is less labor intensive than its foreign competitors. However, the industry is still relatively inefficient, when measured according to labor intensity. More productive machinery and greater automation is needed. However, not only are the funds for such improvements not readily available, the productivity of the new machines is often not high enough to justify their very high costs.

To assess the ability of the textile mill products industry to finance capital investment, the competing uses of capital and the alternative sources of that capital will be examined.

4.8.1 Principal Uses for Capital Funds

There are three principal competing uses for available capital funds:

- Capacity expansion
- Modernization of existing facilities
- Meeting government regulations and standards.

4.8.1.1 Capacity Expansion

Fiber consumption by U.S. textile mills has increased only 3 percent annually since 1969. The industry has been consistently able to increase capacity to match this rate of increase. Only in 1973 did man-made fabric production capacity fail to meet demand as buying accelerated in anticipation of potential shortages due to the Mideast oil crisis. The capacity utilization rates since 1967 for the production of cotton and man-made fabrics are given in Table 4-21. The demand for capital funds to keep capacity expansion abreast of growth is not expected to be a major problem for the industry.

Actually, the expansion of capacity is secondary to the immediate goal of improving production efficiency. Increases in efficiency are necessary if the industry is to remain competitive in the face of increasing labor costs and competition from foreign imports. However, capital expenditures are needed for new, high-speed equipment that is more versatile and dependable, since the use of such equipment can lower unit costs.

4.8.1.2 Modernization of Existing Facilities

The world textile mill products industry is excessively labor intensive in today's textile environment. The U.S. textile mill products industry is more efficient than the textile industries of many other countries, because of recent increased expenditures for modernization, but additional

TABLE 4-21
Capacity Utilization Rates
1967 to 1977
(Annual Average)

YEAR	COTTON FABRICS	MAN-MADE FABRICS
1967	98.1	86.3
1968	92.2	99.1
1969	92.7	98.3
1970	93.4	86.7
1971	96.3	80.8
1972	94.0	91.6
1973	91.4	100.2
1974	86.0	89.8
1975	79.3	74.9
1976	89.4	86.4
1977	83.4	79.3

SOURCE: FEDERAL RESERVE BOARD.

spending is still needed. Table 4-22 indicates the share of capital spending for expansion and modernization since 1971. Modernization is taking a greater share each year, and this trend is expected to continue.

In recent years the purchase of textile machinery equipment has been significantly affected by the development of new fibers. The advanced equipment required for the processing of man-made fiber varies considerably. Fashion trends have also been responsible for making some textile mill equipment obsolete. Knits and nonwovens require specialized equipment, but if the demand for these fabrics declines, the equipment will be idled. New machinery must be far more versatile if textile mill efficiency is to be improved. Decisions on the amount and type of capital expenditures are complex and risky, yet continued growth in the domestic textile mill products industry requires modernization. The more productive new machinery is very expensive, and only the largest firms are usually capable of generating the capital necessary to purchase it. If advances in machinery productivity, with their associated higher costs, continue there will be a tendency to concentrate the industry into fewer, more highly capitalized firms.

4.8.1.3 Government Regulations and Standards

Government regulations and standards requiring significant capital outlays will confront the textile mill products industry over the next decade. For example, the expenditures required to meet cotton dust, noise and pollution standards will reduce the amount available for productivity improvements. (Chapter 5 discusses government policies affecting the performance of the textile mill products industry.) The cotton dust standard, for example, could cost the industry more than $700 million annually, according to OSHA. Since annual capital expenditures are presently less than $1 billion and estimates for 1987 are $2.4 billion, compliance will be difficult for the industry. In addition, the noise control standard is estimated by OSHA to require expenditures of $18 to $34 million annually. other regulations discussed in Chapter 5 will require additional expenditures.

In summary, the competing demands for capital over the next decade will rapidly consume the available capital. Raising the funds necessary to meet these demands will be difficult, because access to capital is limited in the industry.

TABLE 4-22
Capital Spending for
Modernization and Expansion
(Percent)

YEAR	TOTAL SPENDING	EXPANSION	MODERNIZATION
1971	610	39	61
1972	730	32	68
1973	770	31	69
1974	840	30	70
1975	680	14	86
1976f	790	27	73

f = FORECAST.

SOURCE: TEXTILE WORLD, JANUARY 1976 AND U.S. DEPARTMENT OF COMMERCE, SURVEY OF CURRENT BUSINESS.

4.8.2 Sources of Capital

There are four potential sources of capital for the industry to consider:

- Equity markets
- Long term debts
- Retained earnings
- Depreciation.

Historically, neither equity markets (stocks) nor long term debts (bonds) have been reliable sources of funds. The relatively low rate of return in the textile mill products industry has made raising capital from external sources difficult.

The common stocks of textile companies have been selling well below their book value. An analysis of seven major textile companies by Merrill Lynch in May 1978 indicated that textile issues were selling at discounts from book value (per share) ranging from 1 to 60 percent. As long as most shares continue to sell below their book value, the equity market is not likely to generate significant amounts of capital for textile companies.

Bonds from textile mill product companies are also considered unattractive investments. Standard and Poor's bond quality ratings for the major textile companies show a few top firms with A ratings, but most others have BB or BBB. The number of firms qualifying for long term debt is very small.

The ratio of long term debt to stockholders' equity (i.e., the debt/equity ratio) in the textile mill industry is about 33 percent. In general, it is desirable to have a high percentage of long term debt relative to stockholders' equity, because a high degree of leverage provides greater growth potential. However, in the textile mill products industry, dividend payments are higher than they are in all manufacturing. The payments are kept high to encourage investment (see Table 4-23). Textile bond issues, by comparison, have unattractive quality ratings. The net result is the conservative 33 percent debt to equity ratio.

Internal sources of funds include retained earnings and depreciation. About 80 percent of all the funds available to textile mill products firms are internal funds. Since the industry is a low margin business, retained earnings are generally low. Dividend payments are not reduced proportionally when profits decline. Textile firms feel that this is necessary to maintain continued investment interest. Consequently, retained earnings may be especially low in lean years.

TABLE 4-23
Dividend Payments for the
Textile Mill Products Industry vs
Those For All Industry
(Percent of Earnings)

	ALL INDUSTRIALS	TEXTILE COMPANION
1977	43.0	40.4
1976	39.5	30.7
1975	43.4	67.5
1974	38.6	36.0
1973	38.9	38.1
1972	47.1	63.4
1971	52.9	99.3
1970	58.2	69.2
1969	53.0	57.4
1968	51.3	51.0

SOURCE: STANDARD & POOR'S INDUSTRY SURVEY: TEXTILES, JULY 13, 1978

Depreciation is the primary source of funds used for plant and equipment investments. However, equipment costs have increased rapidly over the years. Table 4-24 shows the rapid escalation of textile equipment costs since 1960. Given the increased costs of textile machinery, depreciation is inadequate to finance the replacement of old, outdated equipment.

Since the demand for capital funds is high relative to the supply, the textile mill products industry will find financing even the most necessary capital expenditures quite difficult over the next 10 years.

* * * * *

In this chapter, the nature, structure, and economic performance of the textile mill products industry was examined. The ability of the industry to finance capital investments was also discussed. In the following chapter, the effect of government regulatory policies on industry operations and the use of recovered materials will be examined.

TABLE 4-24
Cost Increases for Textile Mill Equipment
(1960 to 1974)

EQUIPMENT	BASIC COST 1960	1974
NEW, HIGH-SPEED CARD WITH SUCTION CLEANING	$ 9,000	$30,000
HIGH-SPEED DRAWING/ DELIVERY	2,200	5,500
ROVING/SPINDLE	125	490
CONVENTIONAL SPINNING SPINDLE	40	90
64" X-3 LOOM	3,800	6,000
85" SULZER LOOM	14,000	34,000
TEXTURIZING/SPINDLE	250	1,000

SOURCE: STATEMENT BY JOHN M. HAMRICK FOR ATMI BEFORE HOUSE WAYS & MEANS COMMITTEE JULY 23, 1975.

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   - Man-Made Fiber Producers Association

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5. GOVERNMENTAL AND REGULATORY INFLUENCE ON THE U.S. TEXTILE INDUSTRY

The federal government, through its departments, agencies, and commissions, has a significant influence on the textile mill products industry. This influence may be direct, transmitted through regulations, policies, and ruling aimed specifically at the various sectors of the industry. It may also be indirect, resulting from policies that, although primarily aimed at other sectors of the economy or other industries, still influence the production and marketing of textile products. This chapter investigates the various agencies of government that have a direct influence on the industry. The level of detail presented for each agency depends on the degree of its influence on the textile mill products industry, and especially on how much the agency's policies may affect the materials recovery targets. The information presented may be used in combination with analyses in other chapters of this report to develop a clearer understanding of the industry's potential for reusing recovered materials.

Each agency can generally affect materials recovery in either a positive or a negative way. With regard to the recycling of textile fibers and products, existing government policy exerts a generally negative influence on the textile mill products industry. This is due either to policies that clearly prohibit the use of recycled materials or to the capital requirements that result from certain regulations. At times these requirements are so large that materials recovery technology must be given a low priority by the industry. Actions necessary to reverse this trend include outright appeal or amendment of certain acts and/or granting of subsidies to the industry to meet its capital requirements. However, the industry has thus far failed in both of these areas.

5.1 SEVERAL AGENCIES OF THE FEDERAL GOVERNMENT IMPACT THE USE OF RECOVERED MATERIALS IN THE TEXTILE MILL PRODUCTS INDUSTRY

The major agencies of government that influence or affect the textile mill products industry through regulations, policies, or rulings are as follows:

- Environmental Protection Agency
- Federal Trade Commission
- Department of Labor
- Department of Commerce
- Treasury Department
- Consumer Product Safety Commission
- Department of Defense
- Department of Energy.

In the following sections, each of these agencies is discussed with respect to its influence on the industry.

5.1.1 Environmental Protection Agency

The Environmental Protection Agency (EPA) has two basic policies that directly affect the ability of the textile mill products industry to implement recovered materials practices. These are its regulation policy on hazardous waste management and its regulation policy on effluent guidelines, pretreatment standards, and performance standards. These policies are discussed in the following paragraphs.

5.1.1.1 Rules and Regulations on Hazardous Waste Management

Under Subtitle C of the Resource Conservation and Recovery Act (RCRA) of 1976, EPA is required to investigate several areas relating to industrial hazardous waste generation. The textile mill products industry is one such area.

Under Section 3001 of RCRA, EPA has prepared a list of hazardous wastes for each industrial category. The sludge generated from textile waste-water treatment processes has been included on this list as a "hazardous waste." Under Section 3002 of the act, EPA is currently investigating treatment options that will make textile sludge amenable to resource recovery. The results of this analysis could require the industry to make additional capital investments in order to comply with the standards and permit requirements for treatment, storage, and disposal of hazardous waste. In this respect, the regulations could be considered a negative factor for materials recovery. The competition for capital to comply with these hazardous waste regulations will make it more difficult to obtain capital for materials recovery technology.

It may appear that the National Energy Conservation and Policy Act (NECPA), under which the materials recovery target setting is mandated, and RCRA, under which resource recovery from hazardous wastes is mandated, have similar purposes and objectives and that they should therefore exert positive influences on each other. That is true with regard to the overall objectives of resource recovery—reducing and controlling solid waste. However, materials recovery is actually directed at recycling waste fibers, while RCRA is directed at recovery of useful materials from textile sludge other than fibers. In actuality, then, the two laws will probably exert negative influences on each other as they will intensify competition for scarce capital to implement new technology. Moreover, since textile waste sludge has been designated "hazardous," it does not qualify as solid waste as defined in NECPA.

5.1.1.2 Rules and Regulations on Effluent Guidelines, Pretreatment Standards, and Standards of Performance

The Clean Water Act of 1977 expanded the spectrum of pollutant parameters in point source discharges that are to receive attention to include potentially toxic compounds, and groupings originally identified in the Consent Decree in NRDC vs Train (8 ERC 2120, D.D.C. 1976) have been made subject to effluent limitations. Of 232 pollutant categories, 65 were selected as the most important. They were selected because they were judged to be of the greatest environmental concern. The selections were based on the following criteria:

- "Substances for which there is substantial evidence of carcinogenicity, mutagenicity, and/or teratogenicity
- "Substances structurally similar to the aforementioned compounds or for which there is some evidence of carcinogenicity, mutagenicity, or teratogenicity
- "Substances known to have toxic effects in sufficiently high concentrations and which are present in industrial effluents."

Within the 65 classes, 129 specific elements or compounds were identified as priority pollutants. These included 13 metals, 114 organic compounds, cyanides, and asbestos.

The priority pollutants judged to be most significant in textile mill wastewaters are the following:

- Acrylonitrile
- Benzene
- 1,2,4-trichlorobenzene
- 2,4,6-trichlorophenol
- Parachlorometacresol
- Chloroform
- 1,2-dichlorobenzene
- Ethylbenzene
- Trichlorofluoromethane
- Naphthalene
- N-nitrosodi-n-propylamine
- Pentachlorophenol
- Phenol
- Bis (2-ethylhexyl)phthalate
- Tetrachloroethylene
- Toluene
- Trichloroethylene
- Antimony
- Arsenic
- Cadmium
- Chromium
- Copper
- Cyanide
- Lead
- Mercury
- Nickel
- Selenium
- Silver
- Zinc.

EPA is now concluding its analysis of control and treatment technologies that are applicable for these priority pollutants in the textile industry. Treatment technologies recommended to remove or reduce these pollutants and the costs of application of these technologies for a full range of mill sizes are being estimated.

The regulations to be published by EPA under Sections 301(b) and (d), 304(b), 306, and 307(b) and (c) of the Federal Water Pollution Control Act, as amended, will be based in part on the EPA report and on the comments received relative to the report. EPA will also consider economic and environmental impact information that is presently being developed. After review and evaluation of the technical, economic, and environmental information, an EPA report will be drafted. The report will set forth EPA's preliminary conclusions regarding the textile industry. The proposed rules will include effluent guidelines and standards, standards of performance, and pretreatment standards applicable to the industry. These rules will have a direct effect on the textile industry, probably in the early 1980's, and will add to its escalating capital requirements, primarily in the finishing and dyeing sectors, where wet processes are employed. The dry processing sector (spinning and weaving) should not be affected significantly by these forthcoming EPA regulations.

Preliminary estimates of capital requirements to implement these regulations vary, and better estimates will be presented in the EPA analysis. However, the National Commission on Water Quality, in their annual report in 1975, estimated that the capital expenditures necessary to meet the 1983 water-related standards would be between $528 and $785 million, with annual operating and maintenance expenditures between $50 and $81 million for the years 1977-1982. Although it is difficult to know exactly which industry sectors will be affected the most, recycling technology will probably be given a lower priority in the competition for already scarce capital to meet the EPA regulations.

5.1.2 Federal Trade Commission

The Federal Trade Commission (FTC) has a considerable impact on the U.S. wool processing industry through two basic labeling acts. These textile-related labeling acts are the Wool Products Labeling Act and the Textile Fiber Products Identification Act. They are discussed in the following paragraphs.

5.1.2.1 Wool Products Labeling Act of 1939, as Amended

The basic purpose of the Wool Products Labeling Act is to prevent unlawful and unfair competition among producers of wool products. Among other things, the law requires strict labeling that gives the origin of the wool used in wool fabric. The act also requires that the designations "reused" and "reprocessed" appear on labels of all wool products if they are not made of "new" or "virgin" wool.

The act and the validity of these designations have been debated for many years. The latest argument was in November 1973, when hearings were held before the Senate Subcommittee on Commerce and Finance for purposes of amending the Act. An amendment was sponsored by two senators representing states where wool reprocessing was a dominant, if declining, industry. The basic theme of the amendment was that the word "recycled" should be substituted for the words "reused" and "reprocessed." The contention of the sponsors of the bill was that the latter two words were confusing to the public and discriminated against the reuse of wool waste products. Excerpts from the hearings indicate the nature of the debate.

From Representative Peter Kyros, State of Maine, a sponsor of the bill:

> ...Our bill would simplify the labeling of woolen products by substituting the term "recycled" wool for the now often confusing terms of "reused" and "reprocessed" wool. This bill in no way changes the definition of wool. Speaking as a layman, I would find it difficult to explain the differences between "reused" wool and "reprocessed" wool. Our bill would end the confusion by substituting a term all consumers understand. The current situation creates considerable difficulty since some shoppers equate "reused" wool (from used and discarded garments) with "reprocessed" wool (from garments never utilized by the ultimate consumer). While this bill, H.R. 9934, would be of benefit to woolen mills across the country it would provide substantial assistance to the hard-pressed textile industry in the Northeast since this is the area of heaviest concentration for the woolen industry.

From R. Reed Grimwade, Vice President of the Northern Textile Association, in favor of the bill:

> ...We believe that the term "recycled" is a more accurate description from the consumer's viewpoint as well.
>
> We make a good product which provides warm coats, jackets, shirts, blankets, and other items within the budget of lower income families and other economy minded customers. Recycled wool is also worn by lumberjacks and others engaged in

outdoor occupations as well as in safety clothing to guard against heat and molten metal in steel mills and other similar occupations.

Imported wool fabrics and apparel are not labeled "reused" and are invariably labeled as "wool" or "reprocessed wool." Such products frequently contain "reused wool" but there is no practical way for Customs to police this. Neither Customs nor the FTC has the same access to the records of foreign mills as the FTC has to records of domestic mills. In view of the fact that these imports constitute about one-third of U.S. consumption we believe it is more equitable to have the single term "recycled."

We assert that microscopic tests of fiber damage offer no evidence or proof of whether a fabric is made of reprocessed wool as contrasted with reused wool. The amount of fiber damage tells us nothing in such fabrics.

From the FTC, in opposition to the bill:

...Under the present Act "reprocessed wool" is defined as "...the resulting fiber when wool has been woven...into a wool product which, without ever having been utilized in any way by the ultimate consumer, subsequently has been made into a fibrous state." "Reused wool" refers to such a fiber which has "...been used by the ultimate consumer." "Reprocessed wool" and "reused wool" are not simply different terms which mean the same thing. They are descriptive of quality differences in wool fibers. According to laboratory tests published in the Wool Handbook, there are approximately three times as many damaged fibers in reprocessed wool as in virgin wool. As the number of damaged fibers in a product increases, the quality of the product decreases.

...The staff of the Commission is currently studying the use of the word "recycled" to describe products in general. The preliminary indication is that it is essential to have definitive meanings for "recycled" which are applicable, insofar as possible, to all products. In addition, it is apparent that a product which is described as recycled should be comparable to a new product of

> the same type insofar as utility and consumer acceptance. The staff is studying the various means of achieving this objective. The Commission is concerned that if both reprocessed wool and reused wool can be described as recycled wool, this may have the effect of tainting the word "recycled" by allowing it to be used to describe lesser quality products. This could be detrimental to any overall program designed to encourage recycling.
>
> ...Therefore, the Commission opposes the proposed amendments for the following reasons: (1) The terms "reprocessed wool" and "reused wool" describe fibers of different qualities. (2) The consumer should be completely informed, insofar as is practicable, as to the origin of wool fibers found in wool products. The proposed amendments would in the Commission's opinion result in consumers receiving significantly less information than they get now. (3) We believe that it is essential to apply the word "recycled" only to products which are substantially the same in utility and in consumer acceptance as new products of the same type.

This bill was never passed from subcommittee, and the original provisions of the act requiring the controversial labeling are still in effect.

The act is judged to be a negative factor in the increased use of materials recovery, at least for industries engaged in the production of woolen textiles. Its strict labeling requirements have helped to reduce the wool industry so much that today wool fibers make up only about 1 percent of all fiber demand and half of that is imported from foreign countries.

5.1.2.2 Textile Fiber Products Identification Act

The Textile Fiber Products Identification Act addresses identification and labeling of textile products other than those made from wool fibers—chiefly cotton and man-made fibers. The use of recycled or reused materials is noted twice in this act under two rules:

- Rule 32—Products Containing Reused Stuffing

- Rule 35—Use of Terms "Virgin" or "New."

Rule 32 requires that any upholstered product, mattress, or cushion that contains stuffing that has previously been used as stuffing must have a conspicuous label attached bearing the words "reused stuffing" or "previously used stuffing." This requirement has apparently caused little or no problem for producers or consumers, since "original stuffing" is being used by the producers of these items, the producers apparently seeing little need to utilize "reused stuffing."

Rule 35 prohibits the use of the word "virgin" or "new" when the product so described is not composed wholly of new or virgin fiber. That is, the fiber must never have been reclaimed from any spun, woven, knitted, felted, bonded, or similarly manufactured product.

The interesting point about this provision, unlike that in the Wool Labeling Act, is that this act stipulates only what a label cannot say, not what it must say. There is no provision for the words "reused" or "reprocessed" in the Textile Fiber Products Identification Act, and consequently it cannot be said to discourage materials recovery. Since it does nothing to encourage the use of recycled fibers, the act's overall effect on materials recovery is neutral.

5.1.3 Department of Labor

The OSHA cotton dust and noise standards will greatly impact the use of recovered materials in the textile mill products industry. These standards are discussed in the sections that follow.

5.1.3.1 OSHA Cotton Dust Standards

In the Federal Register of June 23, 1978 (43 FR 27350), the Occupational Safety and Health Administration (OSHA) published a final occupational safety and health standard, pursuant to Section 6 (b) of the act, regulating worker exposure to cotton dust. The standard applies to all industries in which employees are exposed to cotton dust, with certain specified exceptions, and requires employers to take prescribed measures to control employee exposure to cotton dust. The standard was effective September 4, 1978, and, with limited exceptions, was applicable to all nontextile industries, including cottonseed oil mills, and the textile mill products industry. The permissible exposure limits are shown in Table 5-1 along with other essential provisions of the standard.

On August 21, 1978, OSHA received a request for an administrative stay of the standard from the National Cotton Batting Institute and the Textile Fibers and By-Products Association. The request was made on behalf of the cotton waste processing industries and employers who are purchasers and users of batting containing cotton. This request brought to OSHA's attention a draft report prepared by the National Institute of Safety and Health (NIOSH). The report concerned health hazards experienced by the Stearns and Foster Company's garnetting and mattress workers. This report was not available prior to promulgation of the final standard. Upon preliminary review of this report, OSHA determined that the information it presented warranted further review and analysis. This new evidence was received after the close of the cotton dust record and therefore did not have to be considered as part of this proceeding, but OSHA chose to invite comment on its significance and, in the meantime, to suspend the cotton dust standard as it pertained to the waste processing industries and users of cotton batting. NIOSH submitted a final version of the health hazard evaluation on August 31, 1978.

After additional analysis and commenting by the industry and the public, OSHA concluded that there was no basis for permanently suspending the cotton dust standard for the waste processing industries and users of cotton batting. OSHA concluded with NIOSH that the OSHA standard must be complied with in order to ensure adequate worker safety and health. Currently the cotton dust standard is under a judicial stay while the courts consider its appeal and, although the outcome is uncertain, full compliance by the industry is expected to be required over time.

TABLE 5-1
Essential Provisions of the
OSHA Cotton Dust Standard

Section	Provisions
1	Medical examination and ventilatory function tests before placement and after 6 weeks for new employees; annual medical examination for all employees; retention of medical records for 20 years.
2	Posting of warnings of potential exposure to cotton dust.
3	Personal protective equipment (respirators) for workers exposed to cotton dust concentrations in excess of the prescribed limits.
4	Informing employees of hazards from cotton dust.
5	Work practices to minimize employee exposure.
6	Occupational exposure to lint-free cotton dust (dust less than 15 μm aerodynamic diameter) shall be controlled to the lowest feasible limit as noted below. Required sampling collection and analysis methods are also prescribed.

Permissible Exposure Limits	Major Industry Group Affected	Major SICs Affected
0.2 mg/m	Yarn manufacturing	2211, 2221, 2257, 2201, 2284, 2296
0.5 mg/m	Waste processing	2293, 2294
0.75 mg/m	Weaving	2211, 2221, 2241, 2296

In accordance with Executive Order 11821, Inflationary Impact Statements, OSHA prepared a technological feasibility assessment and inflationary impact analysis of the cotton dust standard. Significant conclusions from that study included the position that feasible dust control measures could be developed to meet the 0.2 mg/m^3 and 0.5 mg/m^3 standards as well as the 0.75 mg/m^3 standard. However, due to the very limited experimentation done with local exhaust ventilation controls, it appears that these control processes will become available only after a considerable period of development. Having determined the technological feasibility of meeting the standards, OSHA considered compliance costs, with results as shown in Table 5-2. This table includes cotton ginning, which is not part of the SIC 22 category, but is put in the exhibit for purposes of comparison. The 0.1 mg/m^3 standard is also shown in the table because it was an earlier NIOSH recommendation. It was subsequently dropped from consideration.

The textile mill products industry claims that the technology for cotton dust control to the limits prescribed by OSHA is not adequately developed and that the costs to implement the provisions of the standards cannot be absorbed by the industry. OSHA appears to feel that those arguments are not valid. To the degree that additional financial burdens are imposed on the cotton textile industries, the cotton dust standard must be considered a negative factor in the development of increased materials recovery. Many of the smaller waste-processing firms may discontinue handling cotton wastes if they cannot justify the costs of implementing required dust control technology.

A weaving firm specializing in cotton and yarn spinning that tries to comply with the cotton dust standards will be likely to experience costs well in excess of profits. Depending on the size of the company, these costs may range from 10 to 20 times the profits (after taxes) of that company. The greatest financial impact will be on the smaller firms, but obtaining compliance capital will be difficult for the entire industry.

5.1.3.2 OSHA Noise Standard

A more significant capital burden may be experienced by textile manufacturers in the area of noise abatement

TABLE 5-2
Total Installed and Annualized Compliance Costs of
OSHA Cotton Dust Standard
(Cost in Millions of Dollars)

INDUSTRY SECTOR	EXPOSURE LIMIT (MG/M^3)	INSTALLED COST	ANNUALIZED CAPITAL CHARGE	DIRECT OPERATING COST	ENERGY COST	TOTAL ANNUALIZED COST
YARN PRODUCTION	0.5	211.8	33.8	6.9	20.6	61.5
	0.2	984.4	158.3	15.6	67.9	241.6
	0.1	2,802.7	450.6	23.3	147.0	620.6
COTTON GINNING	0.5	16.9	2.7	4.9	1.8	9.4
	0.2	292.2	47.0	13.2	30.3	90.4
	0.1	343.6	55.2	14.7	35.4	105.3
COTTON WEAVING	0.5	9.1	1.5	1.7	0.6	3.7
	0.2	1,387.9	223.1	40.7	86.3	350.1
	0.1	3,939.1	633.2	112.6	245.1	990.9
WASTE PROCESSING	0.5	17.3	2.8	2.6	2.5	7.9
	0.2	32.0	5.2	2.9	4.7	12.8
	0.1	56.1	9.0	3.4	8.2	20.6
TOTAL	0.5	255.1	40.8	16.1	25.5	82.5
	0.2	2,696.5	433.6	72.4	189.2	694.9
	0.1	7,141.5	1,148.0	154.0	435.7	1,737.4

NOTE: EXPOSURE LIMIT 0.1 MG/M^3 SUBSEQUENTLY WAS DROPPED FROM CONSIDERATION. IT IS INCLUDED HERE FOR COMPARATIVE PURPOSES ONLY.

SOURCE: INFLATIONARY IMPACT STATEMENT OF THE COTTON DUST STANDARD, OSHA, 1978.

and control. The main thrust of proposed legislation is to encourage industry to design, install, and operate machinery, equipment, and entire plants that produce lower noise levels. Lower noise levels should ensure prevention of hearing loss by workers and improve working conditions. According to the Department of Labor (DOL), the required use of earplugs by employees is a means of last resort and should be relied on only when engineered noise abatement procedures have failed. DOL states that unacceptable noise levels must be reduced by redesigned, modified, or otherwise changed machinery and by changes in the architectural designs of buildings.

OSHA favors a standard that does not permit noise to exceed 90 decibels A-weighted sound level (dBA) for 8 hours of exposure. The OSHA standard also states that the threshold limit value of noise should not exceed a maximum 15 minutes exposure to a constant noise level of 115 dBA. Some textile activities will have problems meeting a 90 dBA requirement. Weaving has the highest average noise level of any textile operation (see Table 5-3). To varying degrees, twisting, spinning, combing, and warping may also be impacted by OSHA noise regulations. On the other hand, the Environmental Protection Agency has recommended that OSHA reduce the noise ceiling to 85 dBA. Under these more stringent conditions, six additional textile activities (roving, spooling, drawing, dyeing, carding, and picking) will be affected to varying degrees.

OSHA published a proposed standard of 90 dBA on October 24, 1974. It intends to maintain this ceiling until further evaluation indicates that a lower noise ceiling of 85 dBA is necessary and would be practical to implement.

In a study entitled "Economic Impact Analysis of Proposed Noise Control Regulation" prepared for OSHA, noise monitoring in all of U.S. industry is estimated to cost approximately $155 million per year ($20 per production worker). Audiometric testing for all workers presently exposed, on a time-weighted basis, to noise levels above 85 dBA will cost approximately $86 million per year, or $12 per worker. Thus, the current proposed regulation will cost industry a total of $241 million annually.

TABLE 5-3
Typical Noise Levels in Textile Plants

AREA	A-WEIGHTED SOUND LEVEL RANGE dBA	AVERAGE dBA
WEAVING	95-103	99
TWISTING	92-97	95
SPINNING	92-93	92
COMBING	91-92	91
ROVING	87-90	89
SPOOLING	86-88	87
DRAWING	86-88	87
DYEING	85-86	86
CARDING	82-87	85
PICKING	76-87	82
FINISHING	81-82	82
WARPING	80-91	81
SLASHING	78-82	80
INSPECTION	79-80	80

SOURCE: COOPER, W.D., AN INTRODUCTION TO THE TEXTILE INDUSTRY OF THE 70'S, NORTH CAROLINA STATE UNIVERSITY, SCHOOL OF TEXTILES, 1973.

Meeting an 85 dBA regulation solely by use of hearing protection would cost about $43 million annually. If audiometric testing and monitoring were also required, the total annual cost would be $284 million ($241 million plus $43 million), or about $38 per worker.

An 85 dBA regulation achieved through engineering controls would require an incremental investment by the industrial sector of about $8 billion dollars. That is, the additional investment necessary to move from full compliance with a 90 dBA standard to full compliance with an 85 dBA standard is $8 billion. The $8 billion capital cost is expected to decrease as the compliance period is extended. Applying a 3 percent per year cost reduction for 10- and 15-year compliance periods reduces capital costs by 18 and 25 percent, respectively. In addition, the annual monitoring cost of $155 million would continue; however; once an 85 dBA regulation is fully implemented, audiometric testing would no longer be necessary. Thus, the $86 million annual cost for testing would not be incurred after compliance is achieved and the annual cost per worker would be $108 spread over 10 years and $73 spread over 15 years.

Impacts of the standards on the textile mill products industry are significant. Assuming the 1977 level of 914,000 workers in the industry, results in the following anticipated costs for compliance with the proposed OSHA noise standards:

- Noise Monitoring — $18 million per year
- Audiometric testing (Above 85 dBA) — $11 million per year
- Worker Hearing protection (85 dBA) — $ 5 million per year

Achieving the 85 dBA regulation through engineering controls would cost the textile mill products industry about $99 million per year over a 10 year compliance period or about $67 million per year over a 15 year period.

The cost estimates for audiometric testing, noise monitoring, and hearing protection programs are based on actual costs incurred by firms that are presently carrying out such activities. The costs of achieving an 85 dBA level through engineering controls are based on data obtained in previous projects and in visits to a sampling of plants.

The requirement that the industry spend large amounts of capital to comply with the OSHA noise regulations is considered a negative factor in the development of increased materials recovery. The capital requirements to implement recycling technology will directly compete with the already heavy demands for capital occasioned by the need to comply with existing OSHA regulations. Of course, in the long term there probably will be a cost payback to the industry due to a reduction in compensation claims and lost work time from noise-related causes. However, these costs are not readily quantifiable at this time.

5.1.4 Department of Commerce Is a Major Participant in Determining International Trade Policies in Textiles and Apparel

The Department of Commerce (DOC) plays a major role in formulating foreign trade policies that affect the textile industry. The Committee for Implementation of Textile Agreements (CITA), established by Executive Order 11651 and chaired by DOC, is comprised of representatives of the Departments of State, Labor, and the Treasury. The Office of the Special Representative for Trade Negotiations is a nonvoting member. CITA is responsible for implementation of all bilateral textile agreements and the Multi-Fiber Agreement (MFA), which is an overall international agreement stating principles and agreements to be followed by all textile exporting and importing countries.

Separate and distinct from the bilateral and MFA negotiations are the Multilateral Trade Negotiations (MTN). These negotiations are conducted periodically between foreign countries with the aim of reducing tariff and nontariff (quota limitations) barriers to trade. The MTN negotiations typically cover a wide spectrum of commodities and products in addition to textiles but, historically, textiles have always been a major topic of discussion with respect to changing trade barriers. The MTN can be viewed as a national marketplace where nations trade off commodities in an attempt to place their countries in the most favorable trade position possible.

The current MTN negotiations in Geneva offer a representative example. The United States appears to be willing to reduce textile tariffs on goods exported from Europe in exchange for some $3 billion of new agricultural export opportunities in Europe. According to a new Congressional Budget Office paper on the negotiations, there will be winners and losers as the trade agreements stand now. While some consumers and producers should benefit greatly from freer trade arrangements, "Some businesses will be forced to close and some workers will lose their jobs because of increased foreign competition," the report says.

Biggest potential U.S. industrial losers: textiles, footwear and other leather products, pottery, food utensils, steel products, radio, television, and jewelry. These industries are relatively labor-intensive or use simple, well-known technologies.

The winners: industries producing tobacco products, semiconductors, computing machines, office machines, mechanized measuring devices, electronic components, aircraft and aircraft equipment. These industries employ new or sophisticated technology. U.S. agriculture also stands to benefit, especially if American negotiators win reduction of nontariff barriers in Europe and Japan.

Lay-offs would be borne disproportionately by semiskilled and minority workers—an impact that would be especially noticeable in the textile industry, where minorities make up 23 percent of the labor force and 65 percent are women. Unless some provision is made for dislocated workers, the report says, Congress is not likely to approve the treaty. The present "adjustment program" is termed inadequate. It should be obvious that foreign trade in textiles is a complex issue that is sensitive to international politics and almost impossible to predict, especially to 1987. However, a review of the recent foreign trade in textiles can be useful in drawing some general conclusions.

Table 5-4 presents data on the trade balance for each fiber for the period 1972-77. The table, along with Figures 5-1 and 5-2, can be used in reaching several significant conclusions:

TABLE 5-4
U.S. Foreign Trade in Textile Manufacture:
Fiber Equivalent Exports, Imports,
and Trade Balance by Fibers
(1,000 pounds)

YEAR	EXPORTS				IMPORTS				TRADE BALANCE			
	COTTON	WOOL	MAN-MADE	TOTAL	COTTON	WOOL	MAN-MADE	TOTAL	COTTON[1]	WOOL[1]	MAN-MADE[1]	TOTAL[1]
1972	290,444	33,332	177,584	501,360	610,703	95,377	480,453	1,186,533	320,259	62,045	302,869	685,173
1973	325,197	33,363	288,227	646,787	563,501	89,962	465,319	1,118,782	238,304	56,599	177,092	471,995
1974	392,493	25,975	390,734	809,202	502,679	74,225	371,252	948,156	110,186	48,250	19,482[2]	138,954
1975	353,663	21,386	322,388	697,437	501,252	68,422	400,376	970,050	147,589	47,036	77,988	272,613
1976	413,154	15,082	352,176	780,412	708,601	98,579	479,487	1,286,667	295,447	83,497	127,311	506,255
1977[3]	369,462	13,038	367,026	749,526	669,407	116,606	531,130	1,317,143	299,945	103,568	164,104	567,617

[1] IMPORT TRADE BALANCE.

[2] EXPORT TRADE BALANCE.

[3] PRELIMINARY.

SOURCE: SUPPLEMENT FOR 1978 TO STATISTICS ON COTTON AND RELATED DATA BULLETIN NO. 535, U.S.D.A., MARCH 1978.

FIGURE 5-1
Textile Foreign Trade Balance,
1972 to 1977

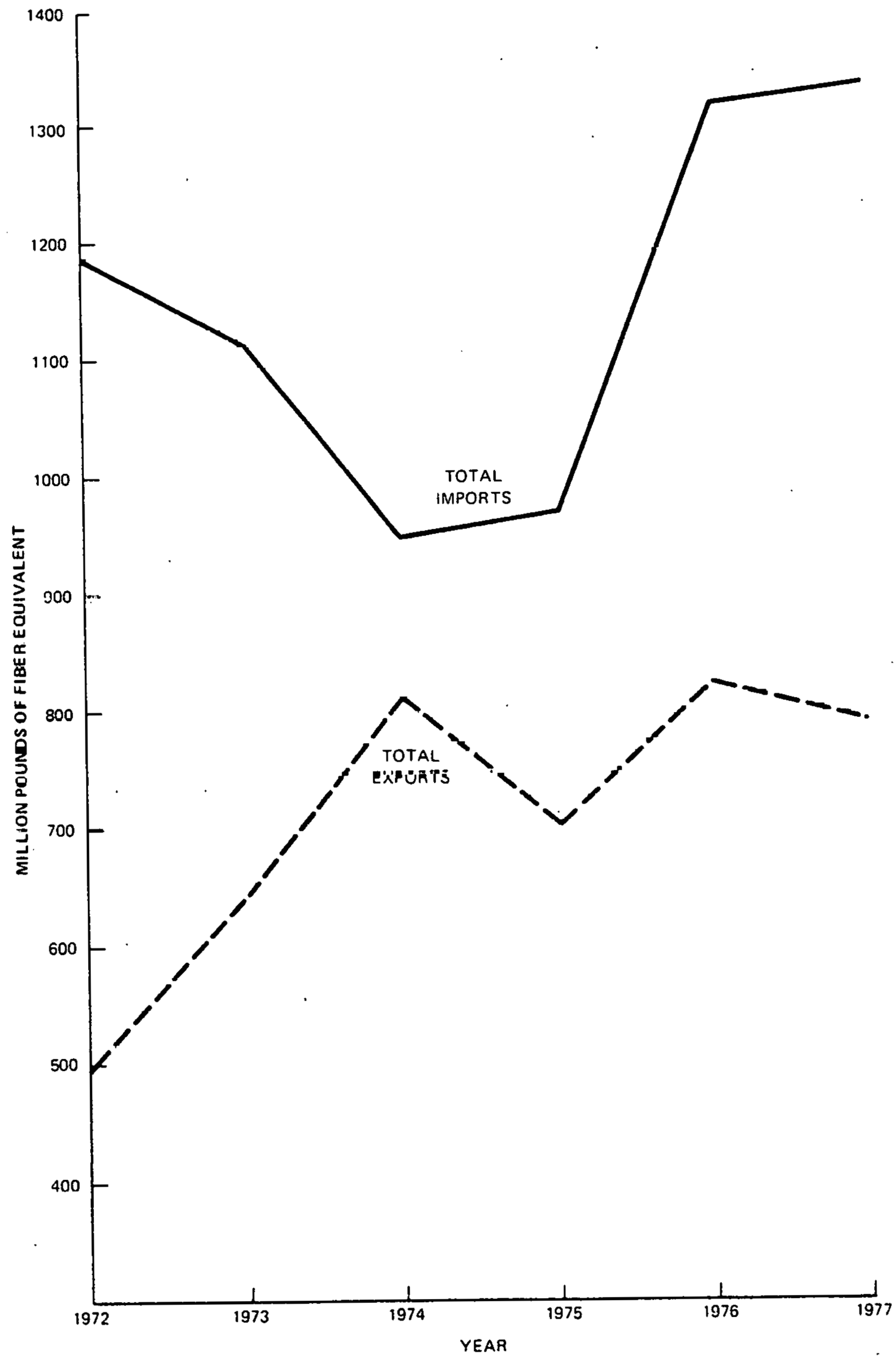
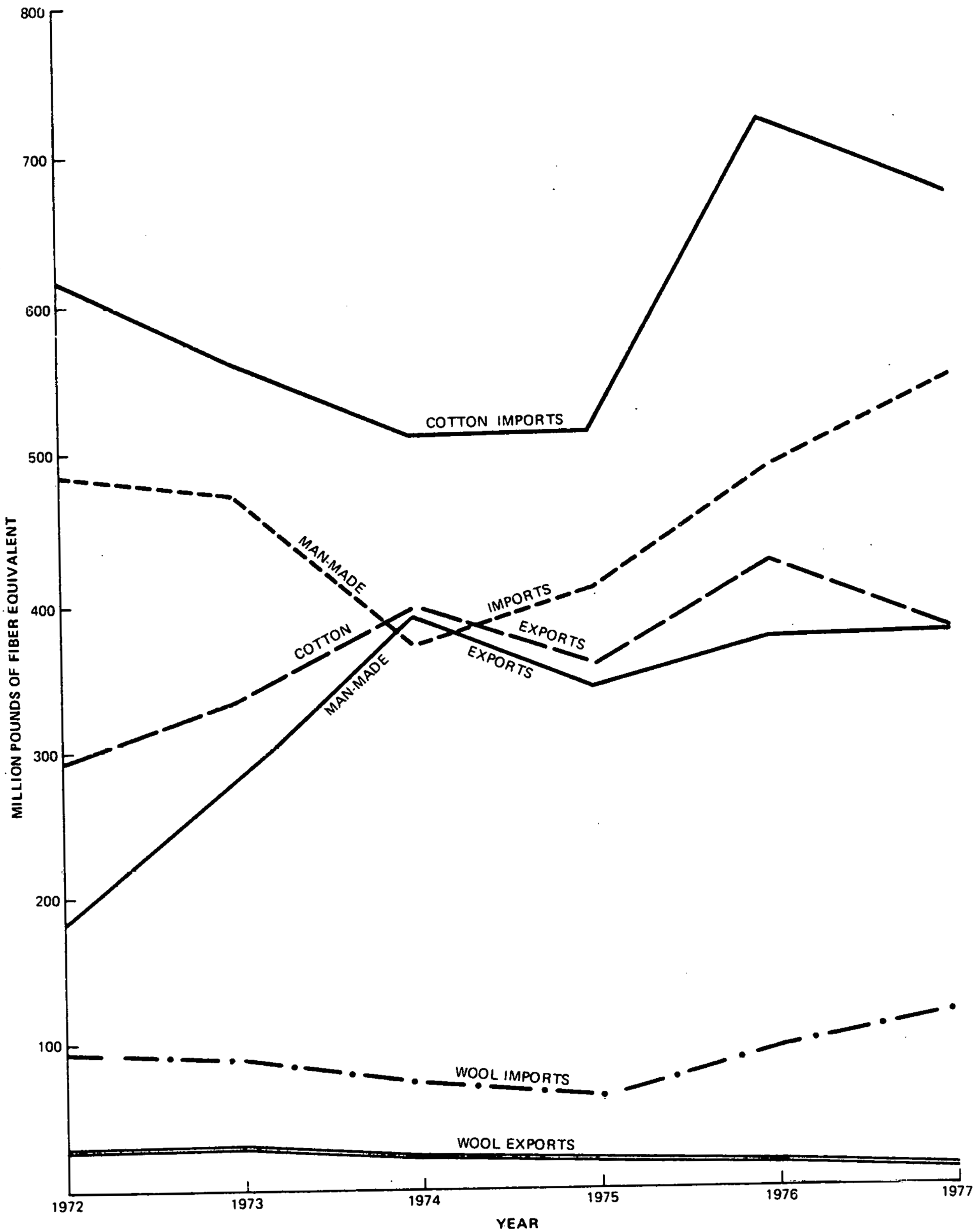


FIGURE 5-2
Textile Foreign Trade Balance by Fiber



- The United States has demonstrated an import trade balance for total textile fibers since 1972. While the trade gap closed significantly in 1972-74, it has continued to widen since then to the point where the United States imported almost twice as much as it exported in 1977.

- Cotton imports represent the largest share of all textile fiber imports, followed by man-made fibers and wool imports, wool representing a relatively small share.

- Man-made fiber imports have steadily risen since 1974, while cotton import levels are erratic over the same period.

- Only man-made fibers showed a slight export trade balance (in 1974), but since then an import trade balance has continued to widen.

- Cotton and man-made fiber export levels have demonstrated similar erratic trends over the last several years, appearing to reach equilibrium around the 380 million pound level.

- Wool exports have been in a gradual decline since 1972, reaching a low of about 13 million pounds in 1977.

The U.S. trade balance of textiles is not limited to yarns and wearing apparel. Waste materials are a significant portion of its foreign trade. Tables 5-5 and 5-6 present data on the raw wool content of U.S. exports and imports. Table 5-5 shows that the United States has exported relatively constant amounts of noils and wastes, even though its total wool exports dropped dramatically between 1972 and 1977. Table 5-6 and Figure 5-3 reveal that noils and wastes represent a large share (up to 30 percent) of total wool imports. This is a rather striking statistic, and there are similar statistics for other fibers. According to DOC data, the United States imported almost 7 million pounds of cotton wastes in 1976 and almost 5.5 million pounds in 1977. This does not include waste "rags," which are thought to be imported in substantial quantities thus making the waste exports to this country even higher. Much of this waste materials market could be diverted to domestic sources instead of

TABLE 5-5
Raw Wool Content of United States Exports
of Domestic Wool Manufactures[1]
(1,000 pounds)

YEAR	TOPS AND ADVANCED WOOL	YARN	FABRICS WOVEN AND KNIT	WOOL BLANKETS	WEARING APPAREL: KNIT	WEARING APPAREL: OTHER THAN KNIT[2]	OTHER MANUFACTURES	FELTS	SUBTOTAL	NOILS AND WASTES[3]	CARPETS AND RUGS	TOTAL
1972	25,548	563	599	88	434	917	910	455	29,514	2,753	1,065	33,332
1973	23,073	395	1,069	217	917	1,427	1,248	432	28,778	2,601	1,984	33,363
1974	13,314	550	924	314	944	2,470	1,592	384	20,492	2,980	2,503	25,975
1975	11,010	813	1,293	530	428	1,717	1,271	257	17,319	2,186	1,880	21,386
1976	4,959	768	954	673	507	1,655	1,516	511	11,543	1,277	2,262	15,082
1977[4]	1,702	1,474	878	704	586	1,829	2,054	234	9,461	1,591	1,986	13,038

[1] INCLUDES MANUFACTURES OF MOHAIR, ALPACA, AND OTHER WOOL-LIKE SPECIALITY HAIR.

[2] INCLUDES MEN'S AND BOYS' SUITS, PANTS, OVERCOATS; WOMEN'S AND CHILDREN'S SUITS, DRESSES, ENSEMBLES, AND WOOL FELT HATS.

[3] NOT INCLUDING RAGS.

[4] PRELIMINARY.

COMPILED FROM REPORTS OF THE BUREAU OF THE CENSUS.

TABLE 5-6

Raw Wool Content of United States Imports for Consumption of Wool Manufactures[1] (1,000 pounds)

YEAR	TOPS AND ADVANCED WOOL	YARNS	WOVEN FABRICS[2]	WOOL BLANKETS[3]	WEARING APPAREL	
					KNIT	OTHER THAN KNIT[4]
1972	425	6,312	8,765	707	19,998	11,247
1973	325	4,931	12,473	386	15,026	12,394
1974	520	5,395	9,251	370	12,735	11,149
1975	338	4,121	8,360	416	12,237	10,677
1976	403	5,375	12,210	380	18,902	14,071
1977[7]	842	5,802	18,651	405	25,866	18,263

YEAR	OTHER MANUFACTURES[5]	SUBTOTAL	NOILS	WASTES[6]	CARPETS AND RUGS	TOTAL
1972	3,272	50,726	21,773	10,589	12,289	95,377
1973	2,136	47,671	17,892	10,801	13,598	89,962
1974	1,348	40,763	13,374	7,592	12,491	74,225
1975	1,063	37,212	13,497	6,299	11,410	68,422
1976	1,331	52,672	21,341	10,507	14,059	98,579
1977[7]	1,224	71,053	9,425	11,290	14,838	116,606

1 INCLUDES MANUFACTURES OF MOHAIR, ALPACA, AND OTHER WOOL-LIKE SPECIALTY HAIR.

2 INCLUDES PILE FABRICS AND MANUFACTURES, TAPESTRY AND UPHOLSTERY GOODS, PRESS, AND BILLIARD CLOTHS.

3 INCLUDES CARRIAGE AND AUTOMOBILE ROBES, STEAMER RUGS, ETC.

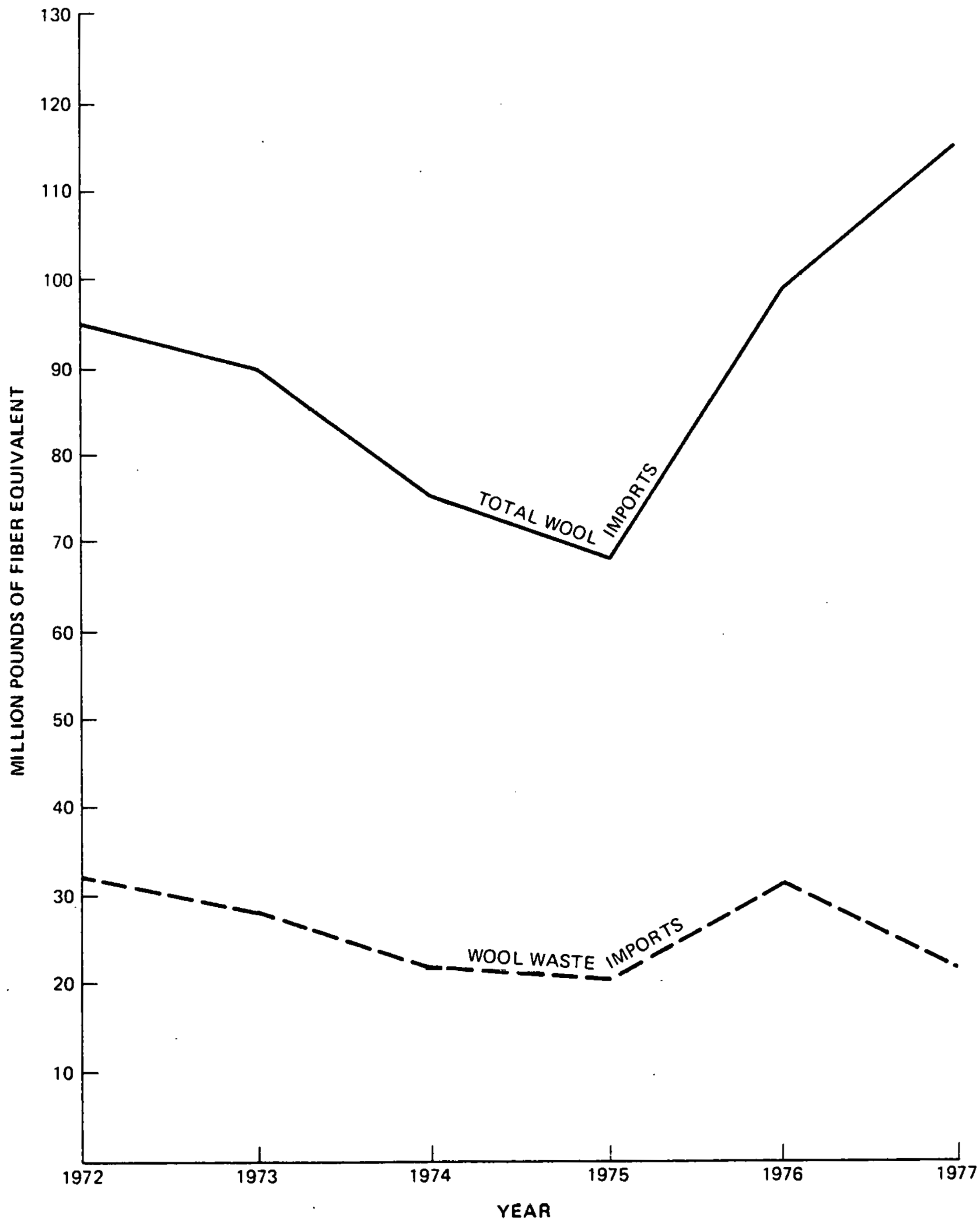
4 INCLUDES LACES, LACE ARTICLES, VEILS AND VEILINGS, NETS AND NETTINGS, WHEN REPORTED IN POUNDS.

5 INCLUDES KNIT FABRICS IN THE PIECE AND MISCELLANEOUS MANUFACTURES NOT ELSEWHERE SPECIFIED.

6 NOT INCLUDING RAGS.

7 PRELIMINARY.

FIGURE 5-3
Wool Waste Imports vs. Total Wool Imports, 1972 to 1977



being imported from foreign manufacturers. Reducing or perhaps eliminating textile waste imports should serve as an impetus to increased waste materials recovery in the United States.

5.1.5 Treasury Department

Two Treasury Department regulations that affect the importing of textile goods into the United States can have a positive impact on the use of recovered materials. The two are the Antidumping Act of 1921 and the Tariff Act of 1932. They are discussed in the following paragraphs.

5.1.5.1 Rules and Regulations Under the Antidumping Act, 1921

The purpose of the Antidumping Act is to protect domestic industries from losses due to imports being sold at less than fair value. In other words, the price of a commodity in the home market of the foreign country is compared with the price for the same commodity sold as an export to the United States. If investigation by the U.S. Customs Service indicates that commodities are being "dumped" in this country, appropriate measures are taken, such as placing additional tariffs or bounties on the product to allow domestic producers to be more competitive. Petitions to investigate dumping by foreign manufacturers can be initiated by any domestic producer. These regulations have a positive influence on the textile industry, because their objective is to foster fair trade and protect domestic manufacturers.

5.1.5.2 Rules and Regulations Under the Tariff Act, 1932

Under this act, the U.S. Customs Service may investigate whether foreign governments are giving benefits (bounties or grants) to their domestic manufacturers who are exporting products to the United States. This is known as a "Countervailing Duty Determination." The objective again is to protect American domestic manufacturers from losses stemming from the unfair competitive advantage a foreign manufacturer can gain when he is subsidized by a foreign government.

The benefits considered to be bounties or grants include the following:

- Income tax exemptions on certain export-related income
- Preferential financing for exports
- Export rebates
- Certain economic development incentives
- Drawback of duty on industrial equipment
- Export risk insurance at low rates.

In the textile sector, there is an average of 10 to 20 petitions filed each year for countervailing duty determinations and antidumping determinations. Half of these result in the conclusion that the foreign countries have not given benefits to their domestic manufacturers. For the other cases, additional duties are imposed by the United States on the foreign textile imports to bring their price up to fair value.

5.1.6 Consumer Product Safety Commission Administers The Flammable Fabrics Act as Amended and Revised, 1967

Since May 1973 the Consumer Product Safety Commission (CPSC) has had responsibility for administering the Flammable Fabrics Act. This responsibility includes the authority to set flammability standards and to inform the public of hazards associated with flammable fabrics. At present there are seven sets of standards implementing the act:

- Standard for Flammability of Clothing Textiles (CS 191-53)
- Standard for Flammability of Children's Sleepwear: sizes 0-6x (FF 3-71)
- Standard for the Surface Flammability of Carpets and Rugs (FF 1-70)
- Standard for the Surface Flammability of Small Carpets and Rugs (FF 2-70)
- Standard for the Flammability of Children's Sleepwear: sizes 7-14 (FF 5-74)

- Standard for the Flammability of Mattresses and Mattress Pads (FF 4-72)

- Draft Standard on Upholstered Furniture Flammability.

Flammability testing carried on by the CPSC consists of exposing samples of these textile products to a flame for 1 second or, in the case of carpets, exposing them to a burning tablet to simulate a small ignition source such as a match. If the burn rate does not exceed certain limits, the sample is considered to meet the standards.

These standards do not appear to be presenting any technical or financial problem to the industry at large. Discussions with textile technologists at CPSC indicate that the use of recycled fibers should not make it any more difficult to meet the flammability standards.

Of particular note is the draft standard on upholstered furniture. Such furniture does use a significant amount of batting and filling material. Like the standards in other areas, the standard for upholstered furniture is a performance standard rather than a design standard. It allows the industry to choose the filling materials and allows for the use of new and better materials as they become available. As long as the furniture meets the required cigarette ignition resistance, a manufacturer may use any combination of fabrics, chemical treatments, finishing techniques, or filling materials that he feels is suitable. With regard to filling materials, the industry prefers to chemically treat cotton batting with boric acid or to use 100 percent polyester fiber waste. Previous reports stated that urethane foam was more competitive and would reduce the market for textile waste materials as filling, but these reports have not been substantiated. On balance, it can be stated that the flammability standards administered by CPSC have neither a positive nor a negative influence on the increased use of recovered material and are therefore classified as neutral.

5.1.7 Department of Defense Establishes Specifications on Military Clothing

Since the Department of Defense (DOD) is a large consumer of textile products, principally in fabrics for military clothing, its policies on the use of recycled fibers were investigated. Officials at the Navy Clothing and Textile

Research Facility stated that specifications are published for each type of fabric used in the military. These specifications pertain to fiber types and fabric characteristics. These characteristics are measured against performance specifications, a list of which is given in Table 5-7.

The use of recycled fibers or waste materials is specifically addressed in only one of the specification documents, the "Wool Cloth" specification. In this case, the use of "noils, laps, or any other wool manufacturing by-product is prohibited" (MIL-C-16290G SA, June 17, 1971). Clearly, this DOD policy discourages further materials recovery in the textile mill products industry, at least with respect to wool products.

With regard to other fabrics, the DOD position is that as long as the performance specificaitons shown in Table 5-7 are met, the use of recycled fibers or waste materials is permitted. However, many senior ranking DOD personnel hold that there is already too much variation in the weave, color, and texture of military uniforms and that specifications should be made more rigid and tolerances narrowed. Uniformity of appearance is very critical to the military, and they test their fabrics before accepting them. In addition, DOD must follow federal laws regarding textiles (e.g. the Wool Products Labeling Act and the Textile Fibers Identification Act). DOD's specifications incorporate the provisions of these acts.

Practically speaking, the DOD policies do not encourage the use of recycled fibers or waste materials. In the case of wool fabrics, they clearly do work against the use of waste products. Even if increased materials recovery were implemented in these areas of the textile mill products industry that produce military fabric, DOD would not be likely to reduce its performance requirements and could in fact make them even more stringent.

5.1.8 Department of Energy

The National Energy Act was passed by the Congress on October 15, 1978. The act is composed of five bills, several provisions of which could affect individual plants substantially. On a total industry basis and specifically with regard to materials recovery, the National Energy Act is viewed as having no substantial effect. The materials recovery targets provision of the act, which is the subject of this report, is considered to have a positive effect on the increased use of waste materials.

TABLE 5-7

Typical Fabric Characteristics for Which Performance Specifications Are Established

Weight

Yarns per inch (cm)
- Warp
- Filling

Breaking strength
- Warp
- Filling

Tear strength
- Warp
- Filling

Flex stiffness
- Warp
- Filling

Air permeability

Weave

Colorfastness to:
- Laundering
- Crocking
- Perspiration
- Dry cleaning
- Light
- Water

Permanence of finish
- Air permeability
- Thickness
- Shrinkage

Heat treating

Nonfibrous materials

pH

Seam slippage

5.1.8.1 Power Plant and Industrial Fuel Use Act of 1978

The Fuel Use Act prohibits new industrial boilers with a fuel heat input rate of 100 million Btu's per hour or greater from using oil or natural gas unless an exemption is granted. The exemption would need to be based on the fact that the use of coal is precluded by environmental regulations, cost, site limitations or other justifiable reasons. For existing industrial boilers, DOE may order coal capable units not to burn oil or gas and to shift to coal. These provisions could negatively influence some textile mills because natural gas and fuel oil account for 50 percent of the total industry energy use while coal represents seven percent.

Since the oil embargo, a few large boilers in textile mills have been reconverted to coal. The rising cost of fuel oil and natural gas plus the relaxing of some state air pollution regulations encouraged this change. These conversions, however, are limited, and there appears to be no particular rush to reconvert to coal. Within the plants that use coal, the use is generally limited to the very largest boilers, those boilers delivering at least 150,000 lbs of steam per hour. Thus, only one large boiler at each plant may use coal, while smaller boilers remain on fuel oil or natural gas. Sampled companies indicate that large boilers will be converted to coal only during routine replacement and not in a "crash program."

Conversion to coal will introduce other problems for affected textile mills: costly electrostatic precipitators will be required to meet emission standards; larger fuel storage facilities and materials handling mechanisms will be required; and disposal problems will become more significant. One industry official noted that an item which would help accelerate the fuel switching would be the availability of a package-type coal burning boiler.

In the event supplies of natural gas are curtailed to textile mills, many mills have standby supplies of propane to which they can convert. Propane, at three times the cost of natural gas, is reportedly the preferred fuel to substitute for natural gas when the latter is not available. Recently, the interest in natural gas led at least one textile company to pursue, on a preliminary basis, exploration for natural gas wells, which would allow the firm to ship gas through interstate pipelines at intrastate rates.

In summary, it appears that the textile industry will be able to use fuels in about the same proportion as presently. There will probably be a few large integrated corporations which will have to bear the inconvenience and costs of converting to coal but on an industry basis the overall influence of the coal conversion provisions of the National Energy Act is considered to be neutral.

5.1.8.2 Natural Gas Policy Act

As large consumers of natural gas, some textile mills could be negatively influenced by the pricing provisions of this act. Under the act, interstate pipelines and distribution companies served by interstate pipelines must pass along the higher costs of new, high-cost, and imported natural gas to their large industrial customers who use gas for boiler fuel to generate steam or electricity. Under incremental pricing, industrial boiler fuel users will bear the increment of gas costs above $1.48 per million Btu (as of March 1978, adjusted each month for inflation), until the price to these users rises to the cost of fuel oil in the region. Only when the rates of all industrial boiler fuel customers reach this level will residential and small commercial users have to bear a portion of the higher gas costs. The act exempts (on an interim basis) small industrial boiler fuel facilities (less than 300,000 cubic feet of gas per day). Assuming that many of the smaller textile mills will fall under this exemption, the increased costs should be felt by only the large producers. Therefore, on a total industry basis, the effects of the Natural Gas Policy Act are considered to be neutral.

5.1.8.3 Energy Tax Act

There are two provisions relative to energy tax credits under this act which effect the textile industry. The first is an additional ten percent investment tax credit for the installation of equipment for the recycling of waste materials. This clearly is positive influence on the further development of materials recovery in the textile industry. The second provision is a negative factor in that it restricts investment tax credits. The restriction is meant as a penalty for those textile firms which construct new oil or gas fired boilers. Such facilities will not be entitled to the current investment tax credit and will be limited to straight-line depreciation. The normal exceptions apply if it can be shown that a new coal facility is precluded by environmental requirements. Assuming that the number of new textile mills constructed in the near future is limited, these provisions are not considered to have either a positive or negative effect on the industry as a whole.

5.1.8.4 National Energy Conservation Policy Act

Title III of this act requires DOE to establish a program to promote increased energy effiency by industry. Requirements of the program include identification of the ten most energy-intensive industry groups and the most energy-consumptive corporations in each such group. The program also provides for the setting of voluntary industrial energy efficiency improvement targets and requires reporting procedures to be followed so that DOE can monitor energy conservation progress. The textile mill products industry was ranked as the tenth most energy-intensive industry and, therefore, the largest textile firms (using one trillion Btu's of energy or more) are presently reporting their energy use to DOE. The effect of these provisions on the textile industry is neutral in that the industry had a proven record of energy conservation and voluntary reporting through their trade associations even before the NECPA was effective. Therefore, these new requirements will not cause any substantial difficulties or problems for the industry relative to materials recovery.

5.1.9 Summary of Governmental Impacts

Table 5-8 briefly summarizes the material in this section. It lists the federal departments, agencies, and commissions whose policies affect the textile mill products industry and in each case indicates whether or not those policies encourage materials recovery.

This section has discussed the effects of major government regulations on the textile mill products industry. Changes that could encourage materials recovery are discussed in the following section.

TABLE 5-8
Summary of Government Influence on the Textile Industry

AGENCY/DEPARTMENT	REGULATION, POLICY, RULING	PRINCIPAL FIBERS AFFECTED			EFFECT ON MATERIALS RECOVERY
		COTTON	WOOL	MAN-MADE	
ENVIRONMENTAL PROTECTION AGENCY	• RULES ON HAZARDOUS WASTE MANAGEMENT	X	X	X	NEGATIVE
	• RULES ON EFFLUENT GUIDELINES, PRETREATMENT STANDARDS, AND STANDARDS OF PERFORMANCE	X	X	X	NEGATIVE
FEDERAL TRADE COMMISSION	• RULES AND REGULATIONS UNDER THE WOOL PRODUCTS LABELING ACT OF 1939		X		NEGATIVE
	• RULES AND REGULATIONS UNDER THE TEXTILE FIBER PRODUCTS IDENTIFICATION ACT, 1958	X		X	NEUTRAL
DEPARTMENT OF LABOR	• OSHA COTTON DUST STANDARD	X			NEGATIVE
	• OSHA NOISE STANDARD	X	X	X	NEGATIVE
	• OSHA TOXIC AND HAZARDOUS SUBSTANCE EXPOSURE STANDARD	X	X	X	NEGATIVE
DEPARTMENT OF COMMERCE	• GENERAL AGREEMENTS ON TARIFFS AND TRADE (GATT)	X	X	X	NEGATIVE
	• ARRANGEMENT REGARDING INTERNATIONAL TRADE IN TEXTILES (MFA)	X	X	X	NEGATIVE
DEPARTMENT OF TREASURY	• RULES AND REGULATIONS UNDER THE ANTIDUMPING ACT, 1921	X	X	X	POSITIVE
	• RULES AND REGULATIONS UNDER THE TARIFF ACT, 1930	X	X	X	POSITIVE
CONSUMER PRODUCT SAFETY COMMISSION	• STANDARDS UNDER THE FLAMMABLE FABRICS ACT, 1953	X	X	X	NEUTRAL
DEPARTMENT OF DEFENSE	• SPECIFICATIONS AND REQUIREMENTS FOR MILITARY CLOTHING	X	X	X	NEGATIVE
DEPARTMENT OF ENERGY	• POWER PLANT AND INDUSTRIAL FUEL USE ACT	X	X	X	NEUTRAL
	• NATURAL GAS POLICY ACT	X	X	X	NEUTRAL
	• ENERGY TAX ACT	X	X	X	NEUTRAL
	• NATIONAL ENERGY CONSERVATION POLICY ACT	X	X	X	NEUTRAL

5.2 GOVERNMENT POLICY CHANGES COULD ENCOURAGE MATERIALS RECOVERY

This section discusses the changes or modifications to existing governmental policies that could encourage the use of recovered materials. Of course, government policy is only one aspect of the situation, and changes within the industry itself would also have to occur. Some of these changes noted below have already been attempted and were unsuccessful.

5.2.1 EPA Rules and Regulations on Hazardous Waste Management, Effluent Guidelines, and Pretreatment Standards

The EPA should consider setting up grants or subsidies to help support the installation of pollution control equipment for industries that practice materials recovery or reuse of waste material. This would help the industry in its increasing need for capital and would encourage the use of materials recovery technology.

5.2.2 FTC Rules and Regulations Under the Wool Products Labeling Act

Investigations should continue on the need to repeal or amend those provisions of the act that discriminate against the use of reused or reprocessed fibers. Perhaps a better definition of wool quality could be developed to include fiber length, strength, and color, rather than classifying fibers by origin or history. This would serve to increase consumer acceptance of secondary wool products and provide an impetus to the resurgence of the wool reprocessing industry in the United States.

5.2.3 OSHA Cotton Dust Standard

Increasing the exposure limit from 0.2 mg/m^3 to 0.5 mg/m^3 would significantly reduce the capital required by the industry to meet the cotton dust standard. Total installed costs would drop from about $2.5 billion to $255 million and total annualized costs would go from about $695 million to $83 million. OSHA has considered this issue several times.

5.2.4 OSHA Noise Standard

Complying with the OSHA 85 decibel noise standard using engineering controls rather than hearing protection devices will place quite a strain on available capital in the textile industry. The standards are effectively in place, and the only feasible policy change that could lessen their impact would be to lengthen the compliance period, thus spreading the costs out over time. Little can be done to lessen the impact of this act except substantially increasing the permissible noise levels, and that appears unlikely in light of the previous stand taken by OSHA.

5.2.5 Department of Commerce Policy Changes

Action should be taken to reverse the escalating import trade balance for textiles, including wastes. Increased U.S. textile export levels should be pursued, and increased tariffs on imported textile goods should be implemented. Of course these steps cannot be done independently, and many other considerations of international trade need to be evaluated before these actions are implemented. Specifically, with regard to waste materials, steps should be taken to encourage the use of domestic wastes to supply the markets that are currently being served by wastes from foreign manufacturers.

5.2.6 Department of Defense Policy Changes

Modifications to current government procurement policy should be considered. The policy could be changed to require or encourage the use of secondary materials in military clothing without sacrificing adherence to performance specifications. Efforts should be increased to eliminate the prohibitions against the use of reused fibers in military textiles.

* * * *

This chapter has described the governmental regulatory environment in which the textile mill products industry operates and has outlined the impact of government actions on the use of recovered materials. In addition, suggestions have been made for modifying existing regulations in order to enhance the use of recovered materials. Current levels of recycling in the textile mill products industry are discussed in the next chapter.

6. CURRENT USE OF RECOVERED MATERIALS IN THE TEXTILE MILL PRODUCTS INDUSTRY

One indication of the importance of recovered materials and by-products in the U.S. textile mill products industry (SIC 22) is the fact that one subsector of the industry (SIC 2294) is currently given over to waste products. However, the use of primary or secondary waste in the fabrication of first tier textile products is limited because there is no known or anticipated technology for processing either. The use of secondary waste is minimal, but the small amount used, as well as most primary textile waste, is consumed by the second tier textile industries (furniture padding, nonwovens, etc.). A small amount of recycling of textile fibers is done in foreign countries; however, the resulting products are unacceptable for the U.S. market and the practice is declining. These factors are discussed in the sections that follow.

6.1 MOST U.S. TEXTILE MILL WASTE IS CURRENTLY RECYCLED, BUT MAJOR SHIFTS IN WASTE GENERATION AND USE ARE ANTICIPATED

Given its low profit margin, the textile mill products industry requires mills to use input materials to their fullest. One way of meeting this requirement and, consequently, reducing waste is to choose fibers which most efficiently provide the characteristics demanded by customers. For example, a mill producing fine-combed cotton yarn tries to purchase cottons with a high percentage of long fibers and with a minimum of short or waste fibers. This reduces waste, but even with a continuous material control program, waste can still be a significant part of the cost of any textile production operation.

Another way to reduce material costs is to reintroduce reworkable fibrous waste back into the process. In some instances, more than half of the waste generated in a plant is used in this manner. In the textile mill products industry this consists of the fibers, sliver, and roving mill-ends that have had no appreciable twist imparted to them. These wastes are generated through normal process operations and are not a regular output of the process.

The textile mill products industry reduces the quantity (as well as the quality) of the generated primary waste through waste control programs. This is done by shifting waste from higher quality first tier mills to lower quality first tier mills (see Figure 6-1). This type of waste control is most often practiced within large and diversified textile companies, although some nonrelated mills also ship their primary waste directly to other first tier mills.

In order to study the use of recovered materials, the American Textile Manufacturers Institute (ATMI) surveyed those of its members that use more than 1 trillion Btu's of energy per year. Table 6-1 gives the results of the survey. A flow diagram is shown in Figure 6-2. The survey covered installations that account for 25 percent of all fibrous materials purchased by the industry and processed in its 7,000 plants.

The average textile mill that uses blended fibers generates primary waste that amounts to between 12 and 16 percent of the total fiber processed. However, after inter- and intra-mill waste utilization programs are carried out, these figures are reduced to about 7.5 percent. Of the 7.5 percent, 6.8 percent is shipped to reprocessors or to second tier operations of other companies, and about 0.7 percent, consisting of short, oily fibers and carpet trim waste is discarded in landfills.

If the survey results are extended to the entire industry, total waste leaving the first tier textile mills in 1978 is estimated to be between 800 million and 1 billion pounds. As indicated in the survey, most of this waste was reprocessed and used by second tier textile operations, with only about 0.7 percent (about 100 million pounds) not being used at all. In general, this unused material was discarded in landfills.

The discarded waste that goes unused is composed of very short fibers (generally less than 0.25 inches) that are contaminated with machine oil, the extremely short fibers from shearing operations (corduroy, toweling), and carpet trim waste that has been structurally changed by the addition of latex backings. The textile producers and waste dealers have not as yet found a method for processing these discarded fibers, although the possibility of burning some types as boiler fuel is being studied. Two textile companies are currently burning shearing waste in boilers to reclaim some of the heating

FIGURE 6-1
Flow of Waste Within the Textile
Mill Products Industry

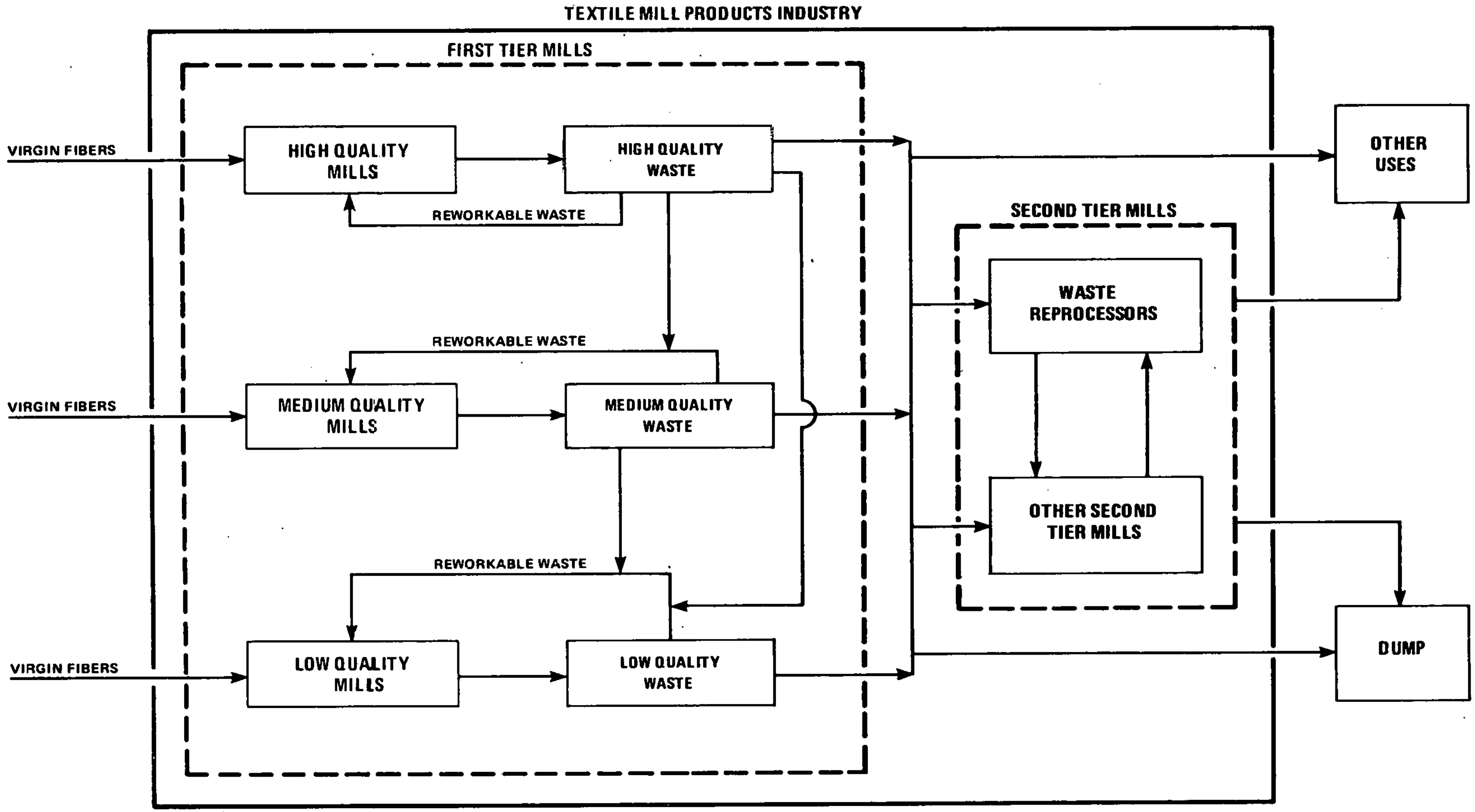
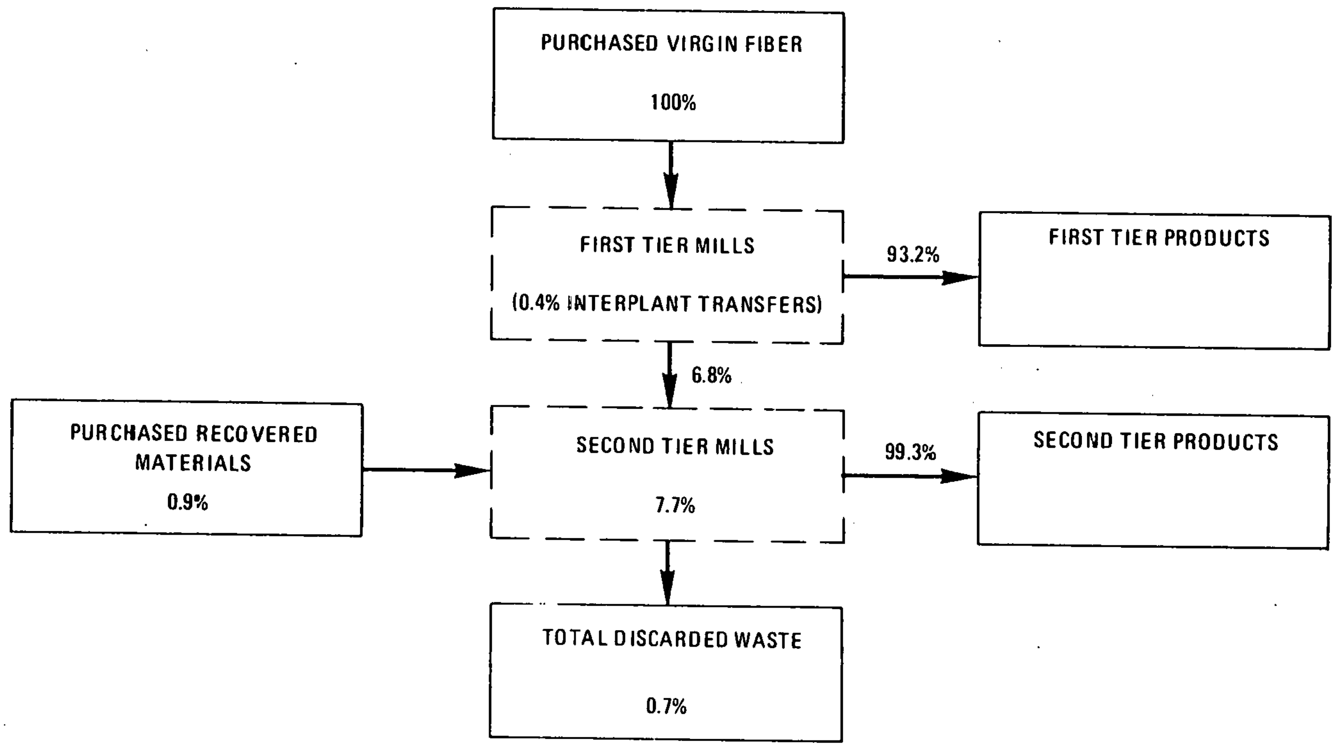


TABLE 6-1
Representative Yearly Materials Flow in the Textile Mill Products Industry*

ITEMS REPORTED IN SURVEY	POUNDS	PERCENT OF SURVEY TOTAL
• TOTAL PURCHASED INPUT OF FIBER, YARN AND FABRIC	3,662,860,351*	100.0
• TOTAL PURCHASED RECOVERED MATERIALS	33,823,076	0.9
• TOTAL RECOVERED MATERIALS SOLD AS BY-PRODUCTS	251,181,137	6.8
• TOTAL RECOVERED MATERIALS TRANSFERRED FROM PLANT TO PLANT (REWORKABLE WASTE)	16,327,154	0.4
• TOTAL DISCARDED WASTE (VERY SMALL AMOUNT BURNED IN BOILERS)	27,234,295	0.7

* SURVEY REPRESENTS OVER 25 PERCENT OF ALL MATERIAL PURCHASED BY THE 7000 TEXTILE PLANTS IN THE INDUSTRY. THE SURVEY WAS MADE IN 1979 BY THE AMERICAN TEXTILE MANUFACTURERS INSTITUTE.

FIGURE 6-2
Typical Waste Flow in the Textile Mill Products Industry



value. The Dalton (Georgia) Utility District is also evaluating the possibility of using carpet trim waste in a central boiler to produce steam, but similar trials have not been economically successful because of the low energy value of the waste material.

Only a small portion of the waste dumped throughout the industry is salable primary waste. The dumped waste is not used primarily for economic reasons, particularly transportation costs. If a mill is geographically distant from the potential uses of the waste, the low value of the waste is quickly offset by high transportation costs. Three factors, then, cause waste to be dumped:

- Low quality of the waste as in the case of short contaminated fibers
- Technological limitation on reprocessing, as in the case of carpet trimmings and other contaminated textiles
- High transportation and reprocessing costs.

Some waste produced by the first tier of the textile mill products industry is used directly by other industries that manufacture nontextile products. Generally these industries buy specific types of waste and are large enough to have their own reprocessing facilities. Examples include the paper industry and some sectors of the automotive industry. First level textile waste is also used by companies engaged in manufacturing, roofing, flooring, and by companies producing wiping cloths and other secondary fabrics.

The use of the waste is primarily based on economic factors such as the following:

- Price offered for the waste
- Cost and length of storage
- Transportation cost.

Noneconomic factors also help determine how the waste is used. These include considerations such as the following:

- Long term contractual relationships with customers
- Established relationships with customers
- Restricted use of the particular waste.

The volume of waste going from the first tier of the textile mill products industry to other industrial areas is difficult to determine. However, numerous interviews with leading textile industry experts indicate that the amount is less than 20 percent of the total waste generated.

Assuming that approximately 150 million pounds of generated waste are sold outside the textile mill products industry and 100 million pounds are discarded in landfills, the second tier textile mills consume an estimated 550 to 750 million pounds of waste generated by the industry (see Table 6-2). This accounts for 4 to 6 percent of the total fibers consumed by the industry.

A large portion of the waste generated by first tier textile mills is reprocessed by the waste reprocessing sector of the textile mill products industry (SIC 2294). This sector is involved in the reprocessing, sorting, blending, and warehousing of waste. It obtains revenues primarily from the mechanical operations of reprocessing; however, the waste reprocessors also act as waste merchants or brokers between waste-producing mills and buyers of waste. This is usually done through "blind shipments," the waste being picked up from the mill by the shipper and transported to the buyer.

Because of the increased use of waste control in first tier mills and the expanded use of synthetic fibers (which result in less waste) the supply of waste has not grown at the rate of fiber production. The demand for pure waste or unblended waste far exceeds the amount generated by the mills. To fill this gap, reprocessors are relying increasingly on other sources (see Figure 6-3).

Since waste reprocessors are generally equipped to recycle only waste that is in an untwisted or unwoven state (roving, sliver, etc.) the shift to other sources of supply will require investment in more sophisticated machinery capable of reducing fabric or yarn into fiber. For most reprocessors, investment in new reprocessing equipment will be directly influenced by the pollution control requirements such as the OSHA cotton dust standard (see Chapter 5). Many reprocessors have already shifted their financial resources to meet federal requirements and have postponed investment in new equipment. There are also indications that some reprocessors may not be able to raise enough capital to meet the OSHA standards. If they

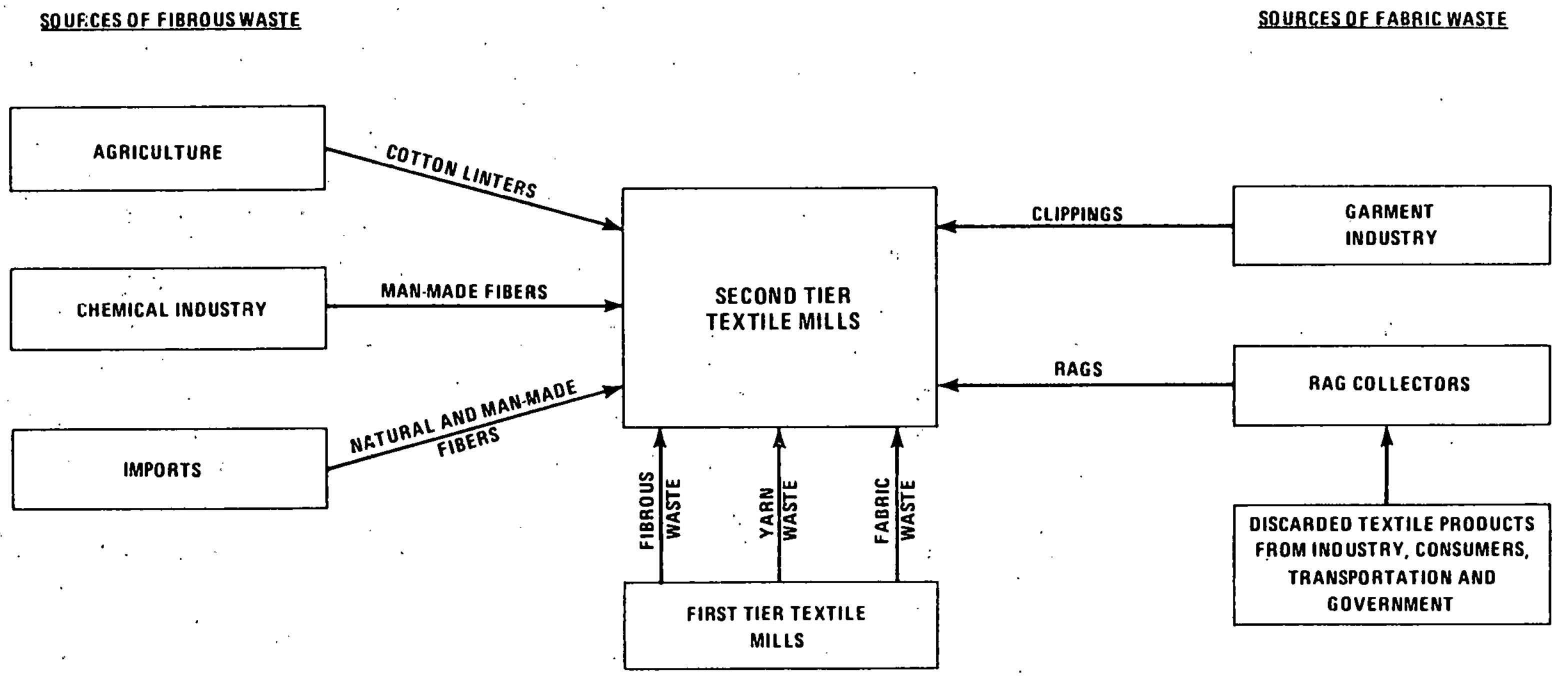
TABLE 6-2
Use of Waste in the Textile Mill Products Industry

CONSUMING SECTOR ITEM	POUNDS (MILLIONS)	PERCENT OF TOTAL WASTE GENERATED
• DISCARDED TO LANDFILL	100,000	13 - 10
• SOLD TO OUTSIDE INDUSTRIAL SECTORS	150,000	19 - 15
• CONSUMED BY THE SECOND TIER TEXTILE MILL PRODUCTS INDUSTRY	550,000 - 750,000	68 - 75
TOTAL WASTE GENERATED	800,000 - 1,000,000	100 - 100

NOTE: IT IS ESTIMATED THAT ABOUT 350 000,000 POUNDS OF THE TOTAL WASTE GENERATED ARE REPROCESSED THROUGH WASTE DEALERS BEFORE BEING UTILIZED BY THE SECOND TIER OF THE TEXTILE INDUSTRY.

FIGURE 6-3

Sources of Waste for the Second Tier of the Textile Mill Products Industry



have limited financial resources, reprocessors must either cease reprocessing cotton waste and shift to man-made fiber reprocessing or stop operations altogether. The long-term effects of the shift in supply and of the new environmental controls are unmeasurable; however, several reprocessors indicated that the above-mentioned changes will certainly make waste less competitive, resulting in a shift in demand from recovered to virgin fibers.

6.2 CHANGING WORLD ECONOMIC CONDITIONS ARE CAUSING A DECLINE IN THE USE OF RECOVERED TEXTILE MATERIALS

The U.S. textile industry is not currently using reprocessed materials primarily because of the high quality requirements placed on it by the U.S. consumer. Unlike consumers in many less-developed countries, the American consumer demands a very high quality textile product. To achieve this quality, it is often necessary to treat textile products with various irreversible finishing processes (see Chapter 7).

Apparently, the technological obstacles to producing such high-quality goods from contaminated textile waste are presently insurmountable. The waste fibers are contaminated by the various textile processes, garment fabrication processes, and consumer wear and care. Many of these processes have irreversible effects and cause the material to be unmarketable.

The standard of living enjoyed by U.S. consumers is strikingly different from that for consumers in less-developed countries. This difference partially accounts for the difference in market response to textile products manufactured from reprocessed materials. A direct relationship has been found to hold between the level of economic development and the quantity of utilized reprocessed material. This relationship is evident in the the United States and in many European countries as well. Until 1945, textile waste reprocessing was widespread on both continents, especially in woolen goods. Since 1945 and the end of World War II, reprocessing in the U.S. has drastically declined. Most European countries have also stopped using reprocessed materials in their first tier textile mill products industries as indicated by recent reports from the Organization for Economic Cooperation and

Development (OECD). The OECD's analysis of textile reprocessing in Denmark summarized the consumer response to reprocessed materials as follows:

> "The small-scale post-war industries based on used textile products have vanished long ago, as a product manufactured from waste material has little chance of meeting the quality standards now stipulated."[10]

The economic structure of the U.S. textile mill products industry is also considerably different from those of textile industries in countries that use waste for first tier textile products. Some foreign textile industries enjoy monopolistic environments quite unlike the highly competitive condition under which their U.S. counterparts operate. The U.S market situation necessitates a high degree of compliance with consumer demands.

U.S. and foreign markets also differ significantly in labor costs. The U.S. textile worker enjoys far better wages and benefits than his counterpart in Spain or Italy (countries that still make use of reprocessing). This makes the American textile product more labor-cost intensive and less suceptible to changes in the price of textile fibers. In the U.S., this labor cost difference also further reduces still further the benefits attainable from less expensive waste materials. The labor intensive nature of recycling, which involves such activities as hand sorting and grading, makes the economics of reprocessing far less attractive in a high labor cost environment. The effect of rising labor costs on textile waste reprocessing is described in an OECD international report, as follows:

> "For some years past, the recovery of textile fibers for spinning has greatly declined in Belgium, owing to the high level of wages and the use of ultra-rapid spinning machinery which can only work with new raw materials."[10]

The American waste collecting infrastructure does not provide a large amount of post-consumer waste. In the earlier part of the 20th century, this was not true, and the push-cart, rag collector's call was a common occurence. These services are no longer available though limited collecting of post-consumer garments is done by some charitable organizations. The loss of the independent collector infrastructure was brought about by the following events:

- Social changes, such as public assistance, made rag collection unattractive.

- Local licensing requirements made it more difficult to collect and peddle rags.

- Enactment of the Wool Labeling Act eliminated the rag collector's most valuable market.

- Development of blended yarns caused a change in the fiber content of the garments, causing fabrics made from such yarns to be unsuitable for certain applications. This further reduced the economic incentive for collection.

- Changes took place in the disposal habits of the consuming public. Textiles now are often downgraded into rags for home use, further reducing their economic value.

6.3 RECOVERED MATERIALS ARE SOMETIMES USED IN TEXTILE INDUSTRIES OUTSIDE THE UNITED STATES

Textile industries in some foreign countries reuse primary textile waste, waste by-products, and secondary (post-consumer) waste in lower quality textile products. In Europe, wool is graded, broken down into fibers, and respun into low-end blankets and some clothing, as well as occasionally being exported to the United States. For example, low quality blankets containing reused wool are sometimes purchased by the Red Cross. Some sweaters made with a portion of reprocessed wool fibers are sold through the discount stores in this country. However, the production of goods with recycled fibers does not include first quality garments. The shorter fiber length and the degradation of the fiber material through use and the unspinning and unweaving processes made the producing of first quality goods impossible. Products made from recycled fibers, while acceptable in certain foreign markets, do not compete well with 100 percent virgin wool products produced in this country.

Other fibers are also reprocessed in foreign countries. The 100 percent cotton T-shirt cuttings from Japan have been broken down into basic fibers and rewoven into second- quality fabrics in Spain on slow-running processing and weaving machines. This is economically feasible for a number of reasons:

- The labor rates are lower, allowing for lower unit costs of production.
- The collection and grading infrastructure for secondary waste is better developed, allowing favorable selection and use of garments.
- Restrictive labeling laws are not as prevalent, allowing a higher percentage of reused materials to be used in garments with little or no labeling required.
- Processing equipment is relatively inefficient, and consistent operation is not a prime consideration for economic existence.
- Additional capital expenditures to meet environmental or industrial safety standards are not required in many foreign countries.

These factors all combine to allow the foreign recycling industries to produce garments and products that are accepted and economical in their markets. These same items would be generally unacceptable in the U.S. market.

6.4 THE USE OF RECYCLED MATERIALS FOR PRODUCING FINISHED GOODS OCCURS MOSTLY IN THE SECOND TIER OF THE TEXTILE MILL PRODUCTS INDUSTRY

The second tier subsectors of the textile mill products industry are the major users of the primary waste and by-products generated in the manufacture of textile products. The waste is often purchased directly from the fiber producers (chemical companies outside the textile industry) and from various segments of the textile industry (see Figure 6-4). The types of waste used by each of the second tier producers are discussed in the following sections.

FIGURE 6-4
Sources of Recovered Materials for Textile Industry Subdivision Utilizing Recovered Materials

KEY:
● SOURCE
BLANK NO RECOVERED MATERIALS UTILIZED

SIC	TEXTILE INDUSTRY SUBDIVISIONS: SUBDIVISION	SOURCES OF RECOVERED MATERIALS: SIC 2211	SIC 2221	SIC 2231	SIC 2241	SIC 2251	SIC 2252	SIC 2253	SIC 2254	SIC 2257	SIC 2258	SIC 2259	SIC 2281	SIC 2283	SIC 2284	SIC 2291	SIC 2292	SIC 2294	SIC 2296	SIC 23 (APPAREL INDUSTRY)	POST CONSUMER WASTE
2211	BROAD WOVEN FABRIC MILLS, COTTON																				
2221	BROAD WOVEN FABRIC MILLS, MAN-MADE FIBER & SILK																				
2231	BROAD WOVEN FABRIC MILLS, WOOL			●										●							
2241	NARROW FABRICS, COTTON, WOOL, SILK & MAN-MADE																				
2251	WOMEN'S FULL-LENGTH AND KNEE-LENGTH HOSIERY																				
2252	OTHER HOSIERY																				
2253	KNIT OUTERWEAR MILLS																				
2254	KNIT UNDERWEAR MILLS																				
2257	CIRCULAR KNIT FABRIC MILLS																				
2258	WARP KNIT FABRIC MILLS																				
2259	KNITTING MILLS, N.E.C.																				
2261	BROAD WOVEN FABRIC FINISHERS, COTTON																				
2262	BROAD WOVEN FABRIC FINISHERS, SILK & MAN-MADE FIBER																				
2269	TEXTILE FINISHERS, N.E.C.																				
2271	WOVEN CARPETS & RUGS																				
2272	TUFTED CARPETS & RUGS																				
2279	CARPETS & RUGS, N.E.C.																				
2281	YARN SPINNING MILLS, COTTON, SILK, MAN-MADE FIBERS																				
2282	YARN TEXTURIZING, COTTON, SILK, MAN-MADE FIBER																				
2283	YARN MILLS, WOOL			●										●							
2284	THREAD MILLS																				
2291	FELT GOODS, EXCEPT WOVEN FELTS & HATS	●	●	●	●										●			●			
2292	LACE GOODS																				
2293	PADDINGS & UPHOLSTERY FILLING	●	●		●										●			●		●	
2294	PROCESSED WASTE & RECOVERED FIBERS & FLOCK	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●		●	●	●
2295	COATED FABRICS, NOT RUBBERIZED																				
2296	TIRE CORD & FABRIC																				
2297	NONWOVEN FABRICS	●	●		●										●			●			
2298	CORDAGE & TWINE																	●	●		
2299	TEXTILE GOODS, N.E.C.																				

A very broad classification of waste has been used to completely document the waste and by-product flows throughout the industry. Any material considered off-quality or unusable in one sector is classified as a waste by-product if it can be used in another sector. For example, 100 percent virgin tire yarn is classified as primary waste if it is used in the manufacture of cordage after being rejected by the tire cord industry because of a slight variation in size. The material has not been reprocessed or altered in any way, but it is still considered a recycled product.

Some of the second tier textile industries can use off-quality or reprocessed material in products hidden beneath other layers of fabric. The material is not required to exhibit the consistency in color or texture required of the outerwear produced in the first tier of the industry. This eliminates many of the problems associated with dyeing, finishing, and weaving of recycled fibers.

The segments included in the second tier of the textile industry, classified by end product, are as follows:

- Felt goods, except woven felts and hats (SIC 2291)
- Paddings and upholstery filling (SIC 2293)
- Tire cord and fabric (SIC 2296)
- Nonwoven fabrics (SIC 2297)
- Cordage and twine (SIC 2298).

Since these groups are defined according to the Standard Industrial Classification system, the categories are broad and include a variety of finished products (see Appendix B). The following sections discuss current recycling in each of these subsectors.

6.4.1 Felt Goods, Except Woven Felts and Hats (SIC 2291)

A significant portion of pressed felt goods is produced with recycled fibers. The primary source of this material is the textile waste sector (SIC 2294). The felts, used in automobiles (for soundproofing and insulation) under carpets, as padding, etc.) are generally not visible. Consequently, the color of the material is unimportant and slight variations in texture, including knots, lumps, different sized fibers, and gaps in the material, are often acceptable. Because most felts are produced for nonvisible use, they include high percentages of recycled waste. The waste used includes synthetic and natural fibers that are chopped, shredded, opened, or picked into a fibrous state. Through the application of heat, moisture, and pressure, these fibers are formed into a pressed felt.

6.4.2 Paddings and Upholstery Filling (SIC 2293)

Padding and upholstery filling are composed primarily of recycled materials. The padding, exclusive of the foams produced by the chemical industry, is usually chopped, picked, or garnetted waste from the textile mills or the waste by-products dealers. This material is used as stuffing in sleeping bags, beds, pillows, upholstery, and similar objects. Properly prepared reprocessed fibers are fluffy and inexpensive; and, since they are not visable in use, their color is not generally an important consideration. Certain applications may require a bleached product, but the color need not be as consistent as it is in the apparel trade. A certain amount of padding sometimes contains virgin fibers when a consistent feel is required and cannot be achieved using a waste product. When flame retardation is required, a layer of virgin polyester is often used as a flame barrier, or the padding may be chemically coated to resist burning.

6.4.3 Tire Cord and Fabric (SIC 2296)

The makers of tire cord and fabric have very high strength and durability requirements. The cord and fabric constitute only a small part of the total value of the finished tire, so the savings that might be realized through the use of recycled or off-quality fibers are not a significant factor. In addition, the Department of Transportation requires product quality and consistency which reinforces the stringent internal company standards. This causes the industry to reject even a certain portion of the virgin tire yarn produced. Rejection could occur for a number of reasons, including failure to meet specifications on elongation, tensile strength, or shrinkage. In fact, if even the fugitive tint is wrong (the color used to identify a certain size or quality of fiber), the fiber will be rejected, even though its other properties are acceptable. These factors all tend to discourage the use of any recycled or off-quality fibers in this subsector.

6.4.4 Nonwoven Fabrics (SIC 2297)

Some nonwoven fabrics consist of recycled fibers. Certain nonwovens are used in padding and insulation where color is not as important as product density or thickness. Nonwovens used in automobile headliners and low-end sleeping bags need not meet the same fashion and feel requirements that nonwovens used in outerwear must meet. For this reason, the use of various natural and synthetic comber and thread waste is acceptable.

Spun bonded nonwovens must contain only virgin fibers because of the nature of the manufacturing process (extrusion of fiber from raw pellets or chips of synthetic materials). However, various other processes can readily accept by-products. Recycled fibers are not used in diapers, sanitary pads, and surgical gowns, because requirements for cleanliness and purity are quite stringent as are the labeling requirements of the Medical Devices Act.

6.4.5 Cordage and Twine (SIC 2298)

Cordage and twine produced in the United States contains a large amount of off-quality or reprocessed waste.

The tire yarn rejected by the tire cord and fabric industry is considered a waste by-product when used in this subsector even though it is 100 percent virgin material. The use of other recycled staple and natural fibers, such as jute and sisal, also occurs in the production of cordage and twine. This is done when high strength is not required in the final product.

The by-products industry is active in the preparation of these waste materials. Mop yarn and lower quality clothes lines are often produced from a high percentage of recycled fibers. The segment of the industry that produces cordage for marine applications and other uses where high strength is a necessity, uses some rejected tire yarn, but relies more heavily on first quality material.

* * * *

This chapter has discussed how recovered materials are currently used in the textile mill products industry. The following chapter discusses the factors that limit recycling, confining it to the relatively low level of activity found in the United States today.

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7. LIMITATIONS ON THE USE OF RECOVERED MATERIALS IN THE U.S. TEXTILE MILL PRODUCTS INDUSTRY

Limitations on the reuse of textile fibers and yarn are created in part by stringent demands for product quality and by requirements that the products have certain characteristics. Satisfactory products result when the various elements of the spinning, weaving, and finishing processes are closely controlled. Some of the elements that must be controlled are as follows:

- The quantity of short, immature, natural (cotton or wool) fibers in the basic yarn
- The quantity, type, merge, and lot number of man-made fibers included in blended yarns and fabrics
- Various processes that irreversibly change the character or chemical/physical makeup of fibers and yarns, particularly man-made fibers and continuous filament.

The following paragraphs describe how these elements can affect the use of recovered materials in the textile mill products industry.

The picking, carding, and combing operations in the initial stages of the spinning process remove foreign matter, align fibers, and remove shorter and undesirable fibers. Natural cotton fibers are up to 1-5/8 inches long. For first tier quality yarn, fibers less than 7/8 inch in length are removed. These shorter fibers tend to lend a bulkiness and uneven surface to the resulting yarn and fabric, giving them undesirable strength, feel, appearance, and dyeability characteristics. In some lower quality goods these shorter fibers are permissible, but most of the fibers are relegated to the second tier of the industry. Some very fine cotton products (combed cotton) have additional fibers combed from the sliver to give a lustre or high sheen to the final fabric. Yarn and fabric are tested extensively to control the quantity of these short fibers. This is done on a continuous basis by both the textile mill and the intermediate customer (apparel, government, or chain retailers).

Currently and in the foreseeable future, there are no technologies available to reduce yarn or fabric waste to the fiber form without producing a predominance of very short fibers (1/4 inch or less). (Yarn and fabric waste are the major non-reworkable primary and secondary wastes available for reuse in the textile mill products industry.) Using fibers reclaimed from yarn or fabric waste or from secondary waste to produce first tier products would result in products with inferior characteristics and would be unacceptable to intermediate and final consumers. Some yarn from these types of fibers is respun in Southern Europe and the Far East, but the resulting fabrics are unacceptable for the U.S. market. Problems with short fibers severely limit the use of yarn or fabric waste and secondary waste as recovered materials in the textile mill products industry.

Continual development and product improvement in the textile mill products industry led to the extensive use of man-made fibers and continuous filament in the manufacture of textile products. These man-made fibers and filaments (polyester, nylon, acrylic, etc.) expand the versatility of the final product, because the man-made fibers have a wide variety of possible characteristics, depending on the following:

- Basic chemical composition
- Variations applied to the chemical composition
- Processing methods for the basic fiber and filament, including texturizing
- Dyeing and finishing processes
- Types of dye stuff and auxiliary chemicals used.

Various blends of cotton, wool, and man-made fibers can give the intermediate and final consumers almost any fiber characteristic desired. This is done on a continuous basis as processors try to generate a growth segment of the market or to gain brand identification in a highly competitive industry. Many textile firms have 200 or more blends that they fabricate for specific customers.

The existence of the extremely large number of blended yarns and fabrics and the sensitivity of the man-made fibers and filament to process changes limit the possible reuse of primary and secondary waste to make first tier products. Since the man-made fibers and filament are so sensitive to process changes, the chemical and textile mill products industries carefully control their production. The fibers and filament are so sensitive to change that a merge number is assigned to each process set-up in a fiber plant. Any time a process change of any kind is made, the merge number is changed. The producer specifies processes, dyestuffs, and auxiliary chemicals and guarantees dyeability within a merge. Shipments or orders to a customer are assigned a lot number within a given merge. Merge numbers and lot numbers are seldom mixed because of the likelihood that yarns and fabrics would not be consistent.

Natural and man-made fibers are also carefully controlled at the textile mill. As mentioned, lot numbers and merge numbers of man-made fibers are seldom mixed. Cotton fibers, which arrive by numbered bale, are tested for maturity and fiber length distribution (micronaire). During the blending process, several bales with averages at the desired micronaire level are mixed layer by layer to give as much consistency as possible. In the blending of 60/40 cotton, man-made fiber, the fibers are measured in 60- and 40-ounce increments to help ensure consistency. One facility receives continuous filament yarn at the rate of a truckload per day. The yarn is mixed from three consecutive truckloads, all within the same lot number and merge number, in order to improve the yarn's consistency.

Examination of records made available to those preparing this report indicated that the major cause of customer claims against the textile mill products companies is variation in color shade (level) and dyeability failures. Laboratory reports indicated several causes for these failures predominate:

- Dyeability variation in a yarn of fixed chemical composition, type, merge number, and lot number.

- Inconsistency in blends. Differences as small as 0.2 percent of the total composition can cause variations in the dyed fabric or yarn.

- Traces of another man-made fiber in the specified fiber can cause different dye characteristics.

Many of the processes to which natural and man-made fibers, yarn, and fabrics are subjected are irreversible. This position is maintained by polymer chemists in universities and industry alike. For example, the twist imparted to yarn for strength during the spinning process is permanent once the fiber passes through subsequent dyeing and finishing processes. This is particularly true of man-made fibers after the heat-setting treatment, which all of them undergo.

These irreversible processes essentially modify the chemical/physical structure of the fibers so that their performance characteristics change. Therefore, a fiber is likely to have a set of characteristics in its second processing much different from the set it had in its first processing. This imposes a tremendous limitation on the reuse of any textile yarn or fabric, particularly secondary or post-consumer waste. Even though the Textile Labeling Act requires identification of fiber blends, small percentages are grouped and the indications are too imprecise for the textile processor. Additionally, making a first tier product requires knowing the precise fraction of each fiber present. For man-made fibers, the fiber manufacturer, merge number, and lot number must also be known, and it must be possible to use this information to achieve the desired blend. For economics, it would be required that sufficient quantities of the fiber by lot number and merge number be available to operate the textile mill. All of these items impose severe limitations on the use of recovered materials in the textile mill products industry. These various factors are discussed further in the sections that follow.

7.1 THE QUALITY OF TEXTILE PRODUCTS GOVERNS THEIR MARKETABILITY

As indicated in Table 7-1, the textile mill products industry ships its products to three primary markets:

- Apparel industry (apparel fabric)
- Direct retail outlets (home furnishings and other consumer products)
- Export market.

The major customers of the industry are the apparel industry and retail chains. The quality and product characteristics demanded by these intermediate customers

TABLE 7-1
Total Textile Industry Fiber Consumption by End Use

	TOTAL CONSUMPTION OF ALL FIBERS			TOTAL COTTON FIBER CONSUMPTION			TOTAL WOOL FIBER CONSUMPTION			TOTAL MAN-MADE FIBER CONSUMPTION		
	1971	1973	1976	1971	1973	1976	1971	1973	1976	1971	1973	1976
TOTAL END USE CONSUMPTION (IN MILLIONS OF POUNDS)	10,619	12,491	11,744	3,933	3,743	3,516	261	221	163	6,425	8,527	8,065
APPAREL	4,687	5,326	4,940	1,857	1,762	1,737	162	134	116	2,668	3,420	3,087
HOME FURNISHINGS	3,340	3,900	3,545	1,230	1,092	941	85	53	33	2,025	2,755	2,571
OTHER CONSUMER-TYPE PRODUCTS & INDUSTRIAL USES	2,341	2,839	2,757	696	669	571	8	9	7	1,637	2,161	2,179
EXPORTS OF DOMESTIC PRODUCTS	251	426	502	150	220	267	6	25	7	95	181	228

determine the type and quality of products produced. The apparel industry is a good example of the control exercised by the intermediate consumer.

7.1.1 Economic Importance of the Apparel Industry

The following points make clear the size and economic importance of apparel manufacturing:

- It ranks sixth in the number of manufacturing facilities, with 15,000 firms and 16,000 plants.
- It is the third largest employer of manufacturing workers (after food and automotive), with 1.3 million employees.
- It is the third largest consumer industry, having a projected $40 million wholesale volume for 1979.
- The industry consumes over 40 percent of the total output of the textile mill products industry.

The apparel industry has tremendous influence on the textile mill products industry and tries to persuade that industry to conform to its requirements and specifications. Also, the competitiveness of the textile mill products industry allows the apparel industry to move from one company to another with relative ease. The textile companies are eager to keep accounts, and their extreme reluctance to lose business to a competitor tends to keep a downward pressure on prices and an upward pressure on quality.

The results of this situation are indicated in Table 7-2, which shows a typical cost structure for a U.S. apparel manufacturer. Net income is approximately 2.5 percent of net sales; however, returns, allowances, and discounts which go back primarily to the textile mill products industry, are 5 percent. With the low profitability of the industry, twice the industry's net income is provided by returned goods, indicating the importance of quality and acceptable characteristics to the apparel industry.

7.1.2 Seasonal Impact on Apparel Industry

Time and season have important effects on the apparel industry. The purchasing, manufacturing, sales, and shipment of apparel items are all strongly influenced by

TABLE 7-2
Costs for a Typical U.S. Apparel Manufacturer

	AVERAGE
GROSS SALES	105.0%
RETURNS, ALLOWANCES, DISCOUNTS	5.0
NET SALES	100.0%
FACTORY COST OF GOODS SOLD:	
BODY GOODS, LINING AND TRIM	40.8[1]
OTHER MATERIALS USED	6.6
DIRECT LABOR	17.0[2]
INDIRECT LABOR	2.7
ALL OTHER FACTORY COSTS	9.9
TOTAL FACTORY COST OF GOODS SOLD	77.0%
SHIPPING AND SELLING EXPENSES	12.1[3]
ADMINISTRATIVE EXPENSES	5.3
TOTAL OPERATING COSTS	94.4%
OPERATING PROFIT BEFORE TAXES AND OTHER INCOME/EXPENSES	5.6
NET INCOME AFTER TAXES	2.5%

[1]MATERIAL IS ROUGHLY 40% OF COSTS
[2]CUTTING LABOR IS ± 1% OF COSTS (ON A COMPOSITE AVERAGE)
[3]SHIPPING LABOR LESS THAN 1% OF COSTS (ON A COMPOSITE AVERAGE)

seasonal fluctuations in consumer demand and buying preferences. Table 7-3 gives the separate marketing seasons in apparel.

Currently, the average men's wear manufacturer has two to three marketing seasons each year, and the average ladies' wear manufacturer has five to six such seasons per year. The trend has been, and continues to be, the creation of additional marketing seasons. This shortens the amount of time available for the forecasting of sales, purchasing of fabric and trim, preparation of samples and cost data, installation of new equipment, training of employees, adoption of quality standards, and shipment of completed garments. Any analysis of the apparel industry must take this time requirement into consideration. The requirement makes it imperative that the textile mill products industry operate with high speed, efficient equipment in order to respond to rapid changes in the apparel industry's needs.

7.1.3 Trends in the Apparel Industry

During the last two decades, the apparel industry has started to polarize. About 98 percent of its companies remain small, privately-owned, and entrepreneurial, but they account for less than one-third of total shipments. The other 2 percent have grown rapidly, gone public, or been acquired by multi-industry conglomerates.

The firms in the 2 percent group have tremendous buying power. As a result, they also have the power to demand quality and specific characteristics from a textile firm. If a textile firm loses one of these major apparel companies as a customer, there is only a limited number of significant accounts among which the textile firm might find a replacement for the lost account.

As indicated in Table 7-2, fabric is the largest single cost factor for a U.S. apparel manufacturer. Normally, fabric is twice as large as labor, the next most significant cost factor. This explains why most recent technological developments in the apparel industry have been implemented in the pre-sewing functional areas such as pattern layout, cutting, etc. This also explains why so much pressure is exerted on the textile producers to provide high quality goods with specific characteristics.

TABLE 7-3
Marketing Seasons in the Apparel Industry

MONTH	BACK-TO-SCHOOL MINOR[2]	FALL MAJOR	HOLIDAY MINOR	RESORT AND CRUISE MINOR	SPRING MAJOR	SUMMER MAJOR	TRANSITIONAL MINOR
APRIL		Manufacturer's showings					
MAY	Manufacturer's showings	Manufacturer's showings					
JUNE							
JULY		Store delivery					
AUGUST	Store delivery	Store delivery					
SEPTEMBER			Manufacturer's showings	Manufacturer's showings			
OCTOBER				Manufacturer's showings	Manufacturer's showings		
NOVEMBER			Store delivery		Manufacturer's showings		
DECEMBER				Store delivery			
JANUARY				Store delivery		Manufacturer's showings	
FEBRUARY					Store delivery		
MARCH							
APRIL						Store delivery	
MAY						Store delivery	Manufacturer's showings
JUNE							
JULY							Store delivery

NOTES:

[1]THE TREND IS TO EARLIER MANUFACTURER'S OPENINGS TO ENSURE BETTER DELIVERIES.

[2]A MAJOR SEASON IN CHILDREN'S AND JUNIOR WEAR.

KEY:

MANUFACTURER'S SHOWINGS (cross-hatched)

STORE DELIVERY (diagonal lines)

Table 7-4 gives the results of a recent survey by Kurt Salmon Associates. The survey points up the proliferation of man-made fibers and their continuing influence on the apparel industry. When these fibers are blended with cotton, the resulting product has characteristics most acceptable to the apparel marketplace. It is anticipated this trend will continue to be true. Coupled with the stringent quality criteria imposed by the apparel industry on the textile mill products industry, the increased use of blended fibers will limit the ability of the textile industry to reuse recovered materials to produce first tier products.

7.1.4 Quality Control In the Apparel Industry

In the past, many apparel manufacturers placed the burden of raw material quality almost entirely on their suppliers. Often this was done without telling suppliers the product to be made or the expected end use. Now, apparel manufacturers, especially the larger firms, are purchasing by specification. The properties of the raw material affect not only its handling characteristics during production, but also the quality of the final product. Any change in the properties of the raw material will change handling methods during production, the behavior of the final product, or both. If there is to be any continuity in production and product quality from lot to lot and style to style, there must be some assurance that the raw material properties will not change. Practical specifications must therefore be set and followed for all critical raw material characteristics.

Fabric specifications must be such that the fabric can be handled with existing machinery, skills, and with no significant deviations from consumer expectations. Thus, fabric specifications fall into two categories, those governing fabric performance during garment manufacture and those governing garment performance during use.

In the first category, performance during manufacture, the fabric properties that must be specified are those that affect the following:

- Handling on the cutting table and the cutting itself
- Sewing and handling during sewing
- Garment finishing.

TABLE 7-4
Current and Projected Fiber Content in Apparel Products*

FIBER CONTENT IN APPAREL PRODUCTS	YEAR			
	1972	1976	1985	2000
COTTON	37	35	32	29
WOOL	3	2	2	2
NON-CELLULOSIC SYNTHETICS (POLYESTER, NYLON, ACRYLIC)	48	57	60	63
CELLULOSIC SYNTHETICS	12	6	5	4
OTHER	–	–	1	2

*KURT SALMON ASSOCIATES DELPHI SURVEY

In the second category performance during use, the fabric properties that must be specified are those that affect garment wear, renovation, or alteration. Actual requirements vary greatly from one product to another and must be separately determined for each end-use item. The buyer knows his requirements in detail, and the seller must know the specifications of his product in the same detail.

Fabric quality specifications generally include the following:

- Physical characteristics—weight, fiber content, count, feel (hand), type of finish, finished width, etc.
- Performance characteristics—colorfastness, shrinkage, durable press features, strength, care characteristics, flame retardant features, etc.
- Visual defects—grading system and acceptable level
- Shade tolerance variation—shade range between and within shipments, bales, or pieces
- Put-up—package type and size, piece lengths or diameters, tube type, ticket information, etc.
- Test methods or procedures—used to ensure compliance with the stated requirements.

In order to produce a quality product at a reasonable cost, the apparel industry determines raw material requirements prior to dealing with the textile mill products industry. After the requirements are set, they are communicated to the textile supplier, and the raw materials characteristics are chosen. The specifications are exactly as indicated in the Specification Data Sheet (see Table 7-5).

Reaching an agreement with a textile manufacturer on physical and performance characteristics and packaging (put-up) are generally the easiest steps in setting specifications. The areas requiring more study are visual defects and shade variation. Several systems are used by the industry to determine visual quality. Any evaluation

TABLE 7-5
Example of a Fabric Specification Data Sheet

SUGGESTED FABRIC SPECIFICATION DATA SHEET

To be prepared by fabric supplier and given to buyer at the time of sample submission.

Fabric Manufacturer: ______________________ **Contract No.:**_____ **Date:** __________
Fabric Brand Name: ______________________ **Construction Name:** ______________
Fiber Content: ______________________ **Special Finish:**______________________

YARNS:
Generic Title: ____________ **Size of Yarn(s): Warp/ Wales:**__________ **Fill/ Course:** __________

No. of turns per inch: Warp/Wales:_________ **Course/Fill:**______________________
Texture Type: Warp/Wales:__________**Course/Fill:** ______________________

Construction Description:
Warp/Wales:______________ **Course/Fill:**_________ **Finished Width** _____ ± _____
Weight: Per sq. yd.________ **oz. ±** _______**Per linear yd.**________**oz. ±** __________
End use of the fabric:______________________________________

Property	Performance Level		Test Method
	Average	Minimum	
STRENGTH: Tensile (W/F) Tear (W/F) Bursting			ASTM-D 1682-64 ASTM-D 1424-63 ASTM-D 231-62
STRETCH: (W/F) %			ASTM-D 2594-72
SHRINKAGE: 1. Hothead Pressing (W/F) 2. Home Laundry & Tumble Dry (W/F)			1. As agreed between buyer and seller 2. AATCC-124-75
ABRASION: Describe Method: 1. ________ 2. ________ 3. ________			ASTM-D 1175-71

TABLE 7-5
(Continued)

Property	Performance Level		Test Method
PILLING: Describe Method: 1. ______ 2. ______			ASTM-D 1375-72 (For laboratory use only. Not recommended for commercial acceptance.)
SNAGGING: Describe Method: 1. ______ 2. ______			AATCC-65-76 (For women's nylon hosiery only)
STIFFNESS: Before Washing After Washing			ASTM-D 1388-64
SMOOTHNESS			AATCC 124-75
SEAM SLIPPAGE			ASTM-D 434-75
CREASE RETENTION			AATCC-88C-75
WATER REPELLENCY: Impact Spray			AATCC-42-77 AATCC-22-77

Colorfastness	Minimum Rating	Test Method
Laundering (C/S) Crocking (W/D) Light Perspiration Atmospheric gases Clorine Retention		AATCC-61-72—AATCC-124-75 AATCC-8-77 AATCC-16A-77 AATCC-15-76 AATCC-23-75 AATCC-3-75

Visual Defects	Performance Level	Lot Maximum	Roll Reject
Points Per 100 Square Yards			

TABLE 7-5
(Concluded)

COMPLIANCE WITH SPECIAL REQUIREMENTS ON PRODUCT

Mandatory Government Requirements:
(A.) F.T.C. Permanent Care Labeling: ____________________
(B.) F.T.C. Fiber Identification: ____________________
(C.) Country of Origin (where applicable) ____________________
(D.) Other: ____________________

Package and Packing Requirements:
Rolls ________ Flat Fold ________ Yds/each, Min. ________ Max. ________
Max. no. of pieces/put up ____________ Length of shortest piece ________

Wrapper: ____________________
Data on tag: ____________
Mfg. Name ____________________
Style No. ____________
Color ____________
Gr. Wt. ____________
Brand Name ____________________
Piece No. ____________________
Gr. Yds. ________ Net Yds. ________
New Wt. ____________

Shipping Case: One shade per case ____________
Label on outside of case to describe content: ____________________
Date of shipment ____________________ Other ____________
____
____
____

Special Instructions: ____________________
____
____

Date ____________ ____________________ Buyer
Date ____________ ____________________ Salesman
Date ____________ ____________________ Other

and testing system may have to be modified to suit particular situations, such as full-width defects, various fabric widths, etc. Pieces which do not meet shade variation requirements or cuttable width requirements or which have incorrect length, excessive barre, etc, generally are rejected without any sophisticated point count determination. Each apparel firm determines by considering where, how, and by whom the garment will be used; product price range; market availability of fabric; cost for various quality levels; and probable losses from seconds.

Stated acceptable point values for an evaluation procedure may vary over a broad range, depending on fabric type and end-use. The following steps are generally used for specification buying in the apparel industry.

- Prepare reporting forms for collecting data and begin accumulating historical data.

- Establish specific test methods and inspection procedures. Reach agreement with the textile manufacturer on a sampling plan and rejection point for individual pieces and/or the complete shipment. Military Standard 105D or other sources may be used to establish the sampling plan.

- Provide for laboratory testing. Pretesting small quantities before finalizing production contracts is desirable. All required tests and/or inspections should be performed as soon as possible after the production fabric is received. Results should be made available before the material is cut.

- Because conditions change, continually analyze accumulated historical data and document the firm's experience with fabrics and end items. Use this information to update specifications.

From this brief overview of the apparel industry, it is apparent that the textile mill products industry faces tremendous pressure to produce high quality goods with carefully specified characteristics. It should also be noted that chain retail outlets that receive household and other consumer goods directly from the textile manufacturers require adherence to similar specifications. Therefore, the textile mill products industry is severely limited in its opportunities to use recovered materials in first tier products.

7.2 RAW MATERIAL MUST BE CONSISTENTLY HIGH IN QUALITY FOR THE TEXTILE MILL PRODUCTS INDUSTRY TO MEET PRODUCT SPECIFICATIONS

Consumers demand uniform appearance, texture, and color in textile fabrics used for apparel and home furnishings. Even when nonuniform effects are desired (printed fabrics, textured fabrics, etc.), they must be either totally random or incorporated in a well defined and controlled pattern. Meeting the consumer's uniformity demands requires careful control of raw materials and processes at every step in the textile production process. Examples of a number of control practices are given in the following paragraphs.

7.2.1 Synthetic Fiber Manufacture

A major portion of apparel and home furnishing fabrics is produced from synthetic fibers (polyester, nylon, acrylic, polypropylene). These fibers are produced in two forms—continuous filament and staple (short length) fibers. Using quality control procedures to ensure fiber uniformity is a major task in synthetic fiber production.

Control begins with the incoming raw materials. Special grades of chemical raw materials designated "fiber grade" or "polymer grade" chemicals are among the most stringent in the chemical industry. Typical specifications for "fiber grade" terephthalic acid for polyester fiber manufacture are shown in Table 7-6. These specifications place extreme demands on the chemical industry, since the chemicals must be of high purity but must still be produced in large volumes. Deviations from these specifications cause polymers to have a molecular weight lower than those required (resulting in lower fiber strength or colors lighter than can be tolerated in fabric production).

Different fiber lots have different dyeing characteristics, making it difficult for fiber manufacturers to achieve color uniformity. If all yarns in a fabric do not accept the same quantity of dye, the different dyeing ends will be very apparent, showing as light or dark streaks in the fabric. Such a fabric is said to exhibit "barre" and is unacceptable for sale. This problem is compounded by the fact that most fabrics are dyed in the fabric form and barre problems are not detected until after the dyeing process. Thus, a manufacturer may have thousands of yards of defective fabric already in inventory before the barre problem is discovered.

TABLE 7-6
Typical Specifications for Fiber Grade Terephthalic Acid for Polyester Fiber Manufacture

ACID NUMBER (mg. KOH/gram)	1.75 ± .2 mg/g
ALKALI EARTH METALS	
Ca	2 ppm MAX.
Na	2 ppm MAX.
K	2 ppm MAX.
Mg	2 ppm MAX.
4-Carbonybenzoldehyde	25 ppm MAX.
HEAVY METALS	
TOTAL	10 ppm MAX.
Fe	2 ppm MAX.
Ni	1 ppm MAX.
Cr	1 ppm MAX.
Cu	1 ppm MAX.
Mo	1 ppm MAX.
Ti	1 ppm MAX.
OTHER	
AR	2 ppm MAX.
Si	2 ppm MAX.
MOISTURE	0.5% MAX.
COLOR (APHA 5% SOLUTION)	10 MAX.
ASH	15 ppm MAX.

Barre can arise from a number of different fiber variations. For example, many dyes used for nylon and acrylic fibers are attracted to the chemical group at the ends of the long polymer chains in the fiber. A slight difference in the number or types of end groups can alter the dyeing behavior. The dye uptake is so sensitive to end group concentration that it can be used as a quantitative analytical procedure for end-group analysis. This type of barre, frequently referred to as "chemical barre," is one of the major factors limiting the use of reprocessed man-made fibers. As the man-made fibers are melted and re-extruded in a process called glycolizing, the reformed polymer chains are of shorter length on average and vary in size due to the losses and changes which occur in the end groups. These changes cause inconsistent dyeability in the fabric, a characteristic that is unacceptable to the apparel industry and to the final consumer.

Small differences in a fiber's solid state structure can affect the quantity of dye absorbed from the dye bath as well as the rate at which the dye is absorbed. The result is termed "physical barre." Most textile fibers consist of a mixture of highly ordered and disordered regions. The relative quantities of ordered and disordered materials, the size of the ordered regions, and the orientation of the ordered regions with respect to the fiber axis are functions of the temperature and tension to which the fiber has been exposed. Even small differences in these variables will cause differences in the fiber's solid state structure. Since the rate of diffusion of dyes into the fiber depends on the solid state structure, physical barre results in fabrics if the yarns have not been exposed to identical temperatures, and tensions for the same periods of time.

The actual physical structure of yarns can also lead to barre problems. If a yarn is small or larger than adjacent yarns in the fabric (due to bulk, tension in manufacture of the fabric, etc.), the human eye will perceive the structural differences as a dark or light streak. This is frequently referred to as "structural barre." Similar effects also occur if the fibers in a yarn have been damaged (for example scraped or rubbed) during yarn or fabric production.

Uniformity requirements for textile fibers have led to the development of strict quality control standards in the manufacture of synthetic fibers. All synthetic fibers are shipped with a merge number clearly marked on the box or bale. Only fibers of the same type and with the same merge number can be used together in fabric production. If two different plants produce the same fiber product, the output of the two plants generally cannot be mixed in a fabric without uniformity problems; therefore, the fibers from the two plants are shipped with two different merge numbers. In many cases, fabric manufacturers only mix specific lots within a given merge number to further ensure product uniformity.

Mixing fibers within a given merge to yield a uniform fabric requires extensive testing by the fiber manufacturer. At one large fiber plant, 3,000 samples of production lots are treated with a sensitive dye and the color of the dyed fabric is measured every day to detect production lots which may not be mergable. Some synthetic fibers cannot be produced with sufficient uniformity to be sold in continuous filament form even when all available state-of-the-art production controls are used. In such cases, the fibers are cut into short lengths (1 to 6 inches) and sold as staple. This permits extensive blending to be done in operations like those used for natural fibers.

7.2.2 Natural Fibers in Staple Fiber Processing

Cotton fibers have variations that must be taken into account when the fibers are used to produce yarn and fabric. (This is true even of cotton fibers coming from the same field.) If the variations are not considered, the fabric will lack uniformity. The variations can be compensated for by putting the fibers through a series of blending operations. Similar processes are used to produce fabric yarn from staple synthetic fibers.

Opening is the first step in producing yarn from staple fiber. Fibers are usually blended during opening by feeding the opening line from 24 to 42 different bales. The fiber is then carded to produce a loose rope of parallel fibers (sliver). A plant with four opening lines would thus process fiber from 96 to 168 bales at any given time.

The card sliver next goes through a series of drawing steps to further blend the fibers making the yarn more uniform. In drawing, six or eight card slivers are usually combined and drawn (or elongated) to give a single sliver. This process is repeated one or more times to ensure a uniform feed for the roving and spinning operations.

Even if three or four blending steps are used, fibers that exhibit significant dyeing differences produce a fabric with pronounced heather effect. In the dyeing of blends of cotton and polyester fibers, the fabrics go through two separate dyeing processes that dye both fibers the same shade (union dyeing) and thus avoid the heather effect.

7.2.3 Avoiding Fiber Contamination

Table 7-7 shows the number of different types of nylon "six-six" fiber that one manufacturer produces for only one end use (carpet manufacture). The 15 varieties of fiber differ in the following points:

- Cross-sectional area—denier per filament
- Length—6.5- to 8-inch staple and continuous filament
- Lustre—amount of titanium dioxide added in polymerization
- Cross-sectional shape
- Type and quantity of dye uptake.

Fiber types must be rigorously segregated in carpet manufacturing to prevent one type from contaminating yarns of another fiber type. Elaborate labels are required on fiber raw materials to ensure proper identification (see Figure 7-1). In addition, the fiber manufacturer or yarn producer usually applies a fugitive (easily removed) identification tint to the fiber. These pink, blue, yellow, green, etc. tinted fibers act to prevent the intermingling of fibers of different types. Without such ready identification, textile manufacturers would have extreme difficulty in preventing fiber contamination.

Very thorough housekeeping practices are necessary to avoid contamination during changeovers from one fiber type to another and during times when two or more types of fiber are run in the same yarn manufacturing area. In changeover, all machines must be thoroughly cleaned, because even one small tuft of contaminating fiber in a yarn creates a light or dark defect in the final fabric.

TABLE 7-7
Types of Nylon "Six-Six" Carpet Fiber
Produced by One Fiber Manufacturer

NYLON STAPLE

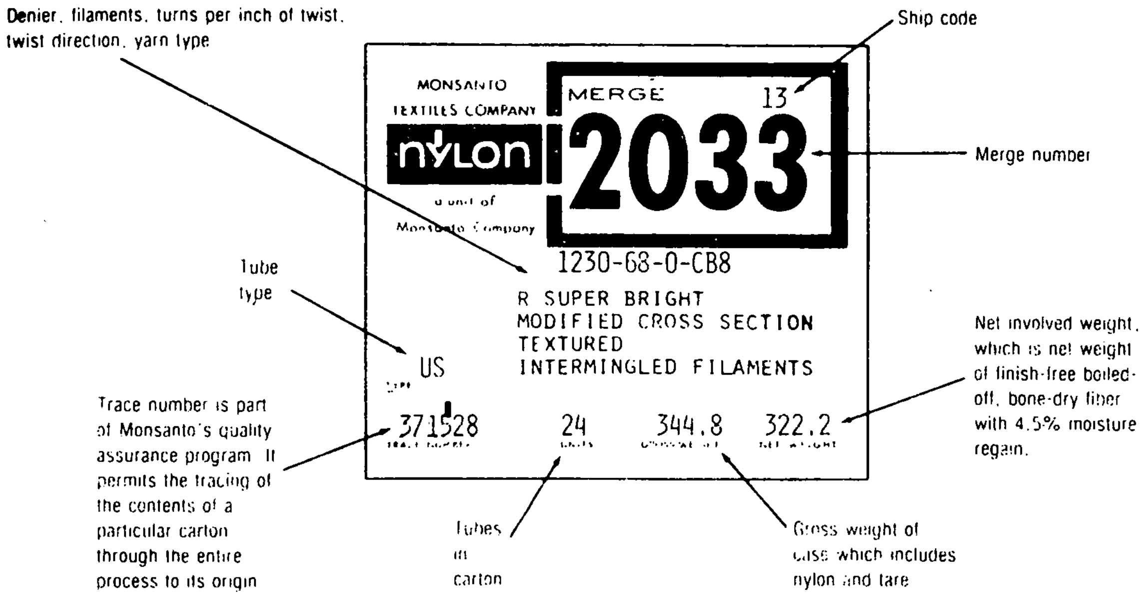
PRODUCT	DPF	CUT LENGTH	LUSTER	CROSS-SECTION	DYE LEVEL
1580-800-BBS	18	8"	SUPERBRIGHT	TRISKELION	CATIONIC
1614-650-ABS	6	6½"	SUPERBRIGHT	TRISKELION	REGULAR
1800-800-CBS	18	8"	SUPERBRIGHT	TRISKELION	REGULAR
1810-750-CBS	18	7½"	SUPERBRIGHT	TRISKELION	REGULAR
1879-800-FBS	18	8"	SUPERBRIGHT	TRISKELION	DEEP
ULTRON*					
1091-650-CES	10	6½"	SUPERBRIGHT	TRILOBAL	REGULAR
1591-750-CES	15	7½"	SUPERBRIGHT	TRILOBAL	REGULAR
1593-750-LES	15	7½"	SEMIDULL	TRILOBAL	REGULAR

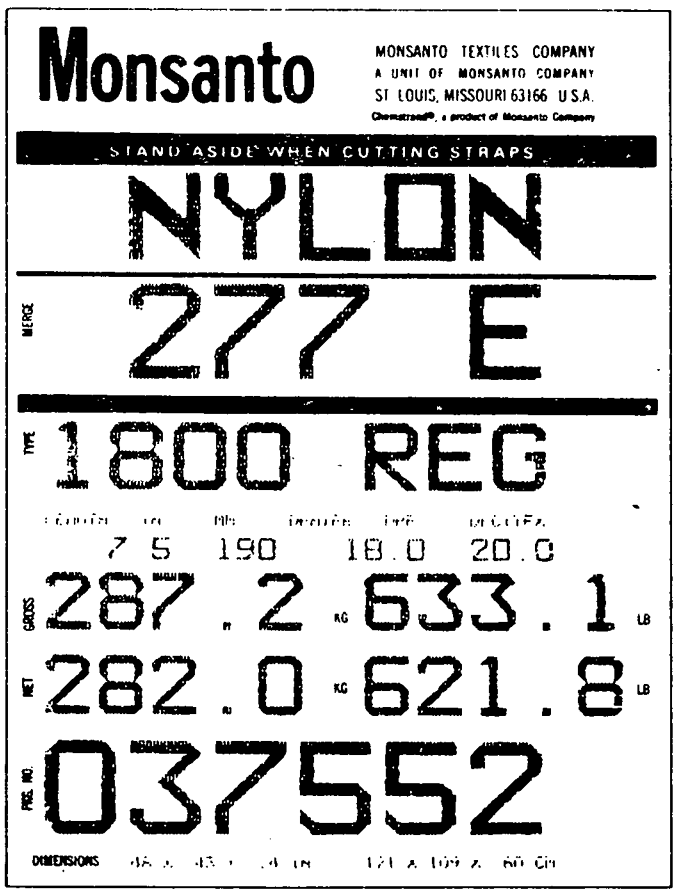
NYLON FILAMENT

PRODUCT	DPF	LUSTER	CROSS-SECTION	DYE LEVEL
1230-68-CB8	18	SUPERBRIGHT	TRISKELION	REGULAR
1300-136-CB8	10	SUPERBRIGHT	TRISKELION	REGULAR
1850-95-CB8	18	SUPERBRIGHT	TRISKELION	REGULAR
2460-136-C68	18	BRIGHT	TRISKELION	REGULAR
3690-204-C68	18	BRIGHT	TRISKELION	REGULAR
1255-85-CB8	15	SUPERBRIGHT	TRILOBAL	REGULAR
ULTRON*				
1276-86-CBE	15	SUPERBRIGHT	TRILOBAL	REGULAR

DECEMBER, 1978

FIGURE 7-1
Typical Shipping Labels for Synthetic Fibers





It is evident, then, that the first tier of the textile mill products industry is extremely careful to ensure uniformity in fabrics for apparel and home furnishings. This means that they are severely limited in how much they can use recovered fiber materials, particularly secondary waste. Fiber waste other than reworkable waste invariably consists of a mixture of fiber types that vary widely in chemical composition, filament size, filament length, cross-sectional shape, lustre, dye receptivity, tension history, thermal history, fiber damage, etc. Even assuming that waste fiber can be segregated by generic type (nylon, polyester, cotton, etc.), the variation within each type is still significant and invariably results in yarn differences that yield nonuniform fabrics. For example, in a typical 12-foot-wide carpet with six tufting needles per inch, one defective or different yarn makes 864 yarns off quality. In a 48-inch-wide fabric with 80 ends per inch, one defective or different yarn makes 3,840 yarns off quality. The economic implications of these simple facts severely limit the possible use of waste fiber in first tier textile mill products.

7.3 SEVERAL PROCESSES USED IN THE TEXTILE MILL PRODUCTS INDUSTRY IRREVERSIBLY CHANGE THE CHARACTERISTICS OF FIBERS AND YARNS

In evaluating the capability of the textile mill products industry to use recovered waste fiber, consideration must be given to the fact that some processes used in textile manufacturing are irreversible. For purposes of this discussion, an irreversible process can be defined as one in which the fiber undergoes a permanent physical, chemical, or structural change, a change that cannot be reversed. In the strictest sense, all textile processes are irreversible, but some processes cause only minor changes in the fiber. In such cases, the fiber can be put through the process again. Processes like this are considered reversible.

7.3.1 Spinning and Weaving Operations

Carding is an example of a reversible process. In carding, individual fibers are physically separated and aligned to form a uniform yarn structure. If clumps of unseparated fiber pass through the card, the resulting yarn has thick areas known as "slubs." During the carding operation, the average length of the fibers is reduced by approximately 5 percent through the mechanical action of the card. Thus, a physical change does occur in the carding process, but the change is not large enough to prevent carded fiber from being rerun through the process. The drawing process also does not cause permanent changes in the fiber.

Reworkable waste fiber that has been through only the carding and drawing processes is currently reused in the first tier textile industry. Even though carding and drawing cause minimal changes in the fiber, these changes are significant enough that no more than 5 percent waste fiber is blended with virgin fiber. A larger proportion of waste produces a yarn end that exhibits nonuniformity in a woven or knit fabric. This results in a significantly higher probability of breaking during subsequent processing steps, reducing machine operating efficiency.

Roving and spinning are the first processes that produce irreversible changes in the fiber. In these steps, the fiber bundle is twisted for the first time, and once this happens, fibers can be recovered for reuse in only a few special cases. This is because the mechanical action necessary to separate and align the twisted fiber bundle is so severe that fiber breakage reduces the average length below a level acceptable for reprocessing. Therefore, after fibers become part of a twisted yarn, they generally cannot be processed on currently available textile equipment for first tier products.

One exception to this rule involves some polyester fibers and fibers with very long staple lengths (4 to 6 inches), such as wool and some acrylics. Although fiber length is significantly reduced in processing, average length is still great enough to permit processing into textile fabrics. Such fabrics are of lower quality than those produced from virgin fiber. Processing long staple fiber represents only a small part of the fiber consumption in the United States. For example, of the 49,000 cards in use in the United States, only 2,670 (5 percent) process long staple fiber.

A second exception to the rule that spinning is an irreversible step involves a thread production mill that uses longer than average staple length cotton. This mill is believed to be recycling in-house spun yarn waste (reworkable). This waste reuse requires a special piece of equipment to separate the fibers in the yarn. This equipment item is not commercially available, and the waste reuse system is probably limited in applicability to sewing thread manufacture involving long-staple cotton. It can be reasonably concluded that after fibers have been twisted into yarn structures, only small and insignificant quantities (less than 1 percent) can be recycled into primary textile fabrics.

Recovering usable fiber is further complicated when yarns are interlaced into woven and knit fabrics. The process of separating individual fibers from the entangled mass and aligning them invariably results in a drastic reduction in average fiber length. Some fiber for second tier end uses (furniture stuffing, felted pads, nonwoven inner linings, etc.) is recovered from waste fabrics (rags) by a process known as garnetting. In this process, the fabric is tightly held between two grooved rollers and ripped into small pieces by a rotating cylinder with large metal teeth. This process has been used to produce a small quantity of wool fiber for second tier fabric use, but recycling of fiber from woven fabric on any reasonable scale is beyond the current state of the art. In summary, by the time fibers have been processed into fabric form, they have become so entangled that removing them for reprocessing invariably causes irreversible damage to the physical structure of the fibers.

7.3.2 Preparation, Dyeing and Finishing Operations

In the preparation, dyeing, and finishing of textiles, broadly termed wet processing, there are a number of points where irreversible chemical and physical changes take place in the polymer/fiber system. The subprocesses that make up the overall wet processing sector of the textile mill products industry are discussed in the following paragraphs.

7.3.2.1 Sizing-Desizing

A plastic film, termed "size", is applied to textile-warped yarns before they are woven. The size temporarily strengthens the yarn and reduces abraison as the warp yarn is passed through the warp by the shuttle during the weaving process. The main materials used for sizes are starch (a natural polymer), polyvinyl alcohol (a synthetic polymer), carboxymethyl cellulose (a cellulose derivative), or some blend of the three. After the fabric is woven and enters a wet processing phase, the bulk of the size is removed in desizing. Desizing uses enzymatic action to remove starch and hot water to remove polyvinyl alcohol and carboxymethyl cellulose. The desizing process is not totally efficient, however, and some residual size is always left in the fiber.

Research indicates that under the best conditions, only about 85 percent of the polyvinyl alcohol is removed in desizing. An additional 10 percent is removed during bleaching, leaving about 5 percent in the fiber. The fiber becomes a type of composite, consisting of fiber polymer and size polymer.

Fabric that is sized and desized ultimately possesses its own distinctive mass and type of residual size. The residual size can affect the dyeing behavior of the fiber; size interferes with dye uptake and penetration. Furthermore, the fibers must be easily and completely wettable; otherwise, results will be uneven in subsequent wet processing. If all fibers are sized and desized in a single plant and in a uniform manner, the residual size in the fabric prior to dyeing will also be uniform. Therefore, the residual size will also be uniform and will not prevent the obtaining of first tier quality goods. On the other hand, fibers from a variety of sources in a recovered materials operation will contain both different size materials and different levels of residual size. Both factors will cause different dyeing and wetting behavior for the individual fibers, thus giving a variable dye uptake and causing uneven dyeing.

7.3.2.2 Singeing

To give a smooth appareance to fabrics produced from staple yarns, fabrics from the loom are singed. In this process, protruding short fibers are burned away with a gas flame without damage to the cloth itself. Since the cloth is not damaged either chemically or physically, singeing is not considered an irreversible process.

7.3.2.3 Scouring

Scouring is necessary to remove impurities from natural fibers. These impurities include natural fats and waxes, insect parts, woody matter, etc. The main chemical for cotton scouring is sodium hydroxide used at a concentration of 4 grams per liter of mixture, and applied with a surface active agent. Process temperatures are near or above boiling, and, although the caustic solution is fairly weak, it is alkaline and some degradation of cellulose always occurs in an alkaline solution. The solution reacts with the cellulose in two distinct ways:

- In the absence of oxygen, the reducing ends of the cellulose chains are transformed. The terminal residues that stabilize the alkaline degradation ceases on residue formation; thus, the overall molecular weight of the cellulose is not decreased to any appreciable extent on the alkali attack in the absence of oxygen and properties are not measurably affected.

- In the presence of oxygen, alkali degradation of cellulose during scouring can be severe. Chain scission (break) results during the oxygen/alkali degradation, giving a corresponding draw-up in mechanical properties of the fibers. The properties of a fiber polymer (strength and dyeability) are extremely dependent on molecular weight. A slight decrease in molecular weight due to auto-oxidative chain scission causes a considerable loss in fiber strength in the critical portion of the property-versus-molecular-weight curve and also affects the uptake of dyestuffs.

  Alkali scouring of this kind results in irreversible damage to the polymer structure. The degree of damage greatly depends on the conditions of scouring; therefore, mixtures of fibers from different plants would exhibit different degrees of degradation. Because scouring is required of yarns produced in reprocessed fiber mixtures, further degradation occurs, resulting in further loss of polymer properties.

Wool is especially sensitive to alkaline attack during scouring. A weaker base is used in wool in (a polymer backbone unit), causing a reduction in the dry strength. Use of a mixture of scoured wool fibers from different sources is inadvisable for reasons already given in the discussion of scoured cotton.

7.3.2.4 Bleaching

In bleaching natural colorants are removed from fibers. The bleaching material attacks the conjugated chromophores (light-absorbing species) and other polymers in the yarn and fabric. These attacks break the conjugated sequence, and thus shift the absorbents out of the visible spectrum, causing the yarn or fabric to be white or bleached. Treating cellulose fibers with oxidizing agents leads to chemical attack, polymer chain breakage, and an ultimate loss in tensile strength. Hydrogen peroxide and sodium hypochlorite, both widely used as textile bleaching agents, attack the fiber proper at the same time the conjugated chromophores are being destroyed. To obtain a bleached fiber of satisfactory strength, oxidation control is critical. The objective is to destroy color matter with minimal damage to the remaining portions of the cellulose fiber.

These products of oxidation of cellulose are called oxycelluloses. Due to the chemical nature of cellulose, the possible points of chemical attack are numerous. Thus, the level of degradation for any batch of bleached fiber is highly dependent on the conditions encountered in the plant (time of exposure, temperature, type and concentration of the bleaching agent, etc.).

Bleached fibers that are derived from various sources will, therefore, vary in tensile strength due to differences in bleaching conditions from plant to plant. In addition, since the chemical points of attack are numerous, exposing the mixture of fibers to a second bleaching operation would initiate a new round of oxidative degradation, further weakening the fiber. Fibers would, therefore, have weaker structures each time the material was put through the bleaching process.

7.3.2.5 Mercerization

Fabrics that contain cotton and that are to be used for apparel and sheeting are often treated continuously during preparation with a concentrated (15 to 20 percent by weight) sodium hydroxide solution. This is a process known as "mercerization"; it involves impregnating the open width fabric with caustic solution, allowing it to soak in the solution, and following this with a second alkaline dip. The process is completed by stretching the fabric with a tenterframe and passing it under a series of hot water sprays to wash out the caustic soda.

In an alternate, but related process, cotton yarns or fabrics are mercerized without tension. The process called "slack mercerization," gives the material considerable elasticity. The elastic cellulose material is used principally in white bandages, with a small amount going into casual wear skirts, boat covers, etc. Stretch-mercerized material is dyed in much greater quantities than is slack-mercerized material.

Cotton fibers swell laterally and shrink longitudinally during mercerization, causing radical changes in fabric properties. As indicated in Figure 7-2, the final fiber properties depend on the concentration of sodium hydroxide used. In the optimum concentration range, the following changes take place:

- The fiber shrinks.
- Extensibility decreases.
- The breaking strength actually increases slightly.
- The degree of lustre increases.

The increase in strength is especially interesting. Cellulose impregnated with sodium hydroxide and exposed to air undergoes chemical degradation; and, under normal circumstances, a decrease in strength would be expected. In mercerization, a physical transformation takes place, however, that affects any loss of strength due to chemical degradation. Sodium hydroxide constitutes a small enough molecule that complete penetration of the crystalline regions of the cellulose takes place. The majority of the cellulose hydroxyl groups are converted into the sodium salt during the impregnation phase of mercerization, forming alkali-cellulose or soda-cellulose. When the caustic soda is removed by back-hydrolysis with hot water rinse, cellulose is regenerated, but the crystalline structure of the polymer is altered. The new structure, termed "cellulose II," has different unit cell dimensions in X-ray crystalline analysis from the native fiber, cellulose I (see Table 7-8). The pyranose rings are rotated in cellulose II, accounting for crystalline differences that directly affect its properties, including strength.

FIGURE 7-2
Dependence of the Properties of Mercerized Egyptian Cotton Fibers Upon the Concentration of Sodium Hydroxide

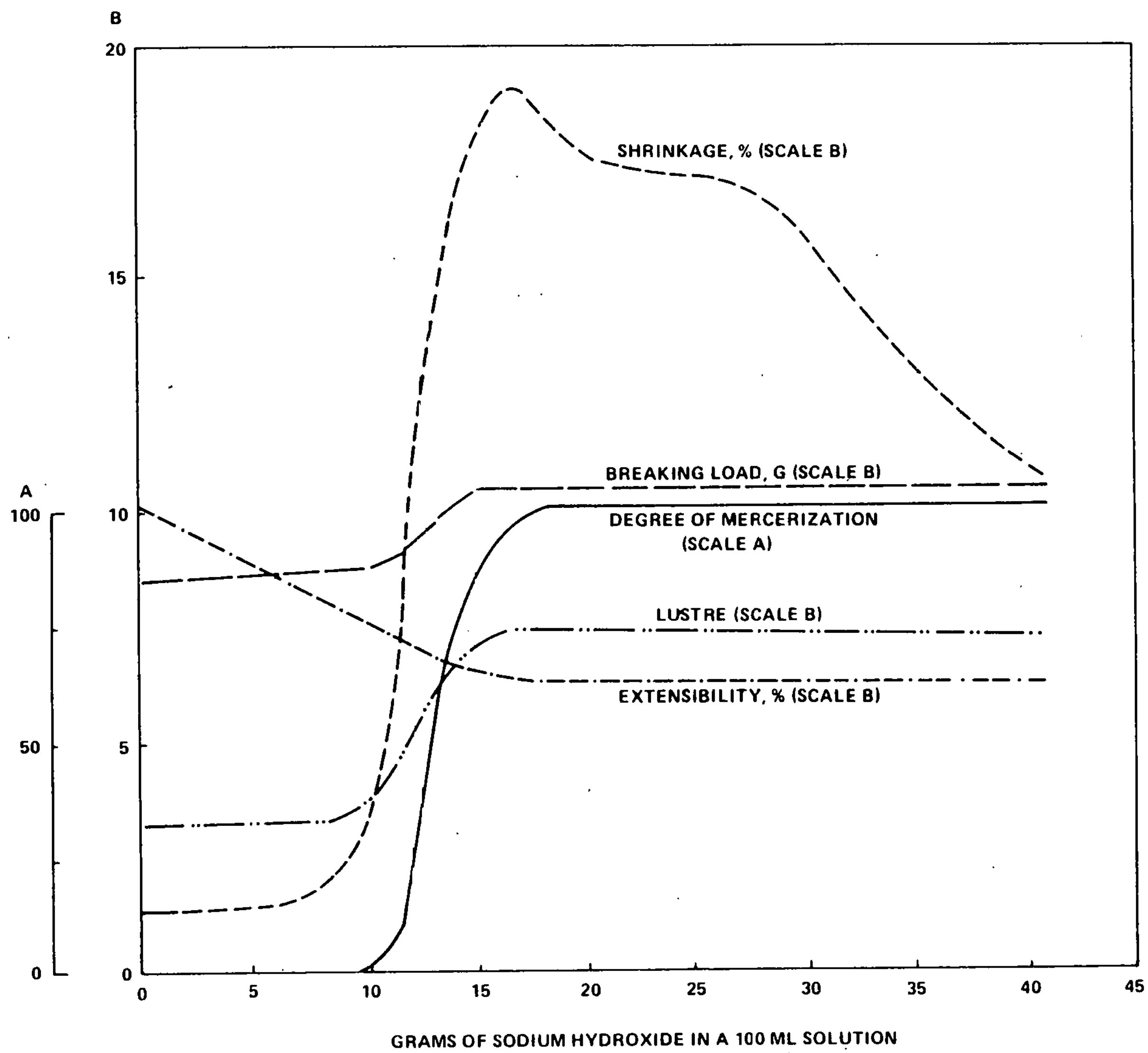


TABLE 7-8
Change in X-Ray Unit Cell Structure on Mercerization of Cellulose

FIBER	UNIT CELL DIMENSION, (Å)			A/C ANGLE (DEGREES)
	A	B	C	
CELLULOSE I (NATURAL)	8.35	10.3	7.9	84
CELLULOSE II (MERCERIZED)	8.1	10.3	9.1	62

Table 7-9 indicates the crystalline cellulose content of various materials. Mercerized samples have approximately 10 to 20 percent less cellulose than native cotton does. The strengthening effect of mercerization can be seen more clearly in Table 7-10.

The most important property changes resulting from mercerization are increases in water uptake and dye affinity. Untreated cotton has about a 40 percent water accessibility factor, while mercerized cotton reaches 70 percent on the same kind of test. Figure 7-3 compares the absorption by mercerized and scoured-only cottons.

Water is the diffusing agent for dyes and chemicals; it enables them to penetrate the fiber and makes chemical treatment possible. Not surprisingly, mercerizing cellulosic fibers increase their absorption of dyes, metal hydroxides, and finishes and raises their rates of hydrolysis and oxidation. Table 7-11 gives the effect of tension in mercerization on the absorption of two common dyes. Slack- and tension-mercerized cottons absorb approximately twice as much dye as the unmercerized standard. The rate of dyeing is also affected by mercerization. The process reduces the time of half absorption by approximately 75 percent, as shown in Table 7-12. The shade of mercerized cotton is also more intense because the almost-cylindrical mercerized fibers scatter less light than do the thin, ribbon-shaped native cotton fibers. The mercerized cotton absorbs finishing chemicals more readily than the unmercerized fabric does, the change here being roughly comparable to the situation with dyes.

It seems, then, that the property modifications stemming from mercerization depend on process variables, such as concentration of sodium hydroxide, tension on the fiber, the degree of hot water washing, etc. Each textile plant has varying mercerization conditions, and fibers from different plants will thus have widely varying chemical absorption properties. A mixture of mercerized and unmercerized cotton fibers would differ even more in such properties. If such a fiber mixture were woven into a fabric and dyed with (for instance) chlorazol sky blue FF, a multi-shade, uneven dyeing would result. Recycling cotton-containing fabrics is not feasible because the fabrics are likely to contain fibers mercerized under different conditions or mercerized fibers mixed with unmercerized fibers. In either case, cross variations in dyeing and finishing properties would result, and the product would be unacceptable.

TABLE 7-9
Crystalline-Cellulose Content of Various Materials Measured by the Rate of Acid Hydrolysis in an Aqueous Solution of Hydrochloric Acid and Ferric Chloride

MATERIAL	CRYSTALLINE FRACTION PERCENT
RAMIE	95
COTTON	82-87
COTTON LINTERS	88
COTTON MERCERIZED UNDER TENSION	78
COTTON MERCERIZED WITHOUT TENSION	68
FORTISAN	83
FIBER G	81
CORDURA ~~HIGH~~-TENACITY RAYON	62
TEXTILE RAYON	68

TABLE 7-10
Strenthening Single Yarn by Mercerization

YARN NUMBER	TWIST TURNS PER INCH	SINGLE-THREAD STRENGTH, LB.		GAIN IN STRENGTH PERCENT
		UNMERCERIZED	MERCERIZED	
12/1	9	0.64	1.39	117
12/1	14	1.46	1.70	16

FIGURE 7-3
Sorption of Water by Mercerized Cotton at 25°C

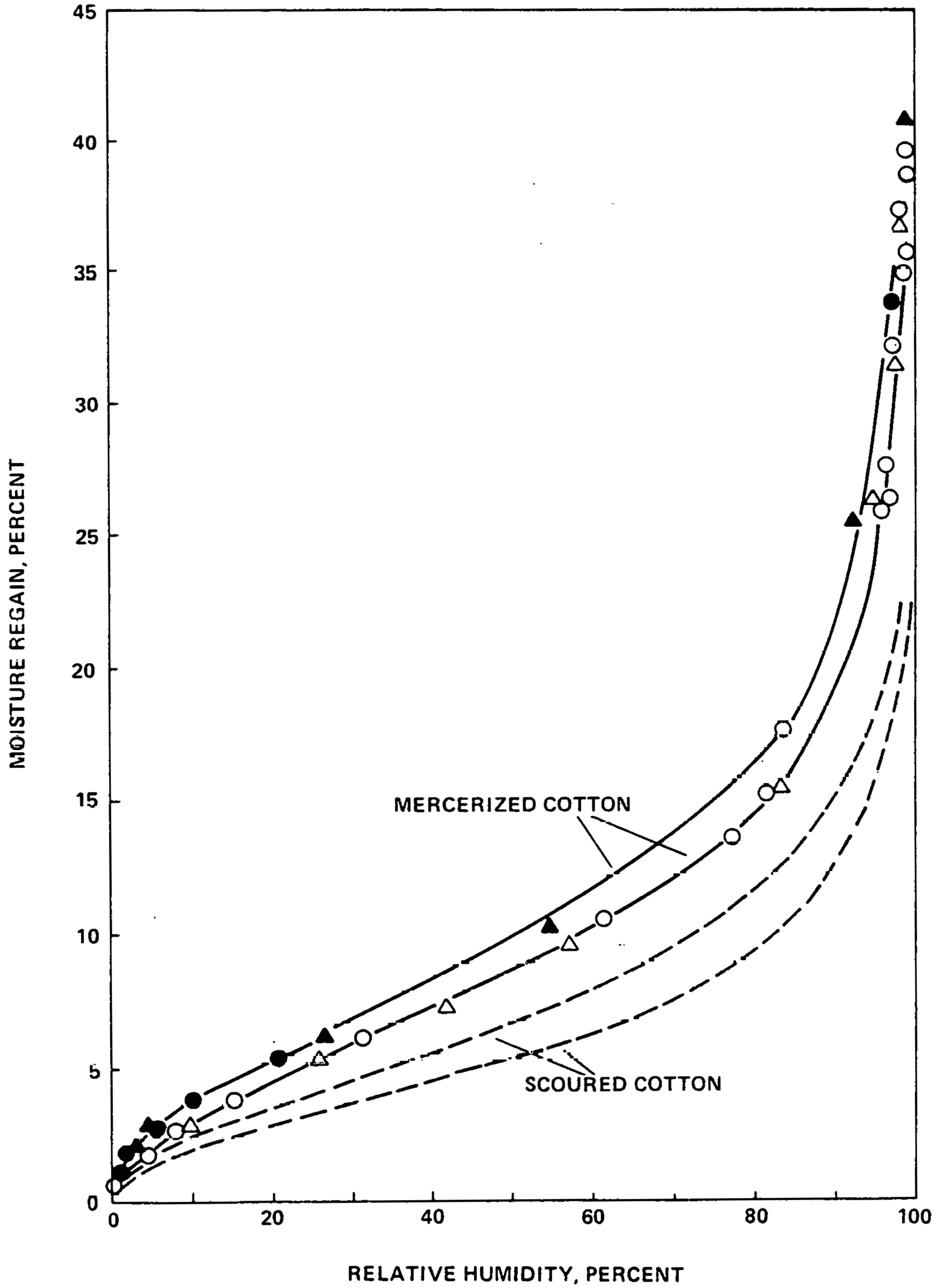


TABLE 7-11
Effect of Tension in Mercerization on the Adsorption of Benzopurpurine 4B and Chlorazol Sky Blue FF
(Hanks Dyed in a Common Bath)

DYE	TREATMENT	DYE ADSORBED (G/100 G FIBRE)
BENZOPURPURINE 4B	UNMERCERIZED	1.5
	MERCERIZED WITH TENSION	2.9
	MERCERIZED WITHOUT TENSION	3.5
CHLORAZOL SKY BLUE FF	UNMERCERIZED	0.15
	MERCERIZED WITH TENSION	0.27
	MERCERIZED WITHOUT TENSION	0.24

TABLE 7-12
Rate of Dyeing

FIBER	TIME OF HALF-ADSORPTION (MINUTES)
SAKEL COTTON	1.1
SAKEL, MERCERIZED WITH TENSION	0.25
AMERICAN COTTON	1.4
AMERICAN, MERCERIZED WITH TENSION	0.35

7.3.2.6 Dyeing

The complexity of dyeing is reflected in the fact that all classes of dyes will not color all types of fabrics. Table 7-13 lists dye types and gives the fibers for which each has an affinity. Few dyes color more than three to five fiber types satisfactorily, and even within a classification, there are severe differences in the level of coloration obtained. For example, the disperse dyes that are used most often to dye polyester fibers include light to heavy shades. However, only very light shades can be obtained on acrylic fibers with disperse dyes, and thus this class of dyes has limited applicability for acrylic fibers such as orlon and acrilan.

Even within a fiber type, such as the generic classification "nylon," slight differences in dyeing behavior persist. There are two dominant subclasses in the main generic class of nylons—six-six and nylon six. Nylon six-six is based on poly-hexamethylene adipamide and nylon six is based on poly-caprolactam. The structures of these two are different in physical characteristics, crystal energy, glass transition temperature, etc. As a result, they dye at different shades under similar conditions. The endgroup content of various commercial nylons influences both the rate of dyeing and the uptake of acid dyes (acid dyes are the most commonly used dyes for nylon). Figure 7-4 shows the relationship between the dye uptake and the group content.

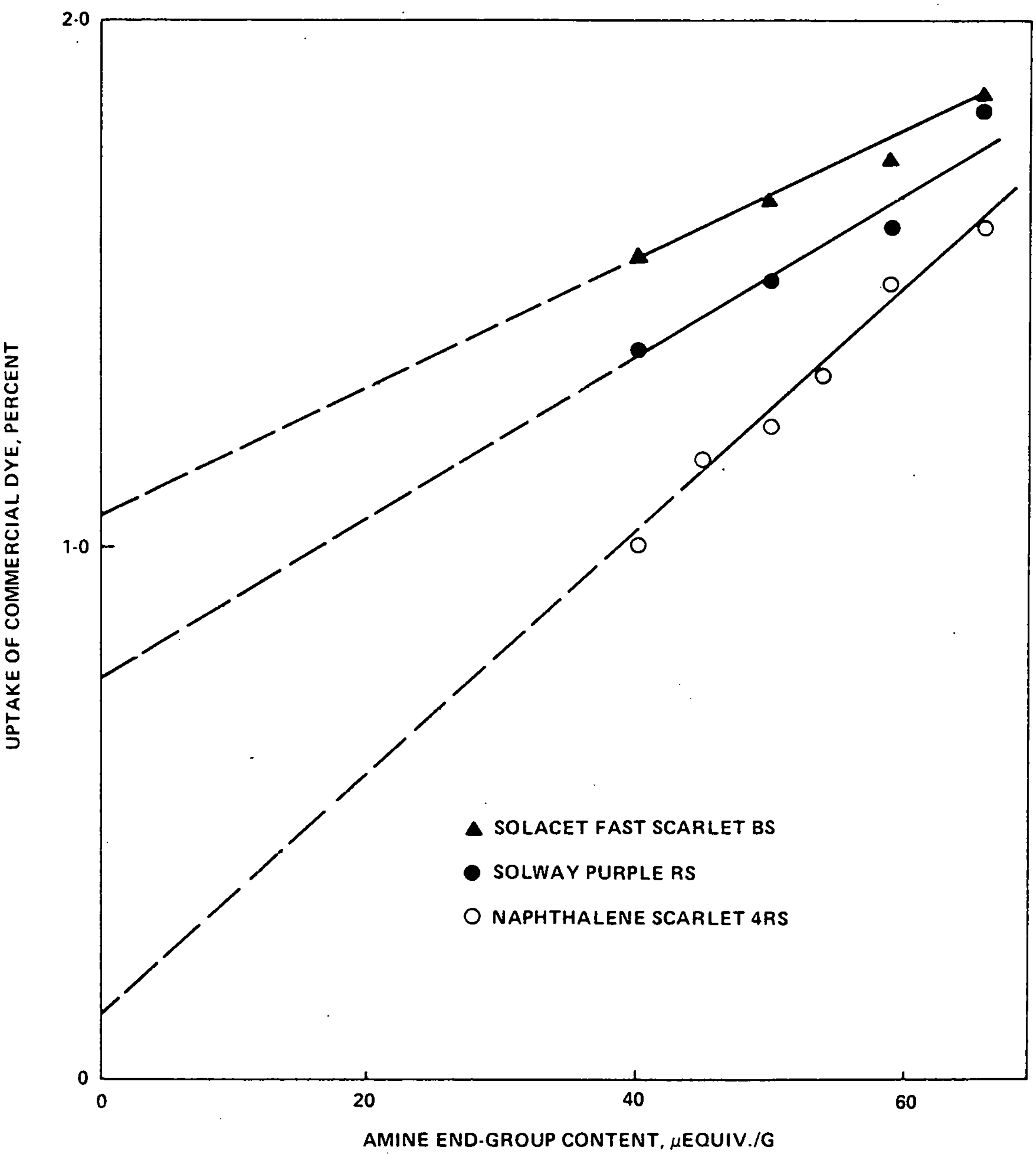
To meet specific end uses, fiber manufacturers often intentionally modify the amine end groups in their standard nylon line by introducing imine, additional amine, or acid functional groups into the structure. Changing the amine end groups yields vastly different shades in a common dye bath. In fact, capping the amine groups with acid groups produces "catonic dyeable" nylon, which has an affinity for basic dyes but not for acid dyes. Such intentional end group modifications result in differential dyeing textile structures, such as regular and deep-dyed tufted carpet.

The effort to obtain controlled multicolor effects has also resulted in modifications to several other generic fiber types. Usually, acrylics are generically defined as materials containing greater than 85 percent acrylonitrile units in repeat chains. The remaining 15 percent consists of various co-monomers that reduce the crystallenity of the acrylic and provide better dyeing characteristics. The co-monomer that is used to produce a particular dye condition is normally chosen with different

TABLE 7-13
Types of Dyes Used in the Textile Industry
and the Fibers to Which They Are Applicable

DYE TYPES	FIBER TYPES								
	ACRYLIC	COTTON	WOOL	ACETATE	RAYON	POLYESTER	POLYESTER/ COTTON	NYLON	NYLON/ COTTON
ACID	●		●					●	●
AZOIC		●			●	●	●		
ANILINE BLACK		●							
BASIC (CATIONIC)	●			●		●	●	●	
DEVELOPED		●			●				
DYE BLENDS							●		
DIRECT		●			●		●		●
DISPERSE	●			●		●	●	●	
FIBER-REACTIVE		●					●	●	
FLUORESCENT	●	●	●	●	●	●	●	●	●
INDIGO		●							●
SULFUR		●			●		●		
VATS		●			●		●		
NATURAL		●							
OXIDATION BASE		●							
MORDANT			●					●	
PIGMENTS		●			●		●	●	●

FIGURE 7-4
Relationship Between Dye Uptake and Amine End-Group Content for Various Commercial Dyes



proportions of vinyl acetate, and, when used under different conditions, it gives different shades. The effect of slight modifications to the acrylic structure is such that a mixture of differently controlled fibers would dye quite differently in either acid or basic dye baths.

Polyester fibers are also subject to structural modifications. Two main subgroups within the generic class are dominant: poly (ethylene terephthalate) and poly (dimethylcyclochexane terephthalate). Dupont's Dacron is an example of the first, and Kodel by Eastman is an example of the second. Dyeability is different between these two, with the Kodel fiber having a higher second order glass transition temperature. Modifications of the basic homopolyester are accomplished by shortening chains, altering spinning conditions, or introducing co-monomers. Such modified polyesters would exhibit radically different dyeing behavior toward a particular dye class.

Nylon, regular dyeable acrylics, polyesters, and viscose rayons from several manufacturers have different dyeing characteristics. These are due to specific differences in structure, crystallinity, molecular weight, etc. Regular dyeable nylons of Monsanto and Dupont can vary by as much as 11 percent in the amine end group content and thus dye differently in a common dye bath.

Physical treatment of fibers after spinning also affects dyeability. The quantity of dye absorbed on polyester decreases with increased draw ratios and shows a clear minimum absorbency. Absorbency is a function of the temperature of the heat-setting treatment. Dye uptake decreases when dry heat-setting rather than steam is used because of oxidation of amine end groups during the hot air process.

In summary, then, reuse of a mass of fibers of unknown chemical/physical makeup and thermal background presents two severe dyeing problems. First, different generic fiber classes require different dye classes— or at least different dye concentrations and conditions— to achieve the same shade. Second, even within generic fiber classes manufacturer-specific differences cause different dye absorptions in a common dye bath. Any mixture of fibers, then, will produce a variety of shades when dyed, resulting in randomly colored fabrics. Such fabrics have only a limited appeal in the textile market, the consumer desiring either uniform coloring or controlled effects achieved with multiple shades.

7.4 CHANGES IN THE CHEMICAL/PHYSICAL STRUCTURE OF TEXTILE PRODUCTS DURING END-USE ARE GENERALLY IRREVERSIBLE

During end use a number of irreversible chemical and physical changes occur in fibers, causing the loss of useful properties. These changes are usually referred to as "degradation," and in most instances they involve a rupture of primary chemical bonds. The yellowing of cotton, the embrittlement of nylon, and the cracking of rubber are all typical examples of polymer degradation.

Like other polymers, fibers are composed of long-chained molecules containing thousands of atoms chemically bonded together. Most of the useful properties of fibers (breaking strength, toughness, etc.) are related to the average length of the polymer chains. If only one bond of the long chain ruptures, the average length of the two fragments is only half the length of the original chain. For example, if one bond in a chain containing a thousand bonds is broken, the extent of degradation would be only 0.1 percent, but the average chain length would be reduced 50 percent and the properties appreciably altered. It is not surprising, therefore, that polymer properties are extremely sensitive to environmental degradation. Some of the types of degradation that come about during the end use of fabrics are briefly discussed in the following paragraphs.

7.4.1 Mechanical Deterioration

Fabrics are subject to severe mechanical action during normal wear. The pockets and knees of pants and the cuffs and elbows of shirts and blouses are constantly subjected to abrasive action. After repeated use of the garment, this abrasive action causes a whitening of color or "frosting" of the fabric. When the fibers from a worn fabric are examined under a microscope, the degradation resulting from mechanical action is immediately apparent. Some fibers in the yarn bundle are broken and the broken ends are exposed. Some fibers have large chunks broken off, and others are ruptured into many fine filaments in a type of degradation called "fibrillation." These mechanical degradation effects are responsible for the whitish appearance of worn fabrics.

7.4.2 Photochemical Deterioration

With the possible exception of acrylics, all of the common textile fibers (cotton, nylon, polyester, polypropylene, rayon, and wool) undergo degradation (a loss in properties) when exposed to sunlight. The degradation severely limits the useful life of polymers and has consequently been the subject of extensive research. Polymer chain cleavage and the subsequent loss of useful properties can be slowed by the use of carefully selected stabilizers, but deterioration cannot be completely prevented. Exposing the fibers to sunlight will inevitably cause a loss of breaking strength, decrease in extensibility, increased brittleness, and yellowing of textile fibers. These are irreversible chemical changes that produce a used fiber significantly different from a virgin fiber.

7.4.3 Chemical Deterioration

Textile fibers in use are constantly exposed to oxygen and moisture, and extensive chemical degradation in the fibers result. Cotton, nylon, and to a lesser extent polyester are all subject to a reaction with water (hydrolysis) which splits the polymer chains. Similarly, oxygen reacts with most synthetic and natural fibers reducing fiber breaking strength and extensibility. During normal use of textile fibers, these chemical reactions cause permanent irreversible changes in fiber structure and properties.

7.4.4 Biological Deterioration

Natural fibers are biodegradable and are attacked by many forms of life. Bacteria, fungi, and insects are all known to cause degradation of natural fibers. Microorganisms produce enzymes which are capable of splitting polymer chains. Discoloration and loss in useful properties accompany biological degradation.

The changes in the chemical/physical structure of fibers that come about during end use are generally irreversible. They cause a loss in useful mechanical properties that greatly limits the possible uses of recovered materials in first tier textile mill products.

*   *   *   *   *

This chapter has discussed several limitations on the use of recovered materials in the textile mill products industry. The following chapter discussed proposed materials recovery targets.

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8. MATERIALS RECOVERY TARGETS FOR THE TEXTILE MILL PRODUCTS INDUSTRY

In the National Energy Conservation and Policy Act (NECPA),* the Department of Energy (DOE) was made responsible for evaluating the textile mill products industry (SIC 22). DOE was also given responsibility for developing materials recovery targets to be achieved progressively by 1987. The targets are for each industry subsector and give the percentages of raw fiber, yarn, and continuous filament input to be composed of by-products generated from recovered materials. Recovered materials for the textile mill products industry are in two categories:

- Primary waste—textile fiber, yarn, and fabric waste generated in the various textile manufacturing operations
- Secondary waste—textile products that have been used for their intended purpose and discarded as no longer useable.

The targets presented in this report were established, as directed by the Congress, at levels which represent the maximum technically and economically feasible increase in utilization of energy-saving recovered materials that can be achieved by January 1, 1987.

Much of the primary waste generated in the textile mill products industry is the separation of fibers into forms suitable for specific textile operations. Essentially all of the wastes generated in the spinning of fibers into yarn for use in the first tier of the industry are utilized in the second tier.

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* See Appendix A for relevant sections of this act.

In defining recovered materials targets for the textile mill products industry, it was decided to set targets for each industry subsector, the subsectors being determined by the 4-digit Standard Industrial Code (SIC) classifications. As mentioned earlier, manufacturing processes and products are so diverse within the industry, that targets for the industry taken as a whole would have absolutely no meaning for an operating plant within the industry. For example, fabrics produced by cotton weaving mills (SIC 2211) are completely different from nonwoven fabrics (SIC 2297) in required characteristics, technical processes, and raw material input, and this is true throughout the industry. There are even many different processes and product requirements within a 4-digit SIC classification, but detailed information on a plant-by-plant basis could not be gathered in the limited time available for this study. Therefore, the 4-digit categories were chosen for establishing targets. The following paragraphs show how the targets were determined.

8.1 IN ORDER TO SET TARGETS, CURRENT RECYCLING LEVELS WERE CALCULATED, AND PROJECTIONS WERE MADE TO 1987

To properly evaluate recovered materials targets for the textile mill products industry, it was first necessary to determine the current flow of materials through the various subsectors and processes within the industry. This was accomplished, as required by the NECPA, through direct contact with the major firms affected and with other firms that influence the use of materials within the industry. The various trade associations previously listed were also contacted, as were research personnel at the following institutions:

- Clemson University, School of Textile Engineering
- Georgia Institute of Technology, School of Textile Engineering
- Institute of Textile Technology
- North Carolina State University, School of Textile Engineering.

These sources and the considerable amount of literature published on the textile mill products industry were used to obtain information on the following subjects:

- Current raw material (natural fiber, man-made fiber, man-made filament) flow through the textile mill products industry
- Current use of primary and secondary waste in the industry
- Technologies currently available and anticipated that will affect the use of recovered materials between now and 1987
- Government policies and regulations that may affect the use of recovered materials in the industry
- Economic and financial conditions in the industry that could influence decisions by company management on the reuse of recovered materials.

This information was then analyzed to project the use of recovered materials by the industry to 1987.

Table 8-1 shows the current pounds processed through each 4-digit SIC subsector of the industry during 1978. These data are the best available for each subsector. Basic data were acquired from the 1972 Annual Survey of Manufacturers prepared by the Bureau of the Census, Department of Commerce. However, individual subsectors were updated to current status whenever possible. In 1972 total fiber consumption was 11.648 billion pounds, and in 1978 it was 12.558 billion pounds. All of the subsectors for which updated levels could not be found were therefore increased by the ratio of 12.558/11.648 to obtain approximations of 1978 values. Sources within the industry indicated that this is reasonable because most sectors grow at the same rate as the industry in general.

TABLE 8-1
Processed Materials Use in the Textile Mill Product Industry

SIC	INDUSTRY SUBDIVISION	PROCESSED MATERIAL	
		MILLION POUNDS	PERCENT OF TOTAL
2211	BROAD WOVEN FABRIC MILLS, COTTON	2,587.8	16.6
2221	BROAD WOVEN FABRIC MILLS, MAN-MADE FIBER & SILK	2,717.5	17.5
2231	BROAD WOVEN FABRIC MILLS, WOOL	178.9	1.1
2241	NARROW FABRICS, COTTON, WOOL, SILK & MAN-MADE	194.3	1.2
2251	WOMEN'S FULL LENGTH & KNEE LENGTH HOSIERY	89.8	0.6
2252	OTHER HOSIERY	120.4	0.8
2253	KNIT OUTERWEAR MILLS	315.7	2.0
2254	KNIT UNDERWEAR MILLS	147.5	0.9
2257	CIRCULAR KNIT FABRIC MILLS	1,094.5	7.0
2258	WARP KNIT FABRIC MILLS	496.9	3.2
2259	KNITTING MILLS, N.E.C.	7.7	0.0
2261	BROAD WOVEN FABRIC FINISHERS, COTTON	N/A	N/A
2262	BROAD WOVEN FABRIC FINISHERS, SILK & MAN-MADE	N/A	N/A
2269	TEXTILE FINISHERS, N.E.C.	N/A	N/A
2271	WOVEN CARPETS & RUGS	83.1	0.5
2272	TUFTED CARPETS & RUGS	1,306.7	8.4
2279	CARPETS & RUGS, N.E.C.	41.6	0.3
2281	YARN SPINNING MILLS, COTTON, SILK, MAN-MADE FIBERS	2,706.1	17.3
2282	YARN TEXTURIZING, COTTON, SILK, MAN-MADE FIBER	891.6	5.7
2283	YARN MILLS, WOOL	123.9	0.8
2284	THREAD MILLS	139.2	0.9
2291	FELT GOODS, EXCEPT WOVEN FELTS & HATS	58.5	0.4
2292	LACE GOODS	5.0	0.0
2293	PADDING & UPHOLSTERY FILLING	330.0	2.1
2295	COATED FABRICS, NOT RUBBERIZED	136.2	0.9
2296	TIRE CORD & FABRIC	741.4	4.8
2297	NON-WOVEN FABRICS	641.0	4.1
2298	CORDAGE & TWINE	95.2	0.6
2299	TEXTILE GOODS, N.E.C.	–	–

The processed material data in Table 8-1 should not be confused with total fiber consumption data. The data presented are the number of pounds processed through each subsector, but a given fiber may actually be processed several times in different subsectors. For example, a man-made filament could be texturized in SIC 2282, woven in SIC 2221, and any waste generated could be processed in SIC 2294 before being used in a second tier subsector such as SIC 2293. In this analysis, the desired information is the total amount of material processed by each subsector.

For subsectors with nonzero targets, current levels of processed material and processed waste were determined (see Table 8-2). These current levels were then projected to 1987 using the best available data on industry and individual subsector growth. From these projected levels, it was possible to calculate percentages of total material expected to be provided by recovered materials (see Table 8-2). These percentages were considered a preliminary level of materials recovery. Qualitative, judgments were then made about the effect of other factors, such as the following:

- Anticipated new technologies that could affect the use of recovered materials by 1987
- Anticipated changes in the intermediate and final markets that could affect the use of recovered materials
- Activities and policies that may be undertaken by the industry and by state, federal, and local governments to increase the use of recovered materials.

The preliminary levels were adjusted to allow for the effects of these factors. The basis for the development of each of the targets is discussed in the next section.

TABLE 8-2
Current and Projected Levels of Waste
in Subsectors With Nonzero Targets

SIC	INDUSTRY SUBDIVISION	1978 PROCESSED MATERIAL			PROJECTED 1987 PROCESSED MATERIAL		
		TOTAL	WASTE (MILLION POUNDS)	PERCENT OF TOTAL	TOTAL (MILLION POUNDS)	WASTE (MILLION POUNDS)	PERCENT OF TOTAL
2231	BROAD WOVEN FABRIC MILLS, WOOL	178.9	23.3	13	178.9	23.3	13
2283	YARN MILLS, WOOL	123.9	16.1	13	123.9	16.1	13
2291	FELT GOODS, EXCEPT WOVEN FELTS & HATS	58.5	34.6	59	76.3	61.0	80
2293	PADDING & UPHOLSTERY FILLING	330.0	307.6	93	430.6	401.3	93
2294	PROCESSED WASTE & RECOVERED FIBERS & FLOCK	350.0	350.0	100	456.7	456.7	100
2297	NONWOVEN FABRICS	641.0	109.0	17	1101.5	165.2	15
2298	CORDAGE & TWINE	95.2	20.9	22	124.2	27.3	22

8.2 RECOVERED MATERIALS TARGETS MUST BE SET GIVING CONSIDERATION TO MARKET-IMPOSED QUALITY REQUIREMENTS

Analysis of material flows through the textile mill products industry indicates that most primary waste generated is used by the second tier of the industry for lower quality products (furniture padding, felting, nonwovens, etc.). Only a relatively small amount of secondary (post-consumer) waste is reused, primarily because there is no established infrastructure other than charitable organizations that collect this waste. An infrastructure has never developed because the cost of collecting, transporting, and preprocessing the material makes the resulting products too expensive for use in the second tier of the textile mill products industry.

One indication that waste is currently being used effectively in the textile mill products industry is the fact that a textile waste industry (SIC 2294) already exists. This industry is composed of many waste dealers who buy, process, broker, and sell textile wastes from the textile mills and apparel factories (SIC 23). Most of these dealers have relatively small businesses operating in limited geographic areas. Smaller firms may just broker the waste, haul it, or buy and sell it; whereas the larger firms buy, separate, inspect, grade, and blend the waste; open and pick it; chop it into short fibers (shoddy); and bale it for use in the second tier of the industry.

The economics of waste handling force companies to be locally oriented. For example, virgin fibers that cost a firm 60 cents per pound are sold to the second tier companies for 8 to 10 cents per pound. At this low price level, waste dealers and textile companies must operate on a thin margin in selling waste. This makes hauling textile wastes over long distances prohibitively expensive. As a result, much apparel industry (SIC 23) waste is not used; the apparel factories (in New York City) being too remote from the second tier textile facilities in the Southeast. The general concentration of the textile mill products industry in the Southeast prevents transportation from being a problem for primary waste.

Primary waste generated in the textile mill products industry is estimated to total from 800 million to 1 billion pounds per year. Of this, about 350 million pounds are processed through the existing waste processing industry (SIC 2294); about 100 million pounds (0.7 percent) are unfit for waste reprocessing and are dumped in landfills; and the remainder is sold directly from one company to another.

Most waste generation in the textile mill products industry actually consists of separating raw material to obtain products of high enough quality for individual textile processes in the industry. The first tier of the industry produces comber noil and wool noil waste, because the short fibers do not give the quality required for combed cotton or worsted wool products. However, comber noils are often added back into other spinning processes as reworkable waste to give body and surface variation to the yarn and subsequent fabric. Wool noils are also used for this purpose and as cheapeners in wool apparel and other wool products. The actual waste generated by the industry consists of unfit fiber waste that is discarded (about 0.7 percent of total fiber consumption) and process ends that are generated during start-up, shut-down, and misoperation of various textile processes.

Primary wastes are entirely consumed in the second tier of the industry, and the textile waste industry exists to move wastes to those that can use it. One major textile mill products company uses no non-reworkable waste because it has no second tier operations. It sells all of its waste products to waste dealers or directly to other firms. Conversely, another major firm sells no waste products; it processes them, instead, in the manufacture of industrial wiping rags. A third firm owns a waste reprocessing company that processes the firm's waste as well as waste purchased from other companies, and sells it to second tier industries.

The economics of waste processing, primarily the capital cost of equipment and the large volume of waste that must be handled to reduce unit costs, make it infeasible for each plant to process its own waste; therefore, specialization in waste reprocessing is common. However, the waste reprocessing industry is currently under pressure from several sources and its economic survival is threatened. The most critical threat is posed by the OSHA cotton dust standard, with its requirements for massive capital expenditures. The effect on the waste processors is particularly severe because of the characteristics of the raw material and the regulation will likely force many of them out of business.

The waste reprocessing industry will also be affected by the following changes:

- Increasing use of open-end spinning, which reduces the generation of primary waste
- Tendency of larger textile companies to sell waste directly to other end users
- Increasing use of blended fibers, which makes the reprocessing of waste more difficult and less profitable.

Another factor affecting the use of recovered materials in the textile mill products industry has to do with spinning and weaving processes. These are continuous, high-speed processes and a company's profits (which average only 2 percent of revenue) depend on efficient operation. Machines are monitored daily, records are kept on each machine, and maintenance programs are extensive to ensure reliability of operation The spinning processes (carding, drawing, roving, etc.) are set for the proper length fibers; therefore the introduction of shorter or reworked fibers, an attempt made on several occasions, has resulted in increased ends-downs (roving breaks) and the necessity to cease operations. In addition to product quality, this is one of the major reasons for removing the shorter fibers, broken yarns, etc., which compose most primary textile waste.

The factors discussed thus far are quite general and affect the use of recovered materials throughout the textile mill products industry. More specific factors affect each of the industry subsectors. Some of these specific factors are discussed in the following paragraphs which also give the basis for the specific targets.

8.2.1 The First Tier of the Textile Mill Products Industry (SICs 2211 through 2284, except 2231 and 2283; SICs 2292 and 2295)

The targets for the subsectors composing the first tier of the textile mill products industry are zero percent of raw fiber and yarn input to be satisfied by recovered materials. It is not technically or operationally feasible to use recycled material to produce first tier textile products (apparel fabric, sheeting, toweling, carpeting, etc.) that are acceptable to U.S. consumers. There are also no technologies foreseen that will be available to the industry by 1987 that will allow the industry to make acceptable first tier quality products using recycled materials.

The textile mill products industry sells its goods to intermediate consumers (apparel industry, retail chains and outlets) and final consumers (individual customers). Consumers in both groups impose stringent requirements on the industry's products. Their requirements cover such characteristics as the following:

- Color shading and consistency
- Colorfastness with repeated cleaning and wear
- Color match between parts of a fitted product
- Correct feel of the product
- Wearability with use
- Lustre and sheen.

Consumer requirements touch on many similar points as well. All of these requirements can be satisfied only if the correct properties are provided by the basic fiber and yarn woven or knitted into the product. Undesirable fibers must be removed and the type or blend of fibers must be precisely controlled. In several steps of the textile process, irreversible properties are imparted to the fibers, yarn, and fabric. These steps are necessary to give characteristics and properties required of the final product, and no way is known for reversing the process in later steps.

Color and color shading are tremendously important to the final consumer and are also the largest single reasons for apparel industry claims for reimbursement against the textile mill products industry. Coloring is so critical and depends on so many factors that constant testing is necessary to keep quality at a minimum level. Much of this testing involves actually dyeing woven goods and checking the results against a master. To a great extent, the final color depends on the basic fibers and yarn used in the fabric; this is particularly true with man-made fibers. In recognition of this situation, man-made fibers are sold by merge number; the merge number certifies that absolutely nothing has changed, including the batch of resin used in making the fiber. Most textile mills try to purchase an entire run by merge number and deliberately mix subsequent deliveries (or lots) of the same merge in an effort to maintain consistency. In some cases, lot numbers in a mill are dyed with a removable color so that their movement can be tracked through the spinning and weaving processes. After they are dyed, the products are constantly checked against master color swatches to ensure consistency. Those that do not conform are downgraded to seconds and sold to the second tier market.

The basic causes of shade and color differences in fabric are differences in yarn dyeability. Different types of fibers have different affinities for a given dye. Dyes for acrylic fibers are completely different from those used for polyester or cotton. In fact, different types of polyester or acrylic also dye differently. A yarn made of shorter fibers gives a different shade (because of light reflectance and absorption) than the same yarn does made with only long fibers. Thus, if a fabric is to be dyed and the results are to be consistent, it is imperative to know the precise composition of the yarn by fiber type, lot number, merge number, and type of preprocessing.

The demand for secondary or post-consumer waste declined rapidly with the advent of man-made fibers. These fibers had many new desirable characteristics (permanent press, integrated colors, stretchability, wash and wear, etc.) that could be obtained by blending various mixes of man-made fibers and natural fibers. As a result, almost all textile products today contain various blends of these fibers. These blends vary from product to product and company to company, and, although the Textile Labeling Law requires labeling as to fiber content, the figure given is only nominal and does not indicate precise content. This blending of fibers makes secondary waste unusable for the first tier market and is the main reason why secondary waste is ignored as a source of recovered material.

Given the problems described here, it was concluded that U.S. textile products from the first tier of the industry would inevitably lose out to foreign products if the use of recovered materials were made mandatory. Therefore, the target for those subsectors producing first tier products was set at zero (zero percent recovered materials to be used in fiber and yarn input).

8.2.2 Broadwoven Wool Fabric and Yarn Mills (SICs 2231 and 2283)

There are two types of mills in the woolen subsectors of the industry—worsted mills and woolen mills. The worsted mills spin yarn and weave fabrics used primarily in men's suits. These fabrics must be lightweight and compact. (Women's apparel fabric is usually quite different; it generally has an irregular surface and is bulky and fluffy.)

In the worsted wool fabric mills, the wool is combed in much the way combed cotton is, to remove the shorter fibers. Because of their increased ends per pound, these fibers increase the bulkiness and thickness of the yarn. (These shorter fibers are termed "wool noils.") The resulting yarn is much thinner, and the fabric it is used in is also much thinner and has fewer fibers protruding from its surface.

Wool noils are perfectly good wool fiber, and they are eagerly purchased by makers of woolen fabric for women's garments, blankets, wool coats, etc. The noils increase bulkiness and insulating capability while still reducing the average price of a given yard of woolen fabric (since they are considerably cheaper than raw wool).

Wool fabric is long and generally very loosely woven; therefore, it can be unwoven to obtain useful wool fibers. This is currently done in Europe, primarily in Italy; and much of the material that is unspun is from U.S. secondary waste goods. After being unspun, the wool fibers are made into consumer products that are sometimes shipped into the United States.

The unspinning operation was discontinued in the United States when the Wool Labeling Act was passed requiring U.S. goods to be labeled "used wool." (The foreign goods carry only the label "all wool.") Customer resistance to goods labeled "used wool" plus the changing apparel market in the United States resulted in the current unsatisfactory position the wool industry currently has in the United States, where only about 2 percent of all processed material is wool.

Wool noils currently are about 13 percent of the material input, and that percentage is unlikely to change between now and 1987. With the Wool Labeling Act and the continued growth in popularity of man-made fibers and man-made/cotton blends, it is doubtful that more wool or more wool noils will be used. More wool/man-made fiber combinations are being used so the usefulness of secondary fibers will probably decrease, even if a way were found for them to be practically used in the U.S. industry. Therefore, the target is 13 percent of the total wool fiber used by the textile mill products industry to be satisfied by recovered materials (wool noils).

8.2.3 Felt Goods, Except Woven Felts and Hats (SIC 2291)

The production of felt goods involves the use of heat, moisture, and pressure to create a matted product. The felt is used in utility-oriented applications such as the following:

- Automobile padding and insulation
- Carpet cushions
- Mats
- Pipe and boiler coverings.

Product strength, density, and thickness are more important than color, feel, and fashion, so recovered materials can be used. Some specifications for pressed wool felts require virgin materials, but such requirements are uncommon.

Currently, about 35 million pounds of recovered materials are used in felts; this is about 59 percent of the total material processed. Members of the industry indicate that this amount will probably increase to 80 percent by 1987. As manufacturers attempt to cut product costs, more recovered materials will be used. At the same time, there will still be some uses for higher quality felts (where the material is more visible), and these will require a high percentage of virgin fibers. Current information indicates that a growth rate of about 3 percent per year can be anticipated, so the quantity of recovered materials used in felts will grow to 61 million pounds by 1987, 80 percent of the 76.3 million pounds to be processed in that year. Therefore, the target for use of recovered materials in this subsector is 80 percent.

8.2.4 Padding and Upholstery Filling (SIC 2293)

Padding and wadding are produced as filling for such items as apparel, upholstery, pillows, quilts, and pads. The padding and wadding are composed primarily of recovered materials, generally primary waste. Bulk and fluffiness are required regardless of color or fiber; therefore, this is an ideal application for opened, chopped, or garnetted fibers. The limitations imposed on the use of reprocessed fibers include requirements for flame retardation. A polyester sheet of fabric is often placed between the outer fabric and the inner padding to keep the padding from burning.

Of the 330 million pounds of fibers currently processed in the manufacture of padding and upholstery filling, 307.6 million pounds (93 percent) are recovered material. The target for 1987 is expected to remain at 93 percent, because the flame retardation requirement calls for some use of virgin polyester fabric. About 430 million total pounds of material are expected to be processed in 1987, assuming a 3 percent per year growth rate. This means that just over 400 million pounds of waste will be processed in that year (93 percent of 430 million pounds).

8.2.5 Processed Waste and Recovered Fibers and Flock (SIC 2294)

Firms classified in the SIC 2294 subsector have as their primary business the processing of waste by-products. The only material processed by these companies is waste, either primary or secondary (post-consumer); the waste is used for padding or felt or it is resold to other subsectors. However, since the SIC 2294 firms deal only in the processing of recovered materials (350 million pounds in 1978) and uses no virgin fibers for which recovered materials could be substituted, the concept of a recovered materials target is not applicable to this subsector of the industry. Therefore, there is no target set for the SIC 2294 companies.

8.2.6 Nonwoven Fabrics (SIC 2297)

Nonwovens are produced using a variety of processes. One of these, the spun bonded process, limits the use of recycled materials in this subsector. (This process involves the extrusion of virgin-synthetic pellets into fibers. A web is formed and is bonded together, using the inherent plasticity of heated resin.) Other limitations include the strict requirement that only labeled fibers be used in medical applications. This limit, imposed through the Medical Devices Act, covers fibers used in surgical gowns, masks, and other related products. This requirement for labeled material is often carried over to diapers, food filters, wet wipes, and sanitary products as well, and they are accompanied by high standards for cleanliness, purity, and color. These requirements cannot often be met using recycled fibers, at least not without a severe economic penalty.

The remaining uses for nonwovens are utility-oriented with few, if any requirements for color or consistency. These uses include automobile headliners, sound insulation, luggage fillers, low-end sleeping bags, and padding. In these uses, if the spun bonded process is not used, recycled fibers are appropriate and are extensively used. The use of recycled fibers occurs, however, in less than 25 percent of the nonwoven market.

Interviews with industry executives and association officials indicate that recovered materials are currently used in the nonwoven segment of the industry at a 17 percent rate (110 million pounds of the 641 million pounds processed in 1978). This percentage is likely to decrease slightly in the period up to 1987. The reason for this is the anticipated increase in popularity of the spun bonded process, with its requirement for virgin-synthetic pellets. (An increase in the use of this process was predicted in a recent study prepared by Arthur D. Little.) Because of this change in the use of the spun bonded process, a target for 15 percent was set for 1987. The overall growth rate for nonwovens has been 6.2 percent per year, so nonwovens should consume 1.1 billion pounds of material in 1987, of which 165 million pounds will be recovered materials.

8.2.7 Cordage and Twine (SIC 2298)

The cordage and twine industry produces cables, cords, ropes, nets, and twine for a variety of uses. The products used in high strength applications require virgin fiber for consistency, tensile strength, and durability. This limits the use of recycled fibers to the other sectors of this group. Off-quality tire yarn is frequently purchased for use in cordage and twine. This yarn has a few minor flaws and does not meet the very strict standards of the tire cord industry. In addition, recycled fibers, both natural and synthetic, are used in varying percentages for lower strength products. Some clothes lines and most mop yarns are made from 100 percent recycled products, but these are sold at the lower end of the market. Including the off-quality tire yarn used in this segment, recovered materials currently used in this sector total roughly 21 million pounds of the 95 million pounds used. This means that recovered materials account for 22 percent of the total raw fiber input. These figures are not expected to change by 1987. Assuming a 3 percent growth rate for the industry, the recovered materials used in 1987 will be about 27 million pounds of the 124 million pounds processed.

8.2.8 Summary of Materials Recovery Targets for the Textile Mill Products Industry

In addition to the facts given in the preceding paragraphs, several general industry conditions affect the materials recovery targets:

- Most of the primary waste generated within the textile mill products industry is used by the second tier of the industry.

- Intermediate and final customers have extremely high requirements regarding the style, fashion, and characteristics of products manufactured in the first tier of the industry.

- Waste dealers, textile manufacturers, and academic researchers all agreed that technology does not exist to manufacture acceptable first tier textile mill products from primary or secondary textile wastes. These individuals also agreed that such technology is not likely to exist by 1987.

- The textile mill products industry generates low levels of capital because of its low profitability (2 to 3 percent of revenues) and because of increasing competition from lower priced imports.

- Existing government regulations regarding environmental control and employee safety will impose tremendous demands on available capital between now and 1987.

In Table 8-3, all but two of the 4-digit codes in the first tier of the textile mill products industry have a target of zero percent. The only exceptions are wool processing, SICs 2231 and 2283. The following subsectors then, all have targets of zero percent:

- SICs 2211 through 2284, except for SICs 2231 and 2283 (broad woven fabric and yarn mills, wool)

- SIC 2292 (lace goods)

- SIC 2295 (coated fabrics, not rubberized).

These sectors do not currently use recovered primary or secondary waste and are not likely to begin doing so by 1987. The technology will not be available for using recovered materials to make products that will be acceptable to the customers of these subsectors.

TABLE 8-3
Recovered Materials Targets for the Textile
Mill Products Industry

SIC	INDUSTRY SUBDIVISION	PROCESSED MATERIAL		1978 LEVEL OF RECOVERED MATERIALS USE	1987 RECOVERED MATERIALS TARGET
		MILLION POUNDS	PERCENT OF TOTAL	PERCENT OF TOTAL FIBER & YARN PROCESSED	PERCENT OF TOTAL FIBER & YARN PROCESSED
2211	BROAD WOVEN FABRIC MILLS, COTTON	2,587.8	16.6	0	0
2221	BROAD WOVEN FABRIC MILLS, MAN-MADE FIBER & SILK	2,717.5	17.5	0	0
2231	BROAD WOVEN FABRIC MILLS, WOOL	178.9	1.1	13	13
2241	NARROW FABRICS, COTTON, WOOL, SILK & MAN-MADE	194.3	1.2	0	0
2251	WOMEN'S FULL LENGTH & KNEE LENGTH HOSIERY	83.8	0.6	0	0
2252	OTHER HOSIERY	120.4	0.8	0	0
2253	KNIT OUTERWEAR MILLS	315.7	2.0	0	0
2254	KNIT UNDERWEAR MILLS	147.5	0.9	0	0
2257	CIRCULAR KNIT FABRIC MILLS	1,094.5	7.0	0	0
2258	WARP KNIT FABRIC MILLS	496.9	3.2	0	0
2259	KNITTING MILLS, N.E.C.	7.7	0.0	0	0
2261	BROAD WOVEN FABRIC FINISHERS, COTTON	N/A	N/A	0	0
2262	BROAD WOVEN FABRIC FINISHERS, SILK & MAN-MADE	N/A	N/A	0	0
2269	TEXTILE FINISHERS, N.E.C.	N/A	N/A	0	0
2271	WOVEN CARPETS & RUGS	83.1	0.5	0	0
2272	TUFTED CARPETS & RUGS	1,306.7	8.4	0	0
2279	CARPETS & RUGS, N.E.C.	41.6	0.3	0	0
2281	YARN SPINNING MILLS, COTTON, SILK, MAN-MADE FIBERS	2,706.1	17.3	0	0
2282	YARN TEXTURIZING, COTTON, SILK, MAN-MADE FIBER	891.6	5.7	0	0
2283	YARN MILLS, WOOL	123.9	0.8	13	13
2284	THREAD MILLS	139.2	0.9	0	0
2291	FELT GOODS, EXCEPT WOVEN FELTS & HATS	58.5	0.4	59	80
2292	LACE GOODS	5.0	0.0	0	0
2293	PADDING & UPHOLSTERY FILLING	330.0	2.1	93	93
2295	COATED FABRICS, NOT RUBBERIZED	136.2	0.9	0	0
2296	TIRE CORD & FABRIC	741.4	4.8	0	0
2297	NON-WOVEN FABRICS	641.0	4.1	17	15
2298	CORDAGE & TWINE	95.2	0.6	22	22
2299	TEXTILE GOODS, N.E.C.	–	–	–	–

In the second tier of the industry, SIC 2296 also has a zero target. This subsector includes the tire cord and fabric industry, whose products are directly related to auto safety, making strength a primary characteristic. The requirements for production of tire cord and fabric are very strict and rigidly controlled by the Department of Transportation.

Several subsectors of the industry currently use primary waste and small amounts of secondary waste for their final products. Except for wool yarn spinning and weaving, these subsectors are in the second tier of the industry. The following materials recovery targets are set for them:

- SIC 2231 Broad Woven Fabric Mills, Wool: 13 percent
- SIC 2283 Yarn Mills, Wool: 13 percent
- SIC 2291 Felt Goods, Except Woven Felt and Hats: 80 percent
- SIC 2293 Padding and Upholstery Filling: 93 percent
- SIC 2297 Nonwoven Fabrics: 15 percent
- SIC 2298 Cordage and Twine: 22 percent

It should be noted that most of the companies involved in these subsectors are relatively small firms, consuming much less than 1 trillion Btu's per year. Therefore, they will not be required to report their recovered materials and energy use to DOE.

8.3 REPORTED USE OF RECOVERED MATERIALS IN THE TEXTILE MILL PRODUCTS INDUSTRY

The Department of Energy (DOE), as required by the National Energy Conservation and Policy Act of 1978 (NECPA) published a Federal Register notice on January 8, 1979 (corrected by a January 19, 1979 notice) asking all corporations which consumed at least one trillion Btu's of energy in calendar year 1977 in any of the 20 major energy-consuming industries to file a certified statement to that effect with DOE. The corporations responding to the notices were identified in the Federal Register identification notices of February 12 and May 16, 1979. A total of 51 corporations were identified that operate in the textile mill products industry (SIC 22).

Section 374A(e) of the NECPA requires each corporation, which consumed at least one trillion Btu's of energy in calendar year 1977, to report to DOE on its use of recovered materials. The initial submission was to report on the volume of recovered materials, by two digit SIC, which the corporation used in each of its manufacturing operations in the United States and its plans, if any, to increase the utilization of such materials in those operations in each of the next ten years. DOE issued Form CS-153 for preparing and submitting the initial reports. Corporations were allowed to report directly to DOE or through a recognized trade association. In the textile mill products industry many firms chose to report through the American Textile Manufacturers Institute (ATMI).

Reports on the use of recovered materials in the textile mill products industry during 1978 were analyzed for additional information in establishing the recovered materials targets. As indicated in Table 8-4, completed CS-153 forms from the ATMI and 13 individual firms were received and analyzed. Each CS-153 form was reviewed to determine if the operations were first or second tier (this was necessary because the corporations are only required to report by two-digit SIC.), the virgin materials consumed and the total prompt and obsolete scrap used (basis for the recovered materials targets with self-generated scrap not included). This information is summarized in Table 8-4.

Only one of the 13 independently reporting companies indicate the use of any prompt scrap (primary waste) and none indicated the use of any obsolete scrap (secondary waste). Two of the reporting companies actually extrude

TABLE 8-4
Reported Use of Recovered Materials in the Textile Mill Products Industry (SIC 22)

(Data From CS-153 Industry Reports For 1978)

REPORTER	TYPE OF OPERATION	TYPE OF RECOVERED MATERIAL	TOTAL PRODUCTION MILLION POUNDS	VIRGIN MATERIALS MILLION POUNDS	SELF-GENERATED SCRAP USED MILLION POUNDS	PROMPT INDUSTRIAL SCRAP USED MILLION POUNDS	OBSOLETE SCRAP USED MILLION POUNDS	PROMPT AND OBSOLETE SCRAP / VIRGIN MATERIALS PERCENT
AMERICAN TEXTILE MANUFACTURERS INSTITUTE	YARN AND FABRIC FORMATION	FIBERS	5,425.3	5,775.3	61.9	125.2	0	2.1
COMPANY 1	NO DATA PROVIDED							
COMPANY 2	COATED FABRICS	VINYL & ABS SCRAP	158.5	147.9	3.8	0	0	0
	TIRE CORD	MANMADE YARN	104.7	102.6	5.2	0	0	0
COMPANY 3	POLYESTER FIBER AND CHIPS	ETHYLENE GLYCOL	410	537	8.6	0	0	0
COMPANY 4	WOVEN FABRIC	NONE	8.4	8.4	0	0	0	0
	FINISHING	NONE	14.1	14.1	0	0	0	0
	CARPET	NONE	213.1	213.1	0	0	0	0
	SPINNING	NONE	50.1	50.1	0	0	0	0
COMPANY 5	EXTRUDED POLYPROPYLENE	POLYPROPYLENE RESIN	45.5	225.9	32.1	13.4	0	5.9
COMPANY 6	SLEEVING	NONE	0.2	0.2	0	0	0	0
COMPANY 7	WOOLEN SPINNING	WOOL WASTE	15	0.3	0	0	0	0
COMPANY 8	NO RECOVERED MATERIALS USED – NOT APPLICABLE TO PRODUCT LINE							
COMPANY 9	NO OPERATION USED RECOVERED MATERIAL IN 1978							
COMPANY 10	TUFTING	NONE	31.5 MILLION YARDS	N/A	0	0	0	0
	DYEING	NONE	13.7 MILLION YARDS	N/A	0	0	0	0
	FINISHING	NONE	31.9 MILLION YARDS	N/A	0	0	0	0
	SPINNING	FIBER	27.9	27.9	1.6	0	0	0
COMPANY 11	CARPET	N/A	34.8 MILLION YARDS	65.3 MILLION YARDS	N/A	N/A	N/A	0
COMPANY 12	TWISTING & HEAT SETTING FILAMENT NYLON YARN	NONE	30.5	30.5	0	0	0	0
	KNITTING & DYEING FABRICS	NONE	4.8	4.8	0	0	0	0
COMPANY 13	CARPET	NONE	27.4 MILLION YARDS	27.4 MILLION YARDS	0	0	0	0
	YARN	NONE	3.5	3.5	0	0	0	0

manmade fibers and should be more appropriately assigned to the chemicals industry. The reported primary waste used is from one of these chemicals companies and the recovered waste material is polypropylene resin. Therefore, its impact on the textile mill products industry is discounted.

Each of the other 11 reporting corporations are in the first tier of the textile mill products industry. These firms all report the use of no recovered primary or secondary waste in their operations. This information reinforces the zero targets for nonwoolen, first tier segments of the textile mill products industry.

Data presented by the ATMI is aggregated for many types of companies, both first and second tier operations, making it impossible to analyze for any specific 4-digit SIC. As indicated in Table 8-4, there is no reported use of secondary waste (obsolete scrap) and about 125 million pounds of primary waste (prompt scrap). This constitutes about 2-percent of the 5.8 billion pounds of virgin fiber reported. At the reported 1978 total fiber consumption for the textile mill products industry, ATMI's report represents over 40 percent of the industry. These data reported by ATMI reinforce the selected materials recovery targets for the textile mill products industry.

Data reported by the ATMI and individual corporations as to their use of recovered materials, reinforces the sample taken by the researchers. These both documented that the major use of primary waste is concentrated in the woolen and second tier sections and that almost no secondary waste is consumed. Based on the reported data, the previously determined recovered materials targets (Table 8-3) will remain unchanged.

* * * *

This chapter has discussed the recovered materials targets determined for the various segments of the textile mill products industry. The following section discusses the effects various government and industry actions could have on the targets.

9. GOVERNMENT AND INDUSTRY ACTIONS THAT COULD INCREASE THE USE OF RECOVERED MATERIALS IN THE TEXTILE MILL PRODUCTS INDUSTRY

Few options for increasing the use of recovered materials in the textile mill products industry are available to the industry, the federal government, or state and local governments. This is true for two reasons:

- It is not technically feasible to use primary or secondary waste to produce first tier, high quality, consumer-oriented textile products acceptable on the U.S. (or European or Japanese) market. This situation is not expected to change between the present and 1987.

- Currently the textile mill products industry uses over 99 percent of its primary waste in producing items common to the second tier sector of the industry. Waste from the apparel industry (SIC 23) is used when excessive transportation costs are not involved.

The primary types of waste that are currently not being fully used are waste generated in the cutting and sewing operations of the apparel industry and secondary (post-consumer) waste. These types of waste should be used and should be the focus of incentive programs to increase the use of recovered materials. However, the technical limitations on first tier product quality must be overcome if effective use is to be made of the 5 to 10 billion pounds of textile waste material in these categories that are currently discarded each year. It was not considered feasible to require the use of recovered primary or secondary waste in first tier textile products. Such a requirement would essentially destroy the U.S. textile industry because consumers would turn increasingly to foreign imports for high quality goods.

Several actions can be taken to increase the reuse of available apparel industry waste. Most such steps would have to be taken by the government; little additional effort can be expected from the textile mill products industry.

9.1 THE TEXTILE MILL PRODUCTS INDUSTRY CAN DO LITTLE MORE TO INCREASE ITS USE OF RECOVERED MATERIALS

As previously stated, the textile mill products industry currently consumes from 550 to 750 million pounds of the waste it generates (reworkable and primary). Only 0.7 percent of the waste generated in SIC 22 is discarded in landfills. Most of the waste plus waste generated in the apparel industry is used by second tier textile mills. These mills use essentially all waste that is economically available to them. From an economic viewpoint, then, there is little the industry can do to increase the use of recovered materials. It has no control over the economics of collecting and transporting secondary waste and primary apparel industry waste, and costs in these areas are currently the factors limiting the use of secondary waste.

The industry could try to change basic textile processes to allow the use of recovered fibers, but certain conditions preclude changes being made in this area. These conditions include the following:

- Lack of discretionary funds for research and development into basic textile manufacturing processes for using shorter, recycled fibers. This lack of funds is created by several factors:
    - The mature textile industry has low profit margins (about 2 percent of revenues).
    - The industry has little access to capital through the debt and equity markets.
    - Most generated capital is being absorbed in meeting government-mandated requirements (EPA, OSHA). This leaves little capital available even for asset replacement.
- There is no capital for purchasing new high risk equipment for waste processing (if the equipment were available). Reasons for this are identical to those cited above. The industry currently does not even generate enough discretionary capital to replace obsolete equipment.

The industry currently uses available waste materials for newly developed products in the second tier of the industry, and it will continue to use waste in this way. However, any products so developed usually compete against existing and imported products, so that economics play a key role in product development decisions. For example, it is not economically practical to transport apparel waste great distances, and competition offered by other products limits the amount that can reasonably be devoted to collecting, grading, and reprocessing secondary waste. Nor does the textile mill products industry control the cost of transporting these materials.

As stated, the textile mill products industry competes in a market that imposes very strict quality and characteristic specifications on its products. Additionally, the industry is under increasingly heavy pressure from cheaper imports that are essentially equal in quality and that exhibit the same characteristics as American made textile goods. The industry cannot lower the quality standards of its first tier products and market inferior goods (goods made from recovered materials). Doing so would, in all likelihood, force its customers further into foreign markets, and this would undermine the industry, possibly causing many of the marginal firms to simply cease operating.

In summary, given current and projected market and economic conditions, there is very little the textile mill products industry can practically do to increase the use of apparel waste (primary) and secondary (post-consumer) waste. Its actions in these areas must be limited to new product development in the second tier of the industry; new products could make possible the increased use of primary and secondary waste but within existing economic conditions.

9.2 SEVERAL POSSIBLE GOVERNMENT ACTIONS COULD STIMULATE THE USE OF RECOVERED MATERIALS IN THE TEXTILE MILL PRODUCTS INDUSTRY

No government agency can do much to affect the buying preferences of the customers of the textile mill products industry. However, several actions could be taken that would influence the use of recovered materials in the industry. Many of these actions have been previously considered during legislative debates, but they have subsequently been defeated. Given this background, then, it seems necessary to add that, between now and 1987, these actions are not likely to become effective incentives for using recovered materials.

9.2.1 Government-Supported Research and Development in Basic Textile Processes

The government could use tax credits, tax holidays, direct subsidies, or research grants to encourage the first tier of the textile mill products industry to use recovered primary and secondary materials in its products. New textile processes making use of the recovered materials would be developed. Processes should be found for using recovered materials to make first tier quality products. Researchers at leading university textile departments indicate that no appreciable research is being done in this area and none is anticipated.

9.2.2 Government-Supported Research and Development in Waste Reprocessing and Handling Equipment

Through tax credits and research grants, the government could encourage the development of methods for reprocessing some primary and secondary waste into forms acceptable to the first tier of the textile mill products industry. No equipment is currently available or anticipated for such work and no research is being done in this area. Development of technologies to make recovered materials usable in first tier products would greatly increase the use of primary and secondary waste.

9.2.3 Amendments to the Wool Labeling Act and Incentives for the Wool Reprocessing Industry

The Wool Labeling Act of 1938 was a major cause of the contraction of the wool industry in the United States, because it made reused and reprocessed U.S. woolen goods unmarketable. Foreign woolen goods are not so restricted; therefore, most woolen goods sold in the United States are imported and many are fabricated from used wool that it is technically feasible to reuse. The government should analyze the possibility of using tax credits, tax holidays, and direct subsibsidies to reestablish the wool reprocessing industry, but first the Wool Labeling Act should be amended. As stated above, an attempt to amend this act was recently made, but to no avail. The current wool industry is so small (1 to 2 percent of the total material used) that its influence is limited, and projections indicate that the use of wool is not likely to grow appreciably between now and 1987 because of the price of wool compared with those of other fibers.

9.2.4 Mandatory Environmental and Regulatory Standards (EPA and OSHA)

As previously discussed, the current environmental and personnel safety standards imposed on the textile mill products industry will consume essentially all of the capital generated by the industry between now and 1987. These standards will create a large continuing demand on generated capital both because of initial installation expenses and because of operating costs. Obviously, capital for additional research and development and for installation of waste reprocessing equipment will have a much lower priority than these mandated expenditures. If these environmental and regulatory standards were relaxed, the program for use of recovered materials could benefit, since capital would be made available for development of new materials recovery equipment.

9.2.5 Transportation Subsidies for Moving Primary and Secondary Waste

The use of secondary waste and of apparel industry (primary) waste is limited by transportation economics. For that reason, a subsidy for hauling such material from areas like the garment districts of New York and New Jersey to the reprocessors and mills in the Southeast could make the use of such waste economically attractive. Reprocessors and second tier textile companies have indicated a need for good quality textile waste but only up to a given price; the extra cost of transportation cannot be too great. A subsidy here could have an immediate and direct effect on the use of recovered materials in the second tier of the textile mill products industry.

9.2.6 Modification of Government Purchasing Policies

Several government policies for purchasing products from the first and second tiers of the textile mill products industry currently require the use of virgin materials. If these requirements were changed, recovered materials could be used in items such as uniforms, blankets, mattresses, and other textile products.

* * * *

This chapter has discussed several ways in which government, primarily the federal government, could encourage the use of recovered materials in the textile mill products industry. None of these options is expected to have an appreciable effect in the industry before 1987.

APPENDIX A

Title IV, Part 4

NATIONAL ENERGY CONSERVATION AND POLICY ACT

Section 374A

Public Law 95-619
95th Congress

An Act

Nov. 9, 1978
[H.R. 5037]

For the relief of Jack R. Misner.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

National Energy Conservation Policy Act.

TITLE I—GENERAL PROVISIONS

SEC. 101. SHORT TITLE AND TABLE OF CONTENTS.

(a) SHORT TITLE.—This Act may be cited as the "National Energy Conservation Policy Act".

(b) TABLE OF CONTENTS.—

TITLE IV—ENERGY EFFICIENCY OF CERTAIN PRODUCTS AND PROCESSES

PART 4—ENERGY EFFICIENCY BY USE OF RECOVERED MATERIALS

SEC. 461. USE OF RECOVERED MATERIALS.

(a) FINDINGS.—The Congress finds that—

(1) significant amounts of industrial energy and other scarce natural resources are conserved in certain major energy-consuming industries where recovered materials are utilized in their manufacturing operations;

(2) substantial additional volumes of industrial energy and other scarce natural resources will be conserved in future years if such major energy-consuming industries increase to the maximum feasible extent utilization of recovered materials in their manufacturing operations;

(3) millions of tons of recoverable materials which could be used by such industries are needlessly wasted and buried each year at great cost to State and local governments, while technology and methods exist whereby those materials could readily be made available for utilization; and

(4) the recovery and utilization of such recovered materials can substantially reduce the dependence of the United States on foreign natural resources and reduce the growing deficit in its balance of payments.

(b) PURPOSES.—The purposes of this subtitle are to conserve valuable energy and scarce natural resources, promote the national security, and protect the environment by—

(1) directing that targets for increased industrial utilization of recovered materials be established for certain major energy-consuming industries;

(2) creating procedures whereby such industries may cooperate with the Federal Government in the establishment and achievement of such targets; and

(3) providing incentives for increased industrial utilization of energy-saving recovered materials in such major energy-consuming industries.

(c) TARGETS FOR USE OF RECOVERED MATERIALS.—Part E of title III of the Energy Policy and Conservation Act, as redesignated by section 441(b)(2) of this Act, is amended by inserting the following new section after section 374:

"TARGETS FOR USE OF RECOVERED MATERIALS

"SEC. 374A. (a) For purposes of this section, the term 'energy-saving recovered materials' means aluminum, copper, lead, zinc, iron, steel, paper and allied paper products, textiles, and rubber, recovered from solid waste, as defined in the Solid Waste Disposal Act.

"(b) Within one year after the date of the enactment of this section, the Secretary shall set targets for increased utilization of energy-saving recovered materials for each of the following industries: the metals and metal products industries, the paper and allied products industries, the textile mill products industry, and the rubber industry. Such targets—

"(1) shall be based on the best available information,

"(2) shall be established at levels which represent the maximum feasible increase in utilization of energy-saving recovered materials each such industry can achieve progressively by January 1, 1987, and

"(3) shall be published in the Federal Register, together with a statement of the basis and justification for such targets.

"(c) In establishing targets under subsection (b), the Secretary shall consult with the Administrator of the Environmental Protection Agency and with each of the major industries subject to this section, and shall consider—

"(1) the technological and economic ability of each such industry progressively to increase its utilization of energy-saving recovered materials by January 1, 1987, and

"(2) all actions taken or which before such date could be taken by each such industry, or by Federal, State, or local governments to increase that industry's utilization of energy-saving recovered materials.

"(d) Any target established under subsection (b) may be modified if the Secretary—

"(1) determines that such target cannot reasonably be attained, or that it should require greater use of energy-saving recovered materials, and

"(2) publishes such determination in the Federal Register, together with a basis and justification for such modification.

"(e) Within each of the industries subject to this section, the Secretary shall notify each corporation which is a major energy consumer (within the meaning of section 373) of the requirements of this section. Not later than January 1, 1979, the chief executive officer of each such corporation (or individual designated by such officer) shall include in his report to the Secretary under section 375, or if section 376(g) applies, prepare and transmit a report which includes, a statement of the volume of energy-saving recovered materials that such corporation is using in each of its manufacturing operations located in the United States and what plans, if any, the corporation has to increase the utilization of such materials in those operations in each of the next ten years. Not later than January 1, 1980, and annually thereafter, each such corporation shall include in such report a statement of the progress it has made to increase its utilization of energy-saving recovered materials to reach targets established under this section by the Secretary for its industry. Such reports shall contain such information as the Secretary determines is necessary to measure progress toward meeting the industry targets established under this section.

"(f) The Secretary shall include in his annual report under section 375(e) a report on the industrial energy and natural resource conservation and recovery program established under this section. Each such report shall include—

"(1) a summary of the progress made toward the achievement of targets set by the Secretary under this section; and

"(2) a summary of the progress made toward meeting such targets since the date of publication of the previous report, if any.".

(d) TECHNICAL AMENDMENTS.—(1) Section 376 of such Act is amended by—

(A) inserting "or 374A" after "section 372" in subsection (b), and

(B) inserting "or any target under section 374A" after "374" in subsections (c) and (f).

(2) The table of contents of such Act is amended by inserting after the item relating to section 374 the following new item:

APPENDIX B

REPRESENTATIVE PRODUCTS PRODUCED WITHIN EACH FOUR DIGIT SUB-DIVISION OF THE TEXTILE MILL PRODUCTS INDUSTRY (SIC 22)

Industry
No.

2211 Broad Woven Fabric Mills, Cotton

Airplane cloth, cotton
Alpacas, cotton
Automotive fabrics, cotton
Awning stripes, cotton: mitse
Bags and bagging, cotton: made in weaving mills
Balloon cloth, cotton
Bandage cloths, cotton
Bark cloth, cotton
Basket weave fabrics, cotton
Bathmats, cotton: made in weaving mills
Batiste, cotton
Bedspreads, cotton: made in weaving mills
Bird's-eye diaper cloth, cotton
Blankets and blanketings, cotton: mitse
Bombazine, cotton
Book cloth, mitse
Broadcloth, cotton
Brocade, cotton
Brocatelle, cotton
Buckram
Bunting cloths, mitse
Butter cloths
Cambric, cotton
Camouflage nets, mitse
Canton flannels, cotton
Canvas, mitse
Card roll fabrics, cotton
Casement cloth, cotton
Chafer fabrics, cotton
Chambrays
Cheese bandages, mitse
Cheesecloth
Chenilles, tufted textile: mitse
Cheviots, cotton
Chintz, cotton
Corduroys, cotton
Corset fabrics, cotton
Cotton broad woven goods
Cottonades
Coutil, cotton
Coverts, cotton
Crash toweling, cotton
Crepes, cotton
Cretonne, cotton
Crinoline
Damasks, cotton
Denims
Diaper fabrics
Dimities
Dishcloths, made in weaving mills
Draperies and drapery fabrics, cotton: mitse
Dress fabrics, cotton
Drills, cotton
Duck, cotton
Duvetyn, cotton
Elastic fabrics, cotton: over 12 inches in width
Express stripes, cotton
Fabrics, broad woven: cotton
Filter cloth, cotton
Flannelette
Flannels, cotton
Frieze, cotton
Friezette, cotton
Furniture denim
Gabardine, cotton
Galatea, cotton
Gauze, mitse
Ginghams
Glass toweling, cotton
Glove fabrics, cotton: mitse
Grosgrain, cotton
Handkerchief fabrics, cotton
Hickory stripes, cotton
Huck toweling
Interlining material, cotton
Jacquard woven fabrics, cotton
Jean fabrics
Laundry fabrics, cotton
Laundry nets, mitse
Lawns, cotton
Leno fabrics, cotton
Long cloth, cotton
Luggage fabrics, cotton
Madras, cotton
Marquisettes, cotton
Matelasse, cotton
Messaline, cotton
Mitten flannel, cotton
Moleskins, mitse
Momie crepe, cotton
Mosquito netting, mitse
Muslin, cotton
Nainsook, cotton
Nets and nettings, mitse
Opaline, cotton
Organdy, cotton
Osnaburgs
Outing flannel, cotton
Oxfords (cotton fabrics)
Pajama checks, textile
Percale
Percaline, cotton
Pile fabrics, cotton
Pillow tubing, mitse
Pillowcases, mitse
Pin checks, cotton
Pin stripes, cotton,
Piques, cotton
Plaids, cotton
Plisse crepe, cotton
Plushes, cotton
Pocketing twill, cotton
Pongee, cotton
Poplin, cotton
Press cloth
Print cloths, cotton
Ratine, cotton
Rep, cotton
Romaines
Sail cloth, mitse
Sateens, cotton
Scrim, cotton
Scrub cloths, mitse
Seat cover cloth, automobile: cotton
Seersuckers, cotton
Sheets and sheetings, cotton: mitse
Shirting fabrics, cotton
Shoe fabrics, mitse
Silesia, cotton
Slip cover fabrics, cotton
Stretch fabrics, cotton
Suiting fabrics, cotton
Surgical fabrics, cotton
Table cover fabrics, cotton
Table damask, cotton
Tapestry fabrics, cotton
Tarlatan, cotton
Tentage, mitse
Terry woven fabrics, cotton
Tickings, mitse
Tobacco cloths, mitse
Towels and toweling, cotton: made in weaving mills
Tracing cloth, cotton
Trouserings, cotton
Tubing, seamless: cotton
Twills, cotton
Typewriter ribbon cloth
Umbrella cloth, cotton
Underwear fabrics, except knit: cotton
Upholstary fabrics, cotton
Velours
Velveteens
Velvets, cotton
Voiles, cotton
Waffle cloth, cotton
Washcloths, except knit: made in weaving mills
Weaving mills, cotton broad woven fabrics
Wignan, cotton
Window shade cloth, cotton
Yarn-dyed fabrics, cotton

Industry
No.

2221 Broad Woven Fabric Mills, Man-Made Fiber and Silk

Acetate broad woven fabrics
Acrylic broad woven fabrics
Automotive fabrics, man-made fiber
Bedspreads, silk and man-made fiber: mitse
Blanketings, man-made fiber
Broad woven fabrics, silk and man-made fiber
Canton crepes
Crepe satins
Draperies and drapery fabrics, man-made fiber and silk: mitse
Dress fabrics, man-made fiber and silk
Duvetyn, man-made fiber and silk
Elastic fabrics, man-made fiber and silk: over 12 inches in width
Fabrics, broad woven: man-made fiber and silk
Failles
Fiberglass fabrics
Flat crepes
French crepes
Fur-type fabrics, man-made fiber
Georgettes
Glass broad woven fabrics
Jacquard woven fabrics, man-made fiber and silk
Leno fabrics, man-made fiber and silk
Lining fabrics, man-made fiber and silk
Linings, rayon or silk: mitse
Marquisettes, man-made fiber
Modacrylic broad woven fabrics
Necktie fabrics, man-made fiber and silk: broad woven
Nylon broad woven fabrics
Nytril broad woven fabrics
Paper broad woven fabrics
Parachute fabrics
Pile fabrics, man-made fiber and silk
Plushes, man-made fiber and silk
Polyester broad woven fabrics
Polyethylene broad woven fabrics
Polypropylene broad woven fabrics
Pongee, man-made fiber and silk
Poplin, man-made fiber
Quilts, man-made fiber and silk: mitse
Rayon broad woven fabrics
Saran broad woven fabrics
Satins
Serges, man-made fiber
Shantungs, man-made fiber and silk
Shirting fabrics, man-made fiber and silk
Silk broad woven fabrics
Slip cover fabrics, man-made fiber and silk
Spandex broad woven fabrics
Suiting fabrics, man-made fiber and silk
Taffetas
Tapestry fabrics, man-made fiber and silk
Textile mills, broad woven: silk and man-made fiber including glass
Textile warping, on a contract basis
Twills, man-made fiber
Underwear fabrics, except knit: man-made fiber and silk
Upholstery fabrics, man-made fiber and silk
Velvets, man-made fiber and silk
Vinal broad woven fabrics
Vinyon broad woven fabrics
Voiles, man-made fiber and silk

Industry
No.

2231 Broad Woven Fabric Mills, Wool (Including Dyeing and Finishing)

Alpacas, mohair: woven
Bale dyeing of yarn and fabrics, of wool and similar fibers: except knit
Billiard cloths, mitse
Blankets and blanketings, of wool and similar fibers: mitse
Bleaching yarn and fabrics, of wool and similar fibers: except knit fabric
Broad woven fabrics, of wool, mohair, and similar fibers
Burling and mending cloth for the trade
Calendering of wool, mohair, and similar fiber fabrics: except knit
Cloth, wool: mending—for the trade
Dyeing and finishing of wool and similar fibers: except knit
Fabric, animal fiber: broad woven
Fabric finishing of wool, mohair, and similar fibers: except knit
Fabrics, broad woven: of wool, mohair, and similar fibers
Felts, of wool, mohair, and similar fibers: woven
Finishing of wool, mohair, and similar fiber fabrics: except knit
Flannels of wool, mohair, and similar fibers
Haircloth of wool, mohair, and similar fibers
Mill menders, contract: wool, mohair, and similar fibers
Napping of wool, mohair, and similar fiber fabrics
Narrow fabrics: dyeing and finishing of wool, mohair, and similar fibers
Overcoatings, of wool, mohair, and similar fibers
Pantings: of wool, mohair, and similar fibers
Papermakers' felts, woven of wool, mohair, and similar fibers
Raw stock dyeing and finishing of wool, mohair, and similar fibers
Refinishing and sponging cloths of wool, mohair, etc., for the trade
Serges of wool, mohair, and similar fibers
Shrinking cloth of wool, mohair, and similar fibers: for the trade
Skirtings
Sponging and refinishing cloth of wool and similar fibers: for the trade
Suitings of wool, mohair, and similar fibers
Trouserings of wool, mohair, and similar fibers
Upholstery fabrics, wool
Vat dyeing of tops, yarn, and textiles: of animal fibers—except knit
Weaving mills, broad woven fabrics: of wool, mohair, and similar fibers
Worsted fabrics, broad woven
Yarn bleaching, dyeing, and finishing: of wool, mohair, and similar fibers

Industry
No.

2241 Narrow Fabrics and Other Smallwares Mills: Cotton, Wool, Silk, and Man-Made Fiber

Apparel webbing
Auto wind lace
Banding, spindle
Beltings, woven or braided
Bindings, textile: mitse
Braids, textile
Braids, tubular nylon and plastic
Cords, fabric
Corset laces
Cotton narrow fabrics
Elastic narrow fabrics, woven or braided
Elastic webbing
Electric insulating tapes and braids, except plastic
Fabric, animal fiber: narrow woven
Fringes, weaving
Gimps, mitse
Glass narrow fabrics
Glove lining fabrics
Hat band fabrics
Hose fabric, tubular
Insulating tapes and braids, electric
Labels, woven
Lace, auto wind
Laces, corset and shoe: textile
Lacings, mitse
Narrow woven fabrics: cotton, wool, silk, glass, and man-made fiber
Rayon narrow fabrics
Ribbons, mitse
Rickrack braid
Rubber thread and yarns, fabric covered
Shoelaces, except leather
Slide fastener tapes
Spindle banding
Strapping webs
Tapes, fabric
Textile mills, narrow woven: fibers including glass
Tie tapes, woven or braided
Trimmings, textile: mitse
Venetian blind tapes
Weaving mills: cotton, wool, silk, and man-made fiber narrow fabrics
Webbing, woven: except jute
Wicking
Zipper tape

2251 Women's Full Length and Knee Length Hosiery

Dyeing and finishing women's full and knee length hosiery
Hosiery, women's and misses' full length and knee length
Panty hose
Stockings, women's and misses' full length and knee length
Stretch tights, seamless and full-fashioned

2252 Hosiery, Except Women's Full Length and Knee Length Hosiery

Anklets (hosiery), seamless or full-fashioned
Dyeing and finishing hosiery, except women's full and knee length
Hosiery, except women's and misses' full length and knee length hosiery
Infants' and children's hosiery
Men's, boys', and girls' hosiery
Slipper socks, mitse
Socks, seamless and full-fashioned
Socks, slipper, mitse
Stockings, except women's and misses' full length and knee length stocking

Industry
No.

2253 Knit Outerwear Mills

Apparel, except gloves, hosiery, and underwear—mitse
Basque shirts, mitse
Bathing suits, mitse
Bathrobes, mitse
Beachwear, mitse
Bedjackets, mitse
Blouses, mitse
Body stockings, mitse
Caps, mitse
Collar and cuff sets, mitse
Dresses, hand knit: for the trade
Dresses, mitse
Dyeing and finishing knit outerwear, except hosiery and gloves
Hand knitting of outerwear, for the trade
Hats, mitse
Headwear, mitse
Housecoats, mitse
Jerseys and sweaters, mitse
Leotards, mitse
Lounging robes, mitse
Mufflers, mitse
Neckties, mitse
Outerwear, except hosiery and gloves: mitse
Scarfs, mitse
Shawls, mitse
Shirts (outerwear), mitse
Shoulderettes, mitse
Ski suits, mitse
Slacks or pants, mitse
Suits, mitse
Sweaters and sweater coats, mitse
Wristlets, mitse

2254 Knit Underwear Mills

Drawers, apparel: mitse
Dyeing and finishing knit underwear
Nightwear, mitse
Panties, mitse
Shirts (underwear), mitse
Slips, mitse
Step-ins, mitse
Underwear, mitse
Union suits, mitse

2257 Circular Knit Fabric Mills

Circular knit fabrics of all materials
Cloth, circular knit: mitse
Dyeing and finishing circular knit fabrics
Fabric, circular knit
Jersey cloth, mitse
Pile fabric, circular knit

2258 Warp Knit Fabric Mills

Cloth, warp knit: mitse
Dyeing and finishing warp knit fabrics
Finishing of warp or flat knit fabrics
Lace, knit
Mosquito netting, warp knit: mitse
Netting, knit
Pile fabric, warp or flat knit
Tricot fabrics
Warp or flat knit fabrics of all materials

2259 Knitting Mills, Not Elsewhere Classified

Bags and bagging, made in knitting mills
Bedspreads, made in knitting mills
Curtains, made in knitting mills
Dishcloths, made in knitting mills
Dyeing and finishing knit gloves and mittens
Elastic girdle blanks, made in knitting mills
Girdles (elastic) and other foundation garments, mitse
Gloves, made in knitting mills
Linings, shoe: made in knitting mills
Meat bagging: made in knitting mills
Mittens, made in knitting mills
Stockinette, made in knitting mills
Towels, made in knitting mills
Washcloths, made in knitting mills

Industry
No.

2261 Finishers of Broad Woven Fabrics of Cotton

Bleaching cotton broad woven fabrics
Bleaching, kier: continuous machine
Calendering of cotton fabrics
Dyeing cotton broad woven fabrics
Embossing cotton broad woven fabrics
Finishing of cotton broad woven fabrics
Fire-resistance finishing of cotton broad woven fabrics
Mercerizing cotton broad woven fabrics
Mildew proofing cotton broad woven fabrics
Napping of cotton broad woven fabrics
Preshrinking cotton fabrics, for the trade
Printing and finishing of cotton broad woven fabrics
Refinishing and sponging cotton broad woven fabrics, for the trade
Shrinking cotton cloth, for the trade
Sponging and refinishing cotton cloth, for the trade
Sueding cotton broad woven goods
Teaseling cotton broad woven goods
Water repellency finishing of cotton broad woven fabrics

2262 Finishers of Broad Woven Fabrics of Man-Made Fiber and Silk

Bleaching man-made fiber and silk broad woven fabrics
Calendering of man-made fiber and silk broad woven fabrics
Dyeing man-made fiber and silk broad woven fabrics
Embossing man-made fiber and silk broad woven fabrics
Finishing of man-made fiber and silk broad woven fabrics
Fire resistance finishing of man-made fiber and silk broad woven fabrics
Napping of man-made fiber and silk broad woven fabrics
Preshrinking man-made fiber and silk broad woven fabrics, for the trade
Printing man-made fiber and silk broad woven fabrics
Shrinking man-made fiber and silk cloth, for the trade
Silk broad woven fabric finishing
Sueding man-made fiber and silk broad woven fabrics
Teaseling man-made fiber and silk broad woven fabrics

2269 Finishers of Textiles, Not Elsewhere Classified

Bleaching raw stock, yarn, and narrow fabrics: except knit and wool
Braided goods except wool: bleaching, dyeing, printing and other finishing
Cloth mending, except wool: for the trade
Dyeing raw stock, yarn, and narrow fabrics: except knit and wool
Embossing linen broad woven fabrics
Finishing raw stock, yarn, and narrow fabrics: except knit and wool
Gassing yarn
Labels, cotton: printed
Linen fabrics: dyeing, finishing, and printing
Mercerizing yarn, braided goods, and narrow fabrics: except knit and wool
Mill enders, contract: cotton, silk, and man-made fiber
Printing narrow fabrics, except knit and wool

2271 Woven Carpets and Rugs

Aircraft floor coverings, woven
Art squares, woven textile fiber
Automobile floor coverings, woven
Axminster carpets
Bathmats, woven textile fiber: not made in weaving mills
Carpets, woven textile fiber
Chenille rugs
Floor coverings, woven textile fiber
Mats and matting, woven cotton and wool
Rugs, machine woven
Smyrna carpets and rugs, machine woven
Wilton carpets

Industry
No.

2272 Tufted Carpets and Rugs

Bathmat sets, tufted
Bathmats, tufted
Carpets, tufted
Dyeing and finishing of tufted rugs
and carpets
Rugs, tufted
Scatter rugs, tufted

2279 Carpets and Rugs, Not Elsewhere Classified

Art squares: twisted paper, grass, reed,
coir, sisal, jute, and rag
Carpets: twisted paper, grass, reed,
coir, sisal, jute, and rag
Door mats: twisted paper, grass, reed
coir, sisal, jute, and rag
Floor coverings: twisted paper, grass,
reed, coir, sisal, jute, and rag
Mats and matting: twisted paper, grass,
reed, coir, sisal, jute, and rag
Rugs, braided and hooked
Rugs: twisted paper, grass, reed, coir,
sisal, jute, and rag

2281 Yarn Spinning Mills: Cotton, Man-Made Fibers and Silk

Acetate yarn, made from purchased
staple: spun
Acrylic yarn, made from purchased
staple: spun
Carded yarn, cotton
Carpet yarn, cotton
Combed yarn, cotton
Cordage yarn, cotton
Crochet yarn: cotton, silk, and man-made
staple
Darning yarn: cotton, silk, and man-made
staple
Embroidery yarn: cotton, silk, and man-made
staple
Knitting yarn: cotton, silk, and man-made
staple
Man-made staple fiber yarn, spun
Modacrylic yarn, made from purchased
staple: spun
Nylon yarn, spinning of staple
Nytril yarn, made from purchased
staple: spun
Polyester yarn, made from purchased
staple: spun
Polypropylene yarn, made from purchased
staple: spun
Rayon yarn, made from purchased
staple: spun
Saran yarn, made from purchased staple:
spun
Spinning yarn: cotton, silk, and man-made
staple
Vinal yarn, made from purchased staple:
spun
Vinyon yarn, made from purchased staple:
spun
Weaving yarn: cotton, silk, and man-made
staple
Yarn, cotton, silk, and man-made staple

2282 Yarn Texturizing, Throwing, Twisting, and Winding Mills: Cotton, Man-Made Fibers and Silk

Acetate filament yarn: throwing, twisting,
winding, or spooling
Acrylic and modacrylic filament yarn:
throwing, winding, or spooling
Beaming yarns, for the trade
Nylon yarn: throwing, twisting, winding,
or spooling of continuous filament
Polyester filament yarn: throwing,
twisting, winding, or spooling
Polypropylene filament yarn: throwing,
twisting, winding, or spooling
Rayon yarn, made from purchased
filament yarn: throwing, twisting,
winding
Saran filament yarn: throwing, twisting, winding,
or spooling
Spooling yarn: cotton, silk, and man-made fiber
continuous filament
Textured yarns
Throwing, winding, or spooling of filament
yarn: silk and man-made fiber
Twisting yarn: silk and man-made fiber
continuous filament
Vinal filament yarn: throwing, twisting, winding,
or spooling
Vinyon filament yarn: throwing, twisting,
winding, or spooling
Winding yarn: cotton, silk, and man-made fiber
continuous filament

Industry
No.

2283 Yarn Mills, Wool, Including Carpet and Rug Yarn

Animal fiber yarn: spinning, twisting, winding, or spooling
Crochet yarn: wool, mohair, or similar animal fiber
Darning yarn: wool, mohair, or similar animal fiber
Embroidery yarn: wool, mohair, or similar animal fiber
Knitting yarn: wool, mohair, or similar animal fiber
Mohair yarn: spinning, twisting, winding, or spooling
Rug yarn: wool, mohair, or similar animal fiber
Thread: wool, mohair, or similar animal fiber
Twisting yarn: wool, mohair, or similar animal fiber
Weaving yarn: wool, mohair, or similar animal fiber
Wool yarn: spinning, twisting, winding, or spooling
Yarn, carpet and rug: animal fiber—spinning, twisting, and spooling
Yarn: weaving machine knitting, and hand knitting animal fiber

2284 Thread Mills

Cotton thread
Crochet thread: cotton, silk, and man-made fiber
Darning thread: cotton, silk, and man-made fiber
Embroidery thread: cotton, silk, and man-made fiber
Hand knitting thread: cotton, silk, and man-made fiber
Man-made fiber thread
Nylon thread
Polyester thread
Rayon thread
Sewing thread: cotton, silk, and man-made fiber
Silk thread
Spinning thread: cotton, silk, and man-made fiber
Tatting thread: cotton, silk, and man-made fiber
Thread, except linen or wool: bleaching, dyeing, and finishing
Thread: except linen wool, mohair, or similar animal fibers

2291 Felt Goods, Except Woven Felts and Hats

Acoustic felts, except woven
Automotive felts, except woven
Carpet cushions, felt
Felt goods, except woven felts and hats: wool, hair, jute, or other fiber
Insulating felts, except woven
Ironing board felts, except woven
Lining felts, except woven
Linings, carpet: felt, except woven
Mats, felt: except woven
Pads and padding, felt: except woven
Pipe and boiler covering, felt
Polishing felts, except woven
Pressed wool felts
Punched felts
Trimming felts, except woven

2292 Lace Goods

Bed sets, lace
Covers, lace: chair, dresser, piano, and table
Curtains and curtain fabrics, lace
Dyeing and finishing lace goods
Edgings, lace
Galloons, lace
Lace goods: curtains, bedspreads, table covers, flouncings, and insertions
Laces: Barmen, bobbinet, levers, and Nottingham
Netting made on a lace or net machine

Industry
No.

2293 Paddings and Upholstery Filling

Apparel filling: cotton mill waste, kapok, and related materials
Batts and batting: cotton mill waste, kapok, and related materials
Hair, curled: for upholstery, pillow, and quilt filling
Padding and wadding, except excelsior
Pads, fiber: henequen, sisal, istle
Pillow filling: curled hair, cotton waste, moss, hemp tow, kapok, etc.
Quilt filling: curled hair, cotton waste, moss, hemp tow, kapok, etc.
Upholstery filling, except excelsior
Wads and wadding, except excelsior

2294 Processed Waste and Recovered Fibers and Flock

Carbonized rags
Fibers, textile: recovery from textile mill waste and rags
Flock (recovered textile fibers)
Garnetting of textile waste and rags
Oakum
Packing, twisted jute
Processing of textile mill waste and recovering fibers
Recovering textile fibers from clippings and rags
Wool shoddy
Wool waste processing

2295 Coated Fabrics, Not Rubberized

Buckram: varnished, waxed, and impregnated
Cambric: varnished, waxed, and impregnated
Cloth, varnished glass
Coating and impregnating of fabrics, except rubberizing
Fabrics, coated and impregnated: except rubberized
Laminating of fabrics
Leather, artificial
Mats, varnished glass
Metallizing of fabrics
Oilcloth
Pyroxylin coated fabrics
Resin (plastic) coated fabrics
Sealing or insulating tape for pipe, fiberglass coated with tar or asphalt
Sleeving, textile: saturated
Tape, varnished: plastic, and other coated (except magnetic) —mfpm
Tubing, textile: varnished
Waterproofing fabrics, except rubberizing
Waxing of cloth
Yarns, plastic coated: made from purchased yarns

2296 Tire Cord and Fabric

Cord for reinforcing rubber tires, industrial belting, and fuel cells
Fabric for reinforcing rubber tires, industrial belting, and fuel cells

2297 Nonwoven Fabrics

Bonded-fiber textiles, except felt
Fabrics, bonded fiber: except felt
Nonwoven textiles, except wool
Ribbon, nonwoven (yarn bonded by plastic)
Spunbonded fabrics

Industry
No.

2298 Cordage and Twine

Binder and baler twine
Blasting mats, rope
Cable, fiber
Camouflage nets, not made in weaving mills
Cargo nets (cordage)
Cord, braided
Cordage: abaca (Manila), sisal, henequen, hemp, jute, and other fibers
Fish nets and seines, made in cordage or twine mills
Fishing lines, nets, seines: made in cordage or twine mills
Hard fiber cordage and twine
Insulator pads, cordage
Nets, rope
Rope, except asbestos and wire
Slings, rope
Soft fiber cordage and twine
Trawl twine
Twine
Wire rope centers

2299 Textile Goods, Not Elsewhere Classified

Bagging, jute: made in jute weaving mills
Burlap, jute
Coir yarns and roving
Crash, linen
Fabrics: linen, jute, hemp, ramie—except felt
Flax yarns and roving
Grease, wool
Hand woven fabrics
Hemp yarn, thread, roving, and textiles
Narrow woven fabrics: linen, jute, hemp, and ramie
Noils, wool and mohair
Preparing textile fibers for spinning (scouring and combing)
Ramie yarn, thread, roving, and textiles
Rayon tops, combing and converting
Roves, flax and jute
Rugbacking, jute or other fiber: except felt
Slubs and nubs (cutting up fibers for use in tweeds)
Textile mills: linen, jute, hemp, and ramie yarn, thread, and fabric
Tops, combing and converting
Tops, man-made fiber
Tow to top mills
Towels and towelings, linen and linen-and-cotton mixtures: mitse
Thread: linen, hemp, and ramie
Webbing, jute
Wool scouring and carbonizing
Wool tops, combing and converting
Yarn: flax, jute, hemp, and ramie
Yarn, metallic, ceramic, or paper fibers
Yarns, specialty and novelty

2311 Men's, Youths', and Boys' Shirts (Except Work Shirts) and Nightwear

Coats: tailored—men's, youths', and boys'
Firemen's uniforms
Formal jackets, men's and youths'
Military uniforms, men's and youths'
Overcoats: men's, youths', and boys'
Policemen's uniforms
Suits: men's, youths', and boys'
Tailored dress and sport coats: men's and boys'
Topcoats: men's, youths', and boys'
Tuxedos
Uniforms, men's: suits, coats, and overcoats
Vests: except suede, leatherette, blanket lined—men's and boys'

Industry
No.

2321 Men's, Youths', and Boys' Shirts (Except Work Shirts) and Nightwear

Blouses, boys': mfpm
Collars, men's and youths': mfpm
Flannel shirts, except work shirts: men's, youths', and boys'
Nightshirts: men's, youths', and boys'—mfpm
Nightwear: men's, youths', and boys' (except robes)—mfpm
Pajamas: men's, youths', and boys'—mfpm
Polo shirts: men's, youths', and boys'—mfpm
Shirts, except work shirts: men's and boys'—mfpm
Shirts, flannel: except work shirts—men's, youths', and boys'
Sports shirts: men's, youths', and boys'—mfpm
T-shirts: men's, youths', and boys'—mfpm
Uniform shirts